การศึกษาตำแหน่งของหลอดเลือดแดงบนใบหน้าโดยอ้างอิงกับตำแหน่งของการฉีดสารเติมเต็ม เพื่อประเมินความเสี่ยงต่อการเกิดภาวะแทรกซ้อนแบบรุนแรงภายหลังการทำหัตถการฉีดสารเติมเต็ม

นางสาวเบญจริตา จิตอารี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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CADAVERIC EVALUATION OF THE LOCATION OF ARTERIES AND THEIR ANASTOMOTIC TERRITORIES ON THE FACE: THE FEASIBILITY DETERMINATION OF RISKY SEVERE COMPLICATIONS REGARDING TO THE FILLER INJECTIONS SITES

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Medical Science
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Thesis Title	CADAVERIC EVALUATION OF THE LOCATION OF ARTERIES AND THEIR ANASTOMOTIC TERRITORIES ON THE FACE: THE FEASIBILITY DETERMINATION OF RISKY SEVERE COMPLICATIONS REGARDING TO THE FILLER INJECTIONS SITES
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เบญริตา จิตอารี : การศึกษาตำแหน่งของหลอดเลือดแดงบนใบหน้าโดยอ้างอิงกับตำแหน่งของการฉีดสารเติมเต็ม เพื่อประเมินความเสี่ยงต่อการเกิดภาวะแทรกซ้อนแบบรุนแรงภายหลังการทำหัตถการฉีดสารเติมเต็ม (CADAVERIC EVALUATION OF THE LOCATION OF ARTERIES AND THEIR ANASTOMOTIC TERRITORIES ON THE FACE: THE FEASIBILITY DETERMINATION OF RISKY SEVERE COMPLICATIONS REGARDING TO THE FILLER INJECTIONS SITES) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. นพ. ธันวา ตันสถิตย์, 301 หน้า.

การเสื่อมสภาพของใบหน้าตามกาลเวลาก่อให้เกิดริ้วรอยและร่องลึก รวมทั้งทำให้รูปทรงของใบหน้ามีการเปลี่ยนแปลง ดังนั้นหัตถการฉีดสารเติมเต็มจึงเป็นทางเลือกที่มีความนิยมอย่างแพร่หลายในปัจจุบันสำหรับการแก้ปัญหาการเสื่อมถอยของใบหน้า อย่างไรก็ตามหัตถการดังกล่าวอาจก่อให้เกิดภาวะแทรกซ้อนอย่างรุนแรงอันเนื่องมาจากการบาดเจ็บต่อหลอดเลือดแดงระหว่างการทำหัตถการ ดังนั้นการวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาตำแหน่งและการเชื่อมต่อของหลอดเลือดแดงบนใบหน้าโดยอ้างอิงกับตำแหน่งการฉีดสารเติมเต็ม เพื่อประเมินความเสี่ยงต่อการเกิดภาวะแทรกซ้อนแบบรุนแรง โดยการวิจัยนี้ทำการศึกษาในร่างของผู้บริจาคร่างกายทั้งหมด 31 ร่าง เพื่อศึกษาหลอดเลือดแดงและตำแหน่งที่ใกล้ที่สุดต่อตำแหน่งการฉีดสารเติมเต็ม และทำการศึกษาในร่างของผู้บริจาคร่างกายทั้งหมด 10 ร่าง เพื่อศึกษาการเชื่อมต่อของหลอดเลือดแดงดังกล่าว จากการศึกษาพบว่า หลอดเลือดแดง supratrochlear วางตัวใกล้ต่อตำแหน่งการฉีดสารเติมเต็มบริเวณหน้าผากมากที่สุด (ร้อยละ 48.4) อย่างไรก็ตามหลอดเลือดแดง supraorbital วางตัวใกล้ต่อตำแหน่งการฉีดสารเติมเต็มบริเวณคิ้วและเปลือกตาบนมากที่สุด ร้อยละ 46.8 และร้อยละ 35.5 ตามลำดับ นอกจากนี้หลอดเลือดแดง superficial temporal (ร้อยละ 50) มีตำแหน่งใกล้ที่สุดต่อตำแหน่งการฉีดสารเติมเต็มบริเวณขมับ โดยบริเวณใบหน้าส่วนกลางพบว่า หลอดเลือดแดง transverse facial วางตัวใกล้ที่สุดต่อตำแหน่งการฉีดร่องแก้มด้านข้าง (ร้อยละ 100) นอกจากนี้หลอดเลือดแดง angular มีตำแหน่งการวางตัวใกล้ต่อตำแหน่งการฉีดร่องใต้ตามากที่สุด (ร้อยละ 43.5) โดยหลอดเลือดแดง infraorbital มีการวางตัวต่อตำแหน่งการฉีด mid cheek มากที่สุด (ร้อยละ 29) อย่างไรก็ตามหลอดเลือดแดง facial มีการวางตัวใกล้ที่สุดต่อตำแหน่งร่องแก้ม (ร้อยละ 58.1) ในการศึกษาบริเวณใบหน้าส่วนล่าง พบว่า หลอดเลือดแดง superior labial มีการวางตัวใกล้ต่อตำแหน่งการฉีดริมฝีปากมากที่สุด (ร้อยละ 88.7) นอกจากนี้หลอดเลือดแดง submental และหลอดเลือด facial มีตำแหน่งใกล้กับตำแหน่งการฉีดคาง (ร้อยละ 61.3) และตำแหน่งการฉีด Jaw line (ร้อยละ 88.7) มากที่สุด ตามลำดับ ผลจากการศึกษาโดยสรุปพบว่า ความเสี่ยงต่อเกิดภาวะแทรกซ้อนแบบรุนแรงจะพบมากที่สุดที่บริเวณใบหน้าส่วนบน แต่อย่างไรก็ตามภาวะแทรกซ้อนแบบรุนแรงอาจเกิดหลังจากการฉีดสารเติมเต็มบริเวณใบหน้าส่วนกลาง เนื่องจากหลอดเลือดบริเวณดังกล่าวมีการเชื่อมต่อกับหลอดเลือดแดง ophthalmic

สาขาวิชา วิทยาศาสตร์การแพทย์	ลายมือชื่อนิสิต ....
ปีการศึกษา 2560	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

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KEYWORDS: FILLER INJECTION / FACIAL ARTERY / ARTERIAL ANASTOMOSIS / FILLER COMPICATIONS

BENRITA JITAREE: CADAVERIC EVALUATION OF THE LOCATION OF ARTERIES AND THEIR ANASTOMOTIC TERRITORIES ON THE FACE: THE FEASIBILITY DETERMINATION OF RISKY SEVERE COMPLICATIONS REGARDING TO THE FILLER INJECTIONS SITES. ADVISOR: PROF. TANVAA TANSATIT, M.D., 301 pp.

The facial aging features are most concerns; therefore, the filler injection procedures are selected to provide the youthful face. However, the several complications following arterial devastating have been reported continually. Therefore, this study objectively evaluated the arterial location relative to filler injection sites. Furthermore, the arterial anastomoses and arterial supply of each injection site were also studied to verify the filler embolic pathways. This dissection was performed on 62 hemi-faces Thai embalmed cadavers to investigate nearest artery and its location of all injection sites. While, the 20 hemi-faces Thai embalmed cadavers were employed with Sihler's staining procedure to examine the anastomotic pathways. The most of nearest artery of forehead landmark was supratrochlear artery (48.4%). For the eyebrow injection site, the most nearest artery was brow branch of supraorbital artery (46.8%). The most nearest artery was lateral rim branch (35.5%) at upper eyelid injection site. At the glabellar area, the main nearest artery was left central artery (32.3%). For the temple injection sites, the closest artery was descending branch of superficial temporal artery (50.0%). At the tear trough, the major nearest artery was angular branch of ophthalmic artery (43.5%). Moreover, the main nearest artery to mid cheek was infraorbital artery (29.0%), whereas transverse facial artery was locating nearest to lateral hollowness injection site. However, facial artery located nearest to nasolabial injection sites (58.1%). The superior labial artery was found mostly locating closest to upper lip injection sites (88.7%). The closest artery to chin and jawline injection sites was right submental (61.3%) and facial artery (88.7%), respectively. To summarize our finding, the upper face may provide highest risk of severe complications when compares with the middle and lower face regions. However, the middle face may confront with the risk of severe complication due to it has anastomosis to the branch of ophthalmic artery.

Field of Study: Medical Science	Student's Signature ....
Academic Year: 2017	Advisor's Signature ....

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LIST OF ABBREVIATIONS

STCA	Supratrochlear artery
SOA	Supraorbital artery
BBSOA	Brow branch of supraorbital artery
OBSOA	Oblique branch of supraorbital artery
LRBSOA	Lateral rim branch of supraorbital artery
STA	Superficial temporal artery
frSTA	Frontal branch of Superficial temporal artery
desSTA	Descending branch of Superficial temporal artery/descending temporal artery
LA	Lacrimal artery
OA	Ophthalmic artery
ZOA	Zygomaticoorbital artery
CA	Central artery
PCA	Paracentral artery
TFA	Transverse facial artery
IOA	Infraorbital artery
LIOA	Lateral branch of IOA
FA	Facial artery
dFA	Detoured branch of Facial artery
bFA	Buccal branch of Facial artery
ZFA	Zygomaticofacial artery

MA	Maxillary artery
pIOA	Palpebral branch of Infraorbital artery
pMA	Palpebral branch of Maxillary artery
pdFA	Palpebral branch of Facial artery
pFA	Palpebral branch of Facial artery
pTFA	Palpebral branch of Transverse facial artery
pbFA	Palpebral branch of Buccal artery
AA	Angular artery
AAoa	Angular artery of Ophthalmic artery
AAioa	Angular artery of Infraorbital artery
AAdfa	Angular artery of detoured branch of facial artery
AAfa	Angular artery of FA
pAAfa	Palpebral branch of angular artery of FA
DNA	Dorsal nasal artery
IAA	Inferior alar artery
LNA	Lateral nasal artery of facial artery
SLA	Superior labial artery
ioaLNA	Lateral nasal artery of Infraorbital artery
aSLA	Alar branch of SLA
sSLA	Septal branch of SLA
ILA	Inferior labial artery
LMA	Labiomental artery
SMA	Submental artery
mbFA	Masseteric branch of facial artery

CHAPTER I

INTRODUCTION

1.1 Background and rationale

The number of nonsurgical aesthetic procedures has increased dramatically in every year.[1] Because natural aging processes such as weakening of the facial muscle and tissue are mainly factors of skin aging, more people extremely concern about this features. Moreover, sun exposure is a cooperative factor to induce aging features including deep wrinkle, skin dehydration, dermal collagen reduction, decreasing of skin thickness and elasticity.[2-3] To provide the youthful face, the minimal invasive procedures following filler injection has became acceptable and successful procedure.[4] Even though these procedures are safely, the several complications have been reported continually. The minimal complications such as bruising, ecchymosis, swelling, and erythema have been commonly found after injection. Such complications are contemporary, and it can be improved lasting for up to 7 days.[4-5] Seriously, the patients who encounter with the severe complications, such as visual impairment, skin necrosis and cerebral infarction, are extremely suffered throughout whole life.[4] However, these complications are closely associated with vascular compromises.[6] Therefore, injector should deeply understand in detailed mechanism of arterial injury, arterial anatomy and anastomosis which can reach most effective injection and low risk of the unexpected complications.[5]

The direct intravascular filler injections as well as external arterial compression are major causes of ischemia which may eventually contribute a blindness, skin necrosis and cerebral infarction. [1, 6] In term of mechanism, injection into the large artery with high pressure can possibly make the retrograde displacement of the filler particle. This situation probably causes necrosis effects, and blindness owing to retinal artery obstruction. [5] Although some patient undergoes immediately pain after injection, numerous patients have no signs at the time of injection; thus, the delayed either compression or occlusion of vascular serves as the mechanism of injury.[4] Due to this reasons, the study of arterial location and its anastomoses are crucial. There are numerous previous studies which describes about single arterial branch of the artery of face relative to anatomical landmarks. The branches of external carotid artery are major arterial supply of the face, while the central of face: eyes region, the upper two thirds of nasal region and the mid forehead region are supplied by the internal carotid artery. The main branch of external carotid artery is the facial artery which gives off the superior labial and inferior labial surrounding the perioral region. In addition, the facial artery also releases the lateral nasal and angular artery to supply the face. [7] In term of the internal carotid artery, it firstly branches into the ophthalmic artery, and ophthalmic artery gives off terminal branches as supraorbital, supratrochlear and dorsal nasal artery.[7] Additionally, the arterial anastomosis is needed to explain due to it occasionally provides the risk of severe complications. There are several injection sites which have been reported complications after filler injection. For example, the periorbital region which contains anastomosis between internal and external carotid vascular systems, so injection in this danger zone should be avoided.[5] According to Kim et al (2015)(A), injection the filler into supratrochlear and supraorbital arteries when performed the glabellar augmentation is probably retrograde embolism via the anastomosis between dorsal nasal and angular artery.[1] Moreover, the injection of the temporal region which has the communication between the superficial temporal artery and ophthalmic artery is probably causes of the retinal artery occlusion as well.[5, 8] Clinically, fillers are commonly used for correcting aging characteristics in several sites of the face; therefore, the arterial supply and its anastomosis in each site are important.

As mentioned above, the anatomy of arteries of the face including location of artery, diameter, arterial variation and arterial anastomoses are necessary for clinician. Although the anatomical of arteries of the face relative to soft tissue landmarks by anatomical dissection technique are well illustrated previously, these data cannot exactly locate the arterial location which associates with real filler injection sites. Moreover, the anatomical dissection cannot clearly explain about all arterial anastomosis due to technical restriction. Furthermore, few studies have investigated the arterial supply and its connection which may be injured in each injection sites of the whole face. Thus, this study objectively evaluated the arterial location relative to filler injection sites. Furthermore, the arterial anastomoses and arterial supply of each injection site was be also studied by using combination of micro-dissection and Modified Sihler's Method.

1.2 Research questions

Primary research question

1. What is the nearest artery, external diameter and distance of this nearest artery to the forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB), temple (TP), tear trough (TT), mid cheek (MC), lateral hollowness (LH), nasolabial fold (NLF), upper lip (LV), chin (CN), jawline (JL), and marionette line (MN) injection sites?

Secondary research questions

1. What is the facial tissue layers that nearest artery lying and the depth from the skin to the nearest artery at the nearest point of all filler injection sites?

2. What is the relationship between the each injection site and its nearest artery?

3. What is the anastomotic pattern, diameter of the anastomotic branches and the number of anastomoses of the facial, ophthalmic, and superficial temporal, infraorbital artery, transverse facial artery and their branches with the neighboring arteries?

4. What arterial anastomoses can be found between right- left sides and between the upper face, middle face and lower face?

5. What are the differences of these anatomical data between sexes?

1.3 Research objectives

1. To explore the nearest artery and study the external diameter and distance of this nearest artery to the forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB), temple (TP), tear trough (TT), mid cheek (MC), lateral hollowness (LH), nasolabial fold (NLF), upper lip (LV), chin (CN), jawline (JL), and marionette line (MN) injection sites

2. To investigate the facial tissue layers that nearest artery lying, and measure the depth from the skin to the nearest artery at the nearest point of all filler injection sites by 3D scanning method

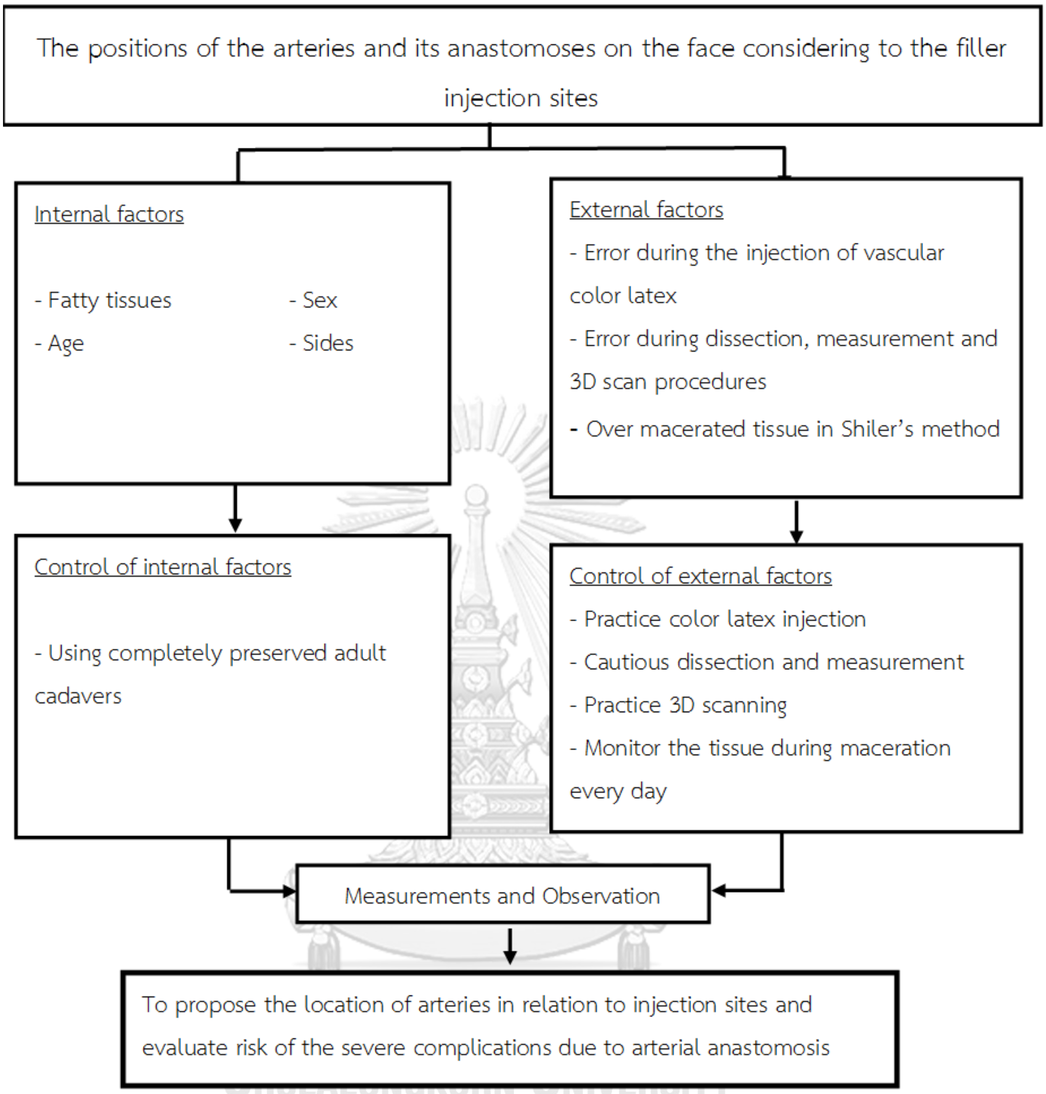
3. To study the relationship between each injection site and its nearest artery

4. To study the anastomotic pattern, diameter of the anastomotic branches and the number of anastomoses of the facial, ophthalmic, superficial temporal, infraorbital artery, transverse facial artery and their branches with the neighboring arteries

5. To study the anastomosis of the artery between right- left sides and between the upper face, middle face and lower face

6. To study the differences of these anatomical data between sexes

1.4 Conceptual Framework



1.5 Keywords

Filler injection, Facial artery, Arterial anastomosis, Filler complications

1.6 Research design

Descriptive research

1.7 Expect benefits and applications

This study will provide accurately arterial branches which may possible injury during filler injection of each injection. Because each injection site is not absolutely supplied by only single artery, our study will provide more detailed of artery including arterial location and diameter. Additionally, the artery is directly measured form the soft tissue landmarks which is clinically used for filler injection of the face; therefore, this data will basically assist the injector to avoid arterial injury. Moreover, the Sihler's staining will excellently present the arterial anastomosis; therefore, the data will provide anastomotic path way which can be caused the severe complications. To conclude, our study will evaluate the possible risk of severe complications in each injection due to intraarterial injection, and the anatomical of artery will give the basic knowledge of clinician.

CHAPTER II

LITERATURE REVIEWS

2.1 Aging

Several cooperative factors including longtime facial muscle activity, weakening of the muscle, confrontation of the sun and gravity are the causes of facial aging. This aging process induces in decreasing of hyaluronic acid (HA) and conducing volume loss. Moreover, it decreases dermal water binding ability and eventually contributes the facial wrinkles.[2] In addition, there are others complicated aging process features: the thickness of the epidermis layer, increasing of bone resorption, diminished elastin and collagen fiber production and subcutaneous fat atrophy.[9] The continuous fat loss starts approximately around the age of 30s. The loss of fat provides facial contour changing including dominant malar eminence, unclear angle and jaw and the descent of both soft tissue and fat pads. From this appearance, development of progressive deep wrinkle and fold are created in the face. [10-11] Surek et al (2015) suggested that the anatomical change during aging closely associates with facial fat compartment and facial retaining ligament. The fat descending along with several ligament results in a segmental facial compartment. [11]

Clinically, the change of aging structures can be defined as several basic aesthetic terminologies including facial creases, skin fold, crow's feet, horizontal forehead lines, glabella frown lines, glabellar transverse lines, jowl sagging, labiomendibular fold, marionette line, midcheek furrow, nasojugal groove, nasolabial fold, palpebromalar groove, preauricular lines, ptotic chin, tear trough, temple depression and vertical lip line (Figure 1). The occurring of facial creases which are clinically known as wrinkle and lines is caused by losing of skin and facial muscle elasticity. Differently, the skin fold appearance is provided by tension change, gravity and sagging within the face.[6]

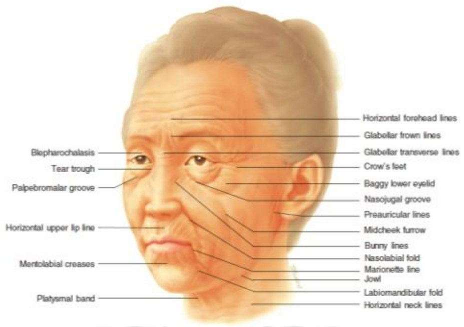


Figure 1 The aging characteristics (Kim et al, 2015(B))

Regarding to aging properties of upper face region, crow's feet feature is the bilateral wrinkles of the lateral eye due to the activity of orbicularis occuli muscle.[6] The horizontal forehead line is a crosswise line along the frontalis muscle. Moreover, the activity of the corrugator supercillii muscle creates creases as the glabella frown line along the glabella region. Additionally, the production of the glabellar transverse line is caused by distortion of the face, so this line perpendicularly appears along with procerus muscle.[6] One of unwanted aging is the temple depression. The decrease of individual soft tissue volume including bony reabsorption, temporalis muscle atrophy and deflation of the fat pad within temporal fossa; thus, all of the occurring induces the changing of the surface from convex into concave, and the appearances exhibit depression lateral to the brow which may produce the bony dominant of the temporal crest or skeletonized feature.[6, 10,12-13] For the aging change of eyebrow, losses of fat volume within the fat compartment gives the tail of brow moving downward and also change the upper eyelid with deep sulcus.[5] Differently, Griepentrog et al (2013) explained that the older woman have elevation of medial and central eyebrow when compared with lateral part of eyebrow. This presentation has been described by the author's assumption that more continuing activation of the frontalis muscle occurs medially to the temporal fusion line; therefore, this mechanism may potentially generate the lateral brown ptosis.(14)

For aging in middle face region, the nasojugal groove is the groove which travels inferolaterally from the medial canthus along with the junction between lower eyelid and cheek region (Figure 1).(6) Moreover, midcheek furrow or groove occurs when the bone and facial soft tissue display volume loss combined with facial skin ptosis. Then, the hollowness and concavity of the facial contour in this area is plainly observed as inferolateral band which continues from the nasojugal deformity.(6, 15) In others, tear trough is one of common aging feature of middle face. This characteristic is a significant sign of the eye and periorbital aging. Bone resorption, soft tissue atrophy and drooping are causes of tear trough appearance. However, the protrusion of the orbital fat can produce a bulge within lower eyelid.(16) According to Kim et al (2015)(B), tear trough has several attributes depending on the attaching between orbicularis retaining ligaments and the medial portion of the orbicularis occuli muscle bands to skin. To observe the tear trough, this depression line extends from medial canthus and runs inferolaterally parallel to infraorbital margin terminating adjacent location of midpupillary line. Relative to tear trough, clinically knows as the palpebromalar groove which extends uninterruptedly from the tear trough deformity. This groove is also named lid-cheek junction because it travels along the connection between lower eyelid and malar region. (6, 17) One of the most common aging forms in the middle face is the nasolabial fold. This fold initially appear when the people coming to 20s. The descending of the malar fat and also the medial cheek fats lead to creating the fold especially expression of smiling.[9, 18] The nasolabial fold starts laterally to the lateral side of nasal alar, and then travels obliquely between upper lip and cheek to surrounding the cheilion area.[6, 18]

Lower face aging, the jowl sagging characteristic is protrusion of the subcutaneous fat and descended of fat pad combined with decreasing in the elasticity of the skin. In addition, Graivier et al (2007) described that the progression of prejowl sulcus is generated by bone loss, soft tissue atrophy and its migration surrounding the fixed fold. [19] Due to this regression, the inferior border of mandible shows unclearly shape and lead to blending of the soft tissue into neck or nearby structures. Furthermore, progressive bone loss may give the depression appearance between the jowl and bony mentum which is over lied by the fat pad. [6, 10] For others lower face aging features, the effect of depressor anguli oris muscle contraction results in the labiomental fold which is beginning from oral commissure and reaching to the inferior border of mandible. Similarly, the marionette line, long and vertical line from the mouth corner, is commonly found with aging; however, the causes of the line are unknown. [6] Augmentation of lip is popular amongst women due to the influences of progressive aging because of the lip becoming thin or flat. Therefore, improving the lip has been commonly performed in order to restore the natural curve, decrease the vermillion creases and enhance rhytids in white lip skin.[10] For the chin, changes caused by aging are presented as the recession correlated with submental crease (Figure 2A). Producing the chin projection is necessary for improving the facial appearances (Figure 2B). [19]

Figure 2 Chin recession during progressive aging (A), chin projection after filler injection (B) (Dallara et al, 2014)

As mentioned above, all aging characteristics quite make the concerning for individual. Therefore, the soft tissue augmentation is currently popular for correcting these aging appearances and giving satisfying youth facial shape.[10] Since the filler injection is the minimal invasive and nonsurgical cosmetic injection procedure, the number of injection interventions has dramatically increases in the recent year.[1]

2.2 Filler products and its mechanism in soft tissue

Both temporary and permanent fillers are classified for soft tissue filler products. The temporary (reversible) filler is the hyaluronic acid (HA) and collagens. However, the paraffin, silicon preparations, polymethyl methacrylate microspheres, hydroxyethyl methacrylate fragments, polyacrylamide hydrogel, polyalkylimide gel and polyvinyl hydroxide microspheres in polyacrylamide gel are components of permanent filler.[20] At the present, the HA is the most common filler products for facial augmentation.[2] Because HA fillers have prolonged lasting and lower immunogenic effects when compares with others soft tissue fillers. Importantly, it is injected with a more comfortable, and can be found easily in the commercial.[21] In term of HA property, the cross-linked HA which composes of two portions: polysaccharide with a simple non-sulfate 2- sugar (D-glucuronic acid and N-acetyl glucosamine) and cross link reagent (for example 1,4 butanediol diglycidyl ether, BDDE) has better effects than non- cross linked HA either long residence time or slow degradation within the soft tissue.[22-23] For mechanism after injection, HA has ability to stimulate fibroblasts and to draw water into matrix. That way collagen and hyaluronic acid are produced leading to increase facial volume.[2,24] Nevertheless, the degree and reagent of crosslinking within HA is used to distinguish the HA in to different types in the comercial. Additionally, the degree of crosslinking is closely associated with viscosity of the gel.[25] Considering to injection sites, the high viscosity and cohesivity of particle is suitable for subcutaneous and supraperiosteal injection, while the deep dermal as well as dermal-subcutaneous junction should be injected with a low viscosity gel.[10] To achieve highest outcomes, not only picking the appropriate filler material is essentially required, but also good injection technique is important for making satisfying results related with no complication.

2.3 Filler injection sites and techniques

Normally, the filler can be injected by using either a needle or a cannula. This type of cannulas, also named atraumatic, is rounded with blunt tip. Choosing each injection instrument is depended on clinician preference and experience. [19,26] However, Hexel et al (2011) suggested that cannulas should be used at the injection sites which it may be injured to tissue and vessels by cutting bevels of needle.[26] Other explanations, Graivier (2007) recommended that selection of either needle or cannulas is based on type of specific procedure and site where the filler is administered. Needles may be suitable to be injected for correcting line and facial wrinkles, whereas cannulas may be used for volumetric restoration. Even though needles have several benefits including the accuracy of movement to injection area, the possibility of injecting intradermal layer and using in small volume, the patient may possibly experience pain, bruising and vascular damaging. Differently, the cannulas also have advantages: lower chance in trauma, less pain and bruising. In contrast, disadvantages of cannulas are requirement of specific training for medical personnel and the necessity of using higher gel volume.[19] However, using cannulas should be considered base on its size. The large cannulas are more likely to avoid injury of arteries compared with small cannula, which provides greater number of possibilities of arterial laceration.[27] As mentioned above, the cannulas seem that it have low risk in occurring of complication compared with using needles. Unlikely, Lee et al (2015)(A) reported that injecting filler by using blunt tip in both needle and cannula combined with aspiration after placement is unable to prevent vascular injury.[28] Base on all reasons, the best choice to prevent complications is detailed understanding of arterial anatomy associated with good product and injection techniques.[5] Clinically, there are several filler injection techniques and each injection sites requires different procedures.

The four main techniques that have been usually performed for filler injection: linear threading or tunneling, serial puncture, radial fanning and crosshatching techniques. Linear treading technique is carried out by inserting the needle along the fold or line. Then, filler is gradually dropped, while the needle is retrogradely removed. This technique is normally used for subcutaneous and deep dermal injection. Regarding to the area of injection, it is generally utilized for correcting nasolabial fold and oral commissure restoration (Figure 3B).[25,29]

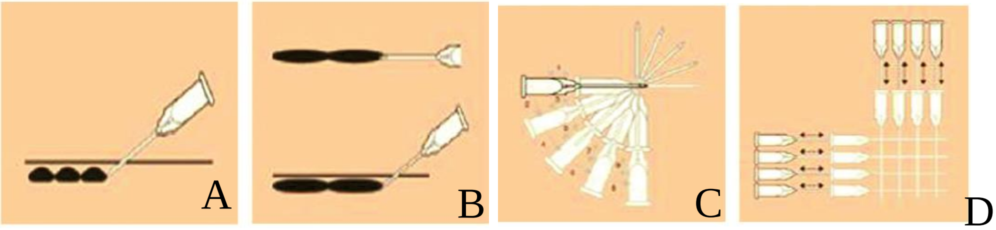


Figure 3 Injection techniques including serial puncture (A), linear treading technique (B), fanning technique (C) and cross hatching technique (D) (Sanche et al, 2010)

For the serial puncture technique, injection is appropriately employed in creases correction especially in mid and upper dermis levels. However, the filler is deposited as small multiple bolus along the wrinkle or line. Additionally, the each filler bolus should be put closely and massaged; otherwise, the irregularity and maldistribution of the gel can appear. (Figure 3B).[25,29] In term of fanning technique, the linear treading technique is applied for fanning. Variously, the needle is reinserted in radial pattern before it is totally withdrawn, so the filler is placed into the new axis. The indication for selecting this technique is the occurring of malar, nasolabial fold and marionette line deformities. (Figure 3C).[25,29] The crosshatching technique is initially performed with numerous parallel filler injection tract crossing the corrected area followed by inserting a needle perpendicular to the previous set of filler line. This technique is regularly done to improve the marionette line and prejowl sulcus. (Figure 3D).[25,29] All techniques mentioned above are the general technique; however, in each facial region as well as aging feature is injected with different method. For this reason, specific technique is required for successful augmenting of the filler for each area.

In the upper face injection, there are several signs of aging in this region; therefore, the injection in each area should be explained in details. The main locations for the upper face injection include forehead, glabella, sunken eye, eye brow, and temporal hollowness. For each injection, it is necessary to consider the injection sites, injection planes, injection technique and injection tools (needle or cannula sizes). Firstly, due to the concavity of the forehead locates between frontal eminence and superciliary arch, defining this area is needed before injection (Figure 4A). There are two filler injection points for the forehead included junction between forehead and temporal region and the median line between the frontal eminences (Figure 4B).[6] Submuscular or supraperiosteal layer injection with retrograde linear treading technique by using 23-25 G cannula is recommended for improving the surface form concave into convex. Differently, filler material must be injected into mid to superficial dermis for correcting forehead line.[5,6] To achieve the most effective results with an injection, it is important to avoid all vessels for forehead region. If that is not likely, the cannula is suggested. However, using cannula does not absolutely guarantee preventing vascular injury.[6]

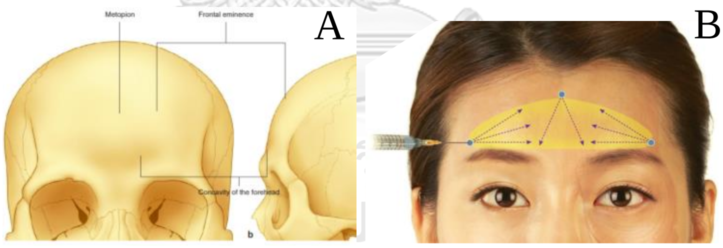


Figure 4 Concavity characteristic on the forehead (A), the two forehead injection points (B) (Kim et al, 2015 (B))

For glabella region, cannula injection is a strong choice because this area composes of high number of vascular supplies. However, if needle is used, the soft tissue is pinched up to access the needle into subdermal layer. Subsequently, the needle is used to put the filler with small volume over the bone.[6] In contrast, Bass (2015) pointed out that filler should be injected into intradermis; otherwise, there is a possibility that the vessels will get injured when performing subdermal injection.[10] Similar to description of Carpintero et al (2010), the filler must be superficially injected at the site of glabella due to the fact, that deep dermal injection can definitely increase the risk of vascular complication such as cutaneous necrosis.[25] Next, injection to correct the sunken eye is performed by enhancing the superior sulcus of the upper eyelid which it is simultaneously produced by decreasing of orbital fat, resulting in dominant of orbital rim.[5,6] Injection should be placed underneath the orbital rim, but cannula must be firstly inserted through the orbicularis occuli muscle and superficially to levator aponeurosis (Figure 5A). Then, it contacts to the periosteum followed by petty removing and put the gel above the orbital septem (Figure 5B).[5,6]

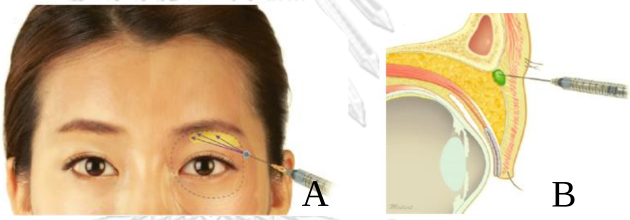


Figure 5 Injection site for sunken eye augmentation (A), the location of filler for sunken eye (B) (Kim et al, 2015 (B))

In order to lift the brow, the cannula is inserted at the lateral one third of eyebrow relative to the superior orbital rim. For the facial plane, the retrograde treading technique is utilized to deposit the filler onto the supraperiosteal layer.[14] For other upper face injection, the temple region is one of the most common areas for filler augmentation. The volume loss within temporal fossa is reformed by cannula or needle filler injection technique. The two locations of injection are created prior to the beginning of the method. Firstly, the tail of the eyebrow is defined for identifying the temporal fusion line, and the orbital rim is palpated. Then, the injection site is marked at 1 cm above the temporal fusion line and lateral to the supraorbital rim 1 cm.[5] Secondly, the entry point at 1 cm superior to the superior border of zygamatic arch and 1 cm lateral to the orbital rim are used for injection of filler. There are four potential temporal injection planes including subcutaneous fat layer, the space between parietotemporal and the deep temporal facia and layer of periosteum below temporalis muscle.[12] However, Sykes et al (2015) suggested that the possibility of intravascular injection may be found when the filler needle injection is injected superficially.[5]

In mid-face region, there are several common aging deformities. In this area, they are corrected by filler in order to deliver the optimal results, for example tear trough, nasojugal groove, palpebromalar groove, nasolabial fold, mid cheek, hollow cheek. To ameliorate shadow of the lower eyelid (tear trough), the 29 gauge needle is inserted towards the bony inferior orbital rim followed by placing the small aliquots of filler above the periosteum. The direction of injection is from the medial to lateral side, and then serial puncture combined with gentle massage is performed. Furthermore, some injection point is restored with retrograde linear treading technique.[16] However, Garem (2014) illustrated that the bolus injection technique can be used for tear trough augmentation. For the method, the horizontal imaginary line is established at 2 cm below the infraorbital rim, and then points A and B are defined as midpupillary line and lateral canthal line, respectively (Figure 6). After providing the injection point, the 28 G needle is perpendicularly injected on both points into the supraperiosteum plane. However, every injection should be performed with aspiration and be injected slowly with low pressure. [17]

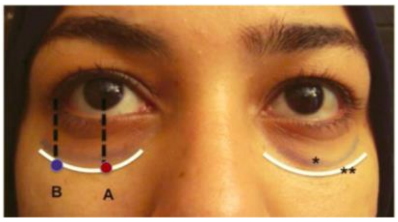


Figure 6 The injection point at midpulpillary line and lateral canthal line (Garem, 2014)

For the technique of Pasquale et al (2013), the filler is injected into three locations including 0.5 cm from medial canthus, mid pupillary level and medial to the lateral canthus with 0.5-0.8 cm. The Injection is deeply done in order to fill the orbital hollowness (Figure 7). [30]

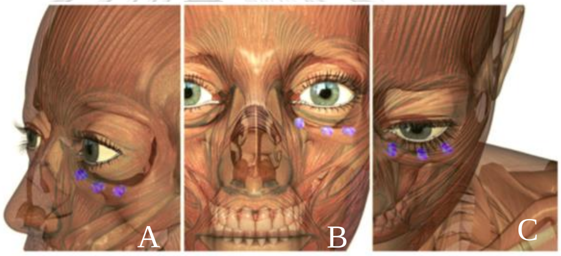


Figure 7 The three injection points following 0.5 cm from medial canthus, mid pupillary level and 0.5-0.8 cm medial to the lateral canthus (A: lateral view, B: frontal view and C superior view). (Pasquale et al, 2013)

Due to injection at the level of medial border of tear trough which is located nearby medial canthus may be possible in vascular embolism, injection at this area should be avoided.[10] Specifically, Kim et al (2015)(B) described that the layer of injection depended on two conditions. Firstly, the deep to suborbicularis oculi fat (SOOF) is selected when soft tissue atrophy is appeared below the orbital retaining ligament. Secondly, the superficial injection into subcutaneous layer over the orbicularis oculi muscle is assorted in the case of full SOOF restoration.[6] Next, injection of nasojugal groove has been administered by the 23-27 G cannula because this area contains various arterial supplies. As for general injection technique for in this region, the cannula entry site is located at the 1 cm from inferior end of the nasojugal groove. Nevertheless, standard technique is used for making the entry point. Concerning the details of this technique, the two axes are made following the vertical axis from lateral canthus and horizontal axis from inferior border of alar (Figure 8A). Then, the intersection between two axes is represented by the entry point. Considering to injection plane, the filler should be injected into prezygomatic space below the SOOF or over periosteum level (Figure 8B).[6]

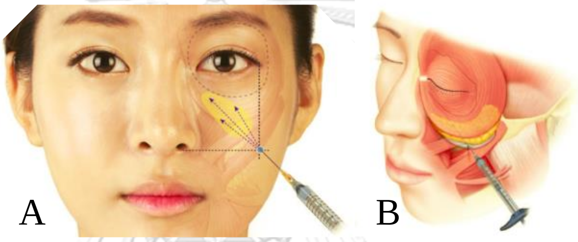


Figure 8 Injection techniques for correcting the nasojugal groove, the intersection between two axes following the vertical axis from lateral canthus and horizontal axis from inferior border of alar (A), the injection of filler into the SOOF (B) (Kim et al, 2015 (B))

To restore the mid cheek groove, the increasing of structure support and filling to the malar and infraorbital region is helpful. Therefore, enhancing the malar complex especially superolateral portion can produce the anterior cheek projection.[10,19] Then, the area of injection is created from the intersection between two imaginary lines including the line from superior border of tragus to superior alar and the line from lateral canthus to oral commissure. Regarding to the injection depth, the bolus injection is used to place filler under malar fat or supraperiosteum level.[10] In others region of mid face injection, nasolabial fold is the usual required area for filler injection.

Basically, both canine fossa and the nasolabial fold line are mainly location for restoring volume of the nasolabial fold characteristic. For the first area, the filler should be injected onto the canine fossa which it positions at the level of 1-5 mm medial to nasolabial fold line. The plane of injection is, in this case, the deep plane or supraperiosteum level.[6] Secondly, material should implant into approximately 1 mm medial and parallel to the fold.[31] The procedure starts with inserting the 27 G needle from the inferior end of the fold followed by tracing the needle superiorly into the area of connection between nasolabial fold and alar. After completed insertion, the needle is withdrawn as the retrograde linear treading technique.[32,33] However, the injection depth in this area should be deep dermal or dermal subcutaneous junction levels.[10,33] In others recommendations, the nasolabial fold should be devided into upper, middle and lower parts regarding the indication of the plane of injection. The middle and lower portions should be injected into superficial subcutaneous or deep dermal plane to prevent injury of facial artery, while either the deep dermal or preperiosteal plane is suitable for upper part injection.[34]

For the lower face augmentation, there are several common areas which are corrected by fillers such as lip, marionette line, jaw line and chin. Each location significantly requires the different injection procedure. Firstly, lip components should be identified before injection. The lip composes of mucous portion and cutaneous portion. In term of mucous portion, this part is separated into dry mucous and wet mucous. The junction between the cutaneous and mucosa is called vermilion border which becomes dimmer with aging (Figure 9A) Moreover, the connection between the dry and wet mucosa is named as dry-wet mucosal junction (Figure 9B).[6] The filler injection of lip can be done in both lip vermilion and the cutaneous and lip volume augmentations. The entry site for lip vermilion is laterally to the

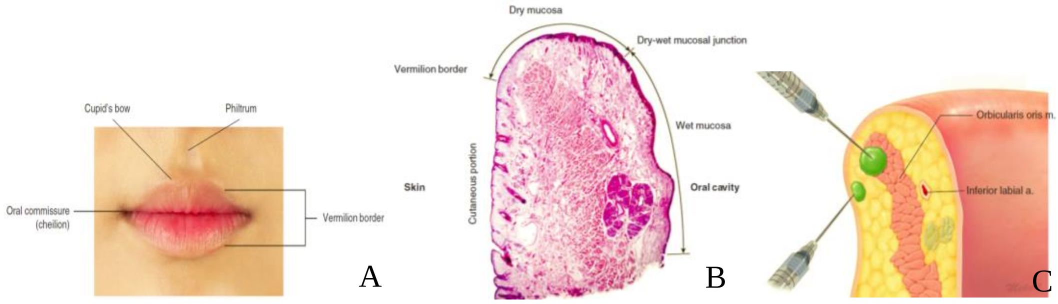


Figure 9 The surface anatomy of the lip (A), the histological section of the lip shows mucosal portion, vermilion border and dry-wet junction (B) and the injection layer (C) (Kim et al, 2015 (B))

oral commissure about 2 mm. Then, the cannula is preceded medially in either subdermal or superficial subcutaneous layer in order to avoid injury to the labial and facial arteries.(27,34) However, Kim et al (2015)(B) suggested that the material can be injected into the dermal layer at the verimilion border. To increase the lip, the injection should be performed in the submucosal or intramusclular plane and at the dry-wet mucosal junction (Figure 9C). The retrograde linear treading technique with 27 G cannula is advised for injecting the lip.(27,35) Next, the marionette line is one of the most common sign of progressive aging due to sagging of the buccal fat pad and superficial buccal fat behind risorious and depressor anguli oris muscle associated with prejowl sulcus dominant. So, this area is advised for injecting filler to provide the youthful lower face. Using this technique, filler can be directly injected by cannula into the marionette line with fanning as well as cross-hatching technique as most successful procedure for improving this type of deformity.(6,10) The layer of injection should be dermal and subdermal planes.(9) Distinctly, Aloiso et al (2016) explained that linear treading or serial puncture techniques can be used to inject the filler in deep dermal plane for correcting marionette line. However, if the area also has the volume loss surrounding the marionette region, a cross-hatching technique should be applied for providing exceeded area volume.(32) To recover the jaw line, two insertion points including mandibular angle and prejowl sulcus are suggested. First injection is inserted a needle or cannula into periosteum layer at inferolateral mandibular border from mandibular angle. Then, retrograde linear treading technique is used for filler replacement. Secondly, reflation of prejowl sulcus is corrected by injecting filler into the deep dermis or subdermal plane.(19) Finally, the filler is basically injected into the preperiosteal, intramuscular and subcutaneous planes at the center of the chin for making the chin in protrusion. In term of injection instrument, a needle is often utilized for chin injection. (6)

Even though the filler injection procedure is safely and has a minimal risk of complications, injection cannot absolutely avoid every adverse event especially vascular complication which it is the most frequent concern for filler injections. Then, the injection technique in each area should be performed with high accuracy. However, the literature reviews show that the injection factors, which have the effect to filler augmentation including injection sites, injection layer, injection techniques and injection instruments, should be carefully determined in every injection area. The injection sites are directly focused in the aging signs or deformities. To achieve the best results, the site of injection should be the most effective result without the risk of complications. However, the injection site in each study is not significantly different, but the planes of injection are quite various with each author. It means that every injection site, plane and using cannula is not guarantee for 100% of safely, but every clinical study try to present the technique which can prevent occurring of severe complications, especially vascular injury which can lead to other severe complications.[6] Therefore, the anatomical location of vessels and its network is strongly crucial for injector in order to reduce the possibility of occurring of severe adverse events for example blindness as well as necrosis.[1]

2.4 Severe Complications after filler injection

The complication of the filler injection can be divided into 2 criteria. The time of appearance classifies complications as early and delayed, whereas the minor and major complications are grouped by the severity. The minor complication, for example bruising, erythema, pain and tenderness, usually relates with early complication, because it occurs immediately or hours to day post injection. However, such complications are contemporary, and it can be improved lasting for up to 7 days.[36] Seriously, severe complication such as visual impairment, skin necrosis and cerebral infarction, are possible to appear during filler injection.[4] Kim et al (2015)(A) reported that the total 7 of 17 patients (4 with the HA filler injection and 3 autologous fat injection into glabella and nasal areas) presented intra-arterial thrombolysis which cerebral angiographic examination completely exhibited ophthalmic artery or its branches occlusion. Additionally, 3 of 4 HA injection patients also underwent skin necrosis, while each of the other patients showed none or mild necrosis. Interestingly, one of the autologous fat injections significantly manifested concomitant to the middle cerebral artery infarction which can lead to pathology associated with it.[1] At here, the severe complications relative to disastrous artery have been described following

2.4.1 The mechanism of arterial injury: how does filler get into artery?

The filler can directly go to the artery when needle or cannula pierces the vascular wall and its opening remains within the arterial lumen. This occurring leads to direct intra-arterial injection, and the filler can be pushed into the vessel which it resulted in arterial embolism eventually. In actual patients, while the needle or cannula passes thought the soft tissue, it is able to produce tunnel, also called pre-tunnelling, for flowing of the filler. During the needle or needle is withdrawn, the filler can flow along this channel. As for unexpected condition, the needle or cannula tears the vessel during injecting the filler into location, which apart from the location of the vessel. Therefore, the filler can run retrogradely along the tunnel into the vessel (Figure 10A). This entire existing is resulted in pathophysiology associated with ischemia.[37]

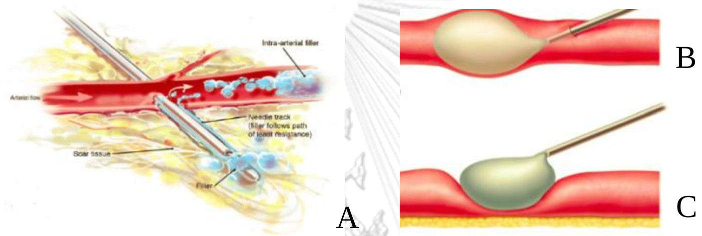


Figure 10 The arterial embolism due to the needle penetrates the artery and filler goes back to the artery along the needle tract (A), the vascular compromise associated with intravascular injection (B) and external compression (C) (DeLorenzi, 2017) (Kim et al, 2015 (B))

2.4.2 The mechanism vascular compromise which leads to ischemia

Kim et al (2015)(B) explained that both intravascular injection and external compression are the causes of vascular compromise.[6] However, Weinberg et al (2009) and Iannitti (2013) described that there were four reasons in vascular compromises including direct intravascular injection, external vascular compression, vascular injury and vasospasm. For the intravascular injection, the filler particle is the blockage of vascular lumen (Figure 10B). In terms of external compression, the injected filler is placed near the vessel and creates high pressure surrounding the vessel, which can then lead to compression of the arterial circulation obstruction (Figure 10C).[4,6,37] Next, the vascular spasm is the tightening of smooth muscle of the blood vessel's wall because of chemical stimuli. However, the HA is harmless material and non-tissue irritation. For this reason, the possibility of vascular embolism from the filler material just does not come from either vascular spasm or external compression.(37)

2.4.3 Severe complications following vascular compromise

- *Tissue necrosis*

The tissue necrosis is the most severe early complication of filler injection. The mechanisms of such complication are due to the direct intra-arterial injury which leads to arterial lumen blockage or embolism by the filler; moreover, the arterial compression can cause the tissue necrosis.(38,39) Then, the arterial embolism is closely related with ischemia. Although, the filler is able to be broken down in to small particle, large particles remain and are unable to penetrate through capillary wall. In addition, the breakdown particle may provide new ischemic area because the product may be transported pass the areas in which collateral vessels are detouring the primary obstruction. However, the vessel which contains the broken down filler may not cause the ischemia until the collateral circulation has a bypassing obstruction as well- then the ischemia is appeared.(37) From this filler obstruction, Kim et al (2015)(A) described that the filler obstruction can initially lead to decreasing of angiographic runoff in the peripheral branches of internal maxillary and facial artery.(1) However, the high injection pressure combined with large lumen of needle or cannula causes the material entrance larger arteries. If that is occurring, it is essentially increasing of the risk of larger necrosis effect.(5) Regarding the amplitude of necrosis, it depends on either proximal or distal of arterial embolism. If intra-arterial injection with large amount of filler material is appeared in the proximal part, it can cause the embolization of extensive area. In the end, this finding results in occlusion of end arterioles. For this condition, the collateral circulation may give ineffective results.[5] Furthermore, Kim et al (2015)(B) illustrated that the filler embolism can spread along the arterial branches; consequently, the necrosis can be found throughout arterial pathway.[6] In order to treat the area necrosis, the hyaluronidase (HYAL) is one of product which can pass the arterial wall and hydrolyze the filler.[10]

- *Blindness*

One of the most severe vascular complications which may occur during filler injection is not only the tissue necrosis but also blindness. In the case reports, occlusion of branches of retinal artery is appeared in the case of autologous fat injection, (Figure 11A). Simultaneously, retinal and choroidal perfusions were delayed in fluorescein angiography (Figure 11B). The cause of such appearance is the proximal obstruction of the ophthalmic artery. In the HA injected patients, the retinal artery is occluded which showed the attenuation and abruption of arterial lumen.[1] As far as the mechanical of occlusion is concerned, Lazzeri et al (2012) explained that the accidental intraarterial filler injection of distal vessels can carry the material retrogradely into the ophthalmic artery, which is located proximal to central retinal artery (Figure 12b).

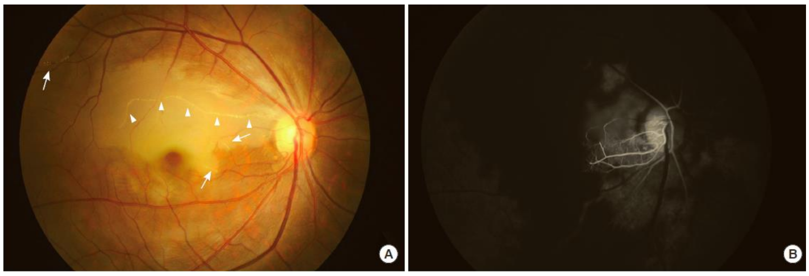


Figure 11 Angiographic finding of retinal artery occlusion, occlusion of branches of retinal artery after autologous fat injection, white arrow (A,), delayed choroidal perfusions in fluorescein angiography (B) (Kim et al, 2015 (A))

The theory is that retrograde flow is appeared when the intravascular injection pressure is higher than sum of systolic arterial pressure and frictional force which it results from pressure drop during viscous flow within the vessels. After that, the filler travels retrogradely along vessel until reaching the proximal area to the origin of the retinal artery. When injection pressure is released, the arterial systemic blood pressure can move the filler into the ophthalmic artery and its branches, so the blood flow is blocked within branches leading to creating symptoms such as blur vision or a vision loss.[38,40] In fact, the resistance flow calculation of terminal artery is less than capillaries, so the injected filler will directly flow into the area with the least resistance.[40]

The chances of blindness when intra-arterial injection is performed are affected by the anastomosis between intraocular and facial arterial system.[41] Therefore, the facial arterial supplies which branches directly from the ophthalmic artery may predominantly give the filler a retrograde channel into proximal ophthalmic artery. After that ophthalmic blood flow reaches the proximal ophthalmic artery and distributes the filler emboli to central retinal as well as posterior ciliary artery which supply the globe.[41] Moreover, the anastomosis between internal carotid system including supraorbital, supratrochlear and dorsal nasal artery and external carotid system (angular and facial artery) (Figure 12a), may also influence the visual loss by passing the emboli through communicating path way (Figure 12b).[6]

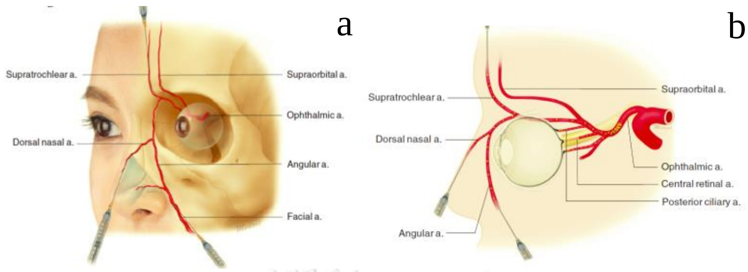


Figure 12 The anastomosis between internal carotid system including supraorbital, supratrochlear and dorsal nasal artery and external carotid system (angular and facial artery) (a), the path way of retrograde filler emboli into the ophthalmic artery (b) (Kim et al, 2015 (B))

- *Cerebral infarction*

The cerebral infarction is a very severe complication, which is a result of a vascular compromise. The very high or sufficient injection pressure within ophthalmic artery can create the possibility of retrograde flow of the filler material into internal carotid artery. This filler migration then goes through the cerebrovascular circulation such as middle cerebral artery; thus, resulting in a stroke.[40,42]

Because all severe complications are potentially permanent, most of the clinicians with their patients exclusively concern with such complications. Since it can make the patient the most suffer. However, the rate in which the complication is occurring is closely related with vascular compromise.[43] Moreover, such defects cannot be recovered by any treatments, so conservative method is the choice after facing the complication. Even through the small volume, slow injection, aspiration, using cannula and sufficient needle or cannula size are all strongly recommended for reducing the vascular complication, the most important is still the anatomical knowledge.[6] The injector should have detailed anatomical knowledge of the artery of the face.

2.5 Anatomy of the arterial supply of the face, its variation and anastomosis

The facial region is anatomically divided into three parts: upper, middle and lower face. The upper face begins at the hair line to the upper arcade of middle face, while middle face is transversely separated into superior border and inferior border following the horizontal line from lateral canthus to the superior border of helix and horizontal line from oral commissure to tragal cartilage, respectively. For the lower face, the boundary extends inferiorly from the lower border of the mid face to chin and the mandibular margin.[7] However, the face can be functionally separated into anterior and lateral facial areas by the vertical line of retaining ligaments for example zygomatic, masseteric and mandibular retaining ligaments.[7] Each facial division is mentioned due to it is clinically associated with filler injection site and arterial supply in each region. As referred above, the most severe complication concerning comes from arterial complications; consequently, the anatomy of arterial supplies of the face is relation to the injection sites must be considered in every injection.

The circulations of the face are formed by the three plexuses included deep facial plexus, subcutaneous plexus and subdermal plexus. Deep facial plexus which runs deep to or penetrates the mimetic muscles communicate with each other by the perforator artery.[7] The arterial supplies of the face are mainly from two systems: the external carotid and internal carotid system. Importantly, both systems are certainly connected, and each arterial branch contributes the blood to supply its angiosome.[44]

Nevertheless, the external carotid system mainly gives off the blood supply to the face, whereas the internal carotid system plays a smaller but a very significant role in supplying central of face following central portion of forehead, eyes area and upper two third of the nose region.[7] Regarding the anterior face, the facial artery (FA), transverse facial artery (TFA) and infraorbital artery (IOA) from external carotid artery are all supplying this region; however, the facial artery is the major supplying branch.[45,46] The lateral face is mainly supplied by the transverse facial artery. In addition, submental artery, zygomatico-orbital artery, facial artery and angular artery are the minor supplying of lateral face.[7] However, the studies of Soikkonen et al (1991) showed that not in every case is the facial artery dominant for supplying the face. Their study found that there was four categories (A to D) represented the three main arteries, including facial, transverse facial and infraorbital artery, supply of the face. In type A (22% (15/69 of cases)), the facial artery was significantly more dominant when compared which IOA and TFA. It was longer branch and also continuously supplied the infraorbital region (Figure 13A). For type B (49% (34/69)), TFA became predominant branch associated with small FA and IOA, and the facial artery ended before reaching the infraorbital area (Figure 13B). The 20% (14/69) in type C showed three arteries were equal of size, and the facial artery remained supplying the anterior portion of the face (Figure 13C). In type D (9% (6/69)), the hypoplastic was found in FA, and then this FA branch terminated under the lower lip (Figure 13D). The finding points out that the essential artery of the face is not only facial artery but also other branches. Therefore, the literature reviews will describe previous studies of all artery of the face.

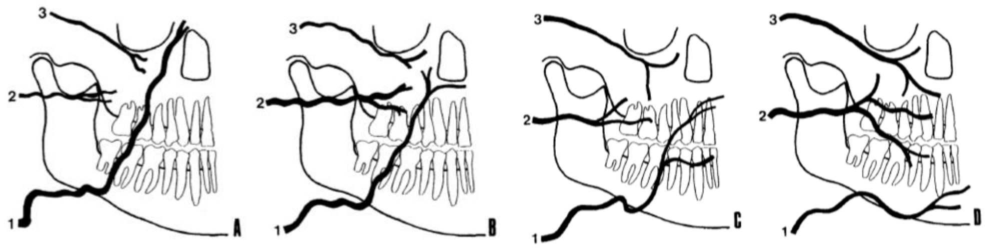


Figure 13 The four categories of the three arteries supply of the face (1=facial artery, 2= transverse facial artery and 3 =infraorbital artery) (Soikkonen et al, 1991)

2.5.1 External carotid system

The external carotid artery gives off facial artery, transverse facial artery, maxillary artery, superficial temporal artery and their branches.

2.5.1.1 Facial artery (FA) and its braches

The facial artery has been well described by the previous studies. The facial artery is derivation of the external carotid artery within the carotid triangle of neck. Its emerging is at the greater cornu of hyoid bone and from carotid bifurcation 1 to 3.5 cm approximately. Then, it travels toward around stylohyoid muscle and posterior belly of digastric muscle until reaching the groove of submandibular gland. Next, the tortuous facial artery runs upward and obliquely crosses the mandibular border to the facial region at anterior portion of masseter muscle. At the area of mouth corner, it gives off the inferior labial artery and superior labial artery, and then it courses continuously and terminates at either lateral nasal artery or angular artery at the medial canthus. Relative to facial vein, facial artery usually runs along with facial vein, but its lying position is superficially to facial vein.[7,15,45] For the function, facial artery is the main blood supply of the mental area, upper lip, lower lip, and lower part of parotidomasseteric region, buccal region, orbital, infraorbital and nasal region.[7]

However, the several previous studies represented that the facial artery had numerous variations in patterns as well as locations.

Pilsl et al (2016) explained that the facial artery gave off the first muscular branch which functionally supplied the muscles such as buccinators muscle, masseter muscle, muscles around chin region, zygomatic muscle and orbicularis oculi muscle. After that it branches into the inferior labial, superior labial, lateral nasal and angular arteries. In 60 halves of the face of this study showed that there were 4 types of the facial artery courses (Figure 14). Type 1(41.7%), the facial artery run medially upward into the mouth corner and then laterally to the nose region. Finally, it terminated surrounding medial part of the eye named as angular artery (Figure 14A). In type 2 (26.7%), the facial artery travels to dorsum of the nose and terminated below the osteochondral junction. In this case, the angular artery came from dorsal nasal artery which it was the branch of ophthalmic artery (Figure 14B). For type 3 (18.3%), the facial artery ended as superior labial artery. Thus, the upper portion the face needed atrial supply from the infraorbial artery and the dorsal nasal artery (Figure 14C). Lastly, the facial artery was divided into two branches after giving the inferior labial artery. The anterior branch gave off superior labial as well as lateral nasal artery, while posterior branch traveled toward the medial angle of the eye and became the angular artery (Figure 14D).[45]

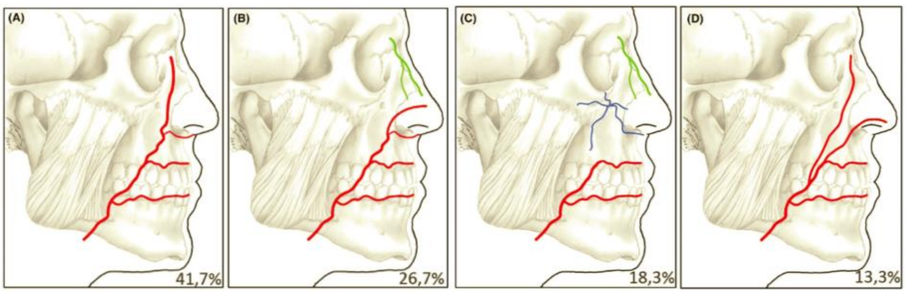


Figure 14 The four types of facial artery (Pilsl et al, 2016)

Differently, Lohn et al (2011) classified the 201 facial arteries distribution into six types based on arterial ending (Figure 15). Type I, the facial artery which terminates as angular artery was found 40 of 201 (20%) specimens. The lateral nasal ending was found in 96 specimens (48%) was subtyped into type II. In type III 35 (17%) of specimens, the facial artery ended as alar artery. For type IV, facial artery of 19 0f 201(10%) of specimen was ended as the superior labial artery. In 6 specimens (6%), the terminal branch of facial artery is inferior labial artery which was classified into type V. Finally, facial artery could not be detected and was divided into type VI (2%).

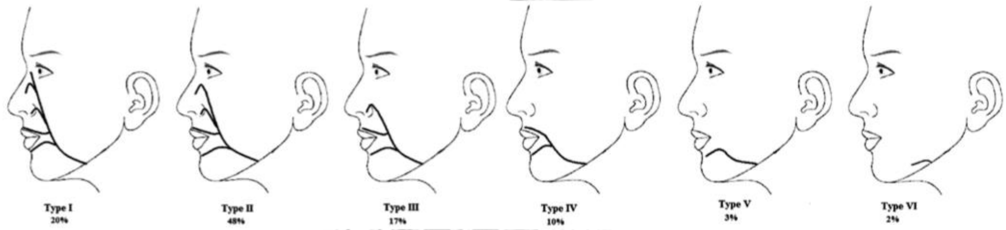


Figure 15 The six types of facial artery based on its termination (Lohn et al, 2011)

Additionally, not only the facial arterial pattern but also the facial artery location relative to anatomical landmark was investigated in the prior studies. In study of Qassemyar et al (2012) demonstrated that length of facial artery at the mandible to nasal alar rim was 12.06 ± 1.84 cm; moreover, the diameter at this level was 2.78 ± 0.44 mm.(47) The mean distance from the oral commissure to facial artery was 15.5 mm (range: 9.0-20.2 mm).[48]

As mentioned above, the facial artery exists in several variations, so it means that the arterial injury during injection may possible occur with different arterial branches even though it is performed in the same location. Moreover, others areas of injection are associated with the branches of facial artery including inferior labial artery, superior labial artery, lateral nasal artery and angular artery.

➤ Superior labial artery (SLA)

The course of superior labial artery is traveling within the junction between mucosa and orbicularis oris muscle at the area of vermilion border. It has anastomotic feature with contralateral artery at the middle of the lip.[49] From the study of Lee et al (2015)(C), there were four superior labial distribution patterns (Figure 16). Type I (56.7% (34 0f 60)), both superior labial artery and alar branches are branches from facial artery. Type II (21.7% (13 of 60)), the superior labial artery comes from facial artery, and then it releases the alar branch. In type III (15.0% (9 of 60)), the superior labial becomes terminal branch of facial artery, and absent of superior artery is classified in type IV (6.7 % (4 of 60)).[50]

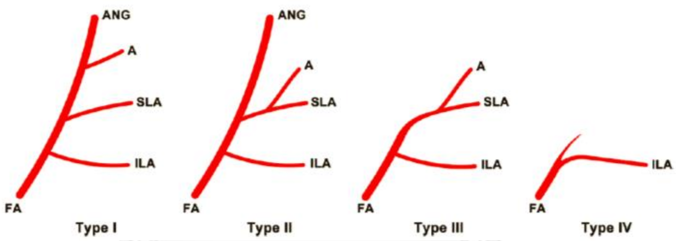


Figure 16 The four types of the superior labial artery (SLA), FA= facial artery, ILA= inferior labial artery, A= alar branch and ANG= angular artery (Lee et al, 2015 (C))

Loukas et al (2006) found that mean distance between oral commissure and superior labial origin was 1.8 mm (range 0-2.7 mm), whereas average distance from the origin to midline was 8 mm (5-10 mm in range).[51] Magden et al (2003) illustrated that the mean length of superiorlabial artery was 45.4 mm (range 29-85 mm). Furthermore, this study also found that mean external diameter of superior labial artery was 1.3 mm (minimum-maximum: 0.3-2.2 mm).[52] Similar to study of Pinar et al (2005), the average diameter of superior labial artery was 1.6 mm (min-max: 0.6-2.8 mm). However, the superior labial also gives off the superficial ascending branch which runs between skin and muscle. Moreover, the deep ascending branch is the branch of superior labial artery and it runs between muscle and mucosa.[48]

- Alar branches

The alar branches usually observe in the facial artery ending as alar type. It composes of inferior and superior alar branch. The inferior alar branch reaches the inferior border of the nostrils and it courses upward the base of columellar of nose. The anastomosis of inferior alar branch is discovered with the ascending branch of superior labial artery. For the superior alar branch, it goes along the nasal tip above the alar nasi and distributes into several small branches to supply the superior nostril and some parts of nasal dorsum.[48]

- Inferior labial artery (ILA)

The major arterial supply of the lower lip region is inferior labial artery. The anatomical study of Edizer et al (2002) found that the mean distance from inferior labial origin to oral commissure and to lower border of mandible were 23.9 mm (min-max: 6-39 mm) and 23.7 mm (min-max: 12-51 mm), respectively. Moreover, the average length of inferior labial artery was 52.3 mm (range from 16-98 mm), while the mean outer diameter was 1.2 mm (range, 1 to 1.8 mm). For the depth of artery, the mean depth from the superior surface of vermilion border at the midline to the inferior labial artery was 5.9 mm (min-max: 3-8.5 mm).[53]

Kawai et al (2004) performed qualitative study of the pattern of inferior labial artery. The investigation found that there were three types of inferior labial artery regarding to its origin. Type A (9 of 12 cases) demonstrated that the inferior labial artery branched from the facial artery at the area surrounding lower border of mandible. In type B (3 of 12 cases), the inferior labial ramified from facial artery at oral commissure, and it released from the superior labial artery in type C (1 of 12 cases).[53] After inferior labial artery emerging from facial artery, it's traveling along the lower lip in the layer between mucosa and orbicularis oris muscle. Then, the peripheral branch occasionally anastomosed with either contralateral inferior labial artery or submental artery. [48]

- Labiomental artery (LMA)

The confusion between labiomental and inferior labial artery still remained; therefore, the labiomental artery should be further clarified in the differentiation from the inferior labial artery. The labiomental artery is categorized into horizontal labiomental artery (HLA) and vertical labiomental artery (VLA) . However, the characteristic of HLA is similar to inferior labial artery. To separate, the inferior labial artery has the direction along with the lower lip, whereas the HLA emerges the facial artery before inferior labial artery, and it travels the middle part of lower lip region. For the VLA, it branches from submental artery and runs vertically to the lower lip area.[54]

- Lateral nasal artery (LNA)

The lateral nasal artery derives from facial artery at the nasolabial groove and travels directly along alar groove, and then goes toward the nose.[48] Marur et al (2014) explained that the lateral nasal gives off the superior alar and inferior alar artery in order to supply the nose.[7] If the termination of facial artery is neither lateral nasal nor alar type, the infraorbital artery or nasoseptal artery from superior labial artery may become the lateral nasal artery.[55] The quantitative study of lateral nasal artery found that mean diameter of lateral nasal on right side was 1.55 mm (range, 0.15 to 2.2 mm), while on the left side was 1.43 mm (range, 0.17 to 1.65 mm).[48]

➢ Angular artery (AA)

The study of Pilsl et al (2016) found that the angular artery was branched by facial and dorsal nasal artery in 33 hemi-face (55%) and 9 hemi-face (15%), respectively. For other 18 specimens (30%), there was no angular artery, so the small branches of infraorbital artery played essential role in supplying the medial angle of the eye.[45]

Kim et al (2014)(C) divided the pattern of angular in relation to neighboring structure into 4 types (Figure 17) including Type I (persistent pattern, 19.3%), type II (detouring pattern, 31.6%), type III (alternative pattern, 22.8%) and type IV (latent pattern, 26.3%). In type I, the angular artery emerges from the lateral nasal artery toward the medial area of eye (Figure 17A). For type II, the facial artery releases the detouring branch, and the branch goes medial to the nasojugal and medial canthal area terminating as angular artery (Figure 17B). The angular artery which originates from ophthalmic artery is grouped in type III (Figure 17C). In type IV, the angular artery is missing and the facial artery ends as lateral nasal artery (Figure 17D).[56] Regarding the variations of angular artery, the filler injection of this region may injured or damage several arterial branches.

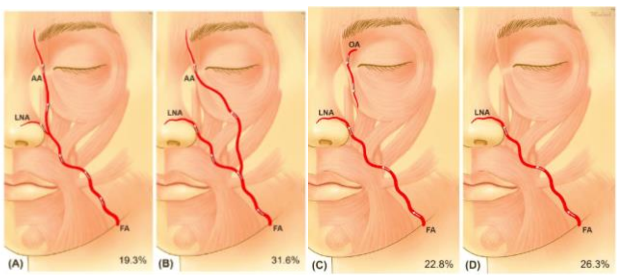


Figure 17 The four pattern of angular artery (Kim et al, 2014 (C))

2.5.1.2 <u>Superficial temporal artery (STA) and its branches</u>

The superficial temporal artery is the terminal branch of external carotid artery. The branch runs in the upward direction within parotid gland and releases transverse facial just before emerging the gland. After leaving parotid gland, the STA continuously ascents and crosses the zygomatic process of the temporal bone within the SMAS layer. When it passes the upper border of zygomatic arch, it branches the zygomatico-orbital artery and middle temporal artery which functions as supplying deep temporal fascia and temporalis muscle. Then, the frontal and parietal branches of STA become terminal ends of the STA.[7,57] The frontal branch is the main supply of the structure of the forehead region such as skin, muscle and pericranium. It provides anastomotic territories with supraorbital and supratrochlear artery, which are the branches of internal carotid system. Moreover, it may also communicate with the opposite frontal branch of STA.[7,58]

Lee et al (2015) (E) divided the frontal branch of STA into two major patterns: type I (62 of 64 (96.9%) of cases) as single frontal STA and type II (2 0f 64 (3%) of cases) as short common trunk from STA (Figure 18). Type I is subdivided into type Ia (46/64 (71.9%)) which the frontal branch STA gives off a single branch crossed lateral border of occipitofrontallis muscle (Figure 18A) and type Ib (16/64 (25%)) where the frontal STA separates into two branches before entering the lateral border of lateral border of occipitofrontallis muscle (Figure 18B). In others, type II is classified into two subtypes including type IIa (1.6%) and type IIb (1.6%). Type IIa shows that the two frontal STA run medially toward the forehead and above the orbicularis oculi muscle (Figure 18C). However, type IIb (1.6%) exhibits that the frontal STA travels below the lateral part of orbicularis oculi muscle (Figure 18D).[57] Pinar (2006) measured the diameter of STA, and found that the mean diameter at level of zygomatic arch was 2.73±0.51 mm. Additionally, the diameter investigation of frontal STA and parietal STA were 2.14±0.54 mm and 1.81±0.45 mm, respectively.[59]

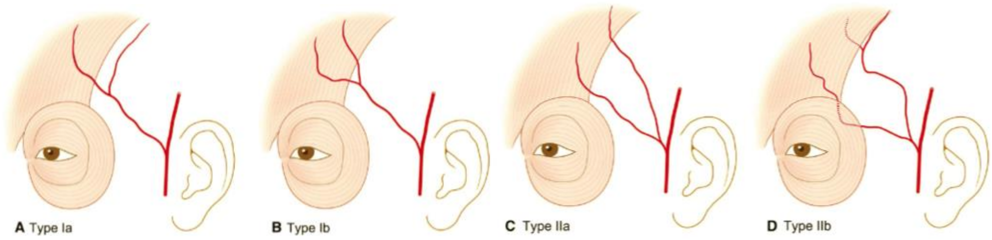


Figure 18 The four types of frontal branch of superficial temporal artery (Lee et al, 2015 (E))

➢ Transverse facial artery (TFA) and their branches

The transverse facial artery is the main arterial supply of the lateral side of the face. It branches from superficial temporal artery inside the parotid gland, and then crosses the masseter muscle parallel with parotid duct.[7,44] Yang et al (2010)(B) explained that TFA ramified from STA into superior and inferior trunk. The superior trunk emerged at the upper border of parotid gland, and ran accompanied with zygomatic branch of facial nerve to supply malar region, masseter muscle and zygomaticus major muscle. For the inferior trunk, it emerges at the lower border of parotid gland and coursed above masseteric fascia to become one of the muscular or cutaneous branches.[44]

➢ Zygomatico-orbital artery (ZOA)

After zygomatico- orbital artery arising from STA, it runs within the two layers (deep and superficial) of temporal fascia, and travels parallel to the zygomatic arch until it reaches the superolateral and inferolateral portion of orbicularis oculi muscle. The study of Pinar (2006) found that the ZOA is consequently connected with frontal branch STA and TFA.[59] In addition, Edizer et al (2009) pointed out that ZOA was also sometimes anastomosed with lacrimal artery. More detailed of this study, the ZOA was absent in 5 of 17 of cases (29.4%). For the quantitative study, the mean right and left diameter of ZOA were 0.5 mm (0.4 ± 0.7 mm) and 0.4 mm (0.2 ± 0.5 mm), respectively.[58]

2.5.1.3 Maxillary artery (MA) and their branches

The maxillary artery comes from the external carotid artery and runs behind the neck of mandibular condyle within infratemporal fossa. In terms of function, it serves as the arterial supply of the deep face region, nasal region and oral cavity. The main branches that associate with filler injection are mental artery, deep temporal artery and infraorbital artery. The mental artery is the terminal branch of the inferior alveolar artery which branches from the first part of MA and enters the mandibular foramen. It leaves the mental foramen and becomes mental artery to supply lower lip and chin.[7] Moreover, the deep temporal artery travels deeply into the temporalis muscle to supply it.[12]

- Infraorbital artery (IOA)

The infraorbital artery is the important branch of the face and comes from the third (pterygopalatine) part of MA. It passes through the infraorbital in the area of orbit, and then emerges the canal via infraorbital foramen to supply the anterior face.[7] The mean diameter of the infraorbital artery was 2.0 mm (min-max: 1.3-2.6 mm) In some cases, the IOA gives off the orbital branch to supply the soft tissue of orbital floor, lacrimal sac, nasolacrimal duct and some part of extrinsic muscle of eye.[60,61] Hwang et al (2011) demonstrated that the branches of IOA are palpebral, nasal and labial branch. The IOA has various anastomotic branches such as facial artery, transverse facial artery and dorsal nasal of the ophthalmic artery.[62]

2.5.2 Internal carotid system

The main branch of the internal carotid artery is ophthalmic artery and its branches which supplies the face. The OA carries the blood to supply the eyes area, the upper nose region, and the forehead area.[7]

- Ophthalmic artery (OA)

The OA is the first branches of internal carotid artery and enters apex of orbit by passing the optic canal or superior orbital fissure. The branches of the OA are supraorbital, supratrochlear, infratraochear, external nasal, dorsal nasal and zygomaticofacial artery.[7,61]

- Supraorbital artery

The supraorbital artery emerges from the orbit at either supraorbital foramen or supraorbital notch accompanied with supraorbital nerve and runs deeply along the periosteum layer reaching to the superolateral portion of the forehead. It functions as arterial supply of the forehead region including skin, muscle and scalp. However, it significantly anastomoses with contralateral supratrochlear and frontal branch of superficial temporal artery.[7,63] The explanation of Cong et al (2017) mentioned that the supraorbital artery changes the direction from the deep to superficial and is then called a superficial branch by passing one to three sites of frontalis muscle. Then, the superficial branch provides the arterial connection with superficial branch of supratrochlear artery and frontal branch of the superficial temporal artery.[63]

➢ Supratrochlear artery

The supratrochlear artery exits the lower part of the median margin of the orbital rim. It composes of two branches: superficial branch and deep branch. Both arteries supply the frontalis muscle.[63]

➢ Dorsal nasal artery

The OA releases the dorsal nasal artery which descends along the nasal dorsum and ends at alar groove. Importantly, it communicates with lateral nasal artery and infraorbital artery. The OA produces blood supplies both the dorsal nasal region and medial portion of eyelid.[7,55]

➢ Zygomaticofacial artery

The zygomaticofacilal artery is one of the branches to be concerned when filler injection is performed. This branch originates from the zygomaticotemporal artery of OA, and then passes through the zygomaticofacial foramen to supply the zygomatic and cheek region. In term of anastomosis, it usually connects with the transverse facial artery.[6,58] Furthermore, Edizer et al (2009) found that the average diameter of zygomaticofacial artery was 0.4 mm (min-max: 0.2-0.6 mm).[58]

As mentioned above, several studies explain anatomically of individual arteries of the face. Some study describes the arterial location correlated with soft tissue landmarks as well as arterial pattern. However, the references of the arterial location are quite different from the real injection site; therefore, it may not guarantee that each injection site is safety. To clarify the risk of complication in each injection site, the arterial location should be deeply investigated.

2.6 Correlation of the arterial branches and injection sites with lead to the complication

The arterial location is crucial for injectors due to the unwanted complications that may occur. Because each injection site is not supplied by a single arterial branch, one must be awared about the entire arteries distribution of the face.

- *Arterial supply of upper face*
  - Periorbital region

Filler injection surrounding eye area should be professionally performed because this region is supply by both internal and external carotid circulation. Therefore, arterial injury of this region may occur with branches of ophthalmic artery including supraorbital, supratrochlear, lacrimal, superior medial palpebral, inferior medial palpebral, dorsal nasal and zygomaticofacial artery. In terms of external carotid artery supply the periorbital region, it is probably due to damage to angular artery of facial artery, zygomaticoorbital artery, transverse facial artery, frontal branch of superficial temporal artery and infraorbital artery.[58] In addition, Lopez et al (2008), described that the upper eyelid receives the blood supply from collateral branches which is provided by anastomosis between ramification of ophthalmic artery (supraorbital, supratrochlear and dorsal nasal artery) and angular branch of facial artery.[64]

  - Forehead region

Hotta et al (2016) stated that blood supply to the medial portion of frontalis muscle is from supraorbital and suprotraochlear, while the frontal branch of superficial temporal artery is laterally distribution of muscle.[13] Similarly to Kelly et al (2006), both supraorbital and supratrochlear are primitive arteries of the forehead. In a case that these two branches are obstructed, the facial artery provides the blood flow up to the midline of forehead area through anastomosis of angular artery and dorsal nasal artery.[65]

- Glabella region

Cong et al (2017) illustrated that the blood supply of glabella region is taken care by the supratrochlear and supraorbital artery which are branches of ophthalmic artery.[63] Related to Hotta et al (2016) reported that risk of vascular complications may occur when glabella region is injected with filler since this region contains the supratrochlear artery which runs superficially under the skin.[13] However, Kwon et al (2013) demonstrated that the glabella receives blood not only from the supratrochlear artery but also angular artery which peripherally ramifies of dorsal nasal artery.[66]

- Temple region

The arterial supply of the temporal area including temporalis muscle and fascia comes from two sources: maxillary artery and superficial temporal artery. The anterior deep temporal and posterior deep temporal arteries, which are released from maxillary artery, should be considered when supraperiosteal injection is performed. However, the superficial portion of temporal area is supplied by frontal branch of superficial temporal artery.[13]

- *Arterial supply of middle face*

- Nasolabial region

The nasolabial region has a complicated blood supply; however, the dominant artery is facial artery. In case of facial artery malformation, the opposite facial artery, ipsilateral transverse facial artery, infraorbital and ophthalmic artery are supplying the region instead of facial artery. Additionally, the inferior portion of the nasolabial fold near modiolus is exclusively supplied by the facial artery.[67]

- Tear trough region

This region associates with inferior palpebral region; hence, the arterial supply surrounding the tear trough region is possibly from both infraorbital and facial arteries. However, the facial artery provides the arterial distribution superficial to muscle or subcutaneous layer of the face.(18) Moreover, Kelly et al (2008) demonstrated that the angular artery is primarily blood supply of paranasal region. When the angular artery is terminated at alar, the infraorbital artery gives off its branches to supply medial canthal region.[65]

- Mid cheek region

The most important arterial content of midcheek region is the superior branch of transverse facial artery. This branch is originated from superficial temporal artery and emerges from the parotid gland superior to the parotid duct along with zygomatic nerve and zygomatic retaining ligament.[68]

- *Arterial supply of lower face*

The blood supply of the perioral region is originated from branches of facial artery including superior labial and inferior labial artery. The superior labial is the predominant artery supply of upper lip; however, its branches included subalar branch and septal branch, the last one being also the upper lip supplement. In terms of lower lip, the arterial plexus is from facial artery and its branches following inferior labial and horizontal labiomental which runs horizontally in the labiomental region. Furthermore, vertical labiomental artery is originated from the submental artery as one of arterial supplies of the lower lip.[48,69]

2.7 Soft tissue layers of the face

Regarding to injection techniques, the filler has been augmented in variety of face soft tissue layers. Therefore, the clinician should deeply understand about the layers of the face. Kim et al (2015)(B) explained that there are generally five soft tissue layers of the face from superficial to deep: skin (1), subcutaneous fat (2), superficial musculoaponeurotic system (SMAS) (3), retaining and space (4) and periosteum and deep fascia (5) (Figure 19A). Specifically, the subcutaneous fat within the face is divided into several parts, for example malar fat and nasolabial fat, whereas deep fat lies underneath of the facial muscles (Figure 19B). For SMAS layer, the components of this layer are facial muscle fibers and superficial fascia of the face. However, the SMAS layer has a different technical term in each portion of the face. The boundary of the lower facial SMAS is platysma muscle, and then it continuously extends to the upper face as galea aponeurosis which is laterally spread into temporoparietal fascia (superficial temporal fascia).[6] Since the arteries of the face have various patterns, understandably the artery does not have the same pattern in each individual. Therefore, it also has unspecific course relative with soft tissue layers in each facial portion.

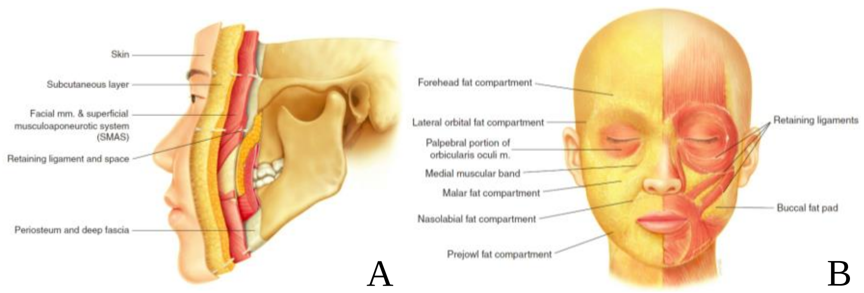


Figure 19 The five soft tissue layers of the face (A), superficial and deep fat compartments of the face (B) (Kim et al, 2015 (B))

2.8 3D scanning procedure for anatomical studies

The three- dimentional (3D) image is generally used for several clinical purposes such as diagnosis of genetic diseases, orthodontic and surgical treatment. Particularly, the 3D photogrammetry is currently used for the cosmetic procedures in order to evaluate the pre and post aesthetic results. However, this 3D scanning base morphological study of the face has now became frequently used in research purpose.[70,71] Lee et al (2017)(F) studied the skin thickness of the ten embalmed cadavers by using 3D scanning, ultrasound (US) imaging system and direct measurement (vernier caliper). The results showed that the ICC value for the correlation between the 3D scanning system and direct measurement represented excellent reliability (0.849, 95% confidence interval = 0.799–0.887). Moreover, there was great level of agreement between 3D scan and direct measurement when performed the Bland-Altman analysis. From this study, the author mentioned that the 3D scanning system provided the precise data of the skin thickness when the skin was removed.[71] Therefore, using 3D scanning system is also appropriate for examining the others anatomical structure of the face for example muscle , arteries and veins with dissecting method.

2.9 Modified Sihler's method for arterial study

Normally, the Sihler's staining procedure is created by Charles Sihler, but the technique is also applied by others researchers. The general objective of this staining is for showing actual intramuscular nerve termination location and also nerve distribution pattern (Figure 20A and B).[72] Nevertheless, this methodology is modified for investigating arterial supply and arterial pattern within the muscle. Due to the fact, that any dissection method cannot definitely preserve small arteries and difficult to study all arterial anastomotic territories on the face, using this method will provide such data in-depth. Following the study of Won et al (2012), the Sihler's method is successfully described the anatomy of arterial supply including the number of branches, location, patterns and anastomosis of the masseter muscle (Figure 20C).[73] However, just few studies use the Sihler's staining method for arterial examination of the face. This study expects to provide deeply detailed information about arteries of the face.

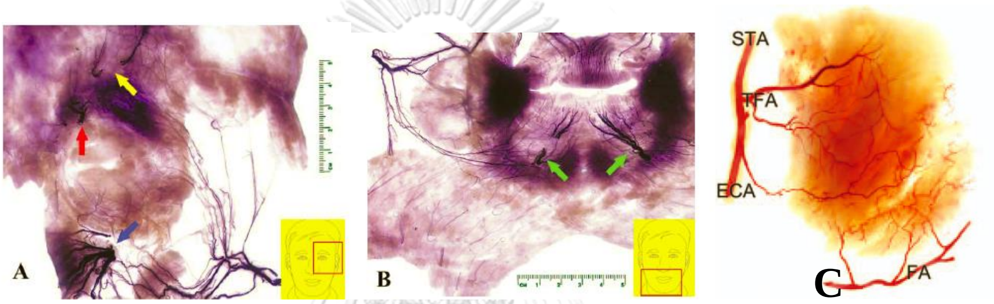


Figure 20 The Shiler's staining procedure for evaluating intramuscular nerve distribution (A and B), the arterial study by using Sihler's method (C) (Lui et al, 2010) (Won et al, 2012)

CHAPTER III

RESEARCH METHODOLOGY

3.1 Target population and Sample population

This study was performed on the faces of Thai embalmed cadavers in the Chula Soft Cadaver Surgical Training center, Faculty of Medicine, Chulalongkorn University.

Inclusion criteria

- The cadavers were preserved completely and there was no apparent damage on the face and on the neck
- The cadavers had red color latex injected entirely into the common carotid artery on both sides of the face

Exclusion criteria

- The cadavers had decomposed and had damaged on the head and neck

3.2 Sample size determination

3.2.1 Sample size determination for 3D scan and dissection method

According to Jeroen et al (2009), this study was conducted in 26 hemi-faces of fresh cadavers. The experiment found that the standard deviation of diameter of facial artery at the nasolabial fold was 0.4 mm. That was calculated for the sample size.(74)(74)

The confidence interval (CI) was set at 95%

$$n = Z^2_{\alpha/2}\,\sigma^2 / d^2$$

While; $Z_{\alpha/2}$ = $Z_{0.05/2}$ = 1.96 (two tail)

σ^2 = Variance of data = $(0.4)^2$

d = Acceptable error = 0.1 mm

So; $n = Z^2_{\alpha/2}\, \sigma^2 / d^2$

$n = (1.96)^2(0.4)^2 / (0.1)^2$

$n = 61.47$

The calculated sample size was at least 61.47~62 hemi-faces. Therefore, The 62 hemi-faces (31 cadavers) were performed in this study.

3.2.2 Sample size determination for Modified Sihler's method

Following the pilot study from 30 hemi-faces of embalmed cadavers found that the standard deviation of diameter of the anastomosis between right and left superior labial artery at the midline was 0.33 mm. That was calculated for the sample size.

The confidence interval (CI) was set at 95%

$n = Z^2_{\alpha/2}\, \sigma^2 / d^2$

While; $Z_{\alpha/2}$ = $Z_{0.05/2}$ = 1.96 (two tail)

σ^2 = Variance of data = $(0.33)^2$

d = Acceptable error = 0.15 mm

So; $n = Z^2_{\alpha/2}\, \sigma^2 / d^2$

$n = (1.96)^2(0.33)^2 / (0.15)^2$

$n = 18.59$

The calculated sample size was at least 19 hemi-faces. Therefore, 10 cadavers (20 hemi-faces) were used in this study.

3.3 Tools

3.3.1 Dissection and 3D scanning

- Materials for dissection consists of operating scissors, operating knife, surgical blade, forceps and probe
- Surgical microscope
- Digital vernier caliper
- Scale
- Pins
- Digital camera
- 3D scan camera

3.3.2 Modified Sihler's stain

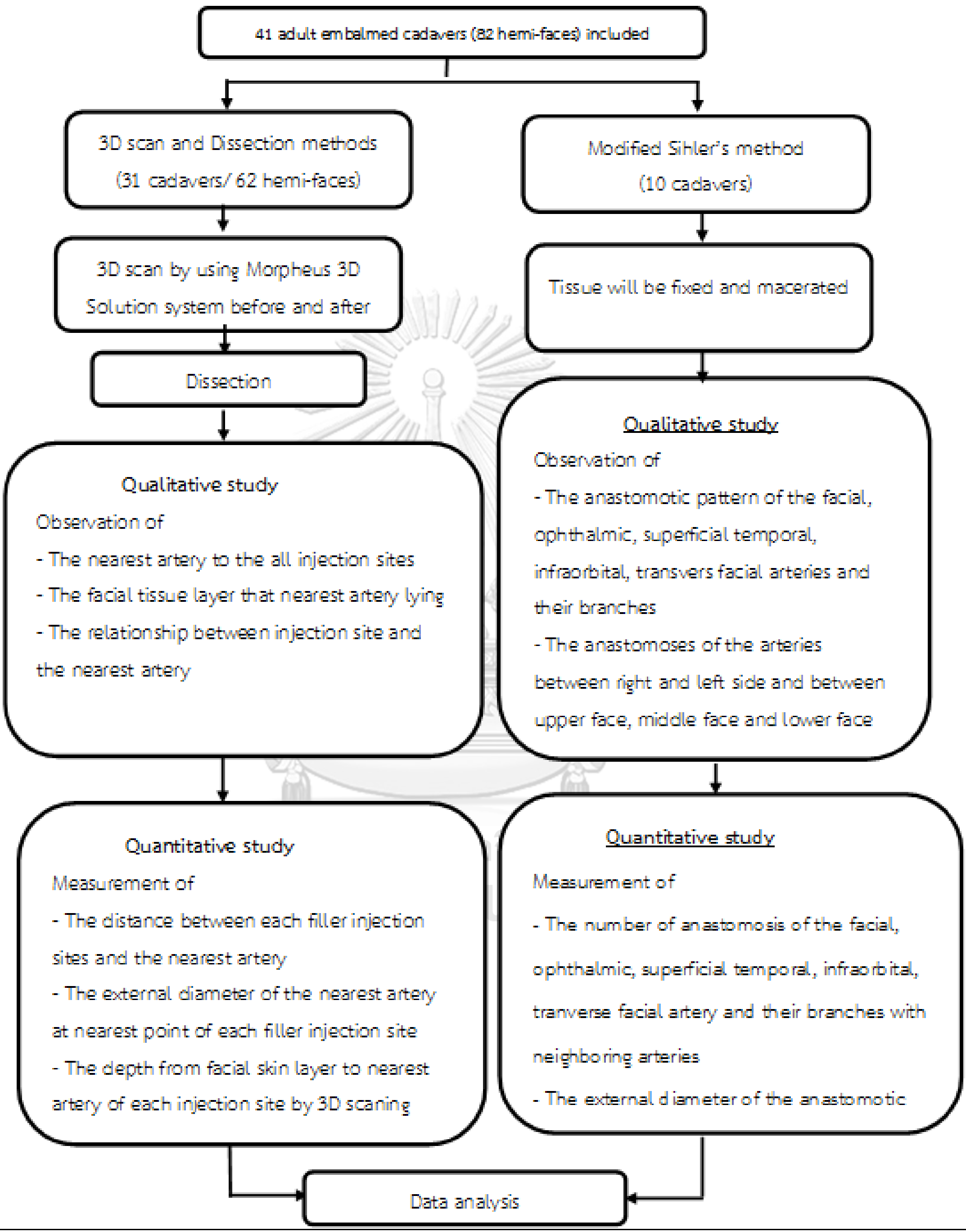
- The chemical following KOH, H_2O_2, acetic acid, glycerin, chloral hydrate, Ehrlich's hematoxilin and Li_2CO_3
- Plastic bottle
- Light source

3.4 Methods

3.4.1 Cadavers preparation

The sample sizes were randomly divided into two groups: 31 cadavers (62 hemi-faces) for dissection with 3D scan methods and 10 cadavers for Modified Sihler's method. All specimens were completely injected with silicone red color latex into the common carotid artery.

3.4.2 Research framework



3D scan and dissection methods

3.4.3 3D scanning method

The 3D scanner (Morpheus3D Solution) was utilized for scanning the whole face of 31 cadavers (62 hemi-faces) before and after dissection. The protocols consist of front scan, right scan and left scan.

- *Front scan*

The cadavers were positioned in the supine position with 60-70 cm of distance from the camera. The front scan were performed by providing vertical line in the midline of the face followed by the two red lines in the center of the face and the horizontal guide line was placed between two red lines. To complete, hair band was used to make the forehead, ear and neck clearly visible (Figure 21A).

- *Right scan*

The camera was set at 45° angle in relation to the specimen. Then, the right scan was done by defining the vertical beam at the lateral canthus and the horizontal line at the same position as the front scan (Figure 21B). The image was successfully done when neck and ear are clearly seen.

- *Left scan*

Lastly, the left scan was carried out similar to the right scan. The camera was installed at 45° angle (Figure 21C).

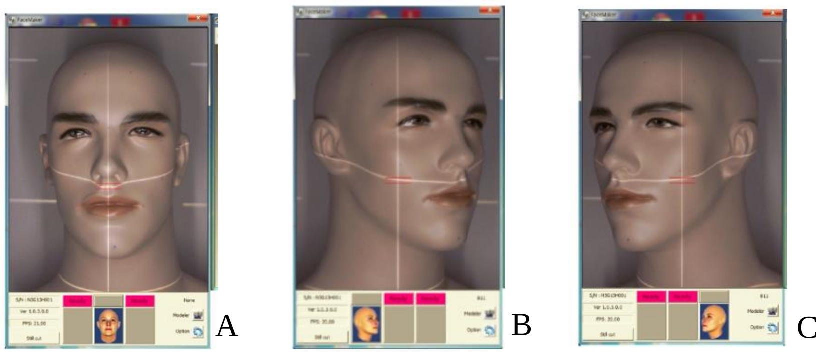


Figure 21 The scanning protocols including front scan (A), right scan (B) and left scan (C) (Ref.: Manual of Morpheus 3D User's Guide, 2013)

➢ *Image registration*

After scanning, the dots were placed at the lateral canthus, nasal alar and the oral commissure in each image (Figure 22A). When the placement and registration is completed, full image was showed in the modeler window (Figure 22B). Then, the image was recorded.

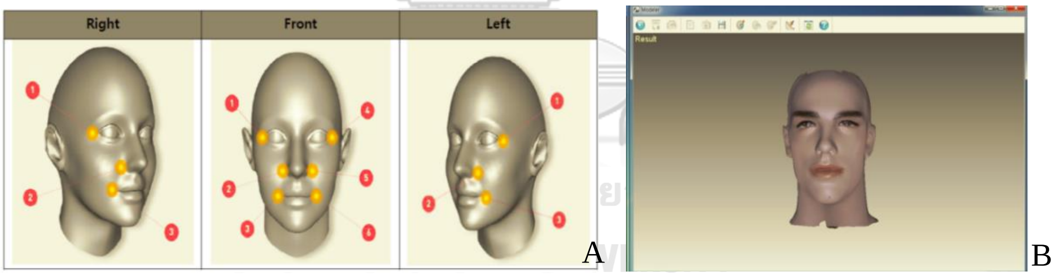


Figure 22 Marking the landmarks (A), the completed making landmarks (B) (Ref.: Manual of Morpheus 3D User's Guide, 2013)

➢ *Providing landmarks*

The saved file was opened in the program. Next, the head pose was employed before identifying the landmark by auto or manual adjust. The landmarks section was preceded by auto or manual detect function in all specimens (Figure 23A and B). The landmarks were remained at the same point in both pre and post dissection 3D screening. In the end, the photo was saved.

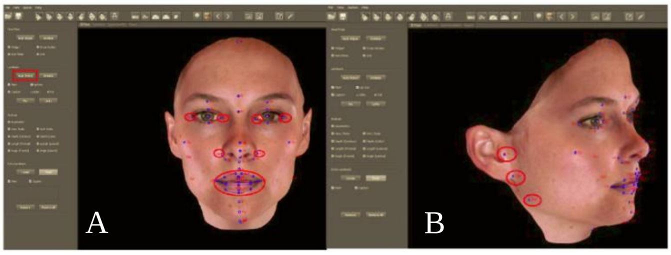


Figure 23 Defining the landmarks of the face anterior marking (A) and lateral marking (B) (Ref.: Manual of Morpheus 3D User's Guide, 2013)

9.8.3.6 The both pre and post images were superimposed by using the program of 3D camera in order to measure the depth changing before and after dissection. The 3D images were saved after ending processes.

<u>3.4.4 Dissection method</u>

➢ ***Dissection technique***

1) <u>Define the injection sites (as anatomical landmarks)</u>

The injection sites which have been commonly performed in clinical filler injection procedures were used as the anatomical landmarks for measurements. The landmarks were made using pins. The injection sites of the face were divided into 3 parts including

1.1 Upper face

The anatomical landmarks which correlate to the injection sites for the upper face compose of forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB) and temple (TP) areas.

➢ <u>Forehead (FH) injection site:</u> The horizontal imaginary line between hairline and the superior orbital rim was created, and then the area between these lines was equally divided into three parts including upper, middle and lower area. The pin was used to mark an injection site at the midline junction between upper and middle area (Figure 24A).

➢ <u>Eyebrow (EB) injection site:</u> This landmark was provided at the lateral one third of the eyebrow along superior orbital rim (Figure 24A).(14)

➢ <u>Sunken eye or upper eyelid (UE) injection:</u> The injection site was the superior sulcus of the upper eyelid which located inferior to the supraorbital rim at the level of lateral canthus (Figure 24A).(5)

➢ <u>Glabella (GB) injection</u>: The horizontal imaginary line was done along the supercilliary ach and radix of the nose. And then, the landmark was defined at mid point between these line and at midline line of the face. (Figure 24A)

➢ <u>Temple (TP) injection:</u> The temple has been usually augmented with filler in two locations including 1 cm superior to temporal fusion line and 1 cm lateral and parallel to the supraorbital rim (TP1) (Figure 24B) and the temporal area within 2 cm diameter (safe zone) by creating an area 2 cm superior to the zygomatic arch and 2 cm lateral to the lateral orbital rim. (TP2) (Figure 24C).(5)

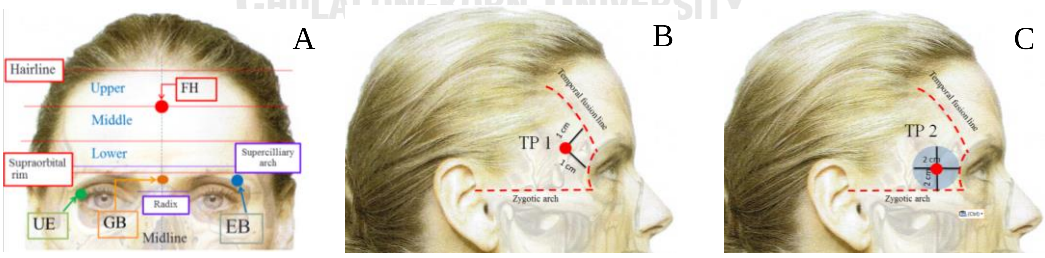


Figure 24 Anatomical landmark for upper face injection site, FH- forehead, GB-glabella, EB- eyebrow and UE- upper eyelid (A), TP1-temporal injection site1(B) and TP2-temple injection site 2 (C) (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

1.2 Middle face

The middle face was injected the filler into five areas following

- Tear Trough (TT) and palpebromalar groove (PM) injection (Figure 25A): For tear trough restoration, the four injection sites along tear though were used as the landmarks. Firstly, it was the intersection between vertical line of the lateral canthus and the horizontal line of nasal alar (TT1).[6] Secondly, inferior margin of the tear trough was marked for TT2. Next, the tear trough deformity was identified at the mid pupil level (TT3). Lastly, the landmark was set at 0.5 cm form medial canthus along the tear trough (TT4).[30]

- Mid Cheek augmentation (MC): The injection site was an intersection point between two imaginary lines: the line from the lateral canthus to the oral commissure and the line from the tragus to the nasal alar (Figure 25B). (Ref.: The manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

- Lateral Hollowness (LH) (Figure 25C): The landmark was marked exactly 2 cm inferiorly to the inferior border of zygomatic arch and horizontally 4 cm from the tragus. (Ref.: The manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

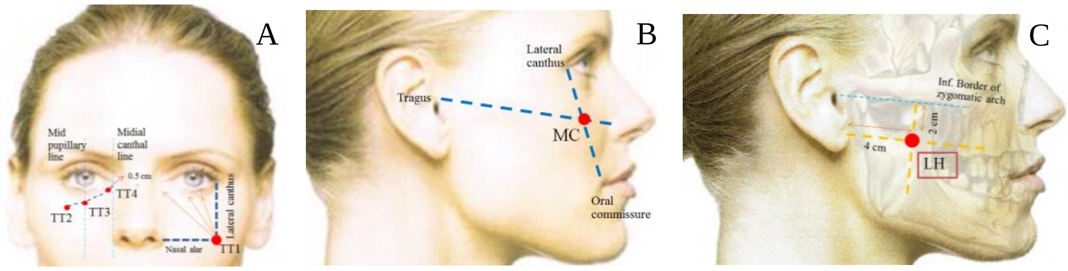


Figure 25 Landmark for the tear trough injection sites (TT1-TT4) (A), mid cheek injection site (MC) (B) and lateral hollowness (LH) (C) (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

➢ <u>Nasolabial fold (NLF) injection:</u> The landmarks were placed along the nasolabial fold following the level of inferior margin of NLF (NLF1), at level of the mid philtrum horizontal line (NLF2) and at the inferior alar (NLF3). Additionally, the superior angle of the nasolabial fold was defined for nasolabial injection (NLF4) (Figure 26).

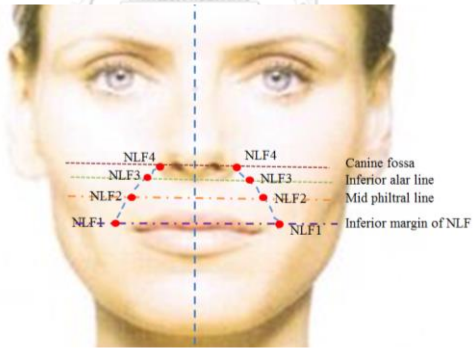


Figure 26 Landmark for the nasolabial fold augmentation (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

1.3 Lower face

➢ <u>Lip (vermillion and volume) (LV) injection (Figure 27A):</u> For lip injection, the landmarks consisted of three locations: 2 mm lateral to the oral commissure (LV1), along the vermillion at lateral alar (LV2) and the vermillion border at midline (LV3).[27]

➢ <u>Chin (CN) injection (Figure 27A):</u> The inferior margin of the mandible at midline was used for making a landmark.

➢ <u>Jawline (JL) injection (Figure 27B):</u> The landmark was the inferior border of the mandibular angle.[19]

Figure 27 Landmarks for the lip vermilion and chin augmentation (A), jawline injection (B) (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

➢ <u>Marionette (MN) injection:</u> The two landmarks following inferior margin of marionette line (MN1) and the marionette line itself at the level of mid pupillary line (MN2) were used for measurement (Figure 28).

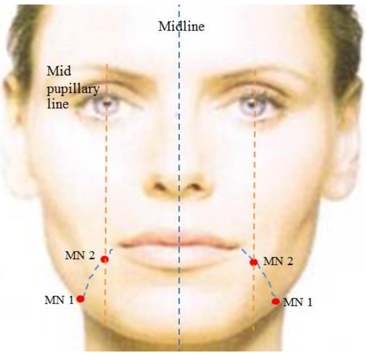


Figure 28 Landmark for the marionette line correction (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

2) Make skin incision and dissection

The dissection was performed layer by layer. Firstly, the skin incision was done following vertical line at midface, horizontal line at intercanthal line, oralcomissure, lateral canthus and submandible. Next, the skin was superficially removed along the incision from the medial to the lateral side. After completing the skin dissection, the subcutaneous tissue layer will be seen (Figure 29).

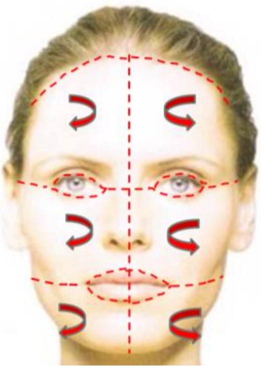


Figure 29 Skin incision and dissection (Ref.: Modified pictures from the manuscript of The 7th International Thaicosderm Congress on Aesthetic Medicine. 2017 July.)

3) Proceed subcutaneous dissection

Next, the subcutaneous fat was carefully removed. When finished this dissection, the superficial musculoaponeurotic system (SMAS) layer will be found (Figure 30).

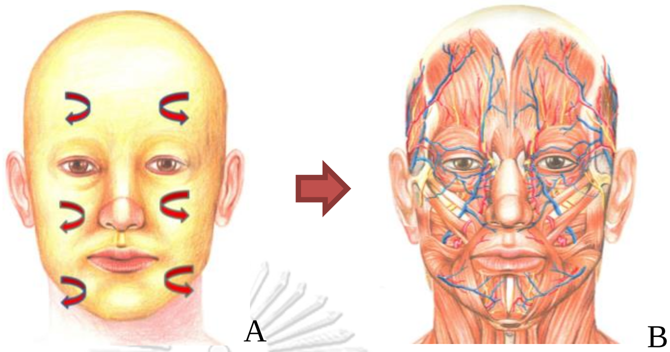


Figure 30 Subcutaneous dissection (A), the SMAS layer after subcutaneous dissection (B)

4) Identify the artery of the face

After that, dissection was continually done for identifying all of the branches of the facial artery, ophthalmic, dorsal nasal, superficial temporal artery, maxillary artery and their branches (Figure 31). In order to expose the facial artery, the dissection started inferiorly to the lower border of mandible at the anterior border of masseter muscle.[51] For the superficial temporal artery, the main branch was traced from the area infront of the tragus.[41] The ophthalmic artery was traced from terminal branches including supraorbital and supratrochlear artery. However, the infraorbital artery was dissected at the approximately 10 cm below infraorbital rim.[58] After finding the main branches, each arterial branch was traced until reaching the terminal branches. If the arterial branches are too small, the dissection under surgical microscope was necessary.

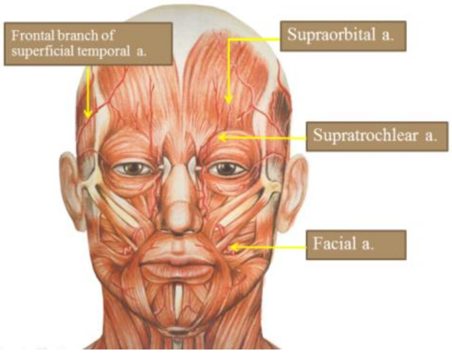


Figure 31 Identifying all of braches of arterial of face

5) Reference the nearest arterial location with each landmark in order to measure the distance: the pins were used for pointing the nearest artery or the arterial branches which located the closest to all injection sites.

➢ ***Observation***

1) The nearest artery to the injection sites including forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB), temple (TP), tear trough (TT), nasolabial fold (NLF), mid cheek (MC), lateral hollowness (LH), upper lip (LV), jawline (JL), marionette line (MN) and chin (CN) injection sites

2) The facial tissue layers in which were the nearest artery located during layer by layer dissection

3) The relationship between the injection site and the nearest artery

➢ ***Measurement***

1) The distance between each filler injection sites and the nearest artery:

The distance of nearest artery to every injection sites including forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB), temple (TP), tear trough (TT), nasolabial fold (NLF), mid cheek (MC), lateral hollowness (LH), upper lip (LV), jawline (JL), marionette line (MN) and chin (CN) injection sites were measured according to standard X axis and Y axis. The X axis was correlated to Frankfort's Horizontal Line which was horizontal extending line from the upper margin of the tragus along with the infraorbital rim.(75)[75] The Y axis was perpendicular line to X axis, and it locates anterior to tragus (Figure 32A). The measurement was performed firstly by marking the nearest artery with the pin, and then the distance X was measured from the injection sites to the nearest artery parallel with Frankfort's Horizontal Line. However, the distance Y measurement was done parallel with Y axis (Figure 32B and C). The measurements were employed following this protocol in all injection sites.

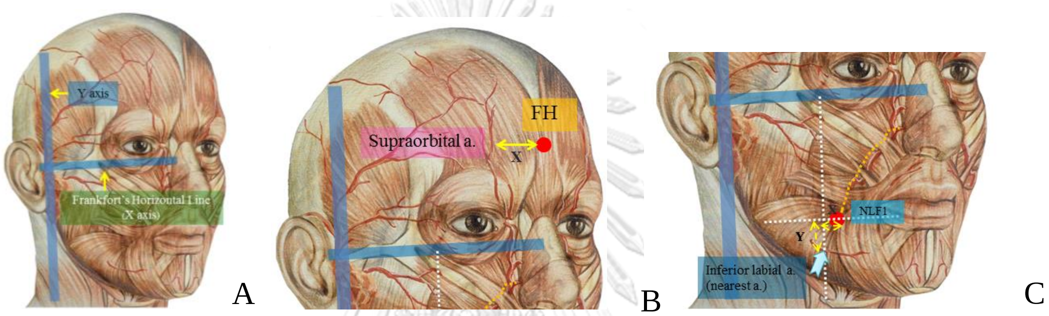


Figure 32 Making Frankfort's horizontal line (X axis) and vertical line perpendicular to (Y axis) (A), measurement the distance between the injection sites to nearest artery (B and C)

2) The external diameter of the nearest artery of all injection sites by using vernier caliper

3) The depth from the facial skin to the nearest artery:

The depth was done by using superimposition function of Morpheus 3D program. The 3D images of the predissection and postdissection were superimposed by MPS 3.0. Then, the location of nearest artery of the predissection image was point P, and the nearest artery of postdissected was point Q which was the perpendicular projection from point P to the postdissection 3D scanned image (Figure 33A andB). The distance between point P-Q was assessed for the depth from the skin to the nearest artery in each injection site, and it was automatically calculated by MPS 3.0 (Figure 33B).[71]

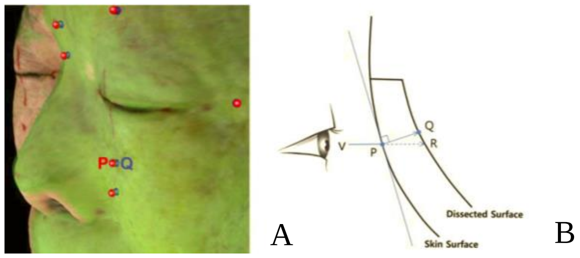


Figure 33 The superimposition of the predissection (Point P) and post dissection (Point Q) 3D scanned images (A and B). And the measurement of the depth between skin to nearest artery (distance P-Q) (B) (Lee et al, 2017(F))

<u>**3.4.5 Modified Sihler's method**</u>

- *Modified Sihler's staining protocol*

The 10 embalmed cadavers were recruited for the modified Sihler's method. Firstly, the skin was dissected very superficially (as thin as possible) because the arteries may get damage. For removing the subcutaneous tissue, the dissection was carefully done under surgical microscope; otherwise, the small vessels might be cut.[72] During dissection, the origin of the external carotid artery (EA), facial artery (FA), superficial temporal artery (STA), ophthalmic artery (OA), transverse facial artery (TFA), deep temporal artery (DTA), Infraorbital artery (IOA) and mental artery (MA) were ligated. Next, the soft tissue flap of the face was harvested. It was done by a superior dissection at the hairline. The base of mandible was used for inferiorly dissection. For the lateral incision, the dissection was performed vertically anterior to the auricle. The flap was harvested through above listed incisions and transitioned deeply to the subperiosteal facial layer (Figure 34).

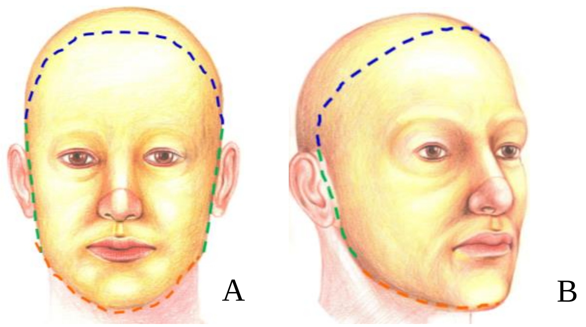


Figure 34 The incision line for harvesting, blue color line- along hair line (A), Green color-anterior to tragus, orange color line- base of the mandible (B)

The harvested 10 flaps was followed modified Sihler's protocol which modified by Liem and Douwe van Willigen (1988). Normally, this method consisted of eight steps starting with fixation followed by maceration and depigmentation, decalcification, staining, destaining, neutralization, clearing and transparency.(76) To observe the arteries, the first two steps of this procedure including fixation and maceration and depigmentation was applied for this study.(73)

- Fixation

In the beginning, the harvested specimens was washed with running tap water, and then immersed in 10% unneutralized formalin for 3 weeks approximately. The specimens were fixed until they became hard.(72,76)

- Maceration and depigmentation

Next, the fixed specimens were washed under running tap water for approximately 1 hour, then macerated and depigmented with 3% potassium hydroxide (KOH). Moreover, the hydrogen peroxide, 0.2 ml of 3% hydrogen peroxide per 100 ml, was also added.(72) The solution was changed twice a week or when it becomes dark brown or cloudy. The duration of this step was around 2-4 weeks depending on size of the sample. In this process, the specimens were gradually whitened.(76) In the end of this period, they became translucent. Furthermore, all arteries, particularly the small arterial branches and its anastomoses, were seen with the prominent red color. After that, the specimens was observed and measured on a medical film readout device, which give sufficient light to present the detailed color of the arteries. [73]

- *Observation*

1) The anastomotic pattern of the facial, ophthalmic, dorsal nasal, superficial temporal, infraorbital, transverse facial arteries and it branches with neighboring arteries

2) The arterial anastomoses between the right and the left side and between upper face, middle and lower face

- *Measurement*

1) The number of anastomoses of the facial, ophthalmic, dorsal nasal, superficial temporal infraorbital, transverse facial arteries and it branches with neighboring arteries

2) The external diameter of the anastomotic branches at the anastomotic point to the main artery.

3.5 Data collection

The data will be collected into the case record form (CRF)

Cadaveric evaluation of the location of arteries and their anastomotic territories on the face	Date: ____ / ____ /_____
Table NO. ____________ Cadaver code __________	Age ______________ years Sex ☐ Male ☐ Female

Left face

1. *Distance from injection points (IJP) to arteries*

Upper face

1.1 Forehead (FH) - Needle

☐ Distance FH1 to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.2 Eyebrow (EB)

☐ Distance EB to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.3 Sunken eye or upper eyelid (UE)

☐ Distance UE to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.4 Glabella (GB)

☐ Distance GB to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

Right face

1. *Distance from injection points (IJP)to arteries*

Upper face

1.1 Forehead (FH) - Needle

☐ Distance FH1 to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.2 Eyebrow(EB)

☐ Distance EB to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.3 Sunken eye or upper eyelid (UE)

☐ Distance UE to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others__________

1.4 Glabella (GB)

☐ Distance GB to..

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

1.5 Temple (TP)

☐ Distance TP1 to......................................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance TP2 to...

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

Middle face

1.6 Tear Trough (TT)

☐ Distance TT1 (intersection) to.........................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance TT2 to.............................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

1.5 Temple (TP)

☐ Distance TP1: Points to......................................

X axis: 1)_________2)________3)_________mm

Y axis: 1)_________2)________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance TP2 to...

X axis: 1)_________2)________3)_________mm

Y axis: 1)_________2)________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

Middle face

1.6 Tear Trough (TT)

☐ Distance TT1 (intersection) to..........................

X axis: 1)_________2)________3)_________mm

Y axis: 1)_________2)________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance TT2 to.............................

X axis: 1)_________2)________3)_________mm

Y axis: 1)_________2)________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)_______3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance TT3 (mid pupil) to............................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance TT4 (med. canthus) to..........................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.7 Mid Cheek augmentation (MC)

☐ Distance MC to...
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.8 Lateral Hollowness (LH)

☐ Distance LH to...
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.9 Nasolabial fold (NLF)

☐ Distance NLF1 (inf. margin) to..........................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm

☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance TT3 (mid pupil) to............................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance TT4 (med. canthus) to..........................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.7 Mid Cheek augmentation (MC)

☐ Distance MC to...
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.8 Lateral Hollowness (LH)

☐ Distance LH to...
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular........... ☐ Muscular...........
☐ Supramuscular.......... ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.9 Nasolabial fold (N LF)

☐ Distance NLF1 (inf. margin) to..........................
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF2 (mid philtrum) to....................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF3 (inf. alar) to..........................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐-Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF4 to.......................................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

<u>Lower face</u>

1.10 <u>Lip (vermillion and volume) (LV) -</u>

☐ Distance LV1(commissure) to..........................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF2 (mid philtrum) to.........................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF3 (inf. alar) to.............................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

☐ Distance NLF4 to ....

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

<u>Lower face</u>

1.10 <u>Lip (vermillion and volume) (LV) –</u>

☐ Distance LV1(commissure) to..........................

X axis: 1)_________2)_________3)_________mm

Y axis: 1)_________2)_________3)_________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)________2)_______3)_________mm

Depth 1)_________2)________3)_________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance LV2 (lat. alar) to……………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance LV3 (midline) to………………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.11 <u>Jawline (JL) - cannula</u>

☐ Distance JL1to…………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.12 <u>Marionette (MN) - cannula</u>

☐ Distance MN1 (inf. margin) to………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance MN2 (lat. canthus) to…………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm

☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance LV2 (lat. alar) to……………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance LV3 (midline) to………………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.11 <u>Jawline (JL) - cannula</u>

☐ Distance JL1 to…………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

1.12 <u>Marionette (MN)</u>

☐ Distance MN1 (inf. margin) to…………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm
Depth 1)________2)_______3)_________mm
Arterial lining plane
☐ Sub dermal ☐ Subcutaneous
☐ Submuscular……….. ☐ Muscular………..
☐ Supramuscular……….. ☐ Supraperiosteum
☐ Parietotemporal fascia ☐ Others__________

☐ Distance MN2 (lat. canthus) to…………………………
X axis: 1)_________2)_________3)_________mm
Y axis: 1)_________2)_________3)_________mm
☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to
injection points
Diameter1)________2)_______3)_________mm

Depth 1)________2)________3)__________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

1.13 Chin (CN)

☐ Distance CN to...

X axis: 1)__________2)_________3)__________mm

Y axis: 1)__________2)_________3)__________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y(below) ☐+Y(above) to injection points

Diameter1)_________2)________3)__________mm

Depth 1)_________2)________3)__________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

2. *Number of arterial anastomosis*

Facial artery

☐ Facial artery: 1)______2)______3)_______

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

Superficial temporal artery

☐Main Superficial temporal artery (STA) : 1)______________2)_____________3)_____________

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

☐Transverse facial artery : 1)_____2)_____3)____

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

Infraorbital artery

☐Infraorbital artery : 1)______2)_______3)_______

Anastomoses to:

Depth 1)________2)________3)__________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

1.13 Chin (CN)

☐ Distance CN to...

X axis: 1)__________2)_________3)__________mm

Y axis: 1)__________2)_________3)__________mm

☐-X (medial) ☐ +X (lateral) ☐ -Y (below) ☐+Y(above) to injection points

Diameter1)_________2)________3)__________mm

Depth 1)_________2)________3)__________mm

Arterial lining plane

☐ Sub dermal ☐ Subcutaneous

☐ Submuscular........... ☐ Muscular...........

☐ Supramuscular.......... ☐ Supraperiosteum

☐ Parietotemporal fascia ☐ Others___________

2.Number of arterial anastomosis

Facial artery

☐ Facial artery: 1)______2)______3)_______

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

Superficial temporal artery

☐Main Superficial temporal artery (STA) : 1)______________2)_____________3)_____________

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

☐Transverse facial artery : 1)_____2)_____3)____

Anastomoses to:

I: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

II: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

III: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

IV: ____________________1)______2)______3)_______

Diameter: 1)_________2)__________3)_________mm

Infraorbital artery

☐Infraorbital artery : 1)______2)_______3)_______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

<u>Ophthalmic artery</u>

☐ Ophthalmic artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Supraorbital artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Supratrochlear artery : 1)_____2)______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Dorsal nasal artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

<u>Ophthalmic artery</u>

☐ Ophthalmic artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Supraorbital artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Supratrochlear artery : 1)_____2)______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

☐ Dorsal nasal artery : 1)______2)_______3)______

Anastomoses to:

I: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
II: ____________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
III: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm
IV: ___________________1)______2)______3)_______
Diameter: 1)_________2)__________3)_________mm

CHAPTER IV

RESULTS

The results of this study composed of two parts including the results of (1) dissection and 3D scanning procedure and (2) the Sihler's staining procedure. The 62 hemi-faces of 31 Thai embalmed cadavers (14 males and 17 females) with an average age of 78.3 years (range of 34- 95 years) were conducted for dissection. While, the 20 hemi-faces Thai embalmed cadavers (5 males and 5 females) with an average age of 74.0 years (range: 65- 93 years) were employed with Siheler's staining procedure. This study was performed at the Chulalongkorn Medical Faculty and the King Chulalongkorn Memorial Hospital.

4.1 The nearest artery, its relationship, its distance to the landmarks, diameter, and facial tissue layers that nearest artery lying, and the depth from the skin to the nearest artery

This dissection and 3D scanning procedure were performed in order to investigate the nearest artery, external diameter and distance of this nearest artery to the forehead (FH), eyebrow (EB), upper eyelid (UE), glabella (GB), temple (TP), tear trough (TT), nasolabial fold (NLF), mid cheek (MC), lateral hollowness (LH), upper lip (LV), jawline (JL), chin (CN) and marionette line (MN) injection sites. Additionally, this study also examined the relationship between the each injection site and its nearest artery, and facial tissue layers that nearest artery lying and the depth from the skin to the nearest artery based on such facial tissue layers.

The locations of the nearest artery correlated to landmarks were defined along the X-axis by the following: –X (referred to medial to landmark) and +X (referred to lateral to the landmarks). For the Y axis, locations were grouped as –Y and +Y, referring to inferior and superior positions to the landmarks, respectively. Moreover, X_0 and Y_0 were indicated that the nearest artery was placed at the landmark. Totally, the relationship between landmarks and the nearest artery was classified into 9 types, including: *Type I*, the artery lining Inferomedial to landmarks (-X, -Y); *Type II*, superomedial (-X, +Y); *Type III*, Inferolateral (+X, -Y); *Type IV*, superolateral (+X, +Y); *Type V*, medial (-X,Y_0); *Type VI*, lateral (+X,Y_0); *Type VII*, inferior (X_0,-Y); *Type VIII*, superior (X_0, +Y); and *Type IX*, at landmark (X_0, Y_0). The results following this procedure consisted of

4.1.1 The nearest artery of the upper face injection sites

The upper face region was supplied by numerous arteries including from dual internal and external carotid system. However, each upper facial injection site was supplied by distinct artery. Therefore, the result of this study found that nearest artery which associated with each filler injection site and its location consisted of following

➢ ***Nearest artery to Forehead (FH) injection site***

The main artery which associated with FH injection sites was supratrochlear artery (STCA). The STCA arose from superior orbitoglabellar branch of the ophthalmic artery (OA) (internal carotid system). This study showed that the right STCA was located nearest to FH in 15 of 31 cases (48.4%) with the diameter of 0.48 ± 0.12 mm (Figure 35A and C). In 14 of 31 cases (45.2%), the nearest artery to FH was left STCA (Figure 35A and E) and its diameter was 0.51 ± 0.20 mm. No statistical significance was found (p-value>0.05) when comparing STCA diameters between genders. However, the right and left terminal branch of STCA had communication and then became the nearest artery to FH injection site knew as anastomotic branch of right and left STCA (2 of 31 cases (6.5%)) with 0.39 ± 0.01 mm of diameter (Figure 35D) (Table 1).

Table 1. Frequencies of the nearest artery at forehead (FH) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to FH landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Left Supratrochlear artery (ltSTCA)	14 (45.2)	0.51 ± 0.20 (0.24-0.94)	6 (42.9)	0.56 ± 0.23 (0.30-0.94)	8 (47.1)	0.47 ± 0.18 (0.24-0.75)
Right Supratrochlear artery (rtSTCA)	15 (48.4)	0.48 ± 0.12 (0.28-0.70)	8 (57.1)	0.47 ± 0.13 (0.28-0.66)	7 (41.2)	0.48 ± 0.12 (0.37-0.70)
Anastomotic branch of right and left supratrochlear artery (Anas. rtSTCA and ltSTCA)	2 (6.5)	0.39 ± 0.01 (0.38-0.40)	-	-	2 (11.8)	0.39 ± 0.01 (0.38-0.40)
Total	31 (100)	0.48 ± 0.16 (0.24-0.94)	14 (100)	0.51 ± 0.18 (0.28-0.94)	17 (100)	0.46 ± 0.14 (0.24-0.75)

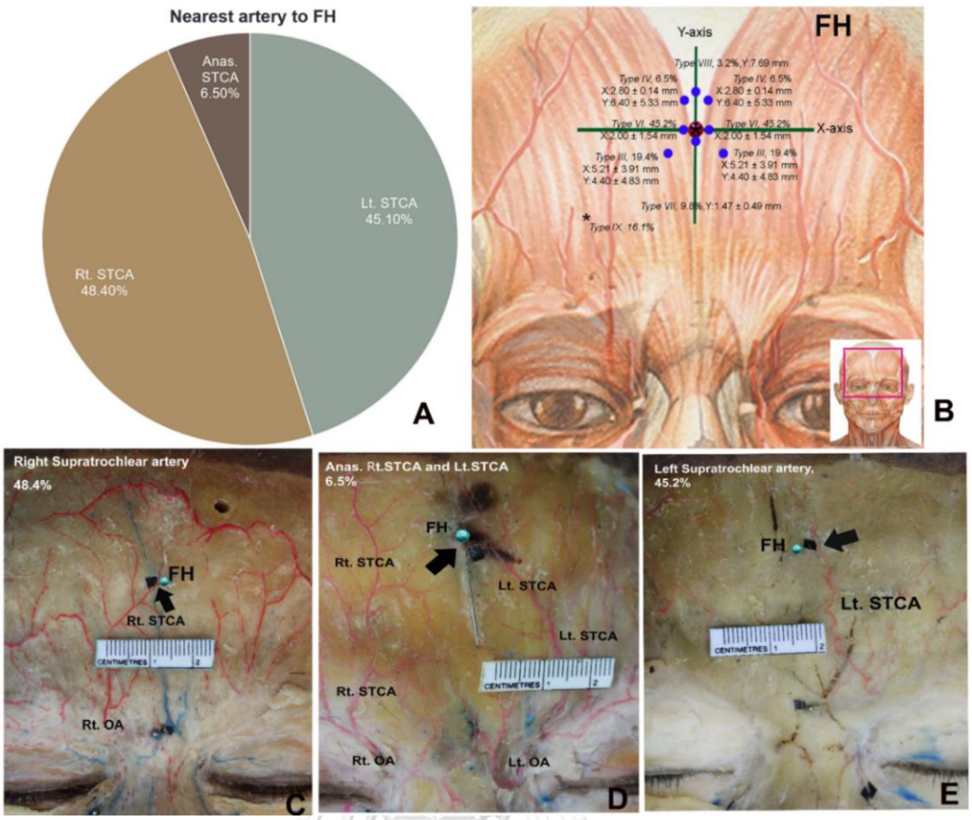


Figure 35 The nearest arteries to FH landmark (A); B: arterial locations related to FH landmark; C: the right supratrochlear artery; D: anastomotic branch of right and left supratrochlear artery; E: the left supratrochlear (arrow)

The relationships and the distances of the nearest artery to FH landmark were variously found in 6 of 9 types and showed in Table 2 and Figure 35B. In most cases (14 of 31 cases (45.2%)), the nearest artery located laterally (Type VI) to FH landmark, and the distance were 2.00 ± 1.54 mm along the X-axis. Additionally, the nearest artery which placed in inferolateral (Type III) direction to FH was found in 6 of 31 cases (19.4%). The X distance and Y distance of this type were 5.21 ± 3.91 mm and 4.40 ± 4.83 mm, respectively. However, this study discovered that the nearest artery located at FH landmark (Type IX) in 5 of 31 cases (16.1%). Whereas three Type IV (superolateral) and Type VII (inferior) were found in 2 cases (6.5%) and 3 cases (9.8%), respectively. The distance along X and Y-axis were 2.80 ± 0.14 mm and 6.40 ± 5.33 mm, respectively in Type IV. For type VII, The distance was 1.47 ± 0.49 mm along the Y-axis. There was only one case that located superior to FH landmark (Table 2).

Table 2. The distance from FH landmark to the nearest artery based on types of arterial locations

Types of arterial locations	N (%)	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)
III. Inferolateral (+X, -Y)	6 (19.4)	5.21 ± 3.91 (1.78 - 11.48)	4.40 ± 4.83 (1.71 - 14.56)
IV. Superolateral (+X, +Y)	2 (6.5)	2.80 ± 0.14 (2.67 - 2.92)	6.40 ± 5.33 (1.78 - 11.01)
VI. Lateral (+X,Y_0)	14 (45.2)	2.00 ± 1.54 (0.53 - 6.39)	0
VII. Inferior (X_0, -Y)	3 (9.8)	0	1.47 ± 0.49 (0.94 – 2.03)
VIII.Superior (X_0, +Y)	1 (3.2)	0	7.69
IX. At landmark (X_0, Y_0)	5 (16.1)	0	0
Total	31 (100)		

Regarding the relationship between such nearest artery and facial tissue layers based on FH landmark, our study found that most of the nearest arteries (28 of 31 cases (87.1%)) at FH was located within subcutaneous layer with the depth of 1.22 ± 0.39 mm. In 2 of 31 cases (6.5%), the nearest artery located above frontalis muscle (supramuscular layer), while supraperiosteal arterial lying layer was found in 1 of 31 cases (3.2%) (Table 3). The depth correlated to supramuscular and supraperiosteum layer was 1.76 ± 0.26 mm and 2.25 mm, respectively (Table 3).

Table 3. Relationship between the location of the nearest artery and fascial tissue layers at FH landmark, and the depth from the skin to nearest artery

Facial layers	Depth from the skin to nearest arteries of FH landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	28 (87.1)	1.22 ± 0.39 (0.80- 1.96)	13 (92.9)	1.24 ± 0.38 (0.82-1.92)	15 (88.2)	1.21 ± 0.40 (0.80- 1.96)
Supramuscular	2 (6.5)	1.76 ± 0.26 (1.53- 1.98)	1 (7.1)	1.53	1 (5.9)	1.98
Supraperiosteum	1 (3.2)	2.25	0 (0)	-	1 (5.9)	2.25
Total	31 (100)		14 (100)		17 (100)	

➢ ***Nearest artery to Eyebrow (EB) injection site***

The landmark for EB injection site was the lateral one third of eyebrow along supraorbital rim. The main associated arteries at this landmark was supraorbital artery (SOA) and superficial temporal artery (STA). In this study, the related branches of SOA which ramified of ophthalmic artery (OA) were observed in brow branch (BBSOA) and oblique branch (OBSOA). However, our study found that the SOA was ramified from either OA or lacrimal artery (LA). In term of the STA, the associated STA was categorized into main frontal branch (frSTA) and descending temporal branch (desSTA) of STA. Moreover, the zygomaticoorbital artery (ZOA) and anastomotic branch of SOA and frSTA were also observed locating nearest to EB landmark (Table 4 and Figure 36). In most case (29 of 62 cases (46.8%)), the nearest artery to EB was BBSOA (Figure 36B). The BBSOA arose from OA, and it ran horizontally to lateral side of the face along the orbital part of orbicularis oculi muscle, and it external diameter was 0.49 ± 0.11 mm.

In 20 of 62 cases (32.3%), the desSTA which ran downward from the main branch of frSTA was found traveling closest to EB landmark with the diameter of 0.52 ± 0.13 mm (Figure 36C). While, the OBSOA, the oblique branches supplied the forehead area, placed nearby EB landmark in 4 of 62 cases (6.5%) and its diameter was 0.79 ± 0.40 mm (Figure 36D). Moreover, the ZOA and frSTA were discovered locating nearest to EB in 3 of 62 cases (4.8%). The ZOA and frSTA diameter were 0.82 ± 0.36 mm and 1.46 ± 0.47 mm, respectively. In the others arteries, the SOA from LA and anastomotic branch of SOA and frSTA placed closest to EB in 2 cases (3.2%) and 1 cases (1.6%), respectively (Table 4). There was no statistical significance was found (p-value>0.05) when comparing vessel diameters between genders at this area (Table 4).

Table 4. Frequencies of the nearest artery at eyebrow (EB) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to EB landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Brow branch of supraorbital artery (BBSOA)	29 (46.8)	0.49 ± 0.11 (0.33-0.72)	10 (35.7)	0.47 ± 0.12 (0.33-0.69)	19 (55.9)	0.50 ± 0.11 (0.34-0.72)
Oblique branch of SOA (OBSOA)	4 (6.5)	0.79 ± 0.40 (0.37-1.28)	1 (3.6)	0.92	3 (8.8)	0.74 ± 0.48
Zygomaticoorbital artery (ZOA)	3 (4.8)	0.82 ± 0.36 (0.41-1.06)	3 (10.7)	0.82 ± 0.36 (0.41-1.06)	-	-
Frontal branch of superficial temporal artery (frSTA)	3 (4.8)	1.46 ± 0.47 (0.93-1.83)	1 (3.6)	1.63	2 (5.9)	1.38 ± 0.64 (0.93-1.83)

Descending temporal branch of frSTA (desSTA)	20 (32.3)	0.52 ± 0.13 (0.36-0.80)	11 (39.3)	0.56 ± 0.16 (0.38-0.80)	9 (26.5)	0.47 ± 0.06 (0.36-0.54)
Supraorbtial artery of lacrimal artery (SOA of LA)	2 (3.2)	0.43 ± 0.13 (0.34-0.52)	2 (7.1)	0.43 ± 0.13 (0.34-0.52)	-	-
Anastomotic branch of SOA and frSTA (Anas. SOA and frSTA)	1 (1.6)	0.49	-	-	1 (3.2)	0.49
Total	62 (100)	0.58 ± 0.28 (0.33-1.83)	28 (100)	0.60 ± 0.28 (0.33-1.63)	34 (100)	0.56 ± 0.29 (0.34-1.83)

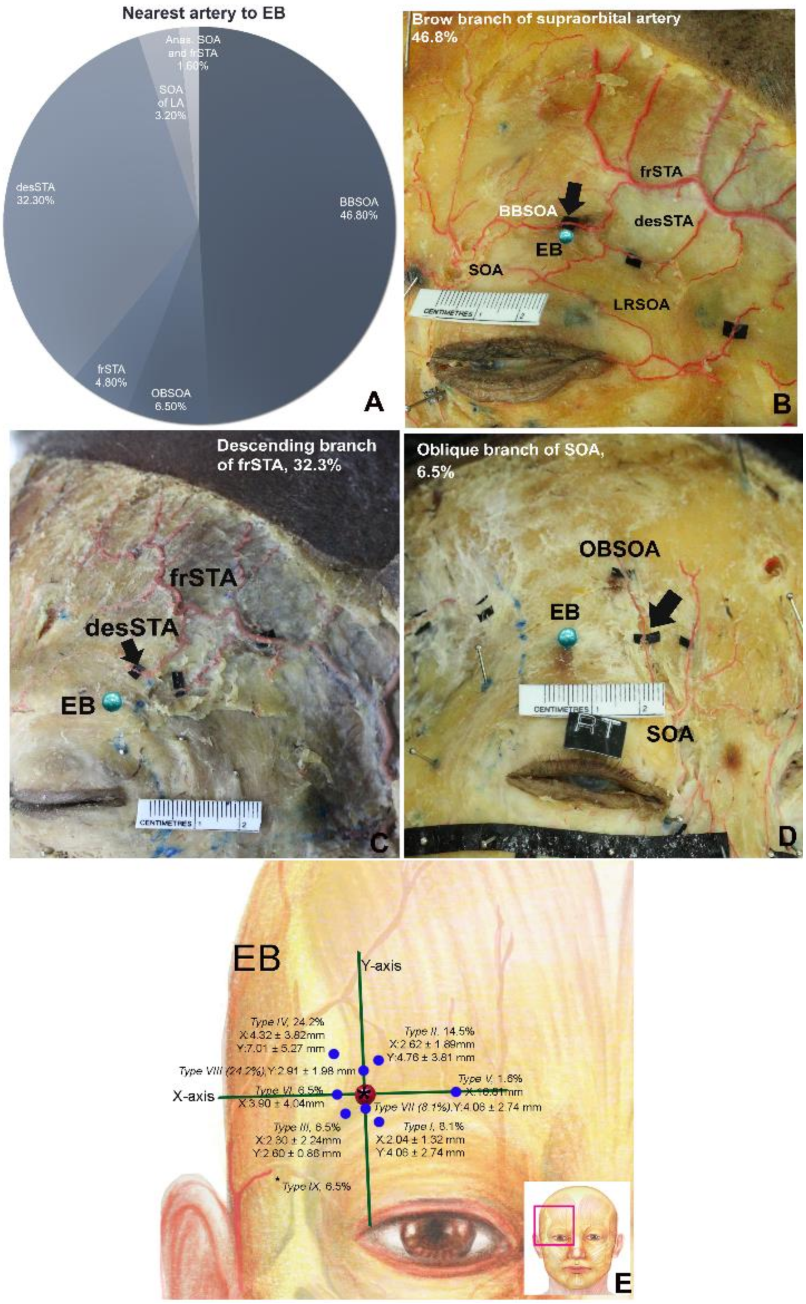


Figure 36 The closest arteries to EB landmark (A-D) (arrow); B: the brow branch of supraorbital artery locating nearest to EB in most case; C: the descending temporal branch of superficial temporal artery; D: oblique branch of supraorbital artery; E: the nearest arterial location of EB landmark

Considering to EB nearest arterial locations, it located equally in both superolateral (Type IV) and superior (Type VIII) to landmark in most cases (15 of 62 cases (24.2%)) (Table 5 and Figure 36E). The distance of Type IV were 4.32 ± 3.82 mm along X-axis and 7.01 ± 5.27 mm along Y-axis. For Type VIII, the Y distance was 2.91 ± 1.98 mm. In addition, the nearest artery located superomedial (Type II) to landmark in 9 of 62 cases (14.5%), and the X and Y distance was 2.62 ± 1.89 mm and 4.76 ±3.81 mm, respectively. In 5 of 62 cases (8.1%), the location of nearest arteries were Type I (inferomedial) and Type VII (inferior). The X and Y distance of Type I were 2.04 ± 1.32 mm and 4.06 ± 2.74 mm, respectively. In Type VII, the distance was 1.55 ± 0.56 mm along Y-axis. Furthermore, the Type III (inferolateral), Type VI (lateral) and Type IX (at landmark) were found in 4 of 62 cases (6.5%). In one case, the nearest artery of EB was located medial to landmark with 16.81 mm of X distance (Table 5 and Figure 36E).

Table 5. The distance from EB landmark to the nearest artery based on types of arterial locations

Types of arterial locations	N (%)	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	5 (8.1)	2.04 ± 1.32 (0.52 - 3.94)	4.06 ± 2.74 (1.02 - 7.27)
II. Superomedial (-X,+Y)	9 (14.5)	2.62 ± 1.89 (0.17 - 6.43)	4.76 ± 3.81 (0.92 - 12.31)
III. Inferolateral (+X, -Y)	4 (6.5)	2.30 ± 2.24 (0.63 - 5.53)	2.60 ± 0.86 (1.74 - 3.51)
IV.Superolateral (+X, +Y)	15 (24.2)	4.32 ± 3.82 (1.47 - 4.32)	7.01 ± 5.27 (1.43 - 17.25)
V. Medial (-X, Y_0)	1 (1.6)	16.81	0
VI. Lateral (+X,Y_0)	4 (6.5)	3.90 ± 4.04 (1.63 - 9.94)	0
VII. Inferior (X_0, -Y)	5 (8.1)	0	1.55 ± 0.56 (0.82 - 2.39)
VIII. Superior (X_0, +Y)	15 (24.2)	0	2.91 ± 1.98 (0.91 - 7.29)
IX. At landmark (X_0, Y_0)	4 (6.5)	0	0
Total	62 (100)		

The examination of nearest arterial depth according individual facial layer found that the arterial lining layer of EB nearest artery was supramuscular layer (orbital part of orbicularis oculi muscle) (37 of 62 cases (59.7%)), and the depth from the skin to nearest artery in this layer was 1.53 ± 0.66 mm. In 7 of 62 cases (11.3%), the nearest artery placed in subcutaneous layer, while the supraperiosteal layer was found in 6 of

62 cases (9.7%). The depth of nearest within the subcutaneous was 1.33 ± 0.38 mm, and the depth to supraperiostial plane was 2.69 ± 0.34 mm. Moreover, the nearest artery traveled underneath the orbicularis oculi muscle in 5 of 62 cases (8.1%) with 2.52 ± 0.50 mm of depth. Finally, the intramuscular (orbicularis oculi muscle) and parietotemporal fascia layer contained the nearest artery in 3 cased (4.8%) and 4 cases (6.5%), respectively. According to depth measurements, the depth of intramuscular layer was 2.46 ± 0.66 mm, while the depth of parietotemporal fascia layer was 2.52 ± 0.40 mm (Table 6).

Table 6. Relationship between the location of the nearest artery and facial tissue layers at EB landmark, and the depth from the skin to nearest artery

Facial layers	Depth from the skin to nearest arteries of EB landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	7 (11.3)	1.33 ± 0.38 (0.90- 1.77)	5 (17.9)	1.26 ± 0.40 (0.90-1.73)	2 (5.9)	1.51 ± 0.37 (1.25- 1.77)
Supramuscular (orbicularis oculi and frontalis muscle)	37 (59.7)	1.53 ± 0.66 (0.75- 3.85)	17 (60.7)	1.46 ± 0.57 (0.75- 2.73)	20 (58.8)	1.60 ± 0.74 (0.87- 3.85)
Intramuscular (orbicularis oculi and frontalis muscle)	3 (4.8)	2.46 ± 0.66 (1.95- 3.20)	3 (10.7)	2.46 ± 0.66 (1.95- 3.20)	0 (0)	-
Submuscular (orbicularis oculi and frontalis muscle)	5 (8.1)	2.52 ± 0.50 (2.00- 3.00)	2 (7.1)	2.43 ± 0.60 (2.00- 2.85)	3 (8.8)	2.60 ± 0.49 (2.05- 3.00)
Supraperiosteum	6 (9.7)	2.69 ± 0.34 (2.07- 3.03)	0 (0)	-	6 (17.6)	2.69 ± 0.34 (2.07- 3.03)
Parietotemporal fascia	4 (6.5)	2.52 ± 0.40 (2.03- 2.92)	1 (3.6)	2.92	3 (8.8)	2.39 ± 0.36 (2.03- 2.75)
Total	62 (100)		28 (100)		34 (100)	

➢ ***Nearest artery to Upper eyelid (UE) injection site***

The superior sulcus of the upper eyelid was set as the landmark for sunken eye or upper eyelid filler injection. In most cases (22 of 62 cases (35.5%)), the nearest artery to UE landmark was lateral rim branch of supraorbital artery (LRBSOA) with the mean diameter of 0.51 ± 0.11 mm (Table 7, Figure 37A and B). The ZOA was found closest to UE landmark in 14 of 62 cases (22.6%), while the desSTA located adjacent to UE landmark in 12 of 62 cases (19.4%) (Figure 37C and D). In term of external diameter, the diameter was 0.57 ± 0.18 mm of ZOA, and 0.60 ± 0.56 mm of desSTA. In 6 of 62 cases (9.7%), the LA gave off the SOA and it ran nearby UE landmark and its diameter was 0.57 ± 0.14 mm. In addition, the two arteries including frSTA and TFA were found locating close to UE in 4 of 62 cases (6.5%) each (Table 7). However, There was no statistical significance was found (p-value>0.05) when comparing vessel diameters between genders of nearest arteries to UE injection site (Table 7).

Table 7. Frequencies of the nearest artery at sunken eye or upper eyelid (UE) injection landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to UE landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Frontal branch of superficial temporal artery (frSTA)	4 (6.5)	1.67 ± 0.56 (0.98-2.33)	-	-	4 (11.8)	1.67 ± 0.56 (0.98-2.33)
Supraorbtial artery of lacrimal artery (SOA of LA)	6 (9.7)	0.57 ± 0.14 (0.45-0.83)	4 (14.3)	0.51 ± 0.07 (0.45-0.59)	2 (5.9)	0.69 ± 0.20 (0.55-0.83)
Zygomaticoorbital artery (ZOA)	14 (22.6)	0.57 ± 0.18 (0.33-0.96)	6 (21.4)	0.62 ± 0.25 (0.33-0.96)	8 (23.5)	0.53 ± 0.10 (0.42-0.72)
Descending temporal branch of Frontal branch superficial temporal artery (desSTA)	12 (19.4)	0.60 ± 0.56 (0.27-2.35)	6 (21.4)	0.72 ± 0.80 (0.27-2.35)	6 (17.6)	0.48 ± 0.10 (0.37-0.61)
Lateral rim branch of supraorbital artery (LRBSOA)	22 (35.5)	0.51 ± 0.11 (0.34-0.77)	10 (35.7)	0.52 ± 0.12 (0.35-0.77)	12 (35.3)	0.50 ± 0.11 (0.34-0.74)
Orbital branch of transverse facial artery (TFA)	4 (6.5)	0.48 ± 0.06 (0.41-0.55)	2 (7.1)	0.45 ± 0.06 (0.41-0.49)	2 (5.9)	0.52 ± 0.05 (0.44-0.55)
Total	62 (100)	0.62 ± 0.40 (0.27-2.35)	28 (100)	0.58 ± 0.38 (0.27-2.35)	34 (100)	0.66 ± 0.42 (0.34-2.33)

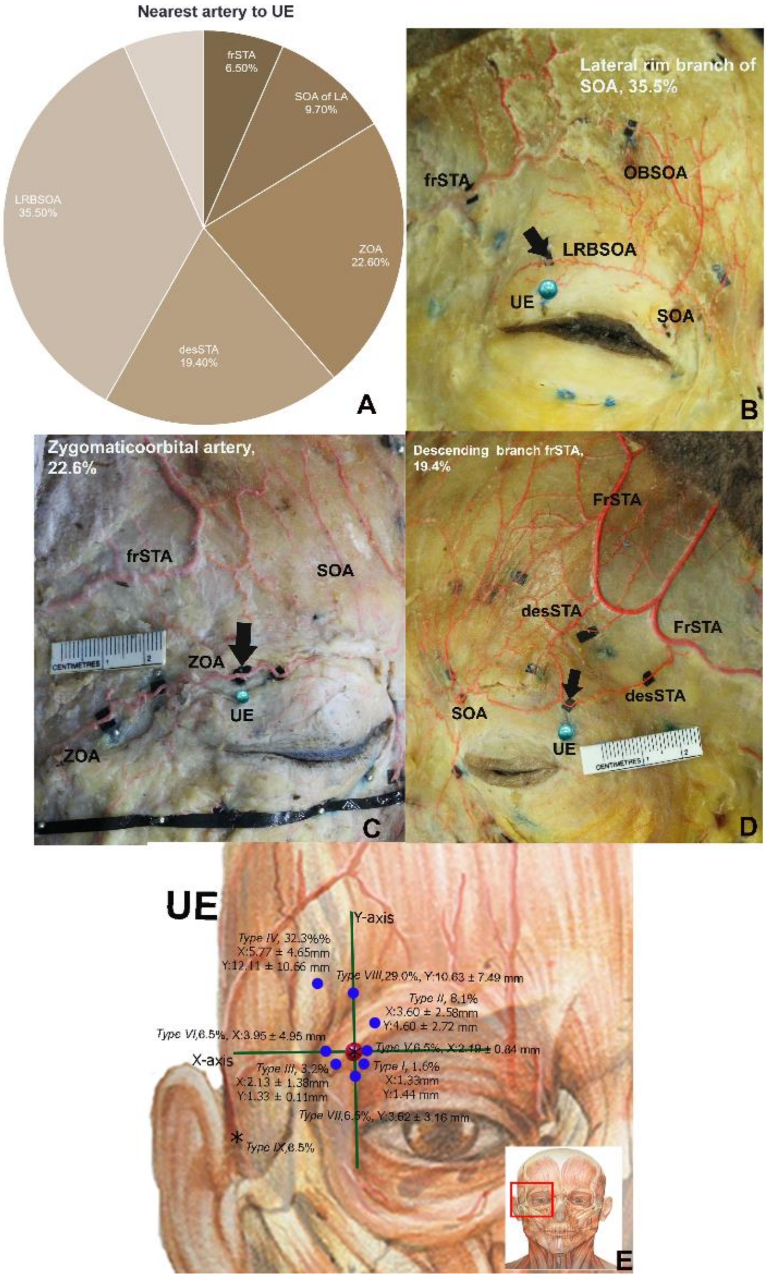


Figure 37 The nearest arteries to UE landmark (arrow); A: the percentage of each nearest artery, B-D: the location of LRBSOA, ZOA and desSTA (arrow) located nearest to landmark; E: the nearest arterial location related to UE injection site.

According to nearest arterial locations, the artery located superior (Type VIII) to UE in most cases (18 of 62 cases (29.0%)) (Table 8 and Figure 37E). The distance related to this type was 10.63 ± 7.49 mm along Y-axis. In 10 of 62 cases (32.3%), the location of nearest artery was positioned at superolateral direction (Type IV). The X and Y distance were 5.77 ± 4.65 mm and 12.11 ± 10.66 mm, respectively. The relationship between nearest artery and UE landmark was superomedial (Type II) in 5 of 62 cases (8.1%). The distance was 3.60 ± 2.58 mm along X-axis, and the distance was 4.60 ± 2.72 mm along Y-axis in Type II. Whereas four types, including Type V (medial), Type VI (lateral), Type VII (inferior) and Type IX (At landmark) were equally found in 4 cases (6.5%). The X distance was 2.19 ± 0.84 mm in Type V, while the distance was 3.95 ± 4.95 mm along X- axis in Type VI. For Type VII, the distance was 10.63 ± 7.49 mm along Y-axis. The locations of nearest arteries correlated with type I (inferomedial) and Type III (inferolateral) were found in 1 cases (1.6%) and 2 cases (3.2%), respectively. The X distance was 1.33 mm, and Y distance was 1.44 mm in Type I. In Type III, the distance were 2.13 ± 1.38 mm of X distance and 1.33 ± 0.11 mm of Y distance (Table 8 and Figure 37E).

Table 8. The distance from UE landmark to the nearest artery based on types of arterial location

Types of arterial locations	N (%)	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	**Mean ± SD (Range)(mm)**
I. Inferomedial (-X, -Y)	1 (1.6)	1.33	1.44
II. Superomedial (-X, +Y)	5 (8.1)	3.60 ± 2.58 (1.62 - 7.46)	4.60 ± 2.72 (2.00 - 8.64)
III. Inferolateral (+X, -Y)	2 (3.2)	2.13 ± 1.38 (1.15 - 3.10)	1.33 ± 0.11 (1.25 - 1.40)
IV.Superolateral(+X, +Y)	10 (32.3)	5.77 ± 4.65 (1.88 - 17.74)	12.11 ± 10.66 (1.68 - 35.91)
V. Medial (-X, Y_0)	4 (6.5)	2.19 ± 0.84 (1.32 - 3.27)	0
VI. Lateral (+X, Y_0)	4 (6.5)	3.95 ± 4.95 (1.14 - 11.37)	0
VII. Inferior (X_0, -Y)	4 (6.5)	0	3.62 ± 3.16 (1.73 - 8.35)
VIII. Superior (X_0, +Y)	18 (29.0)	0	10.63 ± 7.49 (1.58 - 26.72)
IX. At landmark (X_0, Y_0)	4 (6.5)	0	0
Total	62 (100)		

The investigation of the UE nearest arterial location correlated with the facial layer found that, the nearest artery mostly positioned above orbital part of orbicularis oculi and frontalis muscle (supramuscular layer, 36 of 62 cases (58.1%)) with the depth from the skin of 1.50 ± 0.56 mm. In contrast, the arterial placed underneath the orbicularis oculi muscle with 2.74 ± 0.42 mm of depth was discovered in 9 cases

(14.5%). However, the nearest artery which were found inside the muscle was 6 cases (9.7%), and the depth of nearest artery lining in this layer was 2.23 ± 0.40 mm. In addition, the artery addressed within the subcutaneous layer in 5 cases (8.1%) with 1.20 ± 0.32 mm of depth. In 4 cases (6.5%), the artery embedded in parietotemporal fascia layer, and placed over the bone (supraperiosteum layer) in 2 cases (3.2%). The depth closest artery of parietotemporal fascia was 2.28 ± 0.36, while the depth of nearest artery was found 3.20 ± 0.35 mm for the supraperiosteum layer (Table 9 and Figure 37E).

Table 9. Relationship between the location of the nearest artery and fascial tissue layers at UE landmark, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of UE landmark**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	5 (8.1)	1.20 ± 0.32 (0.81-1.55)	2 (7.1)	1.11 ± 0.28 (0.91-1.31)	3 (8.8)	1.26 ± 0.40 (0.81-1.55)
Parietotemporal fascia	4 (6.5)	2.28 ± 0.36 (2.01-2.80)	2 (7.1)	2.13 ± 0.16 (2.01-2.24)	2 (5.9)	2.43 ± 0.52 (2.06-2.80)
Supramuscular	36 (58.1)	1.50 ± 0.56 (0.83-2.77)	16 (57.1)	1.60 ± 0.60 (0.90-2.77)	20 (58.8)	1.41 ± 0.52 (0.83-2.77)
Intramuscular	6 (9.7)	2.23 ± 0.40 (1.73-2.80)	4 (14.3)	2.01 ± 0.26 (1.73-2.35)	2 (5.9)	2.67 ± 0.18 (2.54-2.80)
Submuscular	9 (14.5)	2.74 ± 0.42 (2.35-3.75)	4 (14.3)	2.95 ± 0.54 (2.55-3.75)	5 (14.7)	2.57 ± 0.23 (2.35-2.85)
Supraperiosteum	2 (3.2)	3.20 ± 0.35 (2.95-3.44)	0 (0)	-	2 (5.9)	3.20 ± 0.35 (2.95-3.44)
Total	62 (100)		28 (100)		34 (100)	

➢ *Nearest artery to Glabella (GB) injection site*

This study found that the nearest arteries including STCA, central (CA) and paracentral artery (PCA) were located nearby GB landmark (Table 10 and Figure 38A). The left CA which ramified from left dorsal nasal artery (DNA) were mostly found nearest to GB landmark in 10 of 31 cases (32.3%), and it diameter was 0.49 ± 0.16 mm (Figure 38B). The nearest artery to GB landmark was left STCA 9 of 31 cases (29.0%) (Figure 38C), while right STCA placed closest to such landmark in only 3 cases (9.7%)(Figure 38D). The mean external diameter of left STCA was 0.60 ± 0.17 mm, and the right STCA diameter was 0.42 ± 0.11 mm. Moreover, the right CA was found nearest to GB landmark in 7 of 31 cases (22.6%) with the diameter of 0.42 ± 0.11 mm. In addition, the right PCA from FA was located nearest to GB landmark in two cases (6.5%) (Table 10). There was no statistical significance was found (p-value>0.05) when comparing closest arterial diameters between genders at this area (Table 10).

Table 10. Frequencies of the nearest artery at glabellar (GB) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to GB landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Left Supratrochlear artery (STCA)	9 (29.0)	0.60 ± 0.17 (0.40-0.85)	3 (21.4)	0.58 ± 0.06 (0.53-0.65)	6 (35.3)	0.61 ± 0.21 (0.40-0.85)
Right Supratrochlear artery (STCA)	3 (9.7%)	0.58 ± 0.33 (0.35-0.96)	2 (14.3)	0.40 ± 0.06 (0.35-0.44)	1 (5.9)	0.96
Left central artery (CA)	10 (32.3)	0.49 ± 0.16 (0.27-0.73)	5 (35.7)	0.49 ± 0.19 (0.27-0.73)	5 (29.4)	0.49 ± 0.14 (0.27-0.63)
Right central artery (CA)	7 (22.6)	0.42 ± 0.11 (0.30-0.65)	4 (28.6)	0.39 ± 0.07 (0.30-0.46)	3 (17.6)	0.46 ± 0.17 (0.35-0.65)
Right paracentral artery of (PCA)	2 (6.5)	0.43	-	-	2 (11.8)	0.43
Total	31 (100)	0.51 ± 0.17 (0.27-0.96)	14 (100)	0.47 ± 0.14 (0.27-0.73)	17 (100)	0.55 ± 0.20 (0.27-0.96)

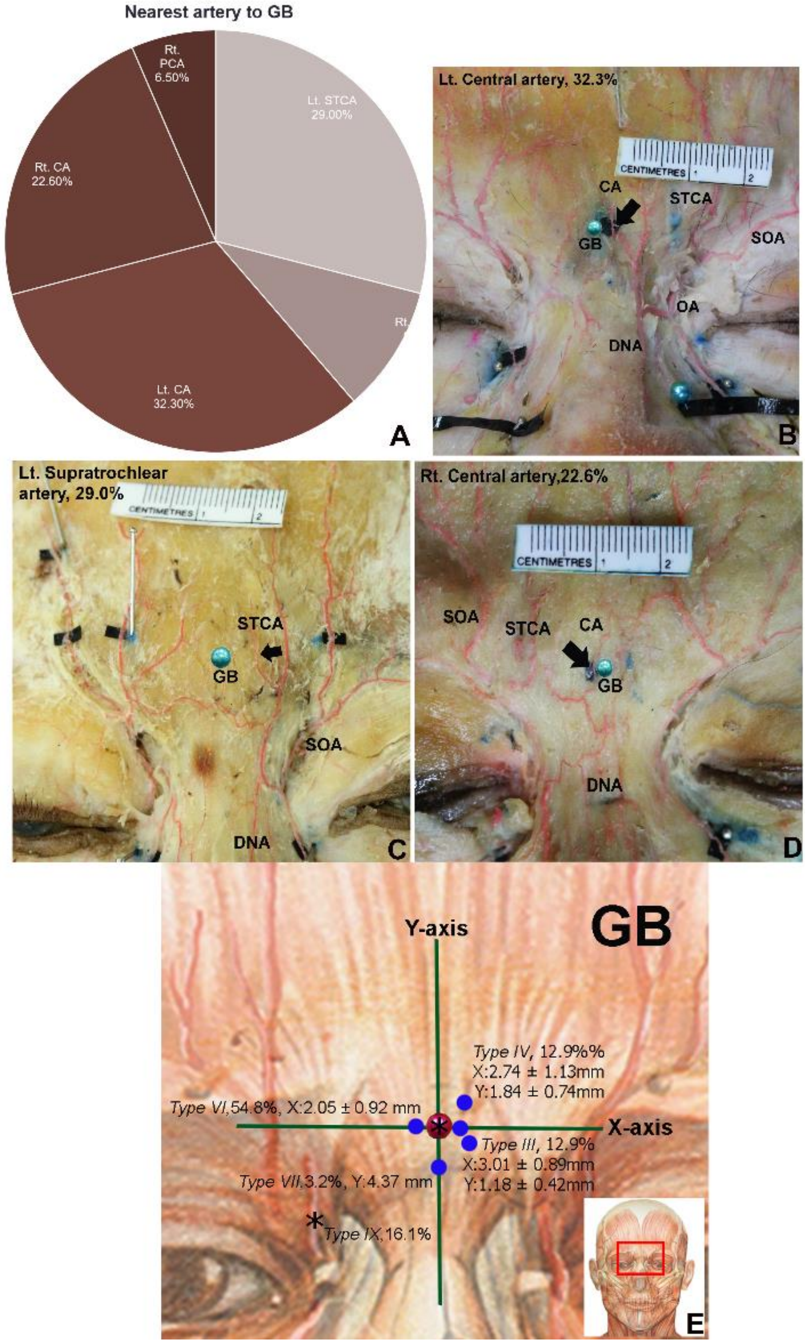


Figure 38 The nearest arteries to GB injection site (A-D) (arrow); B: left central artery; C: left supratrochlear artery; D: right central artery; E: the locations of closest artery relative to GB landmark

Examining of nearest artery location showed that there were variously types of arterial location. In most cases (17 of 31 cases (54.8%)), the relationship between nearest artery and GB injection site was Type VI (lateral). The artery located laterally to GB with 2.05 ± 0.92 mm of distance along X-axis. However, Type IX (at landmark) were uniformly found in 5 of 31 cases (16.1%). In Type III (4 of 31 cases (12.9%)), the nearest artery was located inferolateral direction to GB landmark with 3.01 ± 0.89 mm along X-axis and 1.18 ± 0.42 along Y-axis. Additionally, the nearest artery located superolateral to GB (Type IV) in 4 cases (12.9%). The X and Y distance of this type were 2.74 ± 1.13 mm and 1.84 ± 0.74 mm, respectively. However, Type VII (inferior) were found in only one case (3.2%) (Table 11 and Figure 38E).

Table 11. The distance from GB landmark to the nearest artery based on types of arterial location

Types of arterial locations	**N (%)**	**Distance of artery with X-axis**	**Distance of artery with Y-axis**
		Mean ± SD (Range)(mm)	**Mean ± SD (Range)(mm)**
III. Inferolateral (+X, -Y)	4 (12.9)	3.01 ± 0.89 (1.73 - 4.00)	1.18 ± 0.42 (0.74 - 1.70)
IV. Superolateral (+X, +Y)	4 (12.9)	2.74 ± 1.13 (1.16 - 3.70)	1.84 ± 0.74 (0.94 - 2.60)
VI. Lateral (+X,Y_0)	17 (54.8)	2.05 ± 0.92 (0.92 – 4.19)	0
VII. Inferior (X_0, -Y)	1 (3.2)	0	4.37
IX. At landmark (X_0, Y_0)	5 (16.1)	0	0
Total	31 (100)		

The observation of the association between nearest arteries and fascial tissue layer found that the nearest arteries lined above the procerus muscle (supramuscular layer) in most cases (21 of 33 cases (67.7%)) with the depth of 2.19 ± 0.56 mm. The subcutaneous and intramuscular layers were found in 8 cases (25.8%) and 2 cases (6.5%), respectively (Table 12). However, the depth was 1.71 ± 0.65 mm following the subcutaneous layer, and 2.68 ± 0.35 mm of arterial placing intramuscular layer (Table 12).

Table 12. Relationship between the location of the nearest artery and fascial tissue layers at GB landmark, and the depth from the skin to nearest artery

Facial Layers	**Depth from the skin to nearest arteries of GB landmark**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	8 (25.8)	1.71 ± 0.65 (0.98-3.02)	3 (21.4)	1.83 ± 0.50 (1.24- 2.35)	5 (29.4)	1.64 ± 0.75 (0.98- 3.02)
Supramus-cular (procerus m.)	21 (67.7)	2.19 ± 0.56 (1.36- 3.86)	9 (64.3)	2.04 ± 0.48 (1.36- 3.15)	12 (70.6)	2.32 ± 0.60 (1.54- 3.68)
Intramuscular (procerus m.)	2 (6.5)	2.68 ± 0.35 (2.56 – 3.16)	2 (14.3)	2.68 ± 0.35 (2.56 – 3.16)	0 (0)	-
Total	31 (100)		14 (100)		17 (100)	

➢ ***Nearest artery to Temple (TP) injection sites***

The common injected sites of temple area were TP1 (1 cm superior to temporal fusion line and 1 cm lateral and parallel to supraorbital rim) and TP2 (2 cm superior to zygomatic arch and 2 cm lateral to lateral orbital rim). However, the nearest artery to both TP landmarks were different. The nearest artery to each TP injection site was represented in table 13, Figure 39 and Figure 40.

At TP1 landmark, the nearest artery to TP1 landmark was desSTA which was discovered in 31 of 62 cases (50.0%), and its mean diameter was0.51 ± 0.12 mm (Figure 39B). In 15 of 62 cases (24.2%), the zygomaticoorbital artery (ZOA) was found traveling closest to TP1 with 0.66 ± 0.16 mm of diameter (Figure 39C). Moreover, the frSTA was the nearby artery of TP1 in 11 of 62 cases (17.7%), and the external diameter was 1.43 ± 0.49 mm (Figure 39D). There were equal two nearest arteries including SOA from LA and BBSOA which fairly located nearby TP1 landmark in 2 of 62 cases (3.2%). In one case, the nearest artery was TFA (Table 13). There was no statistical significance was found (p-value>0.05) when comparing nearest arterial diameters between genders at TP1 area.

Table 13. Frequencies of the nearest artery at temple (TP) landmarks and its external diameter

Nearest arteries	Diameter of nearest arteries to TP landmarks					
	TP1					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Frontal branch of superficial temporal artery (frSTA)	11 (17.7)	1.43 ± 0.49 (0.58-2.18)	4 (14.3)	1.35 ± 0.56 (0.58-1.86)	7 (20.6)	1.48 ± 0.49 (0.87-2.18)
Descending temporal branch superficial temporal artery (desSTA)	31 (50.0)	0.51 ± 0.12 (0.34-0.78)	15 (53.6)	0.50 ± 0.13 (0.34-0.78)	16 (47.1)	0.51 ± 0.11 (0.36-0.72)
Zygomaticoorbital artery (ZOA)	15 (24.2)	0.66 ± 0.16 (0.52-1.07)	8 (28.6)	0.69 ± 0.20 (0.52-1.07)	7 (20.6)	0.63 ± 0.11 (0.54-0.86)
Supraorbtial artery from lacrimal artery (SOA of LA)	2 (3.2)	0.51 ± 0.22 (0.35-0.66)	-	-	2 (5.9)	0.51 ± 0.22 (0.35-0.66)
Brow branch branch of supraorbital artery (BBSOA)	2 (3.2)	0.49 ± 0.12 (0.40-0.57)	-	-	2 (5.9)	0.49 ± 0.12 (0.40-0.57)
Superior branch of transverse facial artery (TFA)	1 (1.6)	0.45	1 (3.6)	0.45	-	-
Total	62 (100)	0.70 ± 0.42 (0.34-2.18)	28 (100)	0.67 ± 0.37 (0.34-1.86)	34 (100)	0.73 ± 0.45 (0.35-2.18)

Table 13. Frequencies of the nearest artery at temple (TP) landmarks and its external diameter (Cont.)

Nearest arteries	**Diameter of nearest arteries to TP landmarks**					
	TP2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Frontal branch of superficial temporal artery (frSTA)	11 (17.7)	1.80 ± 0.53 (0.95-2.61)	5 (17.9)	1.96 ± 0.31 (1.57-2.41)	6 (17.6)	1.66 ± 0.65 (0.95-2.61)
Descending temporal branch superficial temporal artery (desSTA)	11 (17.7)	0.49 ± 0.12 (0.38-0.74)	3 (10.7)	0.58 ± 0.15 (0.44-0.74)	8 (23.5)	0.45 ± 0.09 (0.38-0.65)
Zygomatico orbital artery (ZOA)	36 (58.1)	0.61 ± 0.19 (0.31-0.99)	18 (64.3)	0.63 ± 0.21 (0.33-0.99)	18 (52.9)	0.58 ± 0.18 (0.31-0.98)
Supraorbtial artery from lacrimal artery (SOA of LA)	1 (1.6)	0.34	1 (3.6)	0.34	-	-
Superior branch of transverse facial artery (TFA)	2 (3.2)	0.52 ± 0.08 (0.46-0.57)	-	-	2 (5.9)	0.52 ± 0.08 (0.46-0.57)
Zygomaticofacial artery (ZFA)	1 (1.6)	0.53	1 (3.6)	0.53	-	-
Total	62 (100)	0.79 ± 0.54 (0.31-2.61)	28 (100)	0.85 ± 0.57 (0.33-2.41)	34 (100)	0.74 ± 0.52 (0.31-2.61)

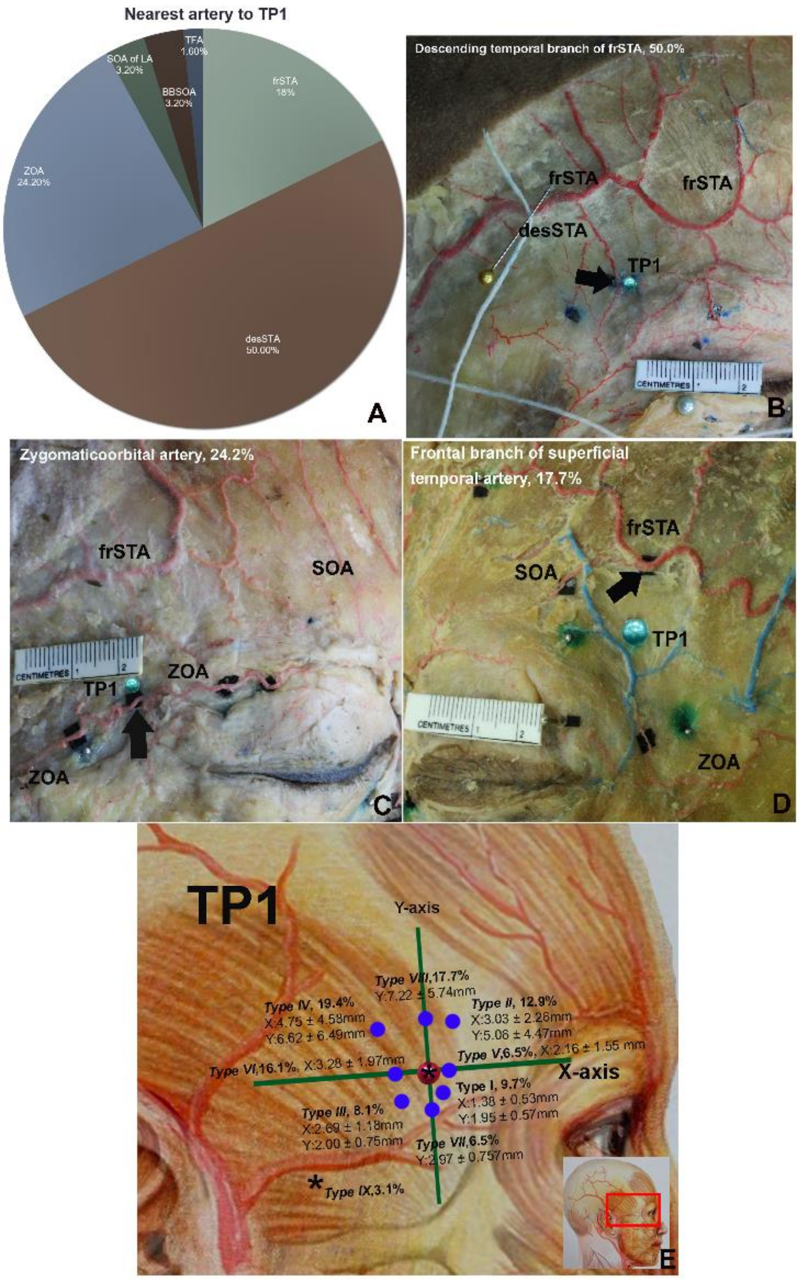


Figure 39 The nearest artery to TP1 injection site (A-D) (arrow); B: descending temporal branch of superficial temporal artery; C: zygomaticoorbital artery; D: main frontal branch of superficial temporal artery; E; the arterial locations and its distances correlated with the TP1 injection site

The location of such nearest arteries was Type IV (superolateral) in most cases (12 of 62 cases (19.4%)), while the Type VIII (superior) was found in 11 of 62 cases (17.7%) (Figure 39E). The distance between TP1 landmark and nearest artery of Type IV was 4.75 ± 4.58 mm with X distance and 6.62 ± 6.49 mm with Y distance. The measurement of Y distance of Type VIII was 7.22 ± 5.74 mm. In 10 of 62 cases (16.1%), the nearest artery located laterally (Type VI) with the distance of 3.28 ± 1.97 mm along X-axis. In Type II (8 of 62 cases (12.9%), the nearest arteries positioned superior and medial direction. The distance was 3.03 ± 2.26 mm along X-axis, while the distance along Y axis was 5.06 ± 4.47 mm. For the others arterial location, the nearest artery was placement at the inferomedial direction (Type I) to TP1 landmark in 6 of 62 cases (9.7%). The X and Y distance of this type were 1.38 ± 0.53 mm and 1.95 ± 0.57 mm, respectively. In 5 cases (8.1%), the Type III which the closest artery lined inferomedial to TP1 was classified as relationship between nearest artery and TP1 landmark. In this type, the distance along X-axis was 2.69 ± 1.18 mm, whereas the distance along Y-axis was 2.00 ± 0.75 mm. The medial (Type V) and inferior (Type VII) location of nearest artery to landmark were evenly in 4 of 62 cases (6.5%). The X distance of Type V was 2.16 ± 1.55 mm, and the Y distance of Type VII was 2.97 ± 0.75 mm. In the remained 2 of 62 cases (3.1%), the nearest artery positioned prominently at TP1 landmark (Table 14 and Figure 39E).

Table 14. The distance from each TP landmarks to the nearest artery based on types of arterial location

Types of arterial location	Land-marks	N (%)	Distance of artery with X-axis Mean ± SD (Range)(mm)	Distance of artery with Y-axis Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	TP1	6 (9.7)	1.38 ± 0.53 (0.82 - 2.38)	1.95 ± 0.57 (1.32 - 2.85)
	TP2	8 (12.9)	3.79 ± 2.99 (1.23 - 8.86)	4.54 ± 2.22 (2.09 - 8.12)
II. Superomedial (-X, +Y)	TP1	8 (12.9)	3.03 ± 2.26 (0.75 - 8.26)	5.06 ± 4.47 (1.06 - 13.37)
	TP2	7 (11.3)	4.37 ± 3.03 (1.17 - 8.79)	7.69 ± 7.71 (1.14 - 23.03)
III. Inferolateral (+X, -Y)	TP1	5 (8.1)	2.69 ± 1.18 (1.32 - 2.69)	2.00 ± 0.75 (0.89 - 2.88)
	TP2	2 (3.2)	2.00 ± 1.03 (1.28 - 2.73)	3.91 ± 2.30 (2.28 - 5.53)
IV.Superolateral (+X, +Y)	TP1	12 (19.4)	4.75 ± 4.58 (1.40 - 16.50)	6.62 ± 6.49 (1.16 - 20.09)
	TP2	19 (30.6)	5.37 ± 3.93 (0.92 - 12.64)	11.45 ± 10.93 (1.38 - 35.40)
V. Medial (-X,Y_0)	TP1	4 (6.5)	2.16 ± 1.55 (0.52 - 4.04)	0
	TP2	2 (3.2)	1.01 ± 0.36 (0.75 - 1.26)	0
VI. Lateral (+X,Y_0)	TP1	10 (16.1)	3.28 ± 1.97 (1.44 - 8.55)	0
	TP2	0 (0)	-	-
VII. Inferior (X_0, -Y)	TP1	4 (6.5)	0	2.97 ± 0.75 (1.95 - 3.69)
	TT2	4 (6.5)	0	3.27 ± 2.45 (1.03 - 5.69)
	TP1	11	0	7.22 ± 5.74

VIII. Superior (X_0, +Y)		(17.7)		(0.76 - 18.84)
	TP2	14 (22.6)	0	6.96 ± 6.71 (1.76 - 25.46)
IX. At landmark (X_0, Y_0)	TP1	2 (3.1)	0	0
	TT2	6 (9.7)	0	0

The nearest arteries to TP1 landmark were closely correlated with the parietotemporal fascia which was housed of the arteries in 30 of 62 cases (48.4%) with the depth from the skin of 2.16 ± 0.90 mm. In 13 of 62 cases (21.0%), the nearest artery located under orbicularis oculi and frontalis muscle (submuscular layer); furthermore, the nearest artery stayed within the subcutaneous layer in 11 of 62 cases (17.7%). The correlated depth of nearest artery to submuscular was 2.64 ± 0.87 mm, while the nearest arterial depth associated with subcutaneous was 2.09 ± 1.06 mm. However, the nearest artery traveled over the orbicularis oculi and frontalis muscle (supramuscular layer) in 5 of 62 cases (8.1%) with 2.43 ± 0.16 mm of the depth. Moreover, the nearest artery also positioned superior to periosteum in 1 cases (1.6 %). The intramuscular (orbicularis oculi) and areolar tissue plane (between parietotemporal fascia and superficial part of deep temporal fascia) were equally found in one case (Table 15).

Table 15. Relationship between the location of the nearest artery and fascial tissue layers at each temple (TP) landmarks, and the depth from the skin to nearest artery

Fascial layers	**Depth from the skin to nearest arteries of TP landmarks**					
	TP1					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	11 (17.7)	2.09 ± 1.06 (0.92- 3.91)	8 (28.6)	2.42 ± 1.04 (1.15- 3.91)	3 (8.8)	1.23 ± 0.53 (0.92- 1.84)
Parietotemporal fascia	30 (48.4)	2.16 ± 0.90 (0.90- 4.30)	13 (46.4)	1.88 ± 0.85 (0.90- 3.57)	17 (50.0)	2.37 ± 0.89 (0.90- 4.30)
Loose areolar tissue (between superficial temporal artery and superficial part of deep temporal artery)	1 (1.6)	2.54	0 (0)	-	1 (2.9)	2.54
Supramuscular	5 (8.1)	2.43 ± 0.16 (2.20- 2.55)	1 (3.6)	2.20	4 (11.8)	2.49 ± 0.10 (2.34- 2.55)
Intramuscular	1 (1.6)	1.58	0 (0)	-	1 (2.9)	1.58
Submuscular	13 (21.0)	2.64 ± 0.87 (1.61- 4.36)	6 (21.4)	2.83 ± 1.31 (1.61- 4.36)	7 (20.6)	2.48 ± 0.63 (1.74- 3.69)
Supraperiosteum	1 (1.6)	2.05	0 (0)	-	1 (2.9)	2.05
Total	62 (100)		28 (100)		34 (100)	

Table 15. Relationship between the location of the nearest artery and fascial tissue layers at each temple (TP) landmarks, and the depth from the skin to nearest artery (Cont.)

Fascial layers	**Depth from the skin to nearest arteries of TP landmarks**					
	TP2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	13 (21.0)	2.39 ± 0.96 (1.19 ± 4.24)	6 (21.4)	2.45 ± 0.91 (1.64- 4.07)	7 (20.6)	2.33 ± 1.06 (1.19- 4.24)
Parietotemporal fascia	37 (59.7)	2.92 ± 1.08 (1.16- 5.79)	16 (57.1)	3.03 ± 1.00 (1.44- 4.60)	21 (61.8)	2.83 ± 1.15 (1.16- 5.79)
Loose areolar tissue (between superficial temporal artery and superficial part of deep temporal artery)	2 (3.2)	3.31 ± 0.16 (3.20- 3.43)	2 (7.1)	3.31 ± 0.16 (3.20- 3.43)	0 (0)	-
Supramuscular	6 (9.7)	2.51 ± 0.94 (1.01- 3.88)	3 (10.7)	2.54 ± 1.45 (1.01- 3.88)	3 (8.8)	2.48 ± 0.32 (2.18- 2.82)
Submuscular	4 (6.5)	2.50 ± 0.87 (1.44- 3.55)	3 (10.7)	2.56 ± 1.06 (1.44- 3.55)	1 (2.9)	2.33
Total	62 (100)		28 (100)		34 (100)	

For TP2 landmark, the ZOA was served as the closest artery to TP2 landmark in most cases (36 of 62 cases (58.1%)), and its diameter was 0.61 ± 0.19 mm (Table 13 and Figure 40A and B). Next, the frSTA and desSTA were uniformly located nearest to TP2 landmark in 11 of 62 cases (17.7%) (Figure 40C and D). The outer diameter of frSTA was 1.80 ± 0.53, while the mean diameter of desSTA was 0.49 ± 0.12 mm. Additionally, the TFA were one of the nearest artery to TP2 which was found in 2 cases (3.2%) with the diameter of 0.52 ± 0.08 mm. Differently, the SOA from LA and the zygomaticofacial artery (ZFA) located nearby TP2 in one cases (Table 13). There was no statistical significance was found (p-value>0.05) when comparing nearest arterial diameters between genders at this area.

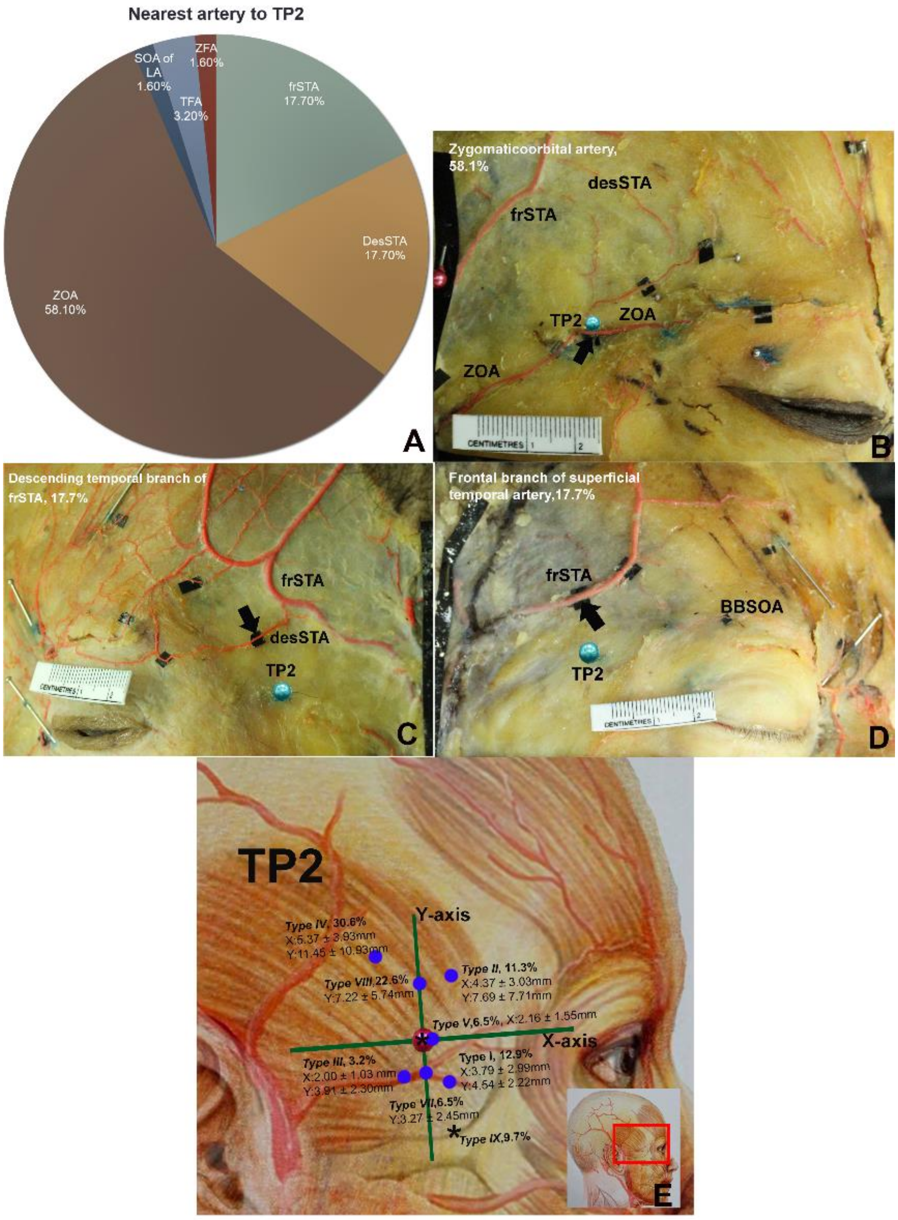


Figure 40 The closest artery to TP2 injection site (A-D) (arrow); B: zygomaticoorbital artery; C: descending temporal branch of superficial temporal artery; D: main frontal branch of superficial temporal artery; E: the relationship between nearest artery and the TP2 landmark

Regarding the arterial locations, the nearest artery of TP2 was Type IV (superolateral) in most cases (30.6%). The distance of Type IV was 5.37 ± 3.93 mm along X-axis and 11.45 ± 10.93 mm along Y-axis. In 14 of 62 cases (22.6%), arteries located superior to landmark (Type VIII) with 6.96 ± 6.71 mm of Y distance. The nearest artery traveled with inferomedial direction (Type I) in 8 of 62 cases (12.9%). In this type, the X and Y distance were 3.79 ± 2.99 mm and 4.54 ± 2.22 mm, respectively. In addition, the arterial location was Type II (superomedial) in 7 of 62 cases (11.3%). The measurement of X and Y distance for this type were 4.37 ± 3.03 mm and 7.69 ± 7.71 mm, respectively. For Type IX (6 of 62 cases (9.7%)), the nearest arteries settled at TP2 landmark. In 4 cases (6.5%), the closest artery to TP2 was Type VII (inferior) with the distance 3.27 ± 2.45 mm along Y distance. The Type III (inferolateral) and Type V (medial) were found in 2 cases (3.2%). The distance of Type III was 2.00 ± 1.03 mm with X distance, and 3.91 c 2.30 mm with Y distance. In Type V, the nearest artery located media to TP2 landmark with 1.01 ± 0.36 mm of X distance (Table 14 and Figure 40E).

The tissue layer which was the most nearest arteries lining was parietotemporal fascia layer (37 of 62 cases (59.7%)) with the depth of 2.92 ± 1.08 mm. Whereas the nearest arteries positioned at subcutaneous layer in 13 of 62 cases (21.0%) with 2.39 ± 0.96 mm of the arterial depth. In 6 of 62 cases (9.7%), the nearest artery placed superior surface of orbicularis oculi muscle, and the depth of nearest artery from the skin was 2.51 ± 0.94 mm. In contrast, the nearest artery located underneath the orbicularis oculi muscle in 4 of 62 cases (6.5%). In remained two cases (3.2%), the nearest artery was embedded in the areolar tissue within the space between parietotemporal fascia/ superficial temporal fascia and superficial part of deep temporal fascia (Table 15).

4.1.2 The nearest artery of the middle face injection sites

➢ ***Nearest artery to Tear trough (TT)***

The landmarks along tear trough deformity was divided into TT1, TT2, TT3 and TT4. However, the nearest artery correlated with each TT landmark were quite distinct because the TT area received a variety of blood supplies. In this study, the nearest arteries of entire landmarks were investigated in total 62 cases and were showed in Table 16.

The TT1 landmark, the intersection between vertical line of the lateral canthus and the horizontal line of the nasal alar, was supplied by TFA in most cases (36 cases (58.1%)) with the diameter of 0.59 ± 0.39 mm (Table 16 and Figure 41A and C). However, there was statistical significance (p-value<0.05) when comparing TFA diameter which locating nearest to TT1 between genders. The diameter was 0.77 ± 0.53 mm in male, and 0.47± 0.21 mm in female. In 6 cases (9.7%), the closest artery to TT1 was palpebral branch of TFA (pTFA) which the branch to supply the inferior part of eyelid. The external diameter of pTFA was 0.45 ± 0.12 mm (Figure 41E). However, the detoured branch of FA (dFA) gave off palpebral branch (pdFA) and located nearest to TT1 in 5 cases (8.1%) (Figure 41G). The outer diameter of pdFA was 0.56 ± 0.12 mm. In 4 cases (6.5%), the nearest artery to TT1 was dFA; moreover, the palpebral branch (pIOA) which arose from infraorbital artery (IOA) became the nearest artery of TT1 before traveling to palpebral area in 3 cases (4.8%). The mean diameter of dFA and pIOA were 1.00 ± 0.42 mm and 0.48 ± 0.06 mm, respectively. The three arteries including main FA, palpebral branch (pMA) of maxillary artery (MA), and palpebral branch (pbFA) of buccal artery (bFA) were equally located nearby TT1 landmark in 2 cases (3.2%). Both IOA and palpebral branch of FA (pFA) were found placing adjacent to TT1 landmark in one cases (1.6%) (Table 16 and Figure 41A).

Considering to arterial locations, the nearest artery of TT1 placed inferior to landmark (Type VII) in most cases (21.1%). The distance was 5.39 ± 3.99 mm along Y-axis. In 10 cases (16.1%), the location of nearest artery was medial (Type V) to TT1 landmark with 2.94 ± 1.79 mm of X distance. The Type III (inferolateral) of nearest arterial location was found in 9 cases (14.5%). The measurement of the X distance was 3.37 ± 1.28 mm, while the Y distance was 7.54 ± 6.78 mm. The three types including Type I (inferomedial), Type VI (lateral), and Type VIII (superior) were discovered as the nearest arterial location of TT1 landmark in 6 cases (9.7%). The distance of Type I was 4.38 ± 3.18 mm along X-axis and 2.58 ± 0.98 mm along Y-axis. In Type VI, the nearest artery located laterally with 2.77 ± 1.28 mm along X-axis, and the distance was 2.35 ± 1.65 mm along Y-axis in Type VIII. The two types: Type II (superomedial) and Type IX (at landmark) were showed in 5 cases (8.1%). The distance of nearest of Type II with X-axis was 4.96 ± 5.64 mm, and the distance with Y-axis was 4.96 ± 5.81 mm. Moreover, the nearest artery located superolateral to TT1 landmark in 2 cases (3.2%). The X and Y distance of these type were 3.23 ± 0.38 mm and 4.53 ± 3.49 mm, respectively (Table 17 and Figure 42A).

The observation of relationship between TT1 nearest arterial location and fascial tissue layers was showed in Table 18. In most cases (48 cases (77.4)), the nearest artery traveled along posterior surface of either orbicularis oculi muscle or origin of zygomaticus major muscle (submuscular layer) with the depth from the skin of 6.96 ± 3.16 mm. However, the arteries were also seen locating within subcutaneous layer in

8 cases (12.9%), and its depth was 3.08 ± 1.65 mm. In 3 cases (4.8%), the nearest arteries placed above the anterior surface of orbicularis oculi muscle with the depth of 6.42 ± 1.83 mm, and they was embedded inside the muscle (intramuscular layer) in 2 cases (3.2%) with the depth of 4.00 ± 2.52 mm. Finally, the location of nearest was supraperiosteum layer in one case (Table 18).

Table 16. Frequencies of the nearest artery at each tear trough landmarks and its external diameter

Nearest arteries	Diameter of nearest arteries to TT landmarks					
	TT1					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
TFA	36 (58.1)	0.59 ± 0.39 (0.35-2.29)	14 (50.0)	0.77 ± 0.53 (0.23-2.29)	22 (64.7)	0.47 ± 0.21 (0.35-1.05)
IOA	1 (1.6)	1.12	1 (3.6)	1.12	-	-
dFA	4 (6.5)	1.00 ± 0.42 (0.52-1.54)	3 (10.7)	1.01 ± 0.51 (0.52- 1.54)	1 (2.9)	0.98
FA	2 (3.2)	0.90 ± 0.23 (0.74-1.06)	-	-	2 (5.9)	0.90 ± 0.23 (0.74-1.06)
pMA	2 (3.2)	0.46 ± 0.06 (0.42-0.50)	2 (7.1)	0.46 ± 0.06 (0.42-0.50)	-	-
pTFA	6 (9.7)	0.45 ± 0.12 (0.24-0.55)	2 (7.1)	0.44 ± 0.11 (0.36-0.51)	4 (11.8)	0.46 ± 0.15 (0.24-0.55)
pIOA	3 (4.8)	0.48 ± 0.06 (0.44-0.55)	3 (10.7)	0.48 ± 0.06 (0.44-0.55)	-	-
pFA	1 (1.6)	0.36	-	-	1 (2.9)	0.36
Palpebral branch of dFA (pdFA)	5 (8.1)	0.56 ± 0.12 (0.44-0.75)	2 (7.1)	0.64 ± 0.16 (0.53-0.75)	3 (8.8)	0.50 ± 0.08 (0.44-0.59)
Palpebral branch of buccal a. (pbFA)	2 (3.2)	0.35 ± 0.04 (0.32-0.37)	1 (7.1)	0.37	1 (2.9)	0.32
Total	62 (100)	0.60 ± 0.35 (0.05-2.29)	28 (100)	0.71 ± 0.44 (0.23-2.29)	34 (100)	0.51 ± 0.23 (0.05-1.06)

Table 16. Frequencies of the nearest artery at each tear trough landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to TT landmarks					
	TT2					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Transverse facial artery (TFA)	3 (4.8)	0.44 ± 0.06 (0.38-0.50)	2 (7.1)	0.47 ± 0.05 (0.43-0.50)	1 (2.9)	0.38
Infraorbital artery (IOA)	3 (4.8)	0.99 ± 0.07 (0.92-1.06)	2 (7.1)	0.99 ± 0.10 (0.92-1.00)	1 (2.9)	0.99
Facial artery (FA)	1 (1.6)	0.88	-	-	1 (2.9)	0.88
pMA	2 (3.2)	0.55 ± 0.14 (0.45-0.65)	-	-	2 (5.9)	0.55 ± 0.14 (0.45-0.65)
pTFA	11 (17.7)	0.50 ± 0.11 (0.35-0.75)	5 (17.9)	0.53 ± 0.14 (0.39-0.75)	6 (17.6)	0.48 ± 0.09 (0.35-0.56)
pIOA	30 (48.4)	0.52 ± 0.15 (0.26-0.89)	14 (50.0)	0.53 ± 0.18 (0.26-0.89)	16 (47.1)	0.50 ± 0.13 (0.27-0.76)
pFA	4 (6.5)	0.49 ± 0.12 (0.38-0.66)	3 (10.7)	0.51 ± 0.14 (0.38-0.66)	1 (2.9)	0.43
pdFA	4 (6.5)	0.54 ± 0.14 (0.35-0.67)	1 (3.6)	0.67	3 (8.8)	0.50 ±0.13 (0.35-0.61)
Angular artery of dFA (AAdfA)	3 (4.8)	1.07 ± 0.33 (0.75-1.40)	1 (3.6)	0.75	2 (5.9)	1.24 ± 0.23 (1.07-1.40)
Palpebral branch of AAfa (pAAfa)	1 (1.6)	0.43	-	-	1 (2.9)	0.43
Total	62 (100)	0.57 ± 0.21 (0.26-0.89)	28 (100)	0.57 ± 0.19 (0.26-1.06)	34 (100)	0.56 ± 0.23 (0.27-1.40)

Table 16. Frequencies of the nearest artery at each tear trough landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to TT landmarks					
	TT3					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Infraorbital artery (IOA)	5 (8.1)	0.75 ± 0.30 (0.39-1.07)	2 (7.1)	0.92 ± 0.06 (0.87-0.96)	3 (8.8)	0.65 ± 0.37 (0.39-1.07)
Detoured branch of facial artery (dFA)	6 (9.7)	1.01 ± 0.33 (0.45-1.36)	3 (10.7)	0.81 ± 0.36 (0.45-1.17)	3 (8.8)	1.21 ± 0.14 (1.08-1.36)
Facial artery (FA)	2 (3.2)	1.19 ± 0.46 (0.86-1.51)	1 (3.6)	1.51	1 (2.9)	0.86
Palpebral branch of MA (pMA)	2 (3.2)	0.65 ± 0.13 (0.56-0.74)	-	-	2 (5.9)	0.65 ± 0.13 (0.56-0.74)
Palpebral branch of TFA (pTFA)	1 (1.6)	-	-	-	1 (2.9)	0.41
Palpebral branch of IOA (pIOA)	39 (62.9)	0.50 ± 0.16 (0.30-0.95)	18 (64.3)	0.52 ± 0.16 (0.33-0.83)	21 (61.8)	0.49 ± 0.17 (0.30-0.95)
Palpebral branch of dFA (pdFA)	3 (4.8)	0.42 ± 0.20 (0.31-0.65)	2 (7.1)	0.48 ± 0.24 (0.31-0.65)	1 (2.9)	0.31
Angular artery of IOA (AAioa)	1 (1.6)	0.31	1 (3.6)	0.31	-	-
Angular artery of FA (AAfa)	3 (4.8)	0.93 ± 0.36 (0.70-1.34)	1 (3.6)	0.74	2 (5.9)	1.02 ± 0.45 (0.70-1.34)
Total	62 (100)	0.61 ± 0.29 (0.30-1.51)	28 (100)	0.61 ± 0.28 (0.31-1.51)	34 (100)	0.61 ± 0.30 (0.30-1.36)

Table 16. Frequencies of the nearest artery at each tear trough landmarks and its external diameter (Cont.)

Nearest arteries	**Diameter of nearest arteries to TT landmarks**					
	TT4					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**
Angular artery of OA (AAoa)	27 (43.5)	0.51 ± 0.18 (0.27-1.13)	15 (53.6)	0.56 ± 0.21 (0.27-1.13)	12 (35.3)	0.44 ± 0.10 (0.28-0.60)
Angular artery of IOA (AAioa)	4 (6.5)	0.58 ± 0.20 (0.45-0.87)	1 (3.6)	0.55	3 (8.8)	0.59 ± 0.24 (0.45-0.87)
Angular artery of dFA (AAdfA)	10 (16.1)	0.66 ± 0.19 (0.35-0.90)	4 (14.3)	0.61 ± 0.20 (0.43-0.83)	6 (17.6)	0.70 ± 0.20 (0.35-0.90)
Angular artery of FA (AAfa)	20 (32.3)	0.62 ± 0.29 (0.27-1.57)	8 (28.6)	0.65 ± 0.41 (0.27-1.57)	12 (35.3)	0.60 ± 0.18 (0.43-1.09)
Dorsal nasal artery (DNA)	1 (1.6)	-	-	-	1 (2.9)	0.74
Total	62 (100)	0.58 ± 0.23 (0.27-1.57)	28 (100)	0.59 ± 0.27 (0.27-1.57)	34 (100)	0.56 ± 0.18 (0.28-1.09)

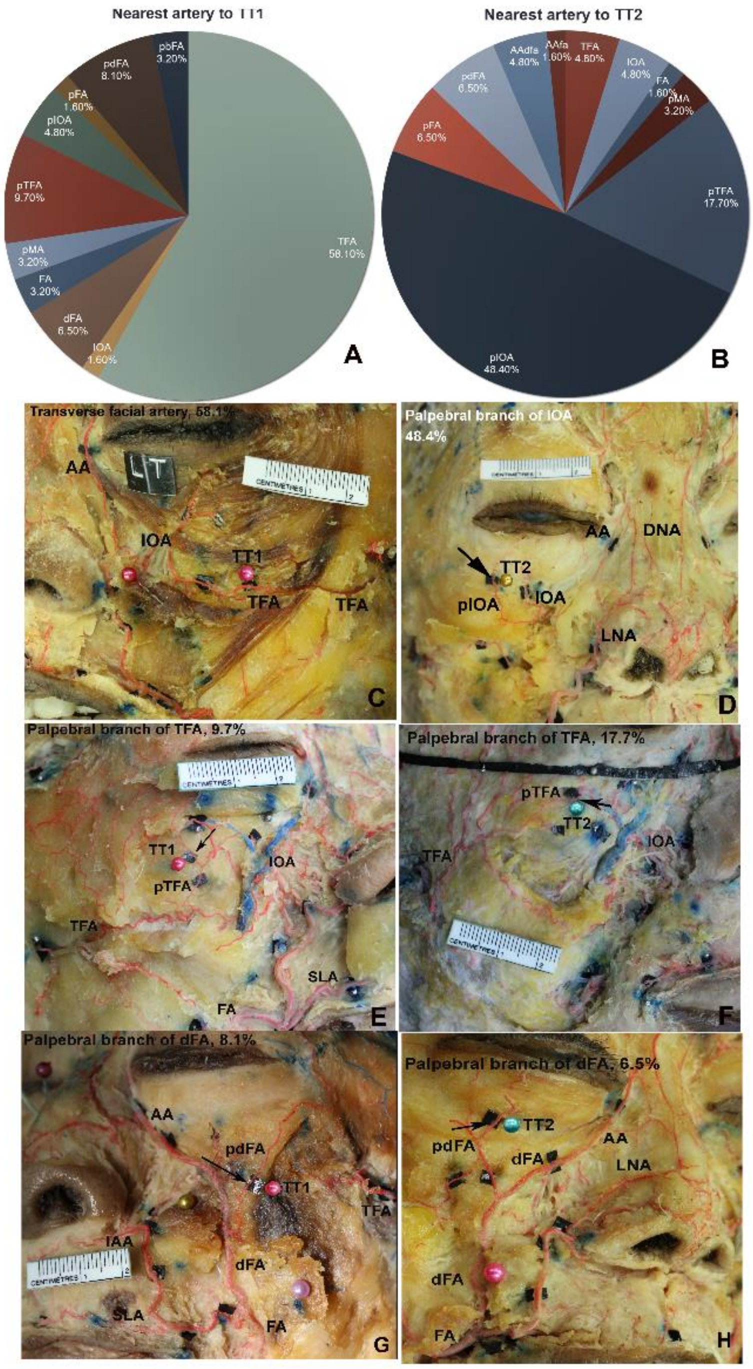


Figure 41 The nearest artery to TT1 and TT2 (A-H) (arrow head); C: transverse facial artery; D: palpebral branch of infraorbital artery; E and F: palpebral branch of transverse facial artery; G and H: palpebral branch of detoured branch of facial artery

Table 17. The distance from each tear trough landmarks to the nearest artery based on types of arterial location

Types of arterial location	Land-marks	N (%)	Distance of artery with X-axis Mean ± SD (Range)(mm)	Distance of artery with Y-axis Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	TT1	6 (9.7)	4.38 ± 3.18 (1.14 - 9.09)	2.58 ± 0.98 (1.45 - 4.18)
	TT2	6 (9.7)	7.95 ± 4.64 (3.67 - 16.58)	7.59 ± 6.15 (2.49 - 15.85)
	TT3	19 (30.6)	4.15 ± 1.68 (1.78 - 8.30)	5.83 ± 5.60 (2.13 - 16.07
	TT4	16 (25.8)	2.51 ± 1.50 (1.00 - 2.51)	2.43 ± 1.49 (0.74 - 6.02)
II.Superomedial (-X, +Y)	TT1	5 (8.1)	4.96 ± 5.64 (1.37 - 14.95)	4.96 ± 5.81 (1.80 - 15.33)
	TT2	6 (9.7)	6.41 ± 4.54 (1.75 - 14.77)	7.13 ± 5.99 (2.75 - 18.57)
	TT3	0 (0)	-	-
	TT4	1 (1.6)	1.85	1.91
III. Inferolateral (+X, -Y)	TT1	9 (14.5)	3.37 ± 1.28 (1.87 - 6.27)	7.54 ± 6.78 (1.94 - 24.17)
	TT2	7 (11.3)	2.79 ± 1.08 (1.63 - 4.67)	2.88 ± 1.57 (1.73 - 5.74)
	TT3	11 (17.7)	4.06 ± 2.31 (0.88 - 9.18)	4.00 ± 1.46 (2.24 - 6.75)
	TT4	0 (0)	-	-
IV. Superolateral (+X, +Y)	TT1	2 (3.2)	3.23 ± 0.38 (2.96 - 3.50)	4.53 ± 3.49 (2.06 - 6.99)
	TT2	1 (1.6)	1.80	1.98
	TT3	3	2.71 ± 1.15	4.40 ± 2.41

		(4.8)	(1.48 - 2.17)	(2.54 - 7.12)
	TT4	0 (0)	-	-
V. Medial $(-X, Y_0)$	TT1	10 (16.1)	2.94 ± 1.79 (1.05 - 7.40)	0
	TT2	12 (19.4)	2.79 ± 1.78 (0.41 - 6.05)	0
	TT3	3 (4.8)	3.96 ± 2.62 (1.66 - 3.96)	0
	TT4	34 (54.8)	4.16 ± 2.40 (0.73 - 10.07)	0
VI. Lateral $(+X, Y_0)$	TT1	6 (9.7)	2.77 ± 1.28 (1.37 - 4.78)	0
	TT2	7 (11.3)	3.99 ± 2.74 (0.89 - 7.46)	0
	TT3	6 (9.7)	4.32 ± 2.63 (1.32 - 9.27)	0
	TT4	3 (4.8)	1.35 ± 1.01 (0.55 – 2.48)	0
VII. Inferior $(X_0, -Y)$	TT1	13 (21.0)	0	5.39 ± 3.99 (0.87 - 13.23)
	TT2	11 (17.7)	0	3.21 ± 3.03 (0.88 - 11.77)
	TT3	7 (11.3)	0	3.45 ± 2.65 (0.84 - 7.37)
	TT4	4 (6.5)	0	2.13 ± 1.65 (1.10 - 4.56)
VIII. Superior $(X_0, +Y)$	TT1	6 (9.7)	0	2.35 ± 1.65 (1.29 - 5.65)
	TT2	3 (4.8)	0	1.20 ± 0.43 (0.84 - 1.67)
	TT3	10 (16.1)	0	2.26 ± 2.58 (0.69 - 9.33)
	TT4	1 (1.6)	0	1.33
IX. At landmark	TT1	5	0	0

(X_0, Y_0)		(8.1)		
	TT2	9 (14.5)	0	0
	TT3	3 (4.8)	0	0
	TT4	3 (4.8)	0	0

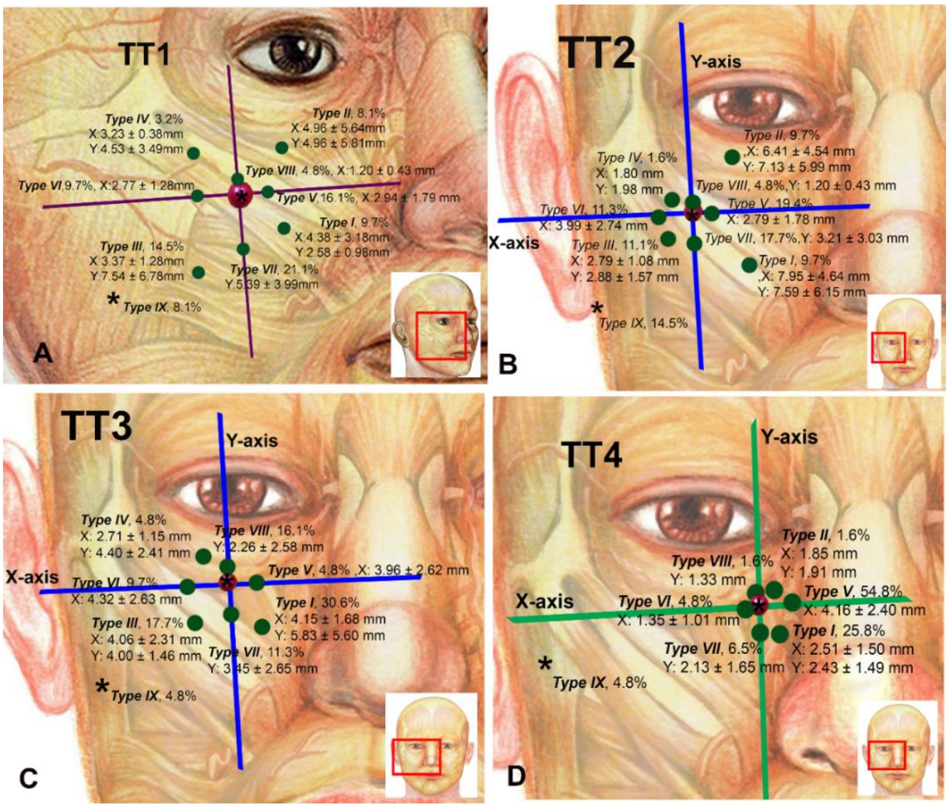


Figure 42 The relationship and the distance between the nearest artery to each TT land mark; A: location of nearest artery of TT1; B: location of nearest artery to TT2; C: location of nearest artery to TT3 and D: location of nearest artery to TT4

At TT2 landmark, the area of TT2 received a variety of blood supplies (Table 16 and Figure 41B). In 30 cases (48.4%), the nearest artery to TT2 was pIOA with the diameter of 0.52 ± 0.15 mm (Figure 42D). In 11 cases (17.7%), pTFA was located closest to TT2, and its diameter was 0.50 ± 0.11 mm (Figure 42F). However, the pFA and the pdFA were found equal distances to the TT2 in 4 cases (6.5%) (Figure 42H). The diameter of pFA was 0.49 ± 0.12 mm, while the mean diameter of pdFA was 0.54 ± 0.14 mm. In 3 cases (4.8%), both the main IOA and the TFA were found closest to TT2. The outer diameters of IOA and TFA were 0.99 ± 0.07 mm and 0.44 ± 0.06 mm, respectively. In addition, the dFA became terminal branch as the angular branch (AAdfa) and located nearest to TT2 in 3 cases (4.8%). In the others artery, the maxillary artery (MA) was found to produce the palpebral branch (pMA) and located nearest to TT2 in 2 case (3.2 %). Furthermore, the terminal branch of FA played the role of angular artery (AAfa) and then the AAfa delivered the palpebral branch (pAAfa) to locate nearest to TT2 as well as the main FA also located closest to TT2 in one case (Table 16 and Figure 41B). There was no statistical significance (p-value>0.05) when comparing TT2 nearest arterial diameters between genders.

The relationships and the distances of the nearest artery to TT2 landmarks were showed in Table 17 and Figure 42B. In the most cases at TT2, this study found that the closest artery located medial to TT2 (Type V) in 12 cases (19.4%), the distances were 2.79 ± 1.78 mm along the X-axis. In 11 cases (17.7%), the nearest artery positioned inferior (Type VII) to TT2 with 3.21 ± 3.03 mm along Y-axis. In Type IX, the nearest artery placed at the TT2 landmark in 9 cases (14.5%). Whereas two types, including Type III (inferolateral) and Type VI (lateral) were found in 7 cases (11.3%). In type III, the distances were 2.79 ± 1.08 mm along the X-axis and 2.88 ± 1.57 mm along the Y-axis, and the distance was 3.99 ± 2.74 mm along the X-axis in Type VI. In 6 cases (9.7%), both of Type I (Inferomedial) and Type II (superomedial) were found equal cases of nearest artery. The distance of Type I was 7.95 ± 4.64 mm along X-axis and 7.59 ± 6.15 mm along Y-axis. For Type II, the X and Y distance were 6.41 ± 4.54 mm and 7.13 ± 5.99 mm, respectively. In 3 cases (4.8%), the location of nearest artery to TT2 was superior direction with 1.20 ± 0.43 mm along Y-axis; nevertheless, the Type V was found in only one case (Table 17 and Figure 42B).

The study of correlation between TT2 nearest artery location and the fascial tissue layer found that the nearest artery located underneath the orbicularis oculi muscle (submuscular layer) in most cases (79.0%) with the depth from the skin of 3.35 ± 1.96 mm. In the opposite, the nearest artery located above the orbicularis oculi muscle (supramuscular layer) in 10 cases (16.1%), and the depth from the skin was 3.31 ± 1.86 mm. While two layers, including intramuscular (orbicularis oculi muscle) and supraperiosteul layer were found in 2 cases (3.2) and 1 cases (1.6), respectively (Table 18).

The major involving artery which located nearby TT3 landmark was pIOA (39 of 62 cases (62.9%)), while the main IOA was found placing nearest to TT3 in 5 cases (8.1%) (Table 16 and Figure 43A, C and G). The external diameter of pIOA was 0.50 ± 0.16 mm. whereas the external diameter of IOA was 0.75 ± 0.30 mm (Table 16). The dFA was the closest branch of TT3 in 6 cases (9.7%) with the outer diameter of 1.01 ± 0.33 mm (Figure 43E). Two arteries, including pdFA and AAfa were uniformly found locating nearest to TT3 in 3 cases (4.8%). In 2 cases (3.2%), the FA and the pMA became the nearest arteries of TT3 landmark, while the pTFA and angular branch of IOA (AAioa) were individually found only one case (1.6%) (Table 16 and Figure 43A). There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this area.

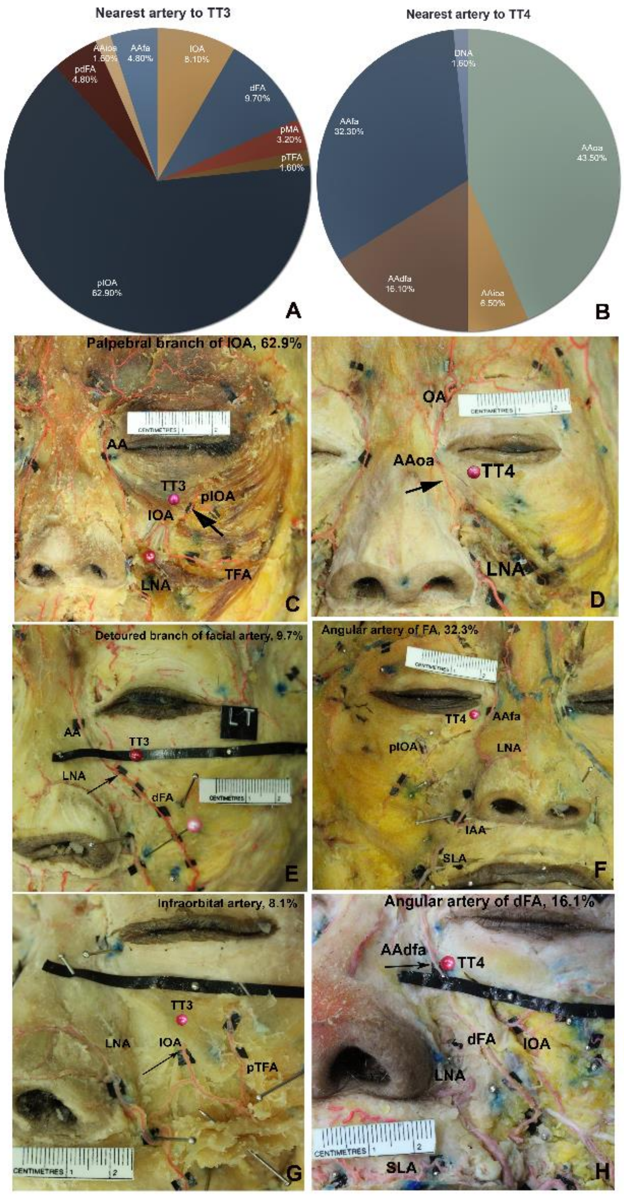


Figure 43 The nearest artery to TT3 and TT4 injection sites (arrow head); A and B: the percentage of nearest artery to TT3 and TT4; C: palpebral branch of infraorbital artery; D: angular artery of ophthalmic artery; E: detoured branch of facial artery; F: angular artery of facial artery; G: main infraorbital artery; H: angular artery of detoured branch of facial artery

The study of location of TT3 nearest artery was showed in Table 17 and Figure 42C. The results found that found that the artery located superomedial direction (Type I) in 19 cases (30.6%). The distance following this type was 4.15 ± 1.68 mm with X-axis, and 5.83 ± 5.60 mm with Y-axis. In 11 cases (17.7%), the nearest artery placed inferolateral (Type III) to TT3. The X and Y distance were 4.06 ± 2.31 mm and 4.00 ± 1.46 mm, respectively. In addition, the Type VIII (superior) of nearest arterial location was discovered in 10 cases (16.1%), and the measurement of Y distance was 2.26 ± 2.58 mm. The nearest artery located inferior (Type VII) to TT3 in 7 cases (11.3%), while the lateral (Type VI) location was found in 6 cases (9.7%). The distance of Type VII was 3.45 ± 2.65 mm with Y-axis as well as the distance of Type VI was 4.32 ± 2.63 mm with X-axis. The remained three types including Type IV (superolateral), Type V (medial) and Type IX (at landmark) were found in 3 cases (4.8%). The distance of Type IV was 2.71 ± 1.15 mm at X-axis, and 4.40 ± 2.41 mm at Y-axis, while the X distance of Type V was 3.96 ± 2.62 mm (Table 17 and Figure 42C).

The study of relationship between TT3 arterial location and facial tissue layers found that the nearest artery lined below either orbicularis oculi or the upper part of zygomaticus major muscle in most cases (37 cases (59.7%)). Moreover, the depth of the closest artery from the skin to submuscular layer was 3.04 ± 1.32 mm. In contrast, the nearest arterial lining was found with supramusucular layer (orbicularis oculi muscle) in 15 cases (24.2%) with the depth from the skin of 3.05 ± 2.26 mm. However, intramuscular (orbicularis oculi muscle) layer as well as supraperiosteal layer severed as the tissue layers containing nearest artery in 4 cases (6.5%). Lastly, the nearest artery stayed in subcutaneous layer in 2 cases (3.2%) (Table 18).

The investigation of nearest to TT4 landmarks found that the AA was found to closely associate with TT4; nevertheless, the AA was ramified from several arterial branches: OA, IOA, mFA, and dFA (Table 16 and Figure 43B). In 27 cases (43.5%), the closest artery to TT4 was the AA, found to branch from the OA with the diameter of 0.51 ± 0.18 mm (Figure 43D). Whereas, the FA terminated as the AA and was located nearest to TT4 in 20 cases (32.3%) (Figure 43F), and its external diameter was 0.62 ± 0.29 mm. Moreover, the peripheral end of the dFA served as the AA (AAdfa), and then traveled closest to TT4 in 10 cases (16.1%) (Figure 43G). The diameter the AAdfa was 0.66 ± 0.19 mm. In 4 cases (6.5%), the AA originating from the IOA were located closest to TT4, while the one remained case of nearest artery to TT4 was the dorsal nasal artery (DNA) (Table 16 and Figure 43B). There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this area.

In terms of TT4 neighboring artery locations (Figure 42D), the closest arteries were located medial (Type V) to TT4 in the most of 34 cases (54.8%), with the distance measured as 4.16 ± 2.40 mm at the X-axis. In Type I (16 cases (25.8%)). The distance correlated with Type I was 2.51 ± 1.50 mm along X-axis, and 2.43 ± 1.49 mm along Y-axis. The nearest arterial location was Type VII (inferior) in 4 cases (6.5%), and the Y distance was 2.13 ± 1.65 mm. In 3 cases (4.8%), the nearest artery located directly at the TT4 landmark. Moreover, the Type VI (lateral) was also found in 3 cases (4.8%) with the X distance of 1.35 ± 1.01 mm. There were two types including Type II (superomedial), and Type VIII (superior) were found in with a single cases (Table 17 and Figure 42D).

Furthermore, this study investigated the relationships between the artery and facial tissue layers based on the TT4 landmarks, and the study found that most of the nearest arteries at TT4 were located supramuscular layer of OOc in 53 cases (85.5%). The depth correlated to the most cases was 1.54 ± 0.56 mm. While the intramuscular layer, the orbicularis oculi muscle contained nearest artery, was found in 2 cases (3.2%). The subcutaneous and submuscular layer (orbicularis oculi muscle) were found in only one case (Table 18).

Table 18. Relationship between the location of the nearest artery and fascial tissue layers at each tear trough landmarks, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of TT landmarks**					
	TT1					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	8 (12.9)	3.08 ± 1.65 (1.48- 6.10)	5 (17.9)	3.47 ± 1.77 (1.55- 6.10)	3 (8.8)	2.43 ± 1.49 (1.48- 4.15)
Supramuscular	3 (4.8)	6.42 ± 1.83 (4.49 – 8.13)	1 (3.6)	6.65	2 (5.9)	6.31 ± 2.57 (4.49 – 8.13)
Intramuscular	2 (3.2)	4.00 ± 2.52 (2.22 – 5.78)	1 (3.6)	2.22	1 (2.9)	5.78
Submuscular	48 (77.4)	6.96 ± 3.16 (1.20- 14.14)	20 (71.4)	7.27 ± 3.36 (1.67–14.14)	28 (82.4)	6.72 ± 3.05 (1.20 – 12.65)
Supraperios-teum	1 (1.6)	7.49	1 (3.6)	7.49	0 (0)	-
Total	62 (100)		28 (100)		34 (100)	

Table 18. Relationship between the location of the nearest artery and fascial tissue layers at each tear trough landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	**Depth from the skin to nearest arteries of TT landmarks**					
	TT2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Supramuscular	10 (16.1)	3.31 ± 1.86 (1.30 – 7.36)	3 (10.7)	3.57 ± 1.80 (1.86 – 5.44)	7 (20.6)	3.20 ± 2.02 (1.30 - 7.36)
Intramuscular	2 (3.2)	2.59 ± 1.53 (1.51 - 3.67)	2 (7.2)	2.59 ± 1.53 (1.51 - 3.67)	0 (0)	-
Submuscular	49 (79.0)	3.35 ± 1.96 (1.13 - 11.17)	23 (82.1)	3.30 ± 1.71 (1.13 – 7.24)	26 (76.5)	3.41 ± 2.18 (1.19 – 11.17)
Supraperiosteum	1 (1.6)	4.67	0 (0)	-	1 (2.9)	4.67
Total	62 (100)		28 (100)		34 (100)	

Table 18. Relationship between the location of the nearest artery and fascial tissue layers at each tear trough landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	**Depth from the skin to nearest arteries of TT landmarks**					
	TT3					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	2 (3.2)	2.12 ± 0.55 (1.73 - 2.51)	2 (7.1)	2.12 ± 0.55 (1.73 - 2.51)	0 (0)	-
Supramuscular	15 (24.2)	3.05 ± 2.26 (1.05–10.68)	7 (25.0)	2.54 ± 0.86 (1.05 – 3.67)	8 (23.5)	3.49 ± 3.01 (1.16–10.68)
Intramuscular	4 (6.5)	2.54 ± 0.92 (1.98 – 3.91)	2 (7.1)	2.02 - 0.06 (1.98 – 2.06)	2 (5.9)	3.06 ± 1.20 (2.21 – 3.91)
Submuscular	37 (59.7)	3.04 ± 1.32 (1.02 – 8.45)	15 (53.6)	3.35 ± 1.69 (1.74 – 8.45)	22 (64.7)	2.83 ± 0.98 (1.02 – 5.62)
Supraperios-teum	4 (6.5)	4.42 ± 3.36 (1.51 – 9.27)	2 (7.1)	6. 30 ± 4.21 (3.32 – 9.27)	2 (5.9)	2.55 ± 1.47 (1.51 – 3.59)
Total	62 (100)		28 (100)		34 (100)	

Table 18. Relationship between the location of the nearest artery and fascial tissue layers at each tear trough landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	Depth from the skin to nearest arteries of TT landmarks					
	TT4					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	1 (1.6)	1.45	1 (3.6)	1.45	0 (0)	-
Supramuscular	53 (85.5)	1.54 ± 0.56 (0.75 – 3.25)	24 (85.7)	1.61 ± 0.56 (0.75 – 3.09)	29 (85.3)	1.49 ± 0.57 (0.75 – 3.25)
Intramuscular	2 (3.2)	1.46 ± 0.81 (0.89 – 2.04)	0 (0)	-	2 (5.9)	1.46 ± 0.81 (0.89 – 2.04)
Submuscular	1 (1.6)	2.60	0 (0)	-	1 (2.9)	2.60
Supraperios-teum	5 (8.1)	3.30 ± 1.64 (1.79 – 4.75)	3 (10.7)	4.00 ± 0.82 (3.12 – 4.75)	2 (5.9)	2.25 ± 0.66 (1.79 – 2.72)
Total	62 (100)		28 (100)		34 (100)	

- ***Nearest artery to Mid cheek (MC) injection site***

The MC was the area of the middle face, and this space received various arterial branches (Figure 44A). The most common nearest artery of MC landmark was lateral branch of infraorbital artery (LIOA) (18 of 62 cases (29.0%)) (Figure 44B), and its diameter was 0.79 ± 0.38 mm. In 14 of 62 cases (22.6%), the IOA released the palpebral branch (pIOA) to lateral palpebral area and it became the nearest branch of MC landmark

(Figure 44C). The outer diameter of such pIOA was 0.46 ± 0.14 mm. Additionally, the nearest artery of MC was the main TFA in 8 of 62 cases (12.9%) (Figure 44D), and the mean diameter was 0.48 ± 0.10 mm. However, the pTFA which ramified of TFA was found as the closest artery in 5 of 62 cases (8.1%). Next, the dFA as well as pdFA was the nearest arterial branch of MC in 4 of 62 cases (6.5%). The pFA was also located nearest to MC in 3 of 62 cases (4.8%). Furthermore, both pMA and pbFA (buccal branch of facial arttery) were equally found placing adjacent MC in 2 of 62 cases (3.2%). For the remained two arteries, the FA and palpebral branch of AAfa (pAAfa) served as the nearest artery in one case (Table 19 and Figure 44A). However the mean diameter of all remaining cases was represented in Table 19. There was no statistical significance (p-value>0.05) when comparing MC nearest arterial diameters between genders.

Table 19. Frequencies of the nearest artery at mid cheek (MC) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to MC landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
TFA	8 (12.9)	0.48 ± 0.10 (0.34-0.61)	2 (7.1)	0.58 ± 0.02 (0.56-0.59)	6 (17.6)	0.45 ± 0.10 (0.34-0.61)
IOA	18 (29.0)	0.79 ± 0.38 (0.34-1.54)	9 (32.1)	0.87 ± 0.37 (0.41-1.54)	9 (26.5)	0.71 ± 0.40 (0.34-1.49)
dFA	4 (6.5)	0.96 ± 0.34 (0.71-1.43)	2 (7.1)	1.07 ± 0.51 (0.71-1.43)	2 (5.9)	0.84 ± 0.17 (0.72-0.96)
FA	1 (1.6)	-	-	-	1 (2.9)	0.98
pMA	2 (3.2)	0.84 ± 0.21 (0.69-0.99)	2 (7.1)	0.84 ± 0.21 (0.69-0.99)	-	-
pTFA	5 (8.1)	0.50 ± 0.09 (0.38-0.62)	2 (7.1)	0.44 ± 0.08 (0.38-0.49)	3 (8.8)	0.54 ±0.07 (0.48-0.62)
pIOA	14 (22.6)	0.46 ± 0.14 (0.28-0.73)	8 (28.6)	0.45-0.15 (0.28-0.73)	6 (17.6)	0.47 ± 0.14 (0.30-0.62)
pFA	3 (4.8)	0.43 ± 0.16 (0.31-0.62)	1 (3.6)	0.62	2 (5.9)	0.34 ± 0.04 (0.31-0.37)
pdFA	4 (6.5)	0.53 ± 0.18 (0.33-0.75)	-	-	4 (11.8)	0.53 ± 0.18 (0.33-0.75)
pbFA	2 (3.2)	0.39 ± 0.06 (0.35-0.43)	2 (7.1)	0.39 ± 0.06 (0.35-0.43)	-	-
pAAfa	1 (1.6)	-	-	-	1 (2.9)	0.42
Total	62 (100)	0.62 ± 0.30 (0.28-1.54)	28 (100)	0.67 ± 0.33 (0.28-1.54)	34 (100)	0.57 ± 0.27 (0.30-1.49)

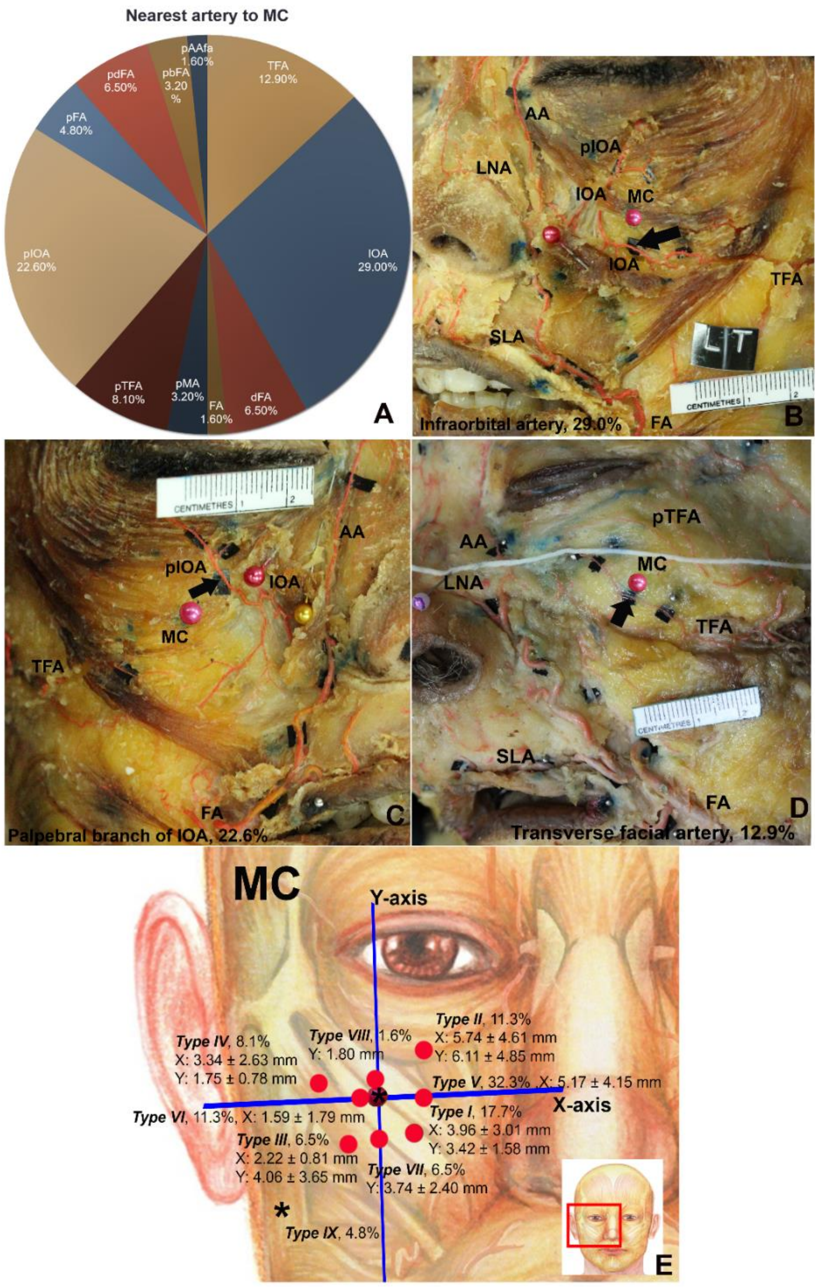


Figure 44 The nearest artery to MC (A-D) (arrow); B: lateral branch of infraorbital artery; C: palpebral branch of infraorbital artery; D: transverse facial artery and E: the distance between MC landmark and the nearest artery based on the types of arterial locations

Considering the arterial locations and it distance from MC landmark (Table 20 and Figure 44E), the study found that the most common type (20 of 62 cases (32.2%)) of arterial location was Type V (medial). The distance following this type was 5.17 ± 4.15 mm at X-axis. In 11 of 62 cases (17.7%), the nearest artery positioned inferomedial direction. The measurements of distance were 3.96 ± 3.01 mm with X-axis and 3.42 ± 1.58 mm with Y-axis. Both Type II (superomedial) and Type VI (lateral) were found each in 7 of 62 cases (11.3%). In type II, the distance along X-axis was 5.74 ± 4.61 mm, while the distance along Y-axis was 6.11 ± 4.85 mm. The X distance of Type VI was 1.59 ± 1.79 mm. The arterial location was type IV (superolateral) in 5 of 62 cases (8.1%). The distance of this type was 3.34 ± 2.63 mm at X-axis and 1.75 ± 0.78 mm at Y-axis. The two types including Type III (inferolateral) and Type VII (inferior) were found in 4 of 62 cases (6.5%). The mean distance of Type III was 2.22 ± 0.81 mm along X-axis, while the distance along Y axis was 4.06 ± 3.65 mm. In term of Type VII, the Y distance was 3.74 ± 2.40 mm. In addition, the Type VIII (superior) and Type IX (at landmark) were found in one (1.6%) and 3 cases (4.8%), respectively (Table 20 and Figure 44E).

Table 20. The distance from MC landmark to the nearest artery based on types of arterial location

Types of arterial location	N (%)	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	11 (17.7)	3.96 ± 3.01 (1.18 - 10.06)	3.42 ± 1.58 (1.45 - 6.53)
II. Superomedial(-X, +Y)	7 (11.3)	5.74 ± 4.61 (1.64 - 14.95)	6.11 ± 4.85 (1.52 - 15.33)
III. Inferolateral (+X, -Y)	4 (6.5)	2.22 ± 0.81 (1.26 - 3.24)	4.06 ± 3.65 (1.85 - 9.49)
IV. Superolateral(+X, +Y)	5 (8.1)	3.34 ± 2.63 (0.91 - 7.60)	1.75 ± 0.78 (1.36 - 3.14)
V. Medial (-X, Y_0)	20 (32.3)	5.17 ± 4.15 (0.75 - 17.64)	0
VI. Lateral (+X,Y_0)	7 (11.3)	1.59 ± 1.79 (0.45 - 5.55)	0
VII. Inferior (X_0, -Y)	4 (6.5)	0	3.74 ± 2.40 (2.36 - 7.33)
VIII. Superior (X_0, +Y)	1 (1.6)	0	1.80
IX. At landmark (X_0, Y_0)	3 (4.8)	0	0
Total	62 (100)		

The examining of correlation between arterial location and tissue layer showed that the nearest artery of MC located underneath the zygomaticus major and the orbicularis oculi muscle in most cases (49 of 62 cases (79.0%)) with the depth of 6.67 ± 3.03 mm (Table 21). In 8 of 62 cases (12.9%), the nearest artery placed above the muscle (supramuscular layer), and the depth of nearest artery in this layer was 3.56 ±

1.98 mm. The equal of both subcutaneous and supraperiosteal layer was found in 2 cases (3.2%). The nearest arterial lining in intramuscular layer was found in only one case (Table 21).

Table 21. Relationship between the location of the nearest artery and fascial tissue layers at MC landmark, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of MC landmarks**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	2 (3.2)	1.36 ± 0.43 (1.05 – 1.66)	0 (0)	-	2 (5.9)	1.36 ± 0.43 (1.05 – 1.66)
Supramuscular	8 (12.9)	3.56 ± 1.98 (1.80 – 6.76)	4 (14.3)	4.20 ± 2.59 (1.80 – 6.76)	4 (11.8)	2.92 ± 1.15 (2.06 – 4.59)
Intramuscular (orbicularis oculi m.)	1 (1.6)	2.01	1 (1.7)	2.01	0 (0)	-
Submuscular	49 (79.0)	6.67 ± 3.03 (2.15 – 13.39)	22 (78.6)	7.11 ± 3.32 (2.66 – 13.39)	27 (79.4)	6.32 ± 2.79 (2.15 – 11.52)
Supraperiosteum	2 (3.2)	4.08 ± 1.37 (3.11 – 5.05)	1 (3.6)	3.11	1 (2.9)	5.05
Total	62 (100)		28 (100)		34 (100)	

➢ ***Nearest artery to Lateral hollowness (LH) injection site***

The TFA was only one specific artery which correlated to the LH landmark from in total 62 cases (Table 22 and Figure 45A). The diameter of TFA at this point was 1.08 ± 0.37 mm. The study of relationship between the LH and arterial location found that the TFA usually located inferior (Type VII) to LH landmark in 32 cases (51.6%). The distance of this type was 4.40 ± 2.38 mm along Y-axis. In 15 cases (24.2%), the arteries placed superior (Type VIII) to LH landmark with the Y distance of 3.75 ± 1.96 mm. However, the nearest artery also exactly situated at the LH landmark in 6 cases (9.7%). Moreover, the Type I, nearest artery locating inferomedial to LH landmark, was found in 4 cases (6.5%). The distances along X-axis and Y-axis were 2.02 ± 0.72 mm and 3.89 ± 2.18 mm, respectively. Whereas two types including Type II (superomedial) and Type IV (superolateral) were evenly discovered in 2 cases (3.2%). In Type II, the measurements of the distance were 3.11 ± 1.86 mm with X-axis, and 6.48 ± 6.66 mm with Y-axis. The distance of Type IV consisted of 1.90 ± 0.49 mm at X-axis and 2.15 ± 0.32 mm at Y-axis. In one case, the nearest artery to LH located lateral direction (Table 23 and Figure 45B).

Table 22. Frequencies of the nearest artery at lateral hollowness (LH) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to LH landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Transverse facial artery (TFA)	62 (100)	1.08 ± 0.37 (0.38-1.94)	28 (100)	1.09 ± 0.42 (0.38-1.74)	34 (100)	1.07 ± 0.33 (0.45-1.94)
Total	62 (100)	1.08 ± 0.37 (0.38-1.94)	28 (100)	1.09 ± 0.42 (0.38-1.74)	34 (100)	1.07 ± 0.33 (0.45-1.94)

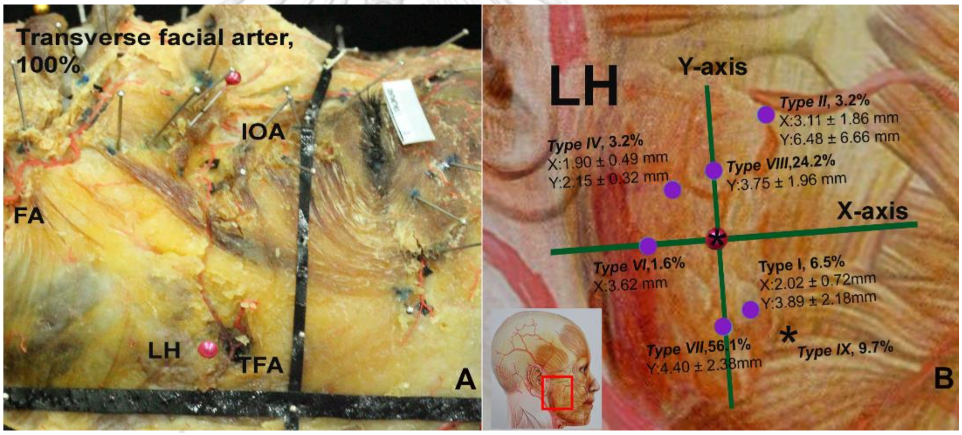


Figure 45 The transverse facial artery locating nearest artery to LH landmark in all cases (A) and the LH nearest arterial locations and its distances (B)

The examination of association between the nearest artery and fascial tissue layer displayed that the nearest artery to LH commonly located within the parotid gland (33 of 62 cases (53.2%)) with 8.04 ± 2.48 mm of the depth. In 20 of 62 cases (32.2%), the nearest artery positioned over the anterior surface of masseter muscle with the depth of 6.90 ± 1.69 mm. However, the arterial lining under the zygomaticus major muscle (submuscular layer) was showed in 2 of 62 cases (3.2%). In 7 of 62 cases

(11.3%), the TFA gave off superficial branch as nearest artery and located in the subcutaneous layer (Table 24).

Table 23. The distance from LH landmark to the nearest artery based on types of arterial location

Types of arterial location	N (%)	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	4 (6.5)	2.02 ± 0.72 (1.18 - 2.75)	3.89 ± 2.18 (1.20 - 6.38)
II. Superomedial (-X, +Y)	2 (3.2)	3.11 ± 1.86 (1.79 - 4.42)	6.48 ± 6.66 (1.77 - 11.19)
III. Inferolateral (+X, -Y)	0 (0)	-	-
IV. Superolateral (+X, +Y)	2 (3.2)	1.90 ± 0.49 (1.55 - 2.25)	2.15 ± 0.32 (1.92 - 2.37)
V. Medial (-X, Y_0)	0 (0)	-	-
VI. Lateral (+X,Y_0)	1 (1.6)	3.62	0
VII. Inferior (X_0, -Y)	32 (51.6)	0	4.40 ± 2.38 (0.70 - 12.30)
VIII. Superior (X_0, +Y)	15 (24.2)	0	3.75 ± 1.96 (1.12 - 8.02)
IX. At landmark (X_0, Y_0)	6 (9.7)	0	0
Total	62 (100)		

Table 24. Relationship between the location of the nearest artery and fascial tissue layers at LH landmark, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of LH landmarks**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	7 (11.3)	6.37 ± 3.00 (3.55 – 12.49)	5 (17.9)	6.80 ± 3.56 (3.55 – 12.49)	2 (5.9)	5.31 ± 0.25 (5.13 – 5.49)
Supra-muscular (masseter m.)	20 (32.3)	6.90 ± 1.69 (4.32 – 9.54)	8 (28.6)	6.89 ± 1.91 (4.54 – 9.54)	12 (35.3)	6.90 ± 1.62 (4.32 – 9.47)
Submuscular (origin of zygomaticus major m.)	2 (3.2)	8.86 ± 1.07 (8.10 – 9.61)	0 (0)	-	2 (5.9)	8.86 ± 1.07 (8.10 – 9.61)
Parotid gland	33 (53.2)	8.04 ± 2.48 (4.19 – 13.66)	13 (46.4)	8.70 (4.58 – 11.45)	20 (58.8)	7.62 ± 2.65 (4.19 – 13.66)
Total	62 (100)		28 (100)		34 (100)	

➢ ***Nearest artery to Nasolabial fold (NLF) injection sites***

The NLF was divided into 4 injection sites: NLF1-NLF4. However, the arterial supplies surrounding the nasolabial region were complicated. Moreover, each injection site consisted of involving nearest artery more than three arteries. Therefore, the study of nearest artery to NLF landmarks were clarified in this study.

Regarding the inferior margin of nasolabial fold (NLF1), the nearby artery of this landmark was the FA which was found in 47 of 62 cases (75.8%) (Figure 46A and B). The diameter of FA which correlated with NLF1 was 1.72 ± 0.52 mm. In addition, the nearby artery of NLF1 was the buccal branch of facial artery (bFA) in 6 of 62 cases (9.7%). The diameter of bFA was 0.56 ± 0.09 mm. The superior labial artery (SLA) which arose from FA traveled nearest to NLF1 landmark in 5 of 62 cases (8.1%) with the diameter of 1.22 ± 0.39 mm. In the remained 4 of 62 cases (6.5%), the nearby artery to NLF1 was the dFA, and is external diameter was 0.87 ± 0.18 (Table 25 and Figure 44A). There was statistical significance (p-value<0.05) when dFA diameters between genders at this NLF1 landmark. However, the diameter was 0.72 ± 0.06 mm in male, and the diameter was 1.01 ± 0.04 mm in female. The type of relationship between arterial location and landmarks was Type I (inferomedial) in the most cases (17 of 62 cases (27.4%)) (Table 26 and Figure 47A). The mean X and Y distance of Type I were 2.86 ± 1.57 mm and 3.26 ± 1.71 mm, respectively. The Type IX (at landmark) and Type VII (inferior) were identically found locating nearest to NLF1 in 11 of 62 cases (17.7%)). The Y distance of Type VII was 4.27 ± 3.33 mm. Moreover, the nearest artery positioned lateral (Type VI) to NLF1 landmark in 8 of 62 cases (12.9%), while the medial (Type V) location was found in 7 of 62 cases (11.3%). The X distance of Type VI was 3.16 ± 2.11 mm, and the X distance of Type V was 3.96 ± 3.04 mm. In 3 of 62 cases (4.8%), the nearest artery located inferolateral (Type III) and superolateral (Type IV) to NLF1 landmark. In Type III, the distances were 2.44 ± 1.95 mm along X-axis, and 1.98 ± 1.03 mm along Y-axis. In term of Type IV, the distances were 5.37 ± 1.83 mm at X-axis, and 2.54 ± 0.84 at Y-axis. Finally, the nearest artery placed superior (Type VIII) to NLF1 landmark in 2 cases (3.2%) with 1.65 ± 0.54 mm of distance Y (Table 26 and Figure

47A). The observation of the nearest arterial location related to fascial tissue layers exhibited that the closest artery to NLF1 landmark generally located adjacent the posterior surface of insertion of zygomaticus major muscle and the modiolus (submuscular layer) in 24 of 62 cases (38.9%) with the depth of 6.13 ± 2.23 mm. In 21 of 62 cases (33.9%), the nearest artery of NLF1 located inside the subcutaneous tissue layer with 4.59 ± 3.36 mm of the depth from the skin surface. The intramuscular and supramuscular layer of insertion of zygomaticus major and levator labii superioris muscle were found in 13 cases (21.0%) and 4 cases (6.5%) (Table 27).

Table 25. Frequencies of the nearest artery at each nasolabial fold (NLF) landmarks and its external diameter

Nearest arteries	**Diameter of nearest arteries to NLF landmarks**					
	NLF1					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**
Detoured branch (dFA)	4 (6.5)	0.87 ± 0.18 (0.67-1.04)	2 (7.1)	0.72 ± 0.06 (0.67-0.76)	2 (5.9)	1.01 ± 0.04 (0.99-1.04)
Buccal branch of facial artery (bFA)	6 (9.7)	0.56 ± 0.09 (0.39-0.66)	4 (14.3)	0.59 ± 0.06 (0.53-0.66)	2 (5.9)	0.48 ± 0.13 (0.39-0.57)
Facial artery (FA)	47 (75.8)	1.72 ± 0.52 (0.65-3.01)	20 (71.4)	1.73 ± 0.54 (0.65-2.44)	27 (79.4)	1.72 ± 0.51 (0.86-3.01)
Superior labial artery (SLA)	5 (8.1)	1.22 ± 0.39 (0.64-1.72)	2 (7.1)	1.21	3 (8.8)	1.22 ± 0.54 (0.64-1.72)
Total	62 (100)	1.51 ± 0.61 (0.39-3.01)	28 (100)	1.46 ± 0.64 (0.53-2.44)	34 (100)	1.56 ± 0.59 (0.39-3.01)

Table 25. Frequencies of the nearest artery at each nasolabial fold (NLF) landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to NLF landmarks					
	NLF2					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Infraorbital artery (IOA)	19 (30.6)	0.50 ± 0.13 (0.29-0.73)	13 (46.4)	0.50 ± 0.14 (0.32-0.73)	6 (17.6)	0.49 ± 0.12 (0.29-0.62)
Detoured branch (dFA)	6 (9.7)	0.85 ± 0.17 (0.57-1.03)	2 (7.1)	1.02 ± 0.02 (1.00-1.03)	4 (11.8)	0.76 ± 0.14 (0.57-0.90)
Facial artery (FA)	36 (58.1)	1.46 ± 0.30 (0.85-2.09)	13 (46.4)	1.59 ± 0.35 (0.85-2.09)	23 (67.6)	1.39 ± 0.24 (0.96 ± 1.99)
Superior labial artery (SLA)	1 (1.6)	0.94	-	-	1 (2.9)	0.94
Total	62 (100)	1.10 ±0.51 (0.29-2.09)	28 (100)	1.04 ± 0.59 (0.32-2.09)	34 (100)	1.14 ± 0.42 (0.29-1.99)

Table 25. Frequencies of the nearest artery at each nasolabial fold (NLF) landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to NLF landmarks					
	NLF3					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Infraorbital artery (IOA)	24 (38.7)	0.58 ± 0.25 (0.33-1.43)	15 (53.6)	0.62 ± 0.27 (0.33-1.43)	9 (26.5)	0.52 ± 0.21 (0.33-1.00)
Detoured branch (dFA)	1 (1.6)	0.84	-	-	1 (2.9)	0.84
Inferior alar artery (IAA)	3 (4.8)	1.06 ± 0.04 (1.03-1.11)	1 (3.6)	1.04	2 (5.9)	1.07 ± 0.06 (1.03-1.11)
Facial artery (FA)	22 (35.5)	1.46 ± 0.35 (0.86-2.07)	7 (25.0)	1.51 ± 0.38 (1.18-2.07)	15 (44.1)	1.44 ± 0.35 (0.86-1.97)
Lateral nasal artery of FA (LNA)	12 (19.4)	1.37 ± 0.23 (0.94-1.71)	5 (17.9)	1.37 ± 0.32 (0.94-1.71)	7 (20.6)	1.37 ± 0.17 (1.05-1.60)
Total	62 (100)	1.07 ± 0.49 (0.33-2.07)	28 (100)	0.99 ± 0.51 (0.33-2.07)	34 (100)	1.14 ± 0.48 (0.33-1.97)

Table 25. Frequencies of the nearest artery at each nasolabial fold (NLF) landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to NLF landmarks					
	NLF4					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Infraorbital artery (IOA)	20 (32.3)	0.70 ± 0.25 (0.41-1.37)	8 (28.6)	0.79 ± 0.26 (0.56-1.37)	12 (35.3)	0.64 ± 0.23 (0.41-1.23)
Facial artery (FA)	9 (14.5)	1.14 ± 0.22 (0.85-1.58)	4 (14.3)	1.12 ± 0.13 (0.98-1.27)	5 (14.7)	1.15 ± 0.29 (0.85-1.58)
Angular artery of facial artery (AAfa)	1 (1.6)	0.41	-	-	1 (2.9)	0.41
Lateral nasal artery of FA (LNA)	31 (50)	1.06 ± 0.27 (0.65-1.62)	15 (53.6)	1.14 ± 0.29 (0.73-1.62)	16 (47.1)	0.99 ± 0.23 (0.65-1.52)
Lateral nasal artery of IOA (ioaLNA)	1 (1.6)	0.58	1 (3.6)	0.58	-	-
Total	62 (100)	0.94 ± 0.32 (0.41-1.62)	28 (100)	1.02 ± 0.31 (0.56-1.62)	34 (100)	0.87 ± 0.31 (0.41-1.48)

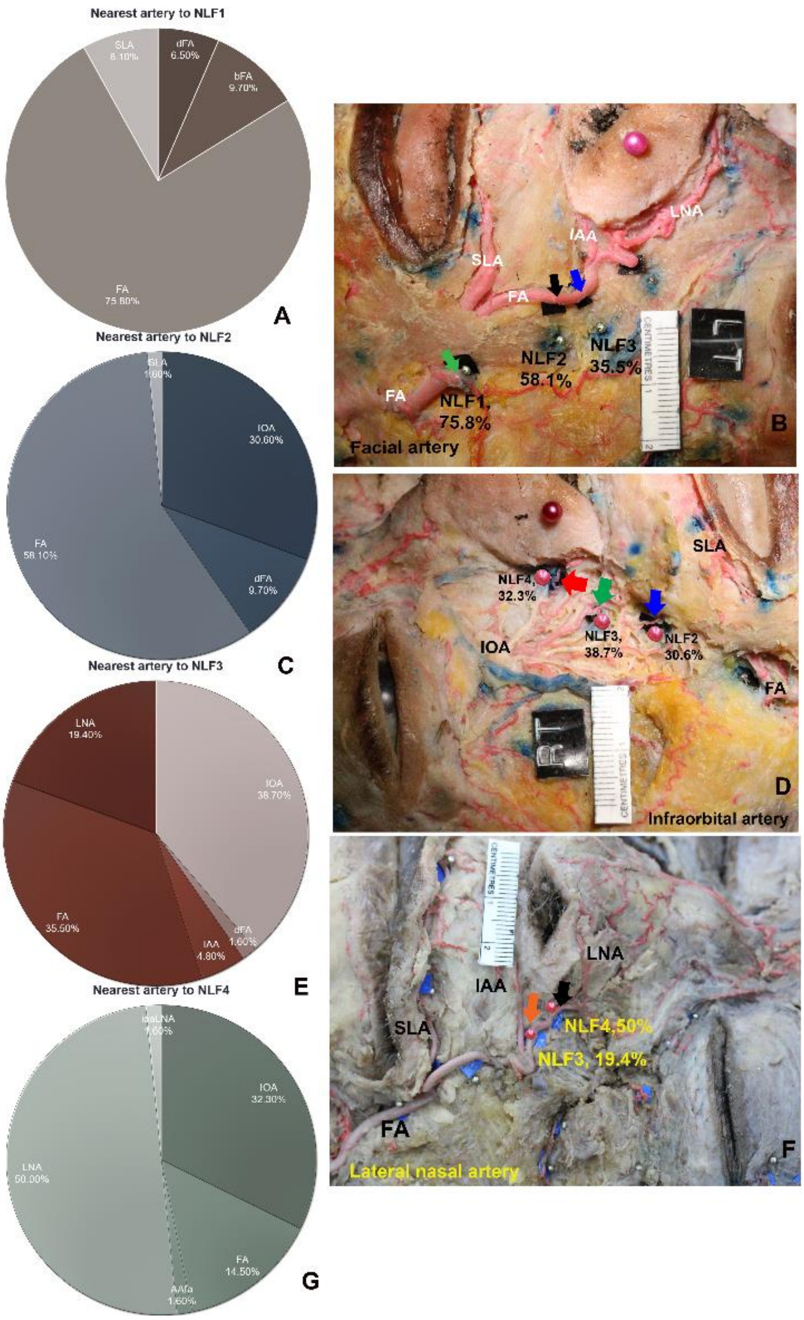


Figure 46 The nearest artery to NLF landmarks (A-G); B; facial artery locating nearest to NLF1, NLF2 and NLF3; D: branch of infraorbital artery locating nearest to NLF2, NLF3 and NLF4; F; the lateral nasal artery locating nearest to NLF3 and NLF4

Table 26. The distance from each NLF landmark to the nearest artery based on types of arterial location

Types of arterial location	Land-marks	N (%)	Distance of artery with X-axis Mean ± SD (Range)(mm)	Distance of artery with Y-axis Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	NLF1	17 (27.4)	2.86 ± 1.57 (1.02 - 7.82)	3.26 ± 1.71 (1.13 - 6.95)
	NLF2	12 (19.4)	4.54 ± 1.97 (2.02 - 9.03)	4.64 ± 3.70 (1.77 - 13.44)
	NLF3	6 (9.7)	2.70 ± 0.80 (1.44 - 3.64)	3.13 ± 1.30 (2.14 - 5.63)
	NLF4	2 (3.2)	2.44 ± 0.83 (1.85 - 3.03)	2.57 ± 0.06 (2.53 - 2.61)
II. Superomedial (-X, +Y)	NLF1	0 (0)	-	-
	NLF2	3 (4.8)	1.95 ± 0.07 (1.87 - 2.01)	3.04 ± 0.94 (1.99 - 3.79)
	NLF3	4 (6.5)	1.86 ± 0.55 (1.06 - 2.30)	2.17 ± 1.10 (0.91 - 2.17)
	NLF4	0 (0)	-	-
III. Inferolateral (+X, -Y)	NLF1	3 (4.8)	2.44 ± 1.95 (1.02 - 4.66)	1.98 ± 1.03 (1.37 - 3.17)
	NLF2	1 (1.6)	5.20	2.15
	NLF3	1 (1.6)	1.69	1.64
	NLF4	4 (3.2)	1.92 ± 0.50 (1.43 - 2.47)	1.35 ± 0.41 (0.85 - 1.84)

IV. Superolateral (+X, +Y)	NLF1	3 (4.8)	5.37 ± 1.83 (3.69 - 7.32)	2.54 ± 0.84 (1.74 - 3.41)
	NLF2	7 (11.3)	3.43 ± 2.22 (1.46 - 7.82)	2.82 ± 1.28 (0.96 - 4.35)
	NLF3	3 (4.8)	2.36 ± 0.84 (1.56 - 3.23)	1.62 ± 0.22 (1.42 - 1.85)
	NLF4	1 (1.6)	1.19	1.08
V. Medial (-X, Y_0)	NLF1	7 (11.3)	3.96 ± 3.04 (0.96 - 8.93)	0
	NLF2	19 (30.6)	4.51 ± 1.91 (0.90 - 8.07)	0
	NLF3	16 (25.8)	2.27 ± 0.84 (1.00 - 3.91)	0
	NLF4	10 (16.1)	1.33 ± 0.39 (0.89 - 1.89)	0
VI. Lateral (+X, Y_0)	NLF1	8 (12.9)	3.16 ± 2.11 (1.07 - 6.88)	0
	NLF2	4 (6.5)	2.84 ± 2.54 (1.26 - 6.63)	0
	NLF3	10 (16.1)	2.30 ± 1.53 (0.84 - 5.95)	0
	NLF4	18 (29.0)	1.61 ± 1.04 (0.93 - 5.27)	0
VII. Inferior (X_0, -Y)	NLF1	11 (17.7)	0	4.27 ± 3.33 (1.11 - 11.11)
	NLF2	1 (1.6)	0	1.24
	NLF3	3 (4.8)	0	2.66 ± 0.86 (1.84 - 3.56)

	NLF4	8 (12.9)	0	1.73 ± 0.77 (0.86 - 3.32)
VIII. Superior to landmark (X_0, +Y)	NLF1	2 (3.2)	0	1.65 ± 0.54 (1.27 - 2.03)
	NLF2	3 (4.8)	0	3.21 ± 0.63 (2.49 - 3.64)
	NLF3	3 (4.8)	0	1.48 ± 0.08 (1.40 - 1.55)
	NLF4	6 (9.7)	0	1.29 ± 0.34 (0.90 - 1.29)
IX. At landmark (X_0, Y_0)	NLF1	11 (17.7)	0	0
	NLF2	12 (19.4)	0	0
	NLF3	16 (25.8)	0	0
	NLF4	13 (21.0)	0	0

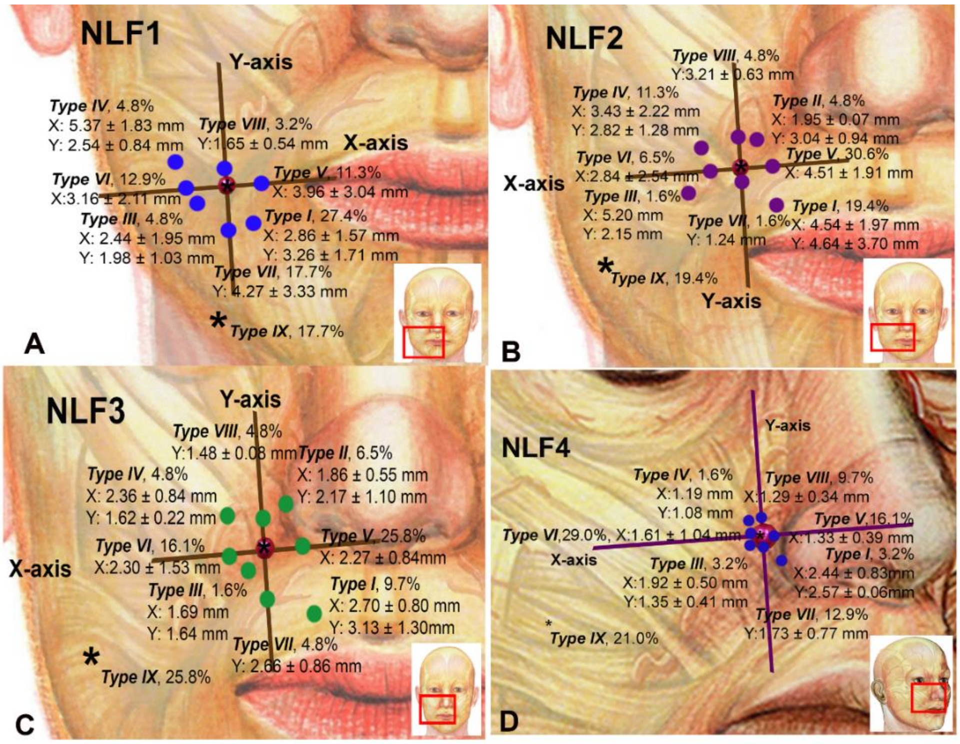


Figure 47 The relationship between nearest artery and NLF landmarks; A: the location of nearest artery of NLF1; B: the nearest arterial location of NLF2; C: the location of nearest artery to NLF3 and D: the nearest arterial location of NLF4

The nearest artery of NLF2 landmark composed of four arteries: FA, IOA, dFA and SLA (Table 27 Figure 46C). In most cases (36 of 62 cases (58.1%)), the main branch of FA produced the SLA, and then became the nearest artery to NLF2 before traveling to nasal alar area (Figure 46B). The diameter of FA was 1.46 ± 0.30 mm. There was statistical significance (p-value<0.05) when comparing FA diameters between genders at this NLF2 landmark. The diameter was 1.59 ± 0.35 mm in male, and the external diameter of FA was 1.39 ± 0.24 mm in female. In the others artery, the IOA released the small labial branch and located nearest to NLF2 landmark In 19 of 62 cases (30.6%) with diameter of 0.50 ± 0.13 mm (Figure 46D). Moreover, the dFA and SLA were placed closest to NLF2 in 6 cases (9.7%) and 1 cases (1.6%), respectively (Table 25 and Figure

46C). The relationship between nearest artery and NLF2 landmark was Type V (medial) in most cases (19 of cases (30.6%)). The X distance following Type V was 4.51 ± 1.91 mm. The nearest artery equally located inferomedial (Type I) and at the NLF2 landmark (Type IX) in 12 of 62 case (19.4%). In Type I, the distances were 4.54 ± 1.97 mm along X-axis and 4.64 ± 3.70 mm along Y-axis. In 7 of 62 cases (11.3%), the nearest artery located superolateral (Type IV), while the nearest artery located lateral (Type VI) to NLF2 landmark in 4 of 62 cases (6.5%). The measurement of distance of Type IV was 3.43 ± 2.22 mm at X-axis and 2.82 ± 1.28 mm at Y- axis, but the distance of Type VI was 2.84 ± 2.54 mm along X-axis. Two types including Type II (superomedial) and Type VIII (superior) were found in 3 of 62 cases (4.8%). The X and Y distances of Type II were 1.95 ± 0.07 mm and 3.04 ± 0.94 mm, respectively. For Type VIII, the nearest artery located superior to NLF2 with 3.21 ± 0.63 mm. In addition, both inferolateral (Type III) and inferior (Type VII) directions of nearest artery to NLF2 were found in 1 cases (1.6%) (Table 26 and Figure 47B). The correlation between nearest artery and fascial tissue layer showed that the common layer which nearest artery lined was submuscular layer (under the insertion of Zygomaticus major and levater labii superioris muscle) (27 of 62 cases (43.5%)) with the depth of 7.25 ± 3.18 mm. Whereas, the arterial lining above such muscles was found in 19 of 62 cases (30.6%); moreover, its depth was 3.69 ± 2.04 mm. Furthermore, the nearest artery embedded inside the muscle, known as intramuscular layer, was discovered in 10 of 62 cases (16.1%). The depth of nearest artery in this layer was 3.59 ± 2.13 mm. In 6 of 62 cases (9.7%), the nearest artery located in the subcutaneous layer (nasolabial fat) with the depth of 5.74 ± 2.72 mm (Table 27).

There were several accurate arteries which associated with the nasolabial fold at the level of inferior to alar border (NLF3) (Table 25 and Figure 46E). In 24 of 62 cases (38.7%), the IOA located closest to NLF3 landmark with the diameter of 0.58 ± 0.25 mm (Figure 46D). In the other nearby artery of NLF3, the FA was found in 22 of 62 cases (35.5%) (Figure 46B), while the LNA which emerged from FA was found placing nearest to NLF3 in 12 of 62 cased (19.4%) (46F). The external diameters of FA and IOA were 1.46 ± 0.35 mm and 0.58 ± 0.25 mm, respectively. In addition, the inferior alar artery (IAA) and dFA positioned nearest to NLF3 in 3 cases (4.8%) and 1 cases (1.6%), respectively (Table 25 and Figure 46E). There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this NLF3 landmark. Considering to arterial locations (Figure 47C), two types including Type V (medial) and Type IX (at landmark) were mostly found with 16 of 62 cases (25.8%). The X distance in Type V was 2.27 ± 0.84 mm. In 10 of 62 cases (16.1%), the nearest artery located lateral to NLF3 (Type VI) with 2.30 ± 1.53 mm at X-axis. However, the nearest artery located inferomedial (Type I) to NLF3 landmark in 6 of 62 cases (9.7%), and it placed superomedial (Type II) to landmark in 4 cases (6.5%). In Type I, the X and Y distance were 2.70 ± 0.80 mm and 3.13 ± 1.30 mm, respectively. The distance of Type II was 1.86 ± 0.55 mm with X-axis and 2.17 ± 1.10 mm with Y-axis. There were three types including Type IV (superolateral), Type VII (inferior) and Type VIII (superior) were uniformly found in 3 of 62 cases (4.8%). In type IV, the X and Y distances were 2.36 ± 0.84 mm and 1.62 ± 0.22 mm, respectively. The Y distance of Type VII was 2.66 ± 0.86 mm, and Y distance of Type VIII was 1.48 ± 0.08 mm. Finally, the nearest artery positioned superolateral to NLF3 landmark in only one case (Table 26 and Figure 47C). The investigation of arterial lining layers found that nearest artery commonly stayed at submuscular layer (under insertion of Zygomaticus major and levater labii superioris muscle) (32 of 62 cases (51.6%)) with the closest arterial depth related to this layer of 6.29 ± 2.65 mm. In contrast, the arterial positioned along anterior surface of the muscles (supramuscular layer) in 16 cases (25.8%, and its depth in this layer was 3.19 ± 1.53 mm. The intramuscular layer was housed of NFF3 nearest artery in 11 cases (17.7%), and the depth of nearest artery in this layer was 3.49 ± 1.11 mm. In one case, the nearest artery located in the supraperiosteal layer. Uniquely, the nearest artery also placed in infraorbital fat compartment, which was once of deep fat compartment of the face, in 2 cases (3.2%).

Table 27. Relationship between the location of the nearest artery and fascial tissue layers at each NLF landmarks, and the depth from the skin to nearest artery

Facial layers	Depth from the skin to nearest arteries of NLF landmarks					
	NLF1					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	21 (33.9)	4.59 ± 3.36 (1.50 – 14.13)	8 (28.6)	4.12 ± 2.85 (2.16 – 10.55)	13 (38.2)	4.87 ± 3.71 (1.50 – 14.13)
Supra-muscular	4 (6.5)	5.87 ± 0.95 (5.04 – 7.09)	3 (10.7)	5.46 ± 0.59 (5.04 – 6.14)	1 (2.9)	7.09
Intramuscular	13 (21.0)	5.70 ± 3.61 (2.01 – 11.62)	6 (21.4)	5.88 ± 3.14 (2.01 – 10.46)	7 (20.6)	5.53 ± 4.03 (2.24 – 11.62)
Submuscular	24 (38.9)	6.13 ± 2.23 (2.10 - 10.46)	11 (39.3)	6.88 ± 2.10 (4.31 – 10.17)	13 (38.2)	5.49 ± 2.22 (2.10 – 10.46)
Total	62 (100)		28 (100)		34 (100)	

Table 27. Relationship between the location of the nearest artery and fascial tissue layers at each NLF landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	**Depth from the skin to nearest arteries of NLF landmarks**					
	NLF2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous (nasolabial fat)	6 (9.7)	5.74 ± 2.72 (2.24 – 9.45)	3 (10.7)	4.28 ± 2.34 (2.24 – 6.84)	3 (8.8)	7.02 ± 2.58 (4.39 – 9.45)
Supramuscular (insertion of zygomaticus major, zygomaticus minor and)	19 (30.6)	3.69 ± 2.04 (1.08 – 9.03)	6 (21.4)	3.88 ± 1.04 (2.90 – 5.73)	13 (38.2)	3.60 ± 2.40 (1.08 – 9.03)
Intramuscular (insertion of zygomaticus major, zygomaticus minor and)	10 (16.1)	3.59 ± 2.13 (2.06 – 7.78)	3 (10.7)	3.05 ± 0.71 (2.35 – 3.76)	7 (20.6)	3.83 ± 2.54 (2.06 – 7.78)
Submuscular (insertion of zygomaticus major, zygomaticus minor and)	27 (43.5)	7.25 ± 3.18 (1.56 – 14.22)	16 (57.1)	7.61 ± 3.01 (2.24 – 14.22)	11 (32.4)	6.73 ± 3.50 (1.56 – 13.02)
Total	62 (100)		28 (100)		34 (100)	

Table 27. Relationship between the location of the nearest artery and fascial tissue layers at each NLF landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	**Depth from the skin to nearest arteries of NLF landmarks**					
	NLF3					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Supramuscular	16 (25.8)	3.19 ± 1.53 (1.19 – 6.43)	5 (17.9)	4.58 ± 1.79 (1.68 – 6.43)	11 (32.4)	2.55 ± 0.90 (1.19 – 3.67)
Intramuscular	11 (17.7)	3.49 ± 1.11 (1.54 – 5.64)	4 (14.3)	3.06 ± 1.14 (1.54 – 4.01)	7 (20.6)	3.73 ± 1.11 (2.07 – 5.64)
Submuscular	32 (51.6)	6.29 ± 2.65 (1.91 – 11.02)	17 (60.7)	7.31 ± 2.46 (3.61 – 11.02)	15 (44.1)	5.12 ± 2.44 (1.91 – 8.86)
Infraorbital fat	2 (3.2)	14.02 ± 0.85 (13.42-4.62)	2 (3.4)	14.02 ± 0.85 (13.42-14.62)	0 (0)	-
Supraperios-teum	1 (1.6)	10.30	0 (0)	-	1 (2.9)	10.30
Total	62 (100)		28 (100)		34 (100)	

Table 27. Relationship between the location of the nearest artery and fascial tissue layers at each NLF landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	Depth from the skin to nearest arteries of NLF landmarks					
	NLF4					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	1 (1.6)	2.89	0 (0)	-	1 (2.9)	2.89
Supramuscular	20 (32.3)	2.58 ± 0.88 (1.64 – 4.34)	8 (28.6)	2.98 ± 0.99 (1.66 – 4.34)	12 (35.3)	2.32 ± 0.72 (1.64 – 3.59)
Intramuscular	5 (8.1)	2.75 ± 1.31 (1.56 – 4.25)	2 (7.1)	1.94 ± 0.05 (1.90 – 1.97)	3 (8.8)	3.30 ± 1.51 (1.56 – 4.25)
Submuscular	32 (51.6)	6.27 ± 3.16 (2.56 – 14.53)	16 (57.1)	6.97 ± 3.19 (3.14 – 14.53)	16 (47.1)	5.58 ± 3.06 (2.56 – 14.03)
Infraorbital fat	4 (6.5)	8.86 ± 6.29 (3.92 – 18.07)	2 (7.1)	11.00 ± 10.01 (3.92 – 18.07)	2 (5.9)	6.72 ± 0.45 (6.40 – 7.04)
Total	62 (100)		28 (100)		34 (100)	

The NLF4 area was supplied by numerous arterial branches (Figure 46G). In most cases (31 of 62 cases (50.0%)), the nearest artery to NLF4 landmark was LNA (Figure 46F), while the IOA was found placing nearest to NLF4 in 20 of 62 cases (32.3%) (Figure 46D). The LNA and IOA outer dimeter was 1.06 ± 0.27 mm and 0.70 ± 0.25 mm, respectively. In 9 of 62 cases (14.5%), the closest artery to NLF4 was FA with the diameter of 1.14 ± 0.22 mm. Moreover, two arteries including AAfa and LNA of IOA were evenly found in only one case (Table 25 and Figure 46G). There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this NLF4 landmark. There were 8 of 9 types of nearest arterial location in this study (Table 26 and Figure 47D). The Type VI (18 of 62 cases (29.0%)) which nearest artery located lateral to NLF4 was largely found with 1.61 ± 1.04 mm of X distance. In 13 of 62 cases (21.0%), the nearest artery was settle at the NLF4 landmark, However, the closest artery located medial (Type V) to NLF4 in 10 cases (16.1%), and the distance was 1.33 ± 0.39 mm along X-axis. Additionally, the Type VII (inferior) was discovered in 8 cases (12.9%) with 1.73 ± 0.77 mm at Y-axis. Whereas the Type VIII (superior) was found in 6 cases (9.7%), and the distance following this type was 1.29 ± 0.34 mm along X-axis. In Type III (4 cases (3.2%)), the closest artery positioned inferolateral direction. The X and Y distance were 1.92 ± 0.50 mm and 1.35 ± 0.41 mm, respectively. Moreover, the Type I (inferomedial) was found in 2 cases (3.2%), and the Type IV (superolateral) was found in only one case. The distances of Type I were 2.44 ± 0.83 mm with X-axis as well as 2.57 ± 0.06 mm with Y-axis (Table 26 and Figure 47D). This study examined the relationship between location of nearest artery and fascial tissue layer and the results showed that the nearest artery located underneath the levator labii superioris and levator labii superioris alaeque nasi muscle with the depth of 6.27 ± 3.16 mm in most cases (32 of 62 cases (51.6%)). While the nearest arterial lining above these muscles as well as the orbicularis oculi muscle was found in 20 of 62 cases (32.3%) with 2.58 ± 0.88 of the depth. In 5 cases (8.1%), the nearest artery stayed inside the muscles with the depth of 2.75 ± 1.31 mm. In the others tissue layer, the closest artery placed in infraorbital fat compartment (4 cases (6.5%)) with 8.86 ± 6.29 mm of the arterial depth. Finally, the nearest artery located in the subcutaneous layer in one case (Table 27 and Figure 47D).

4.1.3 The nearest artery of the lower face injection sites

There were several common filler injection sites for the lower face. However, the nearest artery related to lower face injection sites (landmark) arose from FA. The nearest arteries to each landmark were found as follow

- ***Nearest artery to Lip (vermillion and volume)(LV) injection sites***

The LV landmarks were separated into 3 sites. The nearest artery of each LV landmark were different. The LV1 landmark, 2 mm lateral to the oral commissure, were found associated with FA, SLA, and Inferior alar artery (IAA) (Table 28 and Figure 48A). In 45 of 62 cases (72.6%), the SLA which ramified of FA was found locating nearest to LV1 landmark with the diameter of 1.31 ± 0.57 mm (Figure 48B). The main branch of FA traveled across inferior border of mandible and became the nearest branch of LV1 landmark in 10 of 62 cases (16.1%), while the IAA, which emerged from FA and traveled with inferior border of alar , placed in the remained 7 cases (11.3%) (Table 28). The external diameter of FA was 1.57 ± 0.25, and the mean diameter of IAA was 1.05 ± 0.27 mm. There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this LV1 landmark. The study of the relationship between the LV1 injection site and the nearest artery found that the nearest artery located superolateral (Type IV) to LV1 landmark in most cases (28 of 62 cases (45.2%)) (Table 29 and Figure 49, left). The distances correlated to Type IV were 3.15 ± 0.90 mm along X-axis and 3.92 ± 1.56 mm along Y-axis. However, the Type VIII which the closest artery placed superior to landmark was discovered in 20 of 62 cases (32.3%). The Y distance of this type was 4.93 ± 1.91 mm. In 10 of 62 cases (16.1%), the nearest artery positioned lateral to LV1 landmark with 3.04 ± 1.64 mm at X-axis. Moreover, the nearest artery located inferior to LV1 (Type VII) in 3 cases (4.8%). The Y distance of Type VII was 3.88 ± 2.74 mm. The artery placing at LV1 were individually found in one case (Table 29 and Figure 49, left). In the facial tissue layer observation, the nearest artery generally embedded within orbicularis oris muscle (intramuscular layer), and it was found in 58 of 62 cases (93.5%). The depth of nearest artery in the most cases was 3.85 ± 2.00 mm. In 3 of 62 cases (4.8%), the closest artery placed at submucosa layer, whereas the nearest artery of the remained one case was positioned above the orbicularis oris muscle (supramuscular layer). The depth of nearest artery in submucosa was 6.49 ± 3.26 mm (Table 30).

Table 28. Frequencies of the nearest artery at each lip vermillion (LV) landmarks and its external diameter

Nearest arteries	Diameter of nearest arteries to LV landmarks					
	LV1					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Facial artery (FA)	10 (16.1)	1.57 ± 0.25 (1.17-1.90)	5 (17.9)	1.59 ± 0.25 (1.27-1.83)	5 (14.7)	1.55 ± 0.28 (1.17-1.90)
Superior labial artery (SLA)	45 (72.6)	1.31 ± 0.57 (0.40-2.78)	18 (64.3)	1.39 ± 0.57 (0.43-2.78)	27 (79.4)	1.25 ± 0.57 (0.40-2.26)
Inferior alar artery (IAA)	7 (11.3)	1.05 ± 0.27 (0.65-1.40)	5 (17.9)	1.01 ± 0.31 (0.65-1.40)	2 (5.9)	1.17 ± 0.08 (1.11-1.22)
Total	62 (100)	1.32 ± 0.52 (0.40-2.78)	28 (100)	1.36 ± 0.51 (0.43-2.78)	34 (100)	1.29 ± 0.53 (0.40-2.26)

Table 28. Frequencies of the nearest artery at each lip vermillion (LV) landmarks and its external diameter (Cont.)

Nearest arteries	**Diameter of nearest arteries to LV landmarks**					
	LV2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**
Superior labial artery (SLA)	55 (88.7)	1.17 ± 0.43 (0.41-2.19)	23 (82.1)	1.25 ± 0.38 (0.53-2.19)	32 (94.1)	1.11 ± 0.46 (0.41-2.17)
Ascending branch of SLA (aSLA)	7 (11.3)	0.75 ± 0.23 (0.32-1.09)	5 (17.9)	0.76 ± 0.08 (0.65-0.87)	2 (5.9)	0.71 ± 0.54 (0.32-1.09)
Total	62 (100)	1.12 ± 0.44 (0.32-2.19)	28 (100)	1.16 ± 0.39 (0.53-2.19)	34 (100)	1.08 ± 0.47 (0.32-2.17)

Table 28. Frequencies of the nearest artery at each lip vermillion (LV) landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to LV landmarks					
	LV3					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Ascending branch of SLA (aSLA)	2 (6.5)	0.59 ± 0.23 (0.43-0.75)	-	-	2 (5.9)	0.59 ± 0.23 (0.43-0.75)
Septal branch of SLA (sSLA)	9 (29.0)	0.93 ± 0.43 (0.40-1.91)	6 (21.4)	0.95 ± 0.52 (0.40-1.91)	3 (8.8)	0.90 ± 0.23 (0.63-1.06)
Left superior labial artery. (ltSLA)	14 (45.2)	0.93 ± 0.28 (0.52-1.45)	5 (17.9)	0.91 ± 0.28 (0.57-1.33)	9 (26.5)	0.94 ± 0.30 (0.52-1.45)
Right superior labial artery (rtSLA)	6 (19.3)	1.21 ± 0.50 (0.46-1.70)	3 (10.7)	1.20 ± 0.65 (0.46-1.70)	3 (8.8)	1.21 ± 0.43 (0.72-1.55)
Total	31 (100)	0.94 ± 0.38 (0.40-1.91)	14 (100)	0.99 ± 0.46 (0.40-1.91)	17 (100)	0.94 ± 0.33 (0.43-1.55)

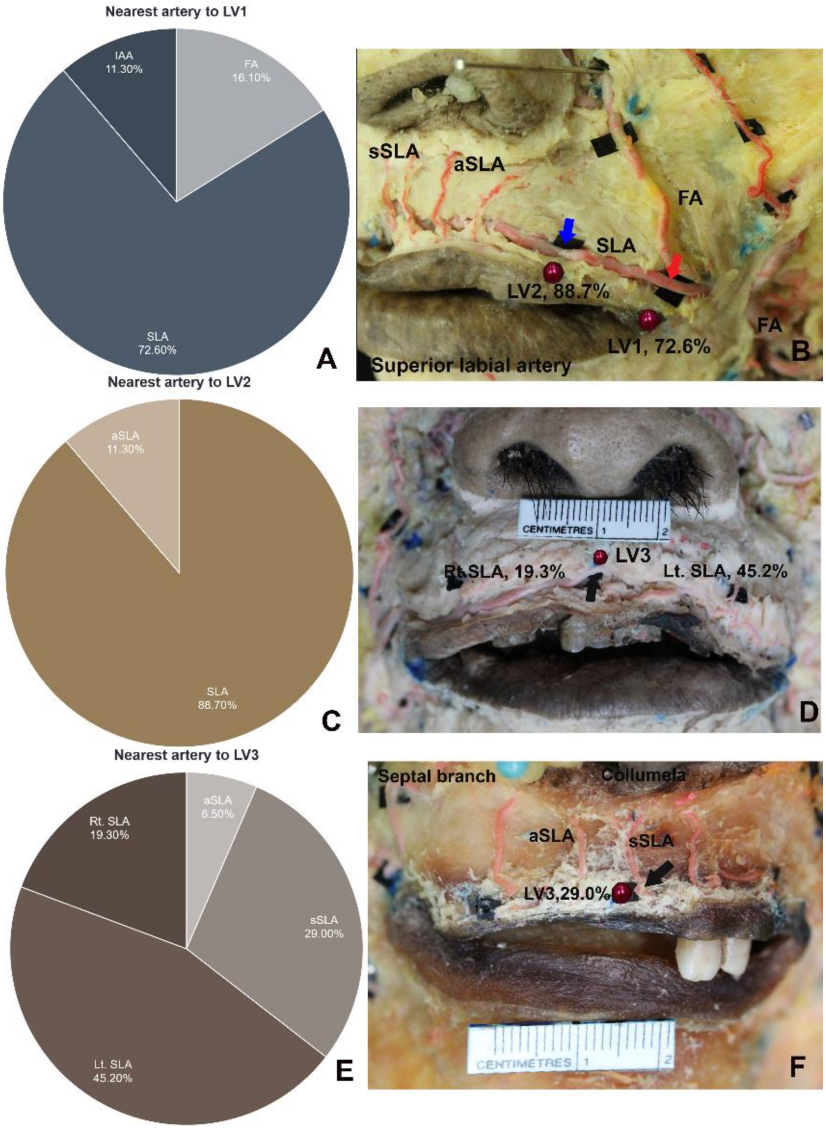


Figure 48 The nearest artery to LV landmarks (A-F) (arrow head); B and D: superior labial locating nearest to all LV landmarks; F: septal branch of superior labial artery locating nearest to LV3 landmarks

The involved nearest artery to LV2 injection site consisted of SLA and ascending branch of SLA (aSLA) (Table 28 Figure 48C). In most cases (55 of 62 cases (88.7%)), the nearest artery to LV2 was SLA (Figure 48B), whereas the aSLA was found placing nearest to LV2 in 7 of 62 cases (11.3%). The mean diameter of SLA was 1.17 ± 0.43 mm, and outer diameter of aSLA was 0.75 ± 0.23 mm. There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this LV2 landmark. According to arterial locations (Table 29 and Figure 49, middle), the nearest artery located inferior to LV2 in 21 cases (33.9%) with 2.02 ± 0.83 mm along Y-axis. However, the nearest artery directly placed at the LV2 landmark (Type IX) in 17 of 62 cases (27.4%). In Type VIII (14 of 62 cases (22.6%)), the nearby artery to LV2 located superior to landmark with 2.59 ± 1.28 mm of Y distance. Additionally, the Type V (medial) was found in 4 cases (6.5%). The distance of this type was 1.27 ± 0.50 mm with X-axis. The Type VI which the nearest artery positioned lateral to LV1 was found in 3 cases (4.8%), and the distance was 1.80 ± 1.14 mm along X-axis. The Type IV (superolateral) and Type I (inferomedial) were found in 2 cases (3.2%) and 1 cases (1.6%), respectively. The distances of Type IV were 1.11 ± 0.16 mm at X-axis and 1.09 ± 0.33 mm at Y-axis (Table 29 and Figure 49, middle). For the fascial tissue layers of the nearest artery to LV2 landmark, the artery stayed inside the orbicularis oris muscle in most cases (54 of 62 cases (87.1%)) , and the arterial depth correlated to this layer was 4.11 ± 2.40 mm. In 6 of 62 cases (9.7%), the other was found locating in the submucosa layer with the depth from the vermillion surface of 5.90 ± 4.02 mm. The supramuscular and subcutaneaous layer were resident of nearest artery in one case (Table 30).

Table 29. The distance from each LV landmark to the nearest artery based on types of arterial location

Types of arterial location	Land-marks	N (%)	Distance of artery with X-axis Mean ± SD (Range)(mm)	Distance of artery with Y-axis Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	LV1	0 (0)	-	-
	LV2	1 (1.6)	1.70	2.27
	LV3	0 (0)	-	-
IV. Superolateral (+X, +Y)	LV1	28 (45.2)	3.15 ± 0.90 (1.43 - 4.54)	3.92 ± 1.56 (1.53 - 7.74)
	LV2	2 (3.2)	1.11 ± 0.16 (1.00 - 1.22)	1.09 ± 0.33 (0.85 - 1.32)
	LV3	0 (0)	-	-
V. Medial (-X,Y_0)	LV1	0 (0)	-	-
	LV2	4 (6.5)	1.27 ± 0.50 (0.76 - 1.78)	0
	LV3	0 (0)	-	-
VI. Lateral (+X,Y_0)	LV1	10 (16.1)	3.04 ± 1.64 (0.98 - 6.15)	0
	LV2	3 (4.8)	1.80 ± 1.14 (0.89 - 3.08)	0
	LV3	13 (41.9)	1.71 ± 1.08 (0.54 - 4.95)	0
VII. Inferior (X_0, -Y)	LV1	3 (4.8)	0	3.88 ± 2.74 (0.72 - 5.65)
	LV2	21 (33.9)	0	2.02 ± 0.83 (0.73 - 2.02)
	LV3	8	0	1.67 ± 0.73

		(29.0)		(0.85 - 2.94)
VIII. Superior (X_0, +Y)	LV1	20 (32.3)	0	4.93 ± 1.91 (1.62 - 9.18)
	LV2	14 (22.6)	0	2.59 ± 1.28 (1.03 - 4.99)
	LV3	5 (16.1)	0	3.32 ± 2.75 (0.79 - 7.00)
IX. At landmark (X_0, Y_0)	LV1	1 (1.6)	0	0
	LV2	17 (27.4)	0	0
	LV3	4 (12.9)	0	0

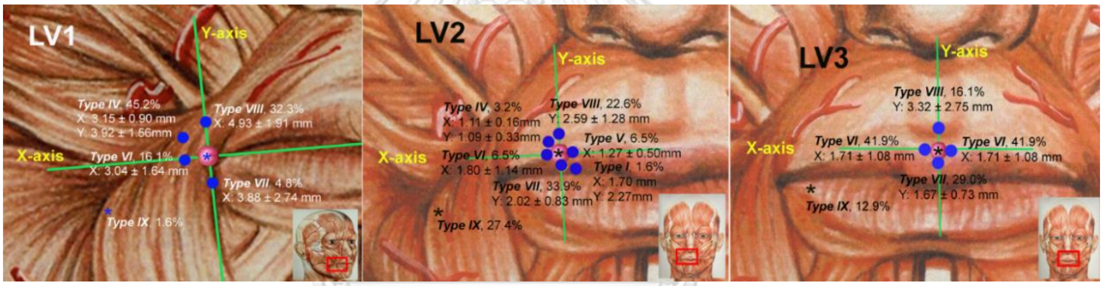


Figure 49 The nearest arterial location relative to LV1 (left), LV2 (middle) and LV3 (right) injection sites

For the LV3 nearest artery total 31 specimen, the nearest artery was left SLA in most cases (14 cases (45.2%)), while the septal branch of SLA (sSLA) was found in 9 cases (29.0%) (Figure 48D and F). The external diameter of left SLA was 0.93 ± 0.28, and the diameter of sSLA was 0.93 ± 0.43 mm. The aSLA and right SLA were discovered in 2 cases (6.5%) and 6 cases (19.3%), respectively (Table 28 and Figure 48E). There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this LV3 landmark. The study of correlation between nearest artery and LV3 injection sites represented that the closest artery located in lateral (Type VI) in 13 of 31 (41.9) cases, and inferior (Type VII) with 8 cases (29.0%) (Table 29 and Figure 49, right). The X distance of Type VI was 1.71 ± 1.08 mm, while the Y distance of Type VII was 1.67 ± 0.73 mm. In 5 cases (16.1%), the nearest artery placed superior to LV3 (Type VIII) with the distance of 3.32 ± 2.75 mm along Y-axis. However, Type IX (at landmark) were found in 4 cases (12.9%) (Table 29). The fascial tissue layer which the LV3 nearest artery located in most cases (19 cases (61.3%)) was the intramuscular layer (orbicularis oris muscle) with the depth to nearest along this layer of 4. 97 ± 2.75 mm. In 9 of 31 cases (29.0%), the nearest artery placed in the submuscular layer with the depth of 5.30 ± 2.23 mm. Furthermore, the closest artery located in subcutaneous layer in 2 cases (6.5%). Additionally, supramuscular layer were individually found in one case (Table 30).

Table 30. Relationship between the location of the nearest artery and fascial tissue layers at each LV landmarks, and the depth from the skin to nearest artery

Fascial layers	**Depth from the skin to nearest arteries of LV landmarks**					
	LV1					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Supramuscular (orbicularis oris)	1 (1.6)	2.19	0 (0)	-	1 (2.9)	2.19
Intramuscular (orbicularis oris)	58 (93.5)	3.85 ± 2.00 (1.71 – 10.50)	25 (89.3)	3.65 ± 1.93 (1.71 – 10.50)	33 (97.1)	4.01 ± 2.06 (1.87 – 9.90)
Submucosa	3 (4.8)	6.49 ± 3.26 (3.27 – 9.87)	3 (10.7)	6.49 ± 3.26 (3.27 – 9.87)	0 (0)	-
Total	62 (100)		28 (100)		34 (100)	

Table 30. Relationship between the location of the nearest artery and fascial tissue layers at each LV landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	**Depth from the skin to nearest arteries of LV landmarks**					
	LV2					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	1 (1.6)	2.75	1 (3.6)	2.75	0 (0)	-
Supramuscular	1 (1.6)	1.18	0 (0)	-	1 (2.9)	1.18
Intramuscular	54 (87.1)	4.11 ± 2.40 (1.56 – 11.92)	23 (82.1)	3.25 ± 1.21 (1.99 – 7.07)	31 (91.2)	4.76 ± 2.85 (1.56 – 11.92)
Submucosa	6 (9.7)	5.90 ± 4.02 (2.72 - 12.33)	4 (14.3)	6.92 ± 4.71 (2.72 – 12.33)	2 (5.9)	3.87 – 1.32 (2.94 – 4.80)
Total	62 (100)		28 (100)		34 (100)	

Table 30. Relationship between the location of the nearest artery and fascial tissue layers at each LV landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	Depth from the skin to nearest arteries of LV landmarks					
	LV3					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	2 (6.5)	3.92 ± 0.68 (3.33 – 4.51)	1 (7.1)	4.51	1 (5.9)	3.33
Supramuscular	1 (3.2)	2.75	0 (0)	-	1 (5.9)	2.75
Intramuscular	19 (61.3)	4. 97 ± 2.75 (2.27 – 10.45)	8 (57.3)	4.18 ± 2.68 (2.27 – 10.30)	11 (64.7)	5.55 ± 2.71 (2.62 – 10.45)
Submucosa	9 (29.0)	5.30 ± 2.23 (2.44 – 8.88)	5 (35.7)	4.78 ± 1.64 (3.21 – 7.58)	4 (8.5)	5.96 ± 2.79 (2.44 – 8.88)
Total	31 (100)		14 (100)		17 (100)	

➢ ***Nearest artery to Chin (CN) injection site***

The main nearest artery to CN landmark was the submental artery (SMA) which was discovered entire 31 cases (Table 31 and Figure 50A). However, it was divided into right and left SMA. The left SMA placed nearest to CN in 12 cases (38.7%) (Figure 50D), while the right SMA positioned closest to landmark in 19 cases (61.3%) (Figure 50C). The right and left SMA diameter was 0.77 ± 0.19 and 0.84 ± 0.29, respectively (Table 31).

Table 31. Frequencies of the nearest artery at chin (CN) landmark and its external diameter

Nearest arteries	**Diameter of nearest arteries to CN landmark**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**	**N (%)**	**Mean ± SD (Range)(mm)**
Left submental artery (ltSMA)	12 (38.7)	0.84 ± 0.29 (0.42-1.35)	8 (57.1)	0.85 ± 0.22 (0.53-1.12)	4 (23.5)	0.81 ± 0.43 (0.42-1.35)
Right submental artery (rtSMA)	19 (61.3)	0.77 ± 0.19 (0.47-1.14)	6 (42.9)	0.87 ± 0.23 (0.57-1.14)	13 (76.5)	0.72 ± 0.15 (0.47-0.96)
Total	31 (100)	0.80 ± 0.23 (0.42-1.35)	14 (100)	0.86 ± 0.22	17 (100)	0.74 ± 0.23 (0.42-1.35)

There were two types of nearest arterial locations: Type III (inferolateral) and Type VI (lateral) (Table 32 and Figure 50B). In most case (30 cases (96.8%)), the nearest artery located lateral to CN with 5.50 ± 4.33 mm along Y-axis. The type III was found in one case (3.2%). The X and Y distance between landmark and nearest artery was 11.85 and 4.93 mm, respectively (Table 32).

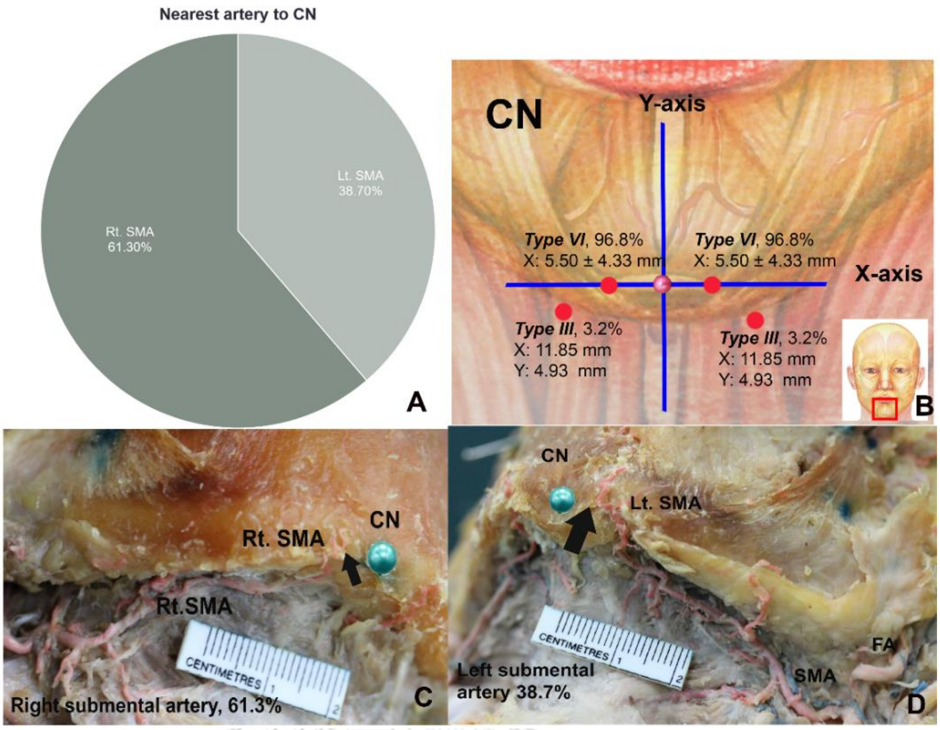


Figure 50 The nearest artery and the locations of such artery (A and B); C: right SMA locating nearest to CN and D: the left SMA placing nearest to CN

Table 32. The distance from CN landmark to the nearest artery based on types of arterial location

Types of arterial location	N	Distance of artery with X-axis	Distance of artery with Y-axis
		Mean ± SD (Range)(mm)	**Mean ± SD (Range)(mm)**
III. Inferolateral (+X, -Y)	1 (3.2)	11.85	4.93
VI. Lateral (+X,Y_0)	30 (96.8)	5.50 ± 4.33 (0.96 - 18.05)	0
Total	31 (100)		

The study of nearest arterial location and fascial tissue layer at chin area exhibited that the nearest artery lined supramuscular layer (mentalis, depressor labii inferioris and depressor anguli oris muscle) in most cases (12 cases (38.7%)), and its depth from the skin of 4.53 ± 1.96 mm. Both of subcutaneous and intramuscular (mentalis muscle) were equally found in 9 cases (29.0%). The arterial lining of subcutaneous and intramuscular layer were 1.79 ± 0.70 mm and 3.22 ± 1.28 mm, respectively. In addition, the submuscular layer (depressor anguli oris) were found as the nearest arterial lining plane in once case (Table 33).

Table 33. Relationship between the location of the nearest artery and fascial tissue layers at CN landmark, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of CN landmark**					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Subcutaneous	9 (29.0)	1.79 ± 0.70 (0.94 – 2.68)	4 (28.6)	1.49 ± 0.63 (0.94 – 2.44)	5 (29.4)	2.02 ± 0.69 (0.98 – 2.68)
Supramuscular	12 (38.7)	4.53 ± 1.96 (1.21 – 8.58)	7 (50.0)	4.39 ± 1.91 (2.35 – 8.58)	5 (29.4)	4.73 ± 2.10 (1.21 – 6.87)
Intramuscular	9 (29.0)	3.22 ± 1.28 (2.08 – 5.39)	3 (21.4)	3.65 ± 1.33 (2.72 – 5.36)	6 (35.3)	3.00 ± 1.26 (2.08 – 5.39)
Submuscular	1 (3.2)	7.95	0 (0)	-	1 (5.9)	7.95
Total	31 (100)		14 (100)		17 (100)	

➢ *Nearest artery to Jawline (JL) injection site*

The JL injection site was set as landmark at the mandibular angle. The nearest arteries to JL landmark were the FA and the masseteric branch of FA (mbFA) (Table 34 and Figure 51A). In most cases (55 of 62 cases (88.7%)), the nearest artery to JL was FA (Figure 51C), while the masseteric branch of FA located closest to JL in remained 7 cases (11.3) (Table 34 and Figure 51D). The external diameter of FA was 2.56 ± 0.64 mm, and the mean diameter of mbFA was 0.94 ± 0.20 mm. There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this JL landmark.

Table 34. Frequencies of the nearest artery at jawline (JL) landmark and its external diameter

Nearest arteries	Diameter of nearest arteries to JL landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Facial artery (FA)	55 (88.7)	2.56 ± 0.64 (1.14-4.44)	21 (75.0)	2.63 ± 0.54 (1.63-3.57)	34 (100)	2.52 ± 0.70 (1.14-4.44)
Masseteric branch of FA (mbFA)	7 (11.3)	0.94 ± 0.20 (0.70-1.19)	7 (25.0)	0.94 ± 0.20 (0.70-1.19)	-	-
Total	62 (100)	2.38 ± 0.80 (0.70-4.44)	28	2.21 ± 0.89 (0.70-3.57)	34 (100)	2.52 ± 0.70 (1.14-4.44)

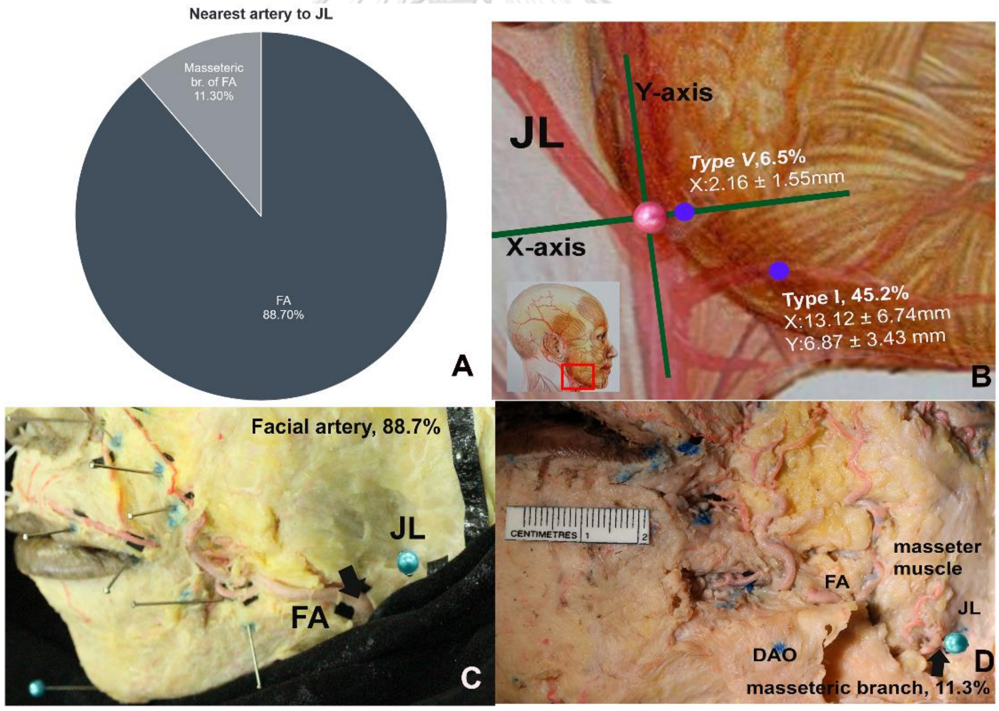


Figure 51 The nearest artery and is relationship to JL landmarks (A-D); B: the arterial location relative to JL landmark; C: the facial artery locating nearest to JL (arrow); D: the masseteric branch of facial artery locating nearest to JL (arrow)

Two types of nearest arterial location including Type I (28 of 62 cases (45.5%)) and Type V (34 of 62 cases (54.8%)) were discovered in the study of relationship between nearest artery and JL landmark (Table 35 and Figure 51B). In Type I, the nearest artery located inferomedial to JL, and the distances were 13.12 ± 6.74 mm along X-axis and 6.87 ± 3.43 mm along Y-axis. Moreover, the nearest artery placed medial to landmark in Type V with the distance of 12.21 ± 4.90 mm at X- axis (Table 35).

Table 35. The distance from JL landmark to the nearest artery based on types of arterial location

Types of arterial location	**N (%)**	**Distance of artery with X-axis**	**Distance of artery with Y-axis**
		Mean ± SD (Range)(mm)	**Mean ± SD (Range)(mm)**
I. Inferomedial (-X, -Y)	28 (45.2)	13.12 ± 6.74 (1.38 - 29.12)	6.87 ± 3.43 (2.42 - 15.22)
V. Medial (-X, Y_0)	34 (54.8)	12.21 ± 4.90 (2.56 - 23.41)	0
Total	62 (100)		

However, the investigation of nearest arterial lining layer showed that the closest artery of all 62 cases placed underneath platysma muscle (submuscular layer) with the depth of 5.35 ± 2.70 mm (Table 36).

Table 36. Relationship between the location of the nearest artery and fascial tissue layers at JL landmark, and the depth from the skin to nearest artery

Fascial layers	Depth from the skin to nearest arteries of JL landmark					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Submuscular (platysma m.)	62 (100)	5.35 ± 2.70 (1.27 – 13.17)	28 (100)	4.94 ± 2.71 (2.55 – 13.17)	34 (100)	5.69 ± 2.69 (1.27 – 10.85)
Total	62 (100)		28 (45.2)		34 (54.8)	

➢ ***Nearest artery to Marionette (MN) injection site***

The marionette line (MN) was divided into MN1 (inferior margin) and MN2 (marionette line at mid pupillary line) for examining the nearest artery. However, the specific related arteries to MN landmarks was infererior labial artery (ILA), labiomental artery (LMA), and main FA (Table 37 and Figure 52A and B).

According to closest artery of MN1, the LMA was chiefly found locating nearest to MN1 in 38 of 62 cases (61.3%) (Figure 52C). The external diameter of LMA was 1.05 ± 0.58 mm. Whereas, both FA and ILA placed closest to MN1 in 23 cases (37.1%) and 1 cases (1.6%) (Table 37 and Figure 52D and E). The FA and ILA external diameter was 2.15 ± 0.61 mm and 1.66 mm, respectively. There was no statistical significance (p-value>0.05) when comparing vessel diameters between genders at this MN1 landmark.

The exploration of the relationship between nearest artery and its location found that the nearest artery mostly located superior to MN1 landmark (25 of 62 cases (40.3%)) (Table 38 and Figure 52F). The Y distance following this type was 5.91 ± 3.93 mm. In 8 cases (12.9%), the nearest artery located in the superomedial direction (Type II). The X and Y distances were 3.08 ± 2.70 mm and 5.32 ± 3.32 mm, respectively.

However, four types including Type IV (superolateral), Type VI (lateral), Type VII (inferior) and Type IX (at landmark) were each individually found in 7 cases (11.3%). The distance of Type IV was 3.66 ± 1.66 mm along X-axis, while the distance was 6.45 ± 3.86 mm along Y-axis. The X distance of Type VI and The Y distance of VII were 4.57 ± 2.82 mm and 2.22 ± 1.08 mm, respectively. Finally, the Type III which the nearest artery located inferolateral to MN was found in only single cases (Table 38 and Figure 52F). The involved fascial tissue layer of MN1 nearest artery was exhibited in table 39. In most cases (52 of 62 cases (83.9%)), the nearest artery positioned below the depressor anguli oris muscle (submuscular layer) with the depth from the skin of 4.07 ± 1.87 mm. The nearest artery located within the depressor labii inferioris muscle in 8 of 62 cases (12.9%), and it also lined at supraperiosteal layer in 2 cases (3.2%). The arterial depth associated with intramuscular was 4.03 ± 1.44 mm, while the arterial depth was 4.47 ± 1.17 mm in the supraperiosteum layer (Table 39).

Table 37. Frequencies of the nearest artery at each marionette (MN) landmarks and its external diameter

Nearest arteries	Diameter of nearest arteries to MN landmarks					
	MN1					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Inferior labial artery (ILA)	1 (1.6)	1.66	-	-	1 (2.9)	1.66
Labiomental artery (LMA)	38 (61.3)	1.05 ± 0.58 (0.34-2.47)	14 (50.0)	1.16 ± 0.65 (0.34-2.47)	24 (70.6)	0.99 ± 0.54 (0.47-2.35)
Facial artery (FA)	23 (37.1)	2.15 ± 0.61 (1.18-3.51)	14 (50.0)	2.23 ± 0.59 (1.18-3.44)	9 (26.5)	2.04 ± 0.65 (1.27-3.51)
Total	62 (100)	1.47 ± 0.79 (0.34-3.51)	28 (100)	1.69 ± 0.82 (0.34-3.44)	34 (100)	1.29 ± 0.73 (0.47-3.51)

Table 37. Frequencies of the nearest artery at each marionette (MN) landmarks and its external diameter (Cont.)

Nearest arteries	Diameter of nearest arteries to MN landmarks					
	MN2					
	Total		Male		Female	
	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)	N (%)	Mean ± SD (Range)(mm)
Inferior labial artery (ILA)	16 (25.8)	0.95 ± 0.55 (0.32-2.32)	6 (21.4)	0.96 ± 0.41 (0.43-1.66)	10 (29.4)	0.94 ± 0.65 (0.32-2.32)
Labiomental artery (LMA)	29 (46.8)	1.08 ± 0.46 (0.37-2.22)	9 (32.1)	1.07 ± 0.45 (0.55-1.95)	20 (58.8)	1.08 ± 0.47 (0.37-2.22)
Facial artery (FA)	17 (27.4)	1.98 ± 0.45 (1.05-2.86)	13 (46.4)	1.97 ± 0.51 (1.05-2.86)	4 (11.8)	2.01 ± 0.20 (1.81-2.25)
Total	62 (100)	1.29 ± 0.64 (0.32-2.86)	28 (100)	1.46 ± 0.66 (0.43-2.86)	34 (100)	1.15 ± 0.59 (0.32-2.32)

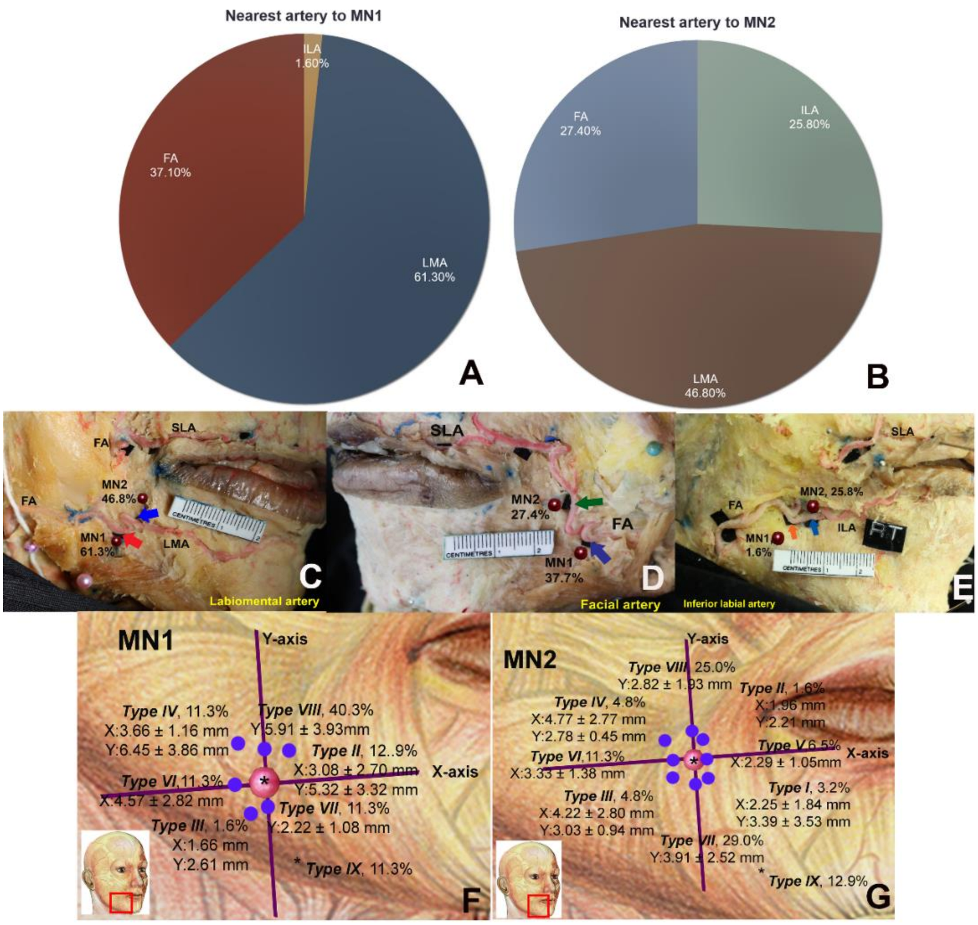


Figure 52 The nearest artery to MN landmarks (A-E) (arrow); C: labiomental artery; D: the facial artery; E: inferior labial artery; F: the relationship between nearest artery and MN1 landmarks and G: location of nearest artery relative to MN2 landmark

Table 38. The distance from each MN landmarks to the nearest artery based on types of arterial location

Types of arterial location	Land-marks	N (%)	Distance of artery with X-axis Mean ± SD (Range)(mm)	Distance of artery with Y-axis Mean ± SD (Range)(mm)
I. Inferomedial (-X, -Y)	MN1	0 (0)	-	-
	MN2	2 (3.2)	2.25 ± 1.84 (0.95 - 3.55)	3.39 ± 3.53 (0.90 - 5.89)
II. Superomedial (-X, +Y)	MN1	8 (12.9)	3.08 ± 2.70 (1.06 - 9.39)	5.32 ± 3.32 (1.59 - 10.11)
	MN2	1 (1.6)	1.96	2.21
III. Inferolateral (+X, -Y)	MN1	1 (1.6)	1.66	2.61
	MN2	3 (4.8)	4.22 ± 2.80 (2.51 - 7.45)	3.03 ± 0.94 (1.99 - 3.83)
IV. Superolateral (+X, +Y)	MN1	7 (11.3)	3.66 ± 1.16 (1.54 - 5.16)	6.45 ± 3.86 (1.96 - 13.95)
	MN2	3 (4.8)	4.77 ± 2.77 (2.42 - 7.42)	2.78 ± 0.45 (2.42 - 3.28)
V. Medial (-X, Y_0)	MN1	0 (0)	-	-
	MN2	4 (6.5)	2.29 ± 1.05 (1.33 - 3.52)	0
VI. Lateral (+X,Y_0)	MN1	7 (11.3)	4.57 ± 2.82 (0.89 - 8.51)	0
	MN2	7 (11.3)	3.33 ± 1.38 (1.54 - 4.96)	0
VII. Inferior (X_0, -Y)	MN1	7 (11.3)	0	2.22 ± 1.08 (1.21 - 4.48)
	MN2	18 (29.0)	0	3.91 ± 2.52 (0.77 - 8.79)
VIII. Superior	MN1	25	0	5.91 ± 3.93

$(X_0, +Y)$		(40.3)		(1.09 - 15.91)
	MN2	16 (25.0)	0	2.82 ± 1.93 (0.84 - 6.67)
IX. At landmark (X_0, Y_0)	MN1	7 (11.3)	0	0
	MN2	8 (12.9)	0	0

At MN2 landmark, the common nearest artery of 62 cases was LMA (29 cases (46.8%)) (Figure 52C), and its diameter was 1.08 ± 0.46 mm. Whereas, the FA and ILA were found placing closest to MN2 landmark in 17 cases (27.7%) and 16 cases (25.8%), respectively (Table 37 and Figure 52C and D). The external dimeter of FA was 1.98 ± 0.45 mm, and the outer diameter of ILA was 0.95 ± 0.55 mm. There was statistical significance (p-value≤0.05) when comparing vessel diameters between genders at this MN2 landmark. The study of relationship between the nearest artery and MN2 landmark was showed in Table 38 and Figure 52G. The most of nearest artery (18 of 62 cases (29.0%)) located inferior (Type VII) to MN2 landmark. The distance Y following such type was 3.91 ± 2.52 mm. Nevertheless, the nearest artery placed superior (Type VIII) to MN2 landmark in 16 cases (25.0%) with 2.82 ± 1.93 mm of Y distance. In 8 cases (12.9%), the nearest artery placed honestly at MN2 landmark. The Type VI (lateral) and Type V (medial) were found in 7 cases (11.3%) and 4 (6.5%) cases, respectively. The X distance of Type VI was 3.33 ± 1.38 mm, while the distance of Type V was 2.29 ± 1.05 mm along X-axis. Both of Type III (inferolateral) and Type IV (superolateral) were equally discovered in 3 cases (4.8%). The X and Y distances of Type III were 4.22 ± 2.80 mm and 3.03 ± 0.94 mm, respectively. In Type IV, the distances were 4.77 ± 2.77 mm with X-axis and 2.78 ± 0.45 with Y-axis. Moreover, the Type I (inferomedial) was found in 2 cases (3.2%), while the Type II (superomedial) was faced in only one case. The measurement of the distance along X-axis of Type I was 2.25 ± 1.84 mm, and the distance along Y-axis was 3.39 ± 3.53 mm (Table 38). As showed in Table 39, the closest artery to MN2 located behind submucosa layer in 52 of 62 cases (83.9%) with the depth from the skin of 4.27 ± 1.63 mm. Whereas, the arterial lining in depressor labii inferioris muscle was observed in 8 cases (12.9%), and the nearest arterial depth of this layer was 3.73 ± 2.12 mm. The supraperiosteal and subcutaneous layers was found one case (Table 39).

Table 39. Relationship between the location of the nearest artery and fascial tissue layers at MN landmarks, and the depth from the skin to nearest artery

Facial layers	**Depth from the skin to nearest arteries of MN landmarks**					
	MN1					
	Total		**Male**		**Female**	
	N (%)	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**	**N (%)**	**Mean ± SD (Range) (mm)**
Supraperiosteum	2 3.2	4.47 ± 1.17 (3.64 – 5.29)	0 (0)	-	2 (5.9)	4.47 ± 1.17 (3.64 – 5.29)
Intramuscular	8 12.9	4.03 ± 1.44 (2.21 – 6.55)	2 (7.1)	3.38 ± 1.65 (2.21 – 4.55)	6 (17.6)	4.24 ± 1.46 (2.37 – 6.55)
Submuscular/ submucosa	52 83.9	4.07 ± 1.87 (1.25 – 11.53)	26 (92.9)	4.16 ± 1.58 (1.82 – 7.66)	26 (76.5)	3.97 ± 2.15 (1.25 – 11.53)
Total	62 (100)		28 (100)		34 (100)	

Table 39. Relationship between the location of the nearest artery and fascial tissue layers at MN landmarks, and the depth from the skin to nearest artery (Cont.)

Facial layers	Depth from the skin to nearest arteries of MN landmarks					
	MN2					
	Total		Male		Female	
	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)	N (%)	Mean ± SD (Range) (mm)
Subcutaneous	1 (1.6)	2.84	1 (3.6)	2.84	0 (0)	-
Intramuscular	8 (12.9)	3.73 ± 2.12 (2.58 – 8.92)	1 (3.6)	3.34	7 (20.6)	3.78 ± 2.28 (2.58 – 8.92)
Submuscular/ submucosa	52 (83.9)	4.27 ± 1.63 (1.81 – 9.71)	26 (92.9)	4.65 ± 1.76 (1.81 – 9.17)	26 (76.5)	3.87 ± 1.41 (2.07 – 8.11)
Supraperiosteum	1 (1.6)	5.33	0 (0)	-	1 (2.9)	5.33
Total	62 (100)		28 (100)		34 (100)	

4.2 Arterial anastomosis of the face

This Sihler's staining method was provided for studying the anastomotic pattern, the number of anastomoses and diameter of the anastomotic branches of the facial, ophthalmic, and superficial temporal, infraorbital artery, transverse facial artery and their branches with the neighboring arteries which correlated to the nearest artery of all injection sites. Furthermore, the anastomosis of the artery between right- left sides and between the upper face, middle face and lower face were explored in this study.

According the observation of the anastomotic pattern of arteries, there were classified into two types: end- end type and end- side type. The communication between terminal branches of two arteries was grouped for end-end type, while the connection between terminal branch and the arterial wall of each other arteries was defined as end-side type.

4.2.1 The arterial anastomosis in 20 hemi-faces, anastomosis patterns, number of anastomosis and diameter of anastomotic point

The analyzed data of arterial anastomoses in 20 hemi-faces using modified Sihler's staining procedure found that there were various anastomotic patterns involved with the arteries of the face. However, we investigated the arterial anastomosis of the upper face (Table 40), middle face (Table 41), and lower face (Table 42). Moreover, the arterial communication between the upper, middle and lower face was also examined (Table 43).

4.2.1.1 The anastomosis of arteries of the upper face

The anastomoses of the upper face region was composed of arterial branch both internal and external carotid system. The results in this study was found as followed

- SOA – STCA

The SOA was the direct branch of OA to supply the forehead area. The SOA usually anastomosed with the supratrochlear artery (STCA) in 12 of 20 cases (60.0%) (Table 40 and Figure 53). However, the end- end anastomotic pattern was found in 11 of 12 cases (91.7%). The number of anastomosis following this pattern was 1.18 (min-max: 1-2), and its anastomotic diameter was 0.22 ± 0.06 mm. In 2 of 12 cases (16.7%), the pattern of SOA-STCA connection was end-side type with one of the anastomotic number. The diameter following this types was 0.37 ± 0.18 mm (Table 40).

➢ SOA – ZOA

In the others communication of SOA, it also connected with the ZOA in 2 of 20 cases (10.0%) (Figure 53B). The ZOA was ramified from STA and traveled transversely along the zygomatic bone to supply the temporal area. Then, the terminal branch of ZOA merged with the terminal branch of SOA (BBSOA or LRBSOA) known as end-end type. This type was found in entire cases (100%) of SOA-ZOA connection with only one of anastomotic number. The anastomotic diameter of SOA-ZOA was 0.27 ± 0.01 mm. (Table 40 and Figure 53B).

➢ frSTA – STCA

The STA was the arterial branch from external carotid system. However, its frontal branch frequently communicated with the STCA from internal carotid system. In this study, the frSTA- STCA anastomosis was found in 9 of 20 cases (45.0%) (Figure 53C). The anastomosis was end- end type, communicating between peripheral branches of both arteries, in 4 of 9 cases (44.4%). The number following this pattern was 1.50 (min-max: 1-2) and the anastomotic diameter was 0.27 ± 0.11 mm. For the remained type, the end- side anastomosis type was found in 7 of 9 cases (77.8%) with one of anastomotic point. Moreover, the diameter of this anastomotic point was 0.35 ± 0.14 mm (Table 40 and Figure 53C).

➢ frSTA – SOA

Additionally, the frSTA provided the connection with SOA which emerged from OA through either supraorbital notch or foramen. Following this study, the frSTA- SOA communication was largely found in 19 of 20 cases (95.0%) (Figure 53D). Both end-end and end- side anastomotic types were equally found in 12 of 19 cases (63.2%). The number of anastomosis in end- end type was 1.58 (min- max: 1-4), while the amount of end- side type was 1.92 (min-max: 1-4). Moreover, the end- end and the end – side anastomotic diameters were 0.30 ± 0.07 mm and 0.32 ± 0.05 mm, respectively (Table 40 and Figure 53D).

- desSTA – ZOA

Furthermore, the frSTA also connected with ZOA which arose from main STA (7 of 20 cases (35.0%)) (Figure 53D). The arterial anastomosis was mainly found with end- end type (5 of 7 cases (71.4%)). Following this type, the desSTA released the terminal branch to join with the superior terminal branch of ZOA. The number of anastomotic point was 1.20 (min- max: 1-2) in these type. However, the end- side type was found in 2 of 7 cases (28.6%), and the number of arterial connection was only one. The results of anastomotic diameter showed that it was 0.23 ± 0.07 mm for end-side type, and 0.27 ± 0.06 mm for end-side type (Table 40).

- ZOA – ZFA

The ZOA which branched of STA communicated with ZFA in 1 of 20 cases (5.0%). The number of anastomotic correlated with end- side type was one. The anastomotic diameter was 0.28 mm (Table 40).

Table 40. The arterial anastomotic patterns, number of anastomosis and the anastomotic diameter of arteries of the upper face

Anasto-motic patterns	N (%) 20 (100)	End to End type			End to Side type		
		N (%)	Number Mean ± SD (Range) (mm)	Diameter Mean ± SD (Range) (mm)	N (%)	Number Mean ± SD (Range) (mm)	Diameter Mean ± SD (Range) (mm)
SOA – STCA	12 (60%)	11 (91.7%)	1.18 ± 0.40 (1.00 - 2.00)	0.22 ± 0.06 (0.15 - 0.32)	2 (16.7%)	1.00	0.37 ± 0.18 (0.24 - 0.50)
SOA – ZOA	2 (10%)	2 (100%)	1.00	0.27 ± 0.01 (0.27 - 0.27)	0 (0%)	-	-
frSTA – STCA	9 (45%)	4 (44.4%)	1.50 ± 0.56 (1.00 - 2.00)	0.27 ± 0.11 (0.20 - 0.43)	7 (77.8%)	1.00	0.35 ± 0.14 (0.25 - 0.63)
frSTA – SOA	19 (95%)	12 (63.2%)	1.58 ± 0.89 (1.00 - 4.00)	0.30 ± 0.07 (0.20 - 0.32)	12 (63.2%)	1.92 ± 0.90 (1.00 - 4.00)	0.32 ± 0.05 (0.23 - 0.43)
desSTA – ZOA	7 (35%)	5 (71.4%)	1.20 ± 1.08 (1.00 - 2.00)	0.23 ± 0.07 (0.13 - 0.32)	2 (28.6%)	1.00	0.27 ± 0.06 (0.23 - 0.32)
ZOA – ZFA	1 (5.0%)	1 (100.0%)	1.00	0.28	0 (0%)	-	-

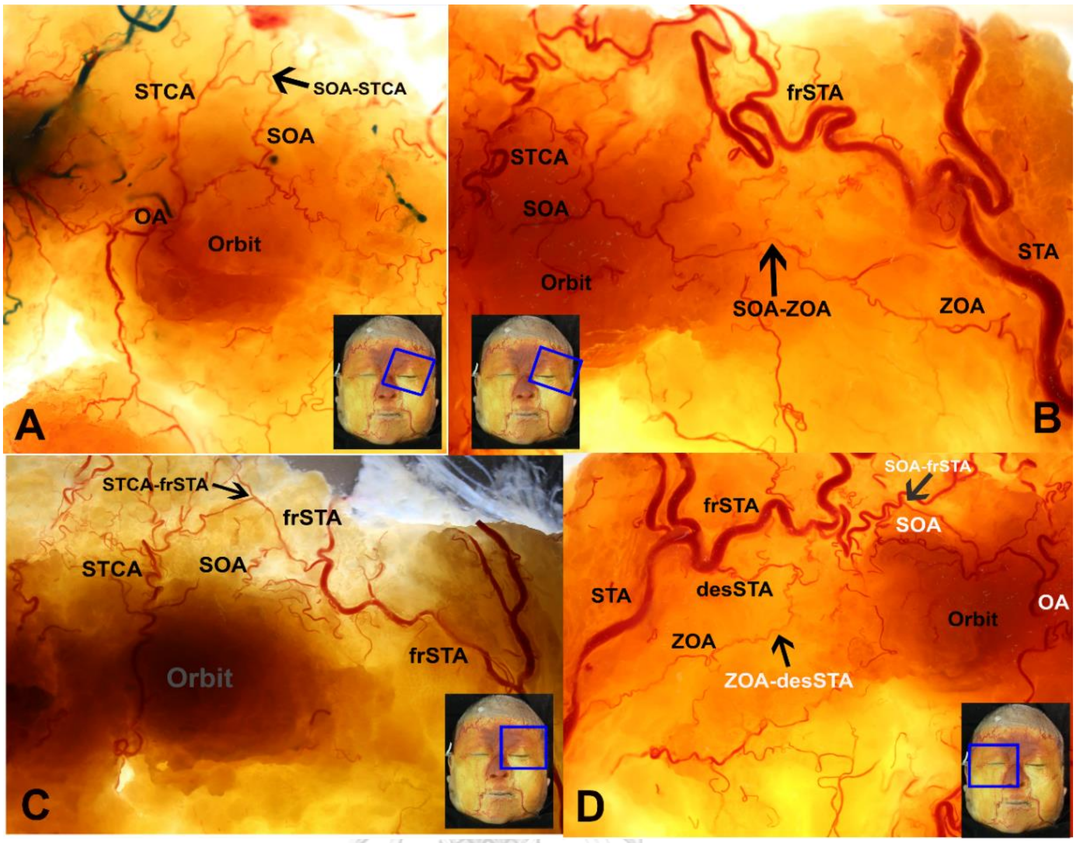


Figure 53 Arterial anastomosis of upper face (arrow head); A: anastomosis between supraorbital artery and supratrochlear artery; B: connection between supraorbital artery and zygomaticoorbital artery; C: anastomosis between supratrochlear and frontal branch of superficial temporal artery and D: anastomosis between descending branch of superficial temporal artery and zygomatico orbital artery and supraorbital artery

4.2.1.2 The anastomosis of arteries of the middle face

➢ AAoa – AAfa

In this study, the angular artery was arose from not only FA (AAfa) but also OA (AAoa). The terminal branch of FA became the angular artery, and then connected with the AAoa which arose from the inferior orbitoglabellar branch of OA was found in 9 of 20 cases (45.0%). The anastomotic pattern of AAoa – AAfa was found in only end-

end type, and the number of anastomosis was one. However, the measurement of the arterial anastomotic diameter was 0.35 ± 0.16 mm (Table 41 and Figure 54A).

- AAoa – pIOA

Moreover, the AAoa also discovered communicating with the IOA in 3 of 20 cases (15.0%). However the IOA which connected with AAoa was the pIOA. The connective patterns were end- end type in 2 of 3 cases (66.7%) and end-side type in 1 cases (33.3%). The anastomotic number of both types was one (Table 43). Whereas the diameter of anastomotic point in end- end type was 0.21 ± 0.04 mm, and diameter of end-side type was 0.36 mm (Table 41 and Figure 54B).

- DNA – LNA

The DNA emerged from the OA to supply the dorsum of the nose. In 15 of 20 cases (75.0%), the DNA anastomosed with the LNA which was the ramification of FA (Figure 54C). Considering of anastomosis patterns, the DNA- LNA connection were mostly found end – side type (14 of 15 cases (93.3%) because the LNA served as terminal branch and communicated with arterial wall of the DNA. The anastomotic number of this type was 1.14 (min- max: 1- 2), and the arterial connective diameter was 0.24 ± 0.08 mm (Table 41). Whereas, the end- end type was found in only one cases and the anastomotic number was one.

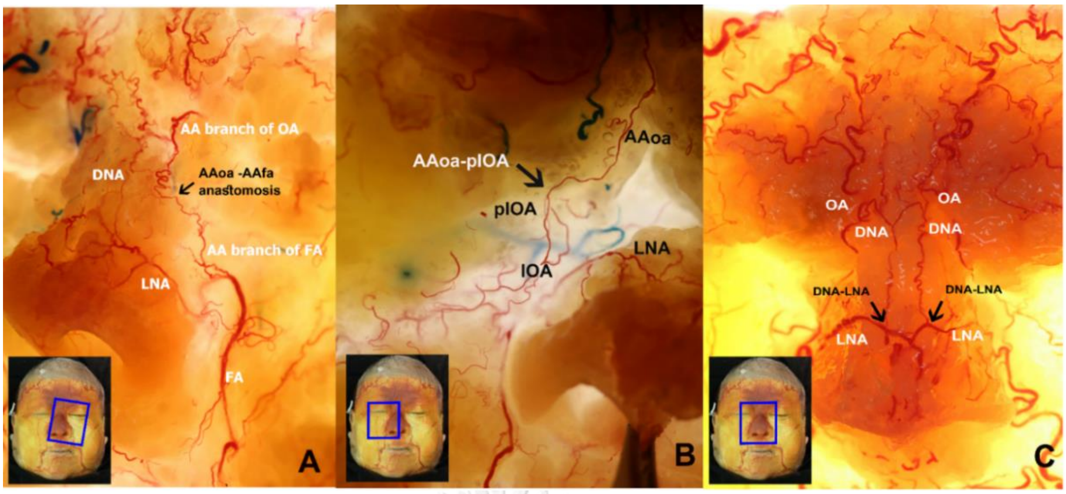


Figure 54 The anastomosis between the internal and external carotid system of the middle face region; A: the connection between AAoa and AAfa; B: end- end anastomosis between AAoa and pIOA; C: the end- side anastomosis between the end of DNA and the lateral side of LNA

➢ FA- TFA

The FA was found anastomosed with the TFA and IOA. The anastomosis between the FA and the TFA was found in 19 of 20 cases (95.0%) (Figure 55A). The connection types of these anastomosis were found both of end-end type (13/19 cases, 68.4%) and end (TFA)–side (FA) type (12/19 cases, 63.2%). In end-end type, the FA gave off small branch prior branching into the ILA, and then anastomosed with the terminal branch of TFA. The number of anastomosis of end-end type was 1.69 (min-max: 1-4), while the number of end-side type was 1.67 (min-max: 1-2) (Table 41). The mean diameter of FA-FTA anastomotic point was 0.27 ± 0.08 mm in end-end type, and was 0.29 ± 0.14 mm in end-side type (Table 41).

➢ FA- IOA

Next, the FA communicated with IOA 19 of 20 cases (95.0%). In 5 of 19 cases (26.3%), the anastomosis was classified as end-end type, and the number of anastomoses was only one. The anastomotic diameter of end-end type was 0.31 ± 0.11 mm. In contrast, the remained 14 of 19 cases (73.7%) was end (IOA) – side (FA) type with the number of connection was 1.57 (min-max, 1-3) (Table 41 and Figure 55B). Moreover, the anastomotic diameter of this type was 0.31 ± 0.11 mm (Table 41).

- TFA – IOA

In 17 of 20 cases (85.0%), the TFA anastomosed with IOA which the emerged from the infraorbital foramen to supply the middle part of middle face (Figure 55C). The end- end type (15 of 17 cases (88.2%)) was found as the connection between the terminal branch of TFA and the peripheral branch of lateral IOA. Whereas, the end-side type was found in 2 of 17 cases (11.8%). The number of arterial anastomosis was 1.47 (min-max: 1-3) in end-end type, and was one in end- side type. (Table 41). Moreover, the anastomotic diameter following end-end type was 0.29 ± 0.13 mm, and the diameter was 0.44 ± 0.07 mm in end- side type (Table 41).

- TFA – AAfa

In addition, the TFA released the terminal branch in order to connect with the lateral arterial wall of AAfa. The anastomosis was found in one of 20 cases (5.0%), and the number of anastomosis was one with 0.30 mm of anastomotic diameter (Table 41 and Figure 55D).

- IOA – AAfa

The IOA produced the medial branch to communicate with AAfa in 2 of 20 cases (10.0%). The total IOA- AAfa anastomosis was end- side type which formed by connecting of peripheral end of IOA and lateral side of AAfa. Moreover, the anastomotic number was one, and the diameter of anastomotic point was 0.28 ± 0.04 mm (Table 41 and Figure 55E).

- IOA – LNA

Additionally, the LNA which arose from FA to supply the lateral of the nose was frequently found communicating with IOA in 12 of 20 case (60.0%). The IOA gave off the small terminal branch to join the lateral arterial wall of LNA. However, this end-side anastomotic type was appeared in all cases with the anastomotic number of 1.42 (min- max: 1-3) (Table 43). The anastomotic diameter was 0.28 ± 0.09 mm (Table 47 and Figure 55F).

Table 41. The arterial anastomotic patterns of arteries of the middle face and its diameter

Anasto-motic patterns	**N (%) 20 (100)**	**End to End type**			**End to Side type**		
		N (%)	**Number** Mean ± SD (Range) (mm)	**Diameter** Mean ± SD (Range) (mm)	**N (%)**	**Number** Mean ± SD (Range) (mm)	**Diameter** Mean ± SD (Range) (mm)
AAoa – AAfa	9 (45%)	9 (100%)	1.00	0.35 ± 0.16 (0.21 - 0.61)	0 (0%)	-	-
AAoa – pIOA	3 (15%)	2 (66.7%)	1.00	0.21 ± 0.04 (0.18 - 0.23)	1(33.3%)	1.00	0.36
DNA – LNA	15 (75%)	1 (6.7%)	1.00	0.53	14 (93.3%)	1.14	0.24 ± 0.08 (0.12 - 0.42)
FA – TFA	19 (95%)	13 (68.4%)	1.69	0.27 ± 0.08 (0.18 - 0.47)	12 (63.2%)	1.67 ± 0.39 (1.00 - 2.00)	0.29 ± 0.14 (0.13 - 0.57)
FA – IOA	19 (95%)	5 (26.3%)	1.00	0.31 ± 0.11 (0.16 - 0.46)	14 (73.7%)	1.57 ± 0.65 (1.00 - 3.00)	0.34 ± 0.10 (0.22 - 0.54)
TFA – IOA	17 (85%)	15 (88.2%)	1.47 ± 0.74 (1.00 - 3.00)	0.29 ± 0.13 (0.18 - 0.67)	2 (11.8%)	1.00	0.44 ± 0.07 (0.39 - 0.49)
TFA – AAfa	1 (5%)	0 (0%)	-	-	1 (100.0%)	1.00	0.30

IOA – AAfa	2 (10%)	0 (0%)	-	-	2 (100.0%)	1.00	0.28 ± 0.04 (0.25 - 0.31)
IOA – LNA	12 (60%)	0 (0%)	-	-	12 (100.0%)	1.42 ± 0.67 (1.00 - 3.00)	0.28 ± 0.09 (0.17 - 0.42)
IOA – DNA	2 (10%)	0 (0%)	-	-	2 (100.0%)	1.00	0.24 ± 0.05 (0.20 - 0.27)

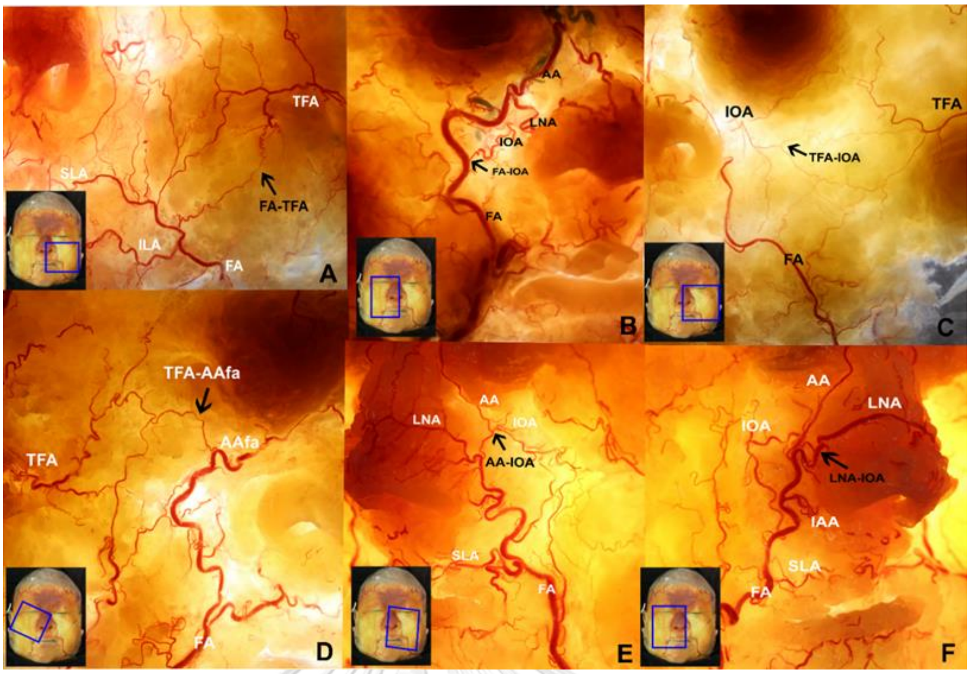


Figure 55 The anastomosis between the arteries of the external carotid system of the middle facial region; A: the FA-TFA communication; B: the connection between FA and IOA; C: the anastomosis of TFA and lateral branch of IOA; D: the anastomosis between pTFA and the AAfa; E: the connection between AA of FA and the branch of IOA; F: IOA and LNA communication

4.2.1.3 The anastomosis of arteries of the lower face

In this study, the main arterial supply area between lower lip and chin was LMA. However, this arterial branch had the communication to others arteries:

- LMA – ILA

Finally, ILA which arose from FA and traveled along lower lip vermilion border also anastomosed with LMA in 8 of 20 cases (40.0%) (Figure 56A). Both end-end type (2 of 8 cases, 25.0%) and end- side type (6 of 8 cases, 75.0%) were found in LMA- ILA anastomosis. The anastomosis number of end-end type was 1.5 (min-max: 1-2), while the amount of connection following end- side type was 1.5 (min-max: 1-2) (Table 42).

The end- end and end- side anastomotic diameters were 0.36 ± 0.29 mm and 0.35 ± 0.17 mm, respectively (Table 42).

- LMA – SMA

The LMA was ramified of FA and ran transversely along mentum to insert the middle part of the lower lip. During its course, terminal branch of SMA which cross the inferior margin of mandible became the anastomosis with the LMA. However, the LMA-SLA was found in 3 of 20 cases (15.0%) and all connections were end- side type with one of the anastomotic number (Table 42 and Figure 56B). Regarding the anastomotic diameter, the measurement was 0.31 ± 0.22 mm (Table 42).

Table 42. The arterial anastomotic patterns of arteries of the lower face and its diameter

Anasto-motic patterns	N (%) 20 (100)	End to End type			End to Side type		
		N (%)	Number	Diameter	N (%)	Number	Diameter
			Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)		Mean ± SD (Range)(mm)	Mean ± SD (Range)(mm)
LMA – SMA	3 (15.0 %)	0 (0%)	-	-	3 (100%)	1.00	0.31 ± 0.22 (0.15 - 0.56)
LMA – ILA	8 (40.0 %)	2 (25.0 %)	1.5 ± 0.71 (1.00 - 2.00)	0.36 ± 0.29 (0.15 - 0.56)	6 (75.0%)	1.5 ± 0.55 (1.00 - 2.00)	0.35 ± 0.17 (0.20 - 0.67)

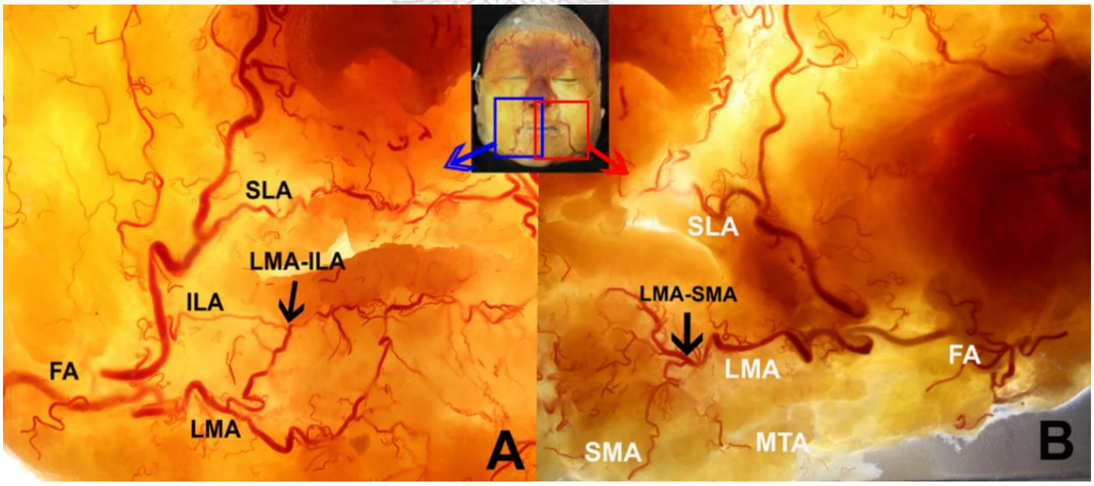


Figure 56 The arterial anastomoses of lower face region; A: the communication between LMA and ILA (arrow); B: connection between LMA and SMA (arrow)

4.2.1.4 The anastomosis between arteries of upper, middle face and lower face

- STA – TFA

The TFA which functioned as arterial supply of the middle face, anastomosed STA in 7 of 20 cases (35.0%) (Figure 57A). In 5 of 7 cases (71.4%), the communication pattern was end- end type with 1.40 (min- max: 1-3) of the anastomotic number. However, the end- side type was found in 2 of 7 cases (28.6%), and the anastomotic number was 2.00 (1-3) (Table 43). Regarding to anastomotic diameter, the end- side type was 0.22 ± 0.08 mm, and the end- side type was 0.42 ± 0.09 mm (Table 43)

- TFA – SOA

Additionally, the terminal branch of superior TFA anastomosed with the terminal branch of transverse branch of SOA in one of 20 cases (5.0%). The diameter of this end- end type was 0.28 mm (Table 43 and Figure 57A).

- TFA – ZOA

The TFA gave off superior branch to communicate with ZOA in 6 of 20 cases (30.0%) (Figure 57B). The study of anastomosis pattern found that the anastomoses between terminal branches of both arties (end- end type) was found in the most cases (5 of 6 cases (83.3%)); nevertheless, the number of anastomosis was only one (Table 43). Following end- end type, the anastomotic diameter was 0.19 ± 0.04 mm. In the remained one case, the communication pattern was end- side type with one connective point, and its diameter was 0.17 mm (Table 43).

➢ IOA – SLA

The IOA produced the terminal branch which ran inferiorly to connect with the wall of SLA (end- side type) in one of 20 cases (5.0%). The number of anastomosis of IOA- SLA was only one, and the anastomotic diameter was 0.30 mm (Table 43).

Table 43. The anastomosis between arteries of upper, middle face and lower face, and its diameter

Anasto-motic patterns	**N (%) 20 (100)**	**End to End type**			**End to Side type**		
		N (%)	**Number** Mean ± SD (Range) (mm)	**Diameter** Mean ± SD (Range) (mm)	**N (%)**	**Number** Mean ± SD (Range) (mm)	**Diameter** Mean ± SD (Range) (mm)
STA – TFA	7 (35%)	5 (71.4%)	1.40 ± 0.89 (1.00 - 3.00)	0.22 ± 0.08 (0.16 - 0.35)	2 (28.6%)	2.00 ± 1.41 (1.00 - 3.00)	0.42 ± 0.09 (0.35 - 0.48)
TFA – SOA	1 (5%)	1 (100.0%)	1.00	0.28	0 (0%)	-	-
TFA – ZOA	6 (30%)	5 (83.3%)	1.00	0.19 ± 0.04 (0.14 - 0.24)	1 (16.7%)	1.00	0.17
IOA – SLA	1 (5%)	0 (0%)	-	-	1 (100.0%)	1.00	0.30

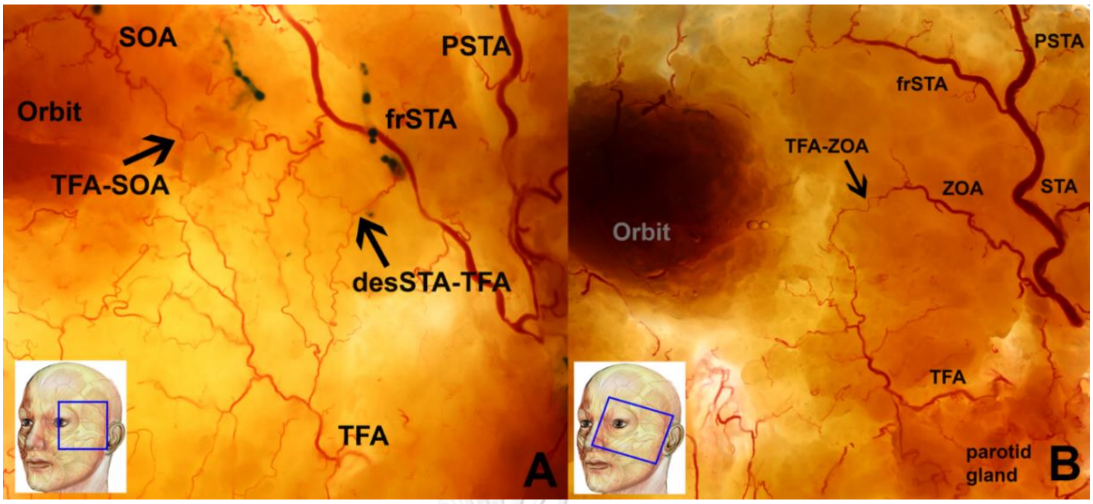


Figure 57 The arterial anastomosis between the upper face and middle face arterial branches; A: anastomosis of TFA and SOA and anastomosis between desSTA and TFA; B: communication between TFA and ZOA

4.2.2 The arterial anastomosis between right and left side of the face, anastomosis patterns, number of anastomosis and diameter of anastomotic point

- STCA – STCA

The anastomosis between right and left STCA was found in 9 of 10 cases (90.0%). In all cases, the terminal branch of medial STCA from each side joined together as end- end type with one of anastomotic number (Table 44 and Figure 58A). However, the STCA anastomotic diameter was 0.36 ± 0.10 mm (Table 44).

- STA – STCA

In addition, this study found that the anastomotic between different arterial branches was showed in the investigation of anastomosis between right and left side of the face. In one (10.0%) case, the STA anastomosed with the STCA in others side. However, the anastomotic type was end- side type with one of communication number (Table 44). The anastomotic diameter was 0.26 mm (Table 44).

➢ DNA – DNA

The communication between right and left DNA was found in 2 of 10 cases (20.0%) (Figure 58B). Both of end- end type and end- side type were evenly found in 1 one case. The anastomotic number of both types was one (Table 44). Whereas the end- end type and end- side diameters were 0.40 mm and 0.25 mm (Table 44), respectively.

➢ LNA – LNA

The LNA of both side traveled medially along the alar groove, and then produced the connection with each other. In this study, this anastomosis was found in 5 of 10 cases (50.0%) (Figure 58B). The end- end type and end- side type were discovered in 4 cases (80.0%) and 1 cases (20.0%), respectively (Table 44). The anastomotic diameter of end- end type was 0.24 ± 0.06 mm, while the diameter of remained type was 0.51 mm (Table 44).

➢ SLA – SLA

For the anastomosis surrounding upper lip area, the both right and left SLA which branched of FA was found connecting in 9 of 10 cases (90.0%)(Figure 58C). The entire cases was end- end types. This type was structured by both terminal branch of SLA. However, the SLA anastomotic number was one in all cases, and its connective diameter was 0.36 ± 0.10 mm (Table 44).

➢ ILA – ILA

Moreover, the anastomosis of lower lip verimilion border was the connection between right and left ILA. The ILA anastomosis was found in 8 of 10 cases (80.0%) in this study (Figure 58C). In 7 of 8 cases (87.5%), both of ILA peripheral branch joined together with the anastomotic number of one. While, the remained one case was end-side type and the anastomotic number was only one (Table 44). The diameter following end- end anastomosis was 0.38 ± 0.10 mm and the end- side type was 0.44 mm (Table 44).

- LMA – LMA

In 5 of 10 cases (50.0%), the right and left LMA was observed in this study. The end- end anastomotic pattern was found in 4 of 5 cases (80.0%) and the amount of anastomotic point was one. In 2 of 5 cases (40.0%), the LMA communication was end-side type with one of the anastomotic number (Table 44). In addition, the diameter of end- end anastomosis was 0.23 ± 0.07 mm, while the diameter was 0.33 ± 0.13 mm of end- side anastomosis (Table 44 and Figure 58C).

- ILA – SMA

The communication between ILA and contralateral SMA was found in 1 case. The SMA released the terminal branch to communicate with ILA (end- side type) with one of anastomotic number (Table 44). Its anastomotic diameter was 0.27 mm (Table 44)

- LMA – SMA

Moreover, LMA also communicated with opposite SMA in 1 cases. The terminal branch of SMA and LMA merged together with only one communication (Table 44). Additionally, the anastomotic diameter was 0.16 mm (Table 44).

- ILA – LMA

Finally, the ILA connected with contrary LMA in 3 of 10 cases (30.0%). However, the end- end type and end- side anastomotic patterns were discovered in 2 of 3 cases

(66.7%) and one of 3 cases (33.3%), respectively. The ILA- LMA anastomotic number of both types was one (Table 46). Moreover, the anastomotic diameter of end- end type was 0.50 ± 0.13 mm, while the diameter of end- side type was 0.25 mm (Table 44 and Figure 58C).

Table 44. The arterial anastomotic patterns between right and left arteries of face and its diameter

Anasto-motic patterns	**N (%) 20 (100)**	**End to End type**			**End to Side type**		
		n (%)	**Number** Mean ± SD (Range)	**Diameter** Mean ± SD (Range) (mm)	**n (%)**	**Number** Mean ± SD (Range)	**Diameter** Mean ± SD (Range) (mm)
rtSTCA – ltSTCA	9 (90%)	9 (100%)	1.22 ± 0.43 (1.00 - 2.00)	0.36 ± 0.10 (0.20 - 0.51)	0 (0%)	-	-
rtSTA – ltSTCA	1 (10%)	0 (0%)	-	-	1 (100%)	1.00	0.26
rtDNA – ltDNA	2 (20%)	1 (50.0%)	1.00	0.40	1 (50%)	1.00	0.25
rtLNA – ltLNA	5 (50%)	4 (80.0%)	1.00	0.24 ± 0.06 (0.20 - 0.33)	1 (20%)	1.00	0.51
rtSLA – ltSLA	9 (90%)	9 (100%)	1.00	0.36 ± 0.10 (0.26 - 0.61)	0 (0%)	-	-
rtILA – ltILA	8 (80%)	7 (87.5%)	1.00	0.38 ± 0.10	1 (12.5%)	1.00	0.44

				(0.21 - 0.58)			
rtLMA – ltLMA	5 (50%)	4 (80.0%)	1.00	0.23 ± 0.07 (0.15 - 0.34)	2 (40%)	1.00	0.51
rtILA – ltSMA	1 (10%)	0 (0%)	-	-	1 (100%)	1.00	0.27
rtLMA – ltSMA	1 (10%)	1 (100%)	1.00	0.16	0 (0%)	-	-
rtILA – ltLMA	3 (30%)	2 (66.7%)	1.00	0.50 ± 0.13 (0.39 - 0.61)	1 (33.3%)	1.00	0.25

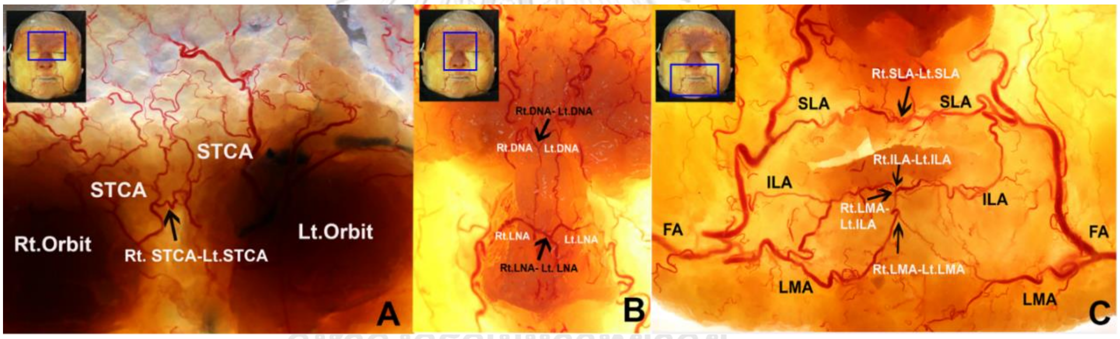


Figure 58 The arterial anastomosis between right and left side of the face; A: the anastomosis of both STCA at the upper face region (arrow); B: the anastomoses of middle face region of both LNA and both DNA (arrow); C: the anastomoses between sides of the arteries of the lower face region (arrow)

CHAPTER V

DISCUSSION

All aging features of the face are targets for clinicians to correct in order to provide the youthful face. However, the largest concern is incurring severe complications associated with inadvertent injury to the arterial supply of the face. The chance of blindness are from two pathways including the direct arterial injection to the branch of OA and the anastomotic pathway between the neighboring arteries and the branches of OA. However, the intraarterial occlusion of the aterial branches which do not relative to the OA may also lead to the skin necrosis. In term of mechanisms, Tanya et al. (2016) described that the anterograde and retrograde arterial occlusions are resulted in the different severe complications. The anterograde fashion appears when the injection pressure less than systemic pressure; consequently, the arterial blood flow has been reduced. Finally, the skin which is supplied by such embolic artery may encounter with the skin changing and may result in necrosis eventually. Whereas the embolus runs retrogradely along the arterial lumen with opposing the systemic pressure, it can carry the embolus travel backward to the arterial bifurcation. If the occlusion has been found with the central retinal artery, the complete blindness has appeared. However, the arterial occlusion of posterior ciliary artery is creating the optic neuropathy instead of blindness.[77]

Therefore, this study has explored the accurate arterial branches which are ultimately correlated with the facial aging characteristics. The anatomical data of this study has proposed the arterial locations which directly associated with the actual facial aging characteristics, and has suggested the safe injection sites based on the findings to avoid intraarterial injection. Afterwards, the possible route after nearest arteries occlusion appearing, and the possibility occurring of severe complications have been verified through the arterial anastomotic territories.

5.1 The nearest artery, its relationship, its distance to the landmarks, diameter, fascial tissue layers that nearest artery lying, and the depth from the skin to the nearest artery

5.1.1 *The nearest artery of the upper face injection sites*

➢ ***Nearest artery to Forehead (FH) injection site***

This study found that, the most concern arterial branch when performs forehead filler injection was the supratrochlear (STCA) (29 of 31 cases). However, the right and left STCA was similarly found locating nearest to FH. Relative to the explanation of Cong et al (2017), the branches of OA including STCA and SOA provide the blood supply of the forehead area.[63] Differently, Kilinc et al (2007) described that the STCA, SOA and STA are the blood supplies of the forehead region.[78] However, the nearest artery of the FH landmark which is set at the midline in this study correlated with only the STCA which directly arises from OA. Similar to the study of Ugur et al (2007), the midline of the forehead was supplied by both right and left STCA.(79) Moreover, this study found that the nearest artery was not only the single STCA but also the anastomotic branch of both STCA (2 of 31 cases). Consequently, injection the filler emboli into the STCA, which is the main terminal branch of OA, can retrograde the particle posterior to vascular bifurcation, then the anterograde emboli can occur with either central retinal or posterior ciliary artery.[77,80] Regarding the locations of the STCA, our study found that the STCA located lateral to FH landmark in most cases (45.2%) with the X distance of 2.00 ± 1.54 mm (range of 0.53- 6.39 mm).

Similarly, Dong et al (2009) found that the STCA placed lateral to midline with distance of 1.35 ± 0.34 mm.[81] While the study of Ugur et al (2007) discovered that the STCA of 60 hemi-forehead located not exceed 5 mm lateral or medial to medial canthal vertical line.(79) Interestingly, the nearest artery of this study was found locating at the FH landmarks in 5 of 31 cases. It means that the artery may immediately get damage when the filler is injected directly to this point. Additionally, the mean total diameter of STCA of FH landmark was 0.48 ± 0.16 mm. To compare with the previous study, the diameter of STCA was 0.81± 0.04 mm.[81] Even though the artery at this site are smaller than the previous study, it can be damaged during filler injection by the small needle size rather than large needle.[77] Additionally, the facial plane is the one of the factors that the clinicians have considered during filler injection. Therefore, this study also investigated the relationship between the nearest artery and the facial tissue layers which correlated to the soft tissue augmentation. The results showed that the nearest artery located inside the subcutaneous layer in most cases (27 0f 31, 87.1%). Based on the finding, the filler injection in this layer may create high possibility of arterial devastation. Similar to description of Tanya et al (2016), they suggested that the filler should be injected to either supraperiosteum or superficial dermis layer due to the STCA locates in the subcutaneous layer[77] Additionally, this finding are likely with the study of Dong et al (2009) which reported that the entire course of STCA ran in the subcutaneous layer. However, its inferior 2/3 lied under fat tissue as well as over the frontalis muscle, while the superior one third placed under the dermal layer.[81] Although the supraperiosteum layer seem to be the safe injection plane, this layer contained the lining artery in one case of our finding. To conclude based on results, the chance of blindness may be appeared causes by the injury of direct branch of OA

(STCA). Moreover, it may also provide the necrosis of the paramedian forehead region when the STCA has been occluded.

According the forehead injection technique from the prior study, they recommended that the bolus injection using needle should be performed at least 2 cm above the eyebrow, and should be placed into the supraperiosteum layer. [82] Moreover the vertical injection of the forehead injection site should be done at the medial line between frontal eminence. [6] Based upon both of our finding and the previous studies, we propose that the injection with superior approach should be employed. The needle or cannula entry point should be superior to FH injection site, and the distance of this site should not be over than 7 mm from FH landmark because the nearest artery was found locating superior to FH in only one case with the Y distance of 7.69 mm (Table 2). Then, the deep injection to supraperiosteum layer should slowly carry on. The tip of the needle should continuously be along the supraperiosteum plane until it reaches the forehead concave surface (target site). After that, the filler should be gently and retrogradely injected. According to suggestion of Cong et al (2016), they recommended that the deep injection to the supraperiosteal plane at the area medial to medial canthal line should be potentially done for preventing arterial injury.[63] Although our study did not investigate the arterial of the forehead depression area surrounding the midline of the forehead, the anatomical study of Cong et al (2016) confirmed that there was no deep branch of STCA locating surrounding the medial forehead in all 20 hemi-faces.[63] Therefore, the injection along supraperiostuem away from FH injection site may certainly safe due to it composed of the small number of artery in this layer (Table 3).

➢ *Nearest artery to Eyebrow (EB) injection site*

This study found that the nearest artery to EB injection site closely associated with dual internal and external carotid systems. The supraorbital artery (SOA), which is the branch of OA, is likely the main branch of the eyebrow region. However, the braches of SOA in this study was classified following the study of Kleintjes et al (2007). He described that the ramifications of SOA consisted of five branches including lateral rim branch (LBR), oblique branch (OB), vertical branch (VB), medial branch (MB), and brow branch (BB).(83) The branches of SOA which served as closest artery to EB landmark in our results were only two branches: BB (29 of 62 cases, 46.8%) and OB (4 of 62 cases, 6.5%) (Table 4). Due to the eyebrow located above the supraorbital margin, so the SOA also related to the superior portion of supraorbital rim and became the nearest artery to EB in this study.(82-83) By contrast, the frontal branch of superficial temporal artery (frSTA) and its branches also placed nearest to EB landmark. There were several branches of frSTA including descending temporal branch, ascending temporal branch, ascending frontal branch, and transverse frontal branch.(83) In our study found that the related branches of frSTA to EB landmark was descending temporal branch (desSTA) (20 of 62 cases, 32.3%), and the main frSTA (3 cases). Although the braches of SOA which derived from OA at the supraorbital foramen or notch was found in most cases, the interested nearest branch of OA was also found with the supraorbital branch of lacrimal artery in 2 of 62 cases (3.2%). Seriously, this branch emerged the lateral portion of the supraorbital rim, and traveled directly to the lateral side of the brow. Based on this finding, the author assumes that injury to lacrimal artery during lateral brow filler injection might possibly causes of blindness. According to description of Lopez et al (2008), they found that the area of lateral eyelid was supplied by the both of the branches of STA and the lacrimal artery of OA.

[64] However, the previous study mentioned that only the STCA and SOA intraarterial injection were main cause of the ocular complication including blindness after upper face injection.[84] This study have recently proposed the lacrimal artery to be one of concerning artery during eyebrow filler injection. The diameter BBSOA are smaller than the diameter of desSTA; thus, using small needle or cannulas size might be considered. There was no examination of nearest artery related to EB injection site in the previous studies, so this study may be the new information of the relationship nearest artery and EB. Following our study, either superolateral (15 of 62 cases, 24.2%) or superior (15 of 62 cases, 24.2%) approaches may provide higher chance of aterial injury. However, the study also found that the nearest artery positioned at the EB landmark in 4 cases (6.5%), this finding may indicate that inject filler directly to this area may not absolutely safe injection site. In the study of the arterial lining layer of nearest artery to EB, the supramuscular layer (orbicularis oculi and frontalis muscle) was found in most cases (59.7%). Cong et al (2017) represented that the SOA divided into two branches including superficial and deep branch after exiting the supraorbital foramen or notch. The deep branch traveled deep to the frontalis muscle, while the superficial branch changed the course to the superficial by piercing the frontalis muscle.[63] The finding of our study was associated with the superficial branch of SOA and the injection to this layer may higher risk of arterial devastation greater than the other remaining layers. To summarize, the eyebrow injection may confront possible risk of blindness when the SOA which is the direct branch of OA has been blocked by the filler particle. Although the desSTA deriving from external carotid artery is found secondly to SOA, it may provide the ocular complication in case of the desSTA anastomosis with branches of OA.

Traditionally, the eyebrow is injected with the filler at the lateral one third relative to the supraorbital rim in order to lift the lateral eyebrow. Moreover, the cannulas have been used to deposit the filler onto supraperiosteum layer. [85] This study may propose the alternative injection by considering the anatomical findings. The entry site should be initially medial to EB with the distance less than 1 cm due to the nearest artery at the medial site to EB injection site was found only one case. The deep bolus injection to supraperiosteal layer at EB landmark (filler target site) can be selected for filler placement. Even through the nearest arterial lining in the supraperiostial layer was found in 6 cases, it did not positioned directly to EB landmark. Similarly, the study of Sykes et al (2016) recommended that the filler should be injected deeply to orbicularis oculi muscle.[85] Differently, Bass et al (2015) suggested that brow injection should be performed lateral to the brow.(10) However, this study have proposed the further recommendation that the lateral injection will safe when the area of lateral third of the eyebrow does not exceed 1 cm due to the maximal distance of nearest artery lateral to EB injection site was 9.94 mm (Table 5).

➢ ***Nearest artery to Upper eyelid (UE) injection site***

The LRBSOA was largely found nearest to UE injection site (22 of 62 cases). Correlated to the study of Lopez et al (2008), the arterial supply of the upper eyelid consisted of the preseptal, supraseptal and marginal arcades; however, the major arterial supplying entire arcades derived from the supraorbital, supratrochlear and the medial palpebral arteries.[64] In term of nearest artery investigation, there was no study that measured the LRBSOA diameter similar to our study which was 0.51 ± 0.11 mm. However, Erdogmus et al (2007) found the mean diameter of SOA at bifurcation was previously found with 0.84 ± 0.30 mm on right side, while the mean SOA diameter was

0.87 ± 0.20 mm on the left side.(86) Additionally, Kilinc et al (2007) described that the SOA have the supralateral direction in order to make anastomosis with the frSTA, its course may involve with the upper eyelid region.[78] For the others nearest artery to UE injection site, the desSTA was found in 12 of 62 cases (19.4%). According to Lopez et al (2008), the crucial arterial branches of the upper eyelid arise from the STCA, SOA, lateral palpebral, FA, and STA. Relative to the finding of our study, the principal aterial supply of the lateral upper eyelid was the STA and the LA.[64] Likewise, our study also found that the LA emerged superolateral direction from the orbit and located nearest to UE landmark in 6 cases (9.7%). Distinctly, our study have found one of the nearest artery to UE, known as ZOA (14 of 62, 22.6%), which it has not been reported in the previous study. The ZOA derived from STA, and traveled horizontally along zygomatic arch to the orbital area. The study of Pinar et al (2006) reported that the ZOA was observed in 21 of 27 samples (77.77%), and the branch traveled from lateral along with the zygomatic arch to the orbicularis oculi muscle.[59] Likely, Edizer et al (2009) discovered that the ZOA was found in 12 of 17 cases (71.6%); furthermore, it functioned as arterial supply of the orbicularis oculi muscle.(58) Considering to the location of UE nearest artery, the maximal cases were located superiorly (Type VIII, 28 of 62 cases), while the minimal locations were inferomedial (Type I, 1 of 62 cases) and inferolateral (Type III, 2 of 62 cases) (Table 8). Dangerously, the closest artery was found at UE landmark in 4 of 62 cases (6.5%); hence, the safest injection based upon the results should be start from either inferomedial or inferolateral to UE. In addition the facial tissue layer which associated to UE was supramuscular layer (orbicularis oculi and frontalis muscle). The finding are similar with the EB injection site. To conclude, the possibility of blindness occurring after upper eyelid injection may cause by the injury of direct branch of OA (LRBSOA) which found in most case.

The general technique for enhancing the sunken eye have been employed by injecting the filler underneath the supraorbital rim along the superior sulcus of the upper eyelid. The layer of superficial injection are performed with the levator aponeurosis, while the deep injection should be done under the orbicularis oculi muscle. [5-6] Based on this study, the injection should be initial done with the entry site from either inferomedial or inferolateral to UE injection site because both locations was found the small number of case. Considering the initial of injection, the needle or cannulas should not place more than 1 mm from UE landmark in both of X and Y distance. After that the needle should be continuously inserted in the superomedial direction until arriving the target injection site (inferior surface of supraorbital rim or the superior sulcus). In term of the arterial injection plane, the author agree with the previous studies and certainly recommend to injection into the sub-orbicularis oculi layer. Although the arterial lining within the submuscular layer was found in 9 of 62 cases, nearest arteries of all submuscular cases located at superolateral (Type IV), inferior (Type VII), and superior (Type VIII) to UE which was not associated with the injection pathway.

➢ ***Nearest artery to Glabella (GB) injection site***

The glabellar region is one of the most concern area for filler injection. Due to the largest global reviews of 98 cases of blindness reported that the glabella injection site is highest risk of ocular complications (38.8%). To compare with the others regions, the nasal region, nasolabial fold, and forehead are 25.5%, 13.3% and 12.2%, respectively. Because its distance are close to the central retinal artery. [77] However, Tanya et al (2016) explained that filler can enter the STCA, which locates superomedial to the orbit, to access the central retinal artery. [77] Relative to this study, the nearest artery to GB injection site was left STCA (9 of 31 cases, 29.4%). Moreover, the study of Skaria (2015) explained that there are numerous arterial branches supplying the glabella, but the two arteries including STCA and DNA served as important branch at this area. [87] However, Vural et al (2000) investigated the related artery with the glabellar frown line and the results showed that the STCA located at glabella frown line in 50%, while the remaining cases located lateral to the line. [88] Differently, the main nearest artery to GB landmarks was CA (right (7 of 31 cases) and left (10 of 31 cases)) in our study (Table 10). Correlated to this findings, Kleintjes et al (2007) discovered that the dorsal nasal introduced the CA which located the area of lower 2/3 of forehead, and the CA was appeared in 43 of 60 hemi-foreheads (76.1%). However, the measurement of CA diameter was found less than 1 mm.[83] Similar to our study, the diameter of CA was 0.49 ± 0.16 mm on the left and 0.42 ± 0.11 mm on the right. Furthermore, the PCA was found nearest to GB only one case (3.2 %) in our study. Correlated to the previous study, the PCA was the proceeded branch of the angular artery (AA), and it was observed in 21 of 60 hemiforeheads (35.0%).[83] The results of nearest arterial location correlated with GB injection site found that the nearest artery located lateral to landmark in most cases (12 of 31 cases, 37.1%) with the X distance of 1.98 mm (min-max: 1.25-4.19 mm). While there was no case of superior location of nearest artery. Even though no measurement is similar to our protocol, Kleintjes et al (2007) described that the STCA located medial or lateral to medial canthal line with 5 mm. Thus, the area medial to STCA are supplied by CA and PCA.[83] The relationship between the nearest artery and the fascial tissue layer showed that the supramuscular layer (procerus muscle) (21 of 31 cases, 67.7%) was the most of nearest arterial lining layer. However, Hotta et al (2016) explained that the STCA initially ran deep to corrugator and frontalis muscle, after that it passed through the frontalis muscle to the superifial position under the skin.[13] Whereas Kleintjes et al (2007) reported that the STCA conversed the location from deep to superficial by piercing the corrugator supercilii muscle, and ultimately located in subcutaneous tissue. [83] Correlated to our study, the nearest artery located in subcutaneous layer in 8 of 31 cases (25.8%). To summarize, the GB was closely associated with the CA of internal carotid system; therefore, the filler injection may get damage of this branch and unfortunately it may retrograde the filler directly to the central retinal artery.

There are several injection techniques from the previous studies. Kim (B) (2015) suggested that the glabella filler injection should be carried out in the either subdermal or supraperiosteum layer. While Bass (2015) and Carpinro et al (2010) recommended that injection should be done in the deep dermal or intradermal layer. [10, 25] Based on our anatomical finding, we propose that the entry site should be marked superior to GB landmark. Afterwards, the filler should be deeply injected to the area of GB injection site in the supraperiosteum layer because of no artery positioning over the bone at GB injection site (filler target site). Moreover, this layer is selected due to it provides the smooth surface comparing with the others layer injection, but the mold is the one option to distribute the filler and provide the smooth injected surface. However, the intradermal as well as deepdermal layer is secondly chosen when the supraperiosteum injection presents incomplete aesthetic outcome. The cannulas is strongly advised for injection in order to prevent the risk of vascular complication.

➢ ***Nearest artery to Temple (TP) injection sites***

The filler is injected into the temporal region in order to correct the aging related concave surface to be slightly flat and convex. [82] However, the filler augmentation should be produced with the effective outcome without vascular complications. Therefore, the study of crucial arteries at temple area are needed. Lee et al (2015) explained that arterial distribution of the temporal region superior to zygomatic arch was frSTA. [57] While, the study of Choi et al (2017) had against to the many researches. His study showed that the ZOA was the most important supplied artery of the temporal area.[89] According to this study, the both frSTA and ZOA are equal significance to temporal filler injection sites and temporal region. However, the desSTA was found nearest to TP1 injection site in most cases (31 of 62 cases, 50%), whereas the TP2 injection site was closely associated with the ZOA (36 of 62 cases, 58.1%). Following this finding, desSTA plays an essential role in arterial supplying the superior part of temporal region, but the ZOA is the main arterial contribution of the lower temporal area. According to Riggio et al (2004), the ZOA arose from the STA, and it traveled to the supraciliary area in 16 of 50 cases. [90] In case of absent ZOA, the transverse facial artery (TFA) and small branches of STA provide the vascular network of the lateral eye region.[59] Although the main nearest artery to TP does not directly relative to the internal carotid system, it can provide the ocular complication via its communication to internal carotid system. However, the arterial location relative to standard temple injection sites was not studied in the previous. The present study found that the Type IV (superolateral) arterial location correlated with TP injection sites was mostly discovered in both TP1 (12 of 62 cases, 19.4%) and TP2 (19 of 62 cases, 30.6%) landmark (Table 14). While the nearest artery was not found lateral to TP2. However, the nearest artery was found located at TP1 and at TP2 in 2 (3.1%) and

6 (9.7%) of 62 cases, respectively. Considering the nearest arterial lining layers, Both TP1 (30 of 62 cases, 48.4%) and TP2 (37 of 59.9%) nearest artery were located in the parietotemporal fascia (superficial temporal fascia). Similar to the findings of Cotofana et al (2016), the SMAS layer, known as superficial temporal fascia, contains the anterior and posterior branches of STA.(91) Additionally, Aveta et al (2016) described that the STA enrolled the superficial temporal fascia at the area above zygomatic arch of 2-4 cm, and then it gave off the frSTA and the parietal STA. [92] In the different, Maio et al (2017) and Lee et al (2015) described that the STA and frSTA positioned inside the subcutaneous tissue.[57,82] However, the nearest artery embedded within the subcutaneous layer was found in 10 of 62 cases (16.1%) for TP1 landmark, and 13 of 62 cases (21%) for TP2 landmark in our study.

The general temporal injection techniques were perpendicular injection to (1) at 1 cm above the temporal fusion line and 1 cm lateral to supraorbital rim (TP1), and (2) at 2 cm lateral to lateral orbital rim and 2 cm superior to superior border of zygomatic arch.[5] Moreover, the filler can be deposited into numerous layers such as subcutaneous layer, interspace between superficial temporal artery and deep temporal fascia, and the periosteum.[12] As the mentioned of Pessa& Rohrich (2012), the subcutaneous loose areolar space which was the area between two temporal fascial layers.[93] Based on our finding, the needle entry site should be performed at inferior or medial to TP1 with the distance less than 2.00 mm from TP1 landmark. After that, the tip of the needle should touch the bone as the filler target site at the area of TP1. The bolus injection should be used to deposit the fill over the bone. For the TP2 injection site, the lateral approach is suitable because the artery at this location is absent. Previously, the filler injection in the interspace between superificial temporal artery and deep temporal artery seem to be the absolute safe injection plane. Nevertheless, this study also found that the ZOA located at this layer in 2 cases (3.2%). Therefore, the deep filler injection into the supraperiosteum of the TP2 injection site should be selected.

5.1.2 *The nearest artery of the middle face injection sites*

➢ ***Nearest artery to Tear trough (TT)***

Filler injection techniques used to amend TT deformities are performed by highly experienced clinicians. [19, 26] Therefore, the clinician should understand and appreciate the arterial anatomy of the midface in great detail. This study revealed that the arterial system surrounding the TT area is derived from numerous arterial branches which depend on the part of the TT deformities. Mojallal and Cotofana (2017) expressed that the vascular system surrounding tear trough originate from FA, AA, IOA, ZOA, TFA, and anterior branch of STA. [94] However, their study did not profoundly investigate the specific artery to each TT area. According to TT1 landmark in this study, the nearest artery was closely associated with main transverse facial artery (TFA) (36 of 62 cases, 58.1). Due to the TT1 which was the intersection between vertical line of lateral canthus and the horizontal line of nasal alar. This landmark located in the area of middle midface area, so it can possibly be supplied by both the arterial of the anterior and lateral face. Yang et al (2009) explained that the TFA emerges from the STA before departing the parotid gland. The TFA serves as not only the main arterial supply of lateral face but also becoming the arterial supply of the periorbital region which correlates with the tear trough area. His study reported that TFA divided into superior and inferior trunk. The superior trunk exited the upper part of the parotid gland to supply the malar area, masseter and zygomaticus major muscle, while the inferior trunk emerged inferior part of parotid gland to be the muscular and cutaneous feeder. [44] Additionally, the TFA was classified as the palpebral branch (pTFA), branch of superior trunk, to reach the orbital region, and positioned nearest to TT1 in 6 of 62 cases (9.7%). This study also investigates the location of nearest artery to TT1 injection site that have not been done in the previous study. The type of arterial location are dispersing in TT1 landmark. In most cases (13 of 62 cases, 21.0%), the nearest artery placed inferior to TT1, while the superolateral was found in the minimal cases (2 cases, 3.2%). Interestingly, 5 of 62 cases (8.1%) was found as the nearest artery located persistently at the TT1 landmark (Table 17 and Figure 42A). Therefore, the injection directly to this area or inferior to area should be avoided. Moreover, the study of Edizer et al (2009) found that the mean diameter of TFA was 0.8 mm (min-max: 0.50 ± 1.1 mm) on the right side and 0.8 mm (min-max: 0.50 ± 1.0 mm) on the left side. [58] In this study, the mean outer diameter was 0.59 mm (rang of 0.35- 2.29 mm). Regarding the arterial lining layer, we found that the nearest artery located underneath posterior surface of the zygomaticus major (submuscular/ sub SMAS layer) in most cases (48 of 62 cases, 77.4%. The classification of the arterial lining layers is associated with the injection technique in our study. In term of anatomy facial tissue layer, this study are related to Schaverien et al (2009), who described that the TFA traveled above the masseter muscle, but deep to parotidomasseteric fascia. [95] Moreover, Cotofana et al (2015) mentioned that the facial layer 3 (SMAS) and layer 4 (deep areolar, sub SMAS layer) are merged together above parotid gland known as parotidomasseteric fascia. However, anterior to this gland it spits and become the premasseteric compartment (deep areolar, sub SMAS layer).[96]

For the TT2 and TT3 injection sites, these sites associated with palpebral branch which derives from several main arteries for example palpebral branch of TFA (pTFA), palpebral branch of IOA (pIOA), palpebral branch of FA (pFA). We classified as the palpebral branch due to the branches reach the inferior palpebral area. As the result of this study, the majority of the arteries closest to TT2 and TT3 were related to pIOA in 48.4% and 62.9% of cases, respectively. Hwang demonstrated that the pIOA was found in 75.0% (21 of 28 orbits). In addition, a single branch of the pIOA was discovered in 20 of 21 orbits and two branches of the pIOA were found in 1 orbit. The pIOA was located approximately half an eye width from the medial canthus; hence, this location was associated with TT deformity surrounding mid pupil level. [62]

This study pointed out that the main artery of TT4 is AA which arose from FA, IOA, and OA. However, the closest artery to TT4 was AA which ramified of the OA in 43.5%. Therefore, the presence of the arteries closest to TT4 may relate to the patterns of AA. Kim et al. found that they were four patterns of AA. In type I (19.3%), the AA emerges from the LNA and projects toward the medial area of the eye. Their findings correlated with our study with 32.3% of the closest arteries to TT4 which was AA from FA. For type II (31.6%), the FA produces the detouring branch and projects medially to the nasojugal and medial canthal area before terminating as the AA.(56) To compare with our findings, the closest arteries to TT4 (16.1%) was the AA branch of dFA (AAdfa), while the nearest artery to TT3 appeared to be the main dFA (9.7%). Additionally, the AA which originates from OA grouped in type III (22.8%). This occurrence associated with the most cases in our study which the nearest artery at TT4 was AAoa (43.5%). In type IV (26.3%), the AA is missing and the FA terminates as the LNA. [56] When this type of AA was found, it may be assumed that the AA may be branches of IOA (AAioa) which was found nearest to TT4 in 4 cases (6.5%) in our study. Similar to Hou et al (2013), the AA emerging from IOA was found in 1 hemi-face (4.5%). [55] Moreover, this study found that the nearest artery can be the DNA and locates nearest to TT4 (1.6%) in cases of absent AA. Pilsl et al. demonstrated that the AA was branched by FA and DNA in 33 hemi-faces (55%) and 9 hemi-faces (15%), respectively. In the other 18 specimens (30%), no AA was found. In this case, the small branches of IOA played an essential role in supplying the medial angle of the eye. [45] However, AA branches originating from the OA may be seriously damaged during filler injection, this anastomosis provides the filler with a retrograde channel which could lead to distribution of the filler emboli to the central retinal artery resulting in visual loss. [6, 41] Although the arterial injury was not directly found in AA, the FA of external carotid system may contribute to the communication with the internal carotid system to reach the embolic pathway of filler particle. [7] Regarding the nearest artery of TT2 and TT3, most cases were not relative to AA, but closely associated with pIOA. [6] In this study, we also presented that the nearest artery to TT1 was pTFA in 16.7%. This finding corresponds to Edizer who explained that the arterial supply to the inferior marginal arcade at the lower eyelid arose from TFA, IOA, and inferior medial palpebral branch of the AA.[58] However, arterial circulation of the TT may provide a lower risk of vascular complications when the anastomoses between internal and external carotid system is absent.

Furthermore, this study provides the concerning arterial locations regarding injection sites of TT. In most case of TT2, the arterial location has several variations including the decreasing number of presence following Type V (19.4%), Type VII (17.7%), and Type IX (14.5%). Interestingly, type IX (artery locating at TT2 landmark) was found in 9 of 62 cases, and so may substantially increase the chance of vascular injury if the clinician incorrectly performs injection at this site. For the location at TT3, the closest artery was located inferomedial to the landmark (Type I, 30.6%). The distance measurements were 4.15 ± 1.69 mm at the X-axis and 5.8-0± 5.60 mm along the Y-axis. This area closely correlated with pIOA, Hwang found that the location of pIOA at medial canthus could range between 40% and 80% of the eye width.[62] Moreover, Type IX (at landmark) was also found in 4.8%; thus, injection directly into this site might not absolutely safe. 15 For the location at TT4, the closest artery was the AA branching from OA and located medial to the landmark (Type V, 54.8%) with 4.16 ± 2.40 mm at the X-axis. Likely, Marur (2014) described that the location of the AA ranged from 6 to 8 mm medial to the medial canthus and 5 mm anterior to the lacrimal sac. [7] The location of our finding pointed out that injection of the TT deformity lateral to medial canthus remains safe due to the distant placement from the AA location. For other parameters, the diameter measurement was found to be less than 1 mm at all TT landmarks. Tansatit recommended that using cannulas should be considered based on the arterial size, furthermore, a larger cannula should be used to avoid arterial injury as smaller cannula provide the greater risk of arterial laceration. [27] The minute arterial branches might be also damaged by the small size of cannula or needle during injection.

Although arterial location and diameter seem to be the main factors of arterial injury cause, the arterial lining plane is one of the main considerations for clinician during injection. There are different types of injection technique for various injection depths and each technique is dependent on the clinician. Hill and Garem explained that the TT should be injected with a 29-gauge needle and filler should be placed superficial to the periosteum to ameliorate the shadow of TT. [16-17] Kim et al. claimed that the injection layer is dependent on two conditions. Firstly, the deep to suborbicularis oculi fat (SOOF) is selected when soft tissue atrophy appears below the orbital retaining ligament. Secondly, the superficial injection into the subcutaneous layer over OOc is utilized in the case of SOOF restoration.[6] Concerning our study, most cases of the arterial lining layer at TT1, TT2 and TT3 were located in the submuscular plane of OOc. Filler injection into the submuscular layer may possibly increase the risk of intravascular injection. However, injection into the superficial or deep subcutaneous layers surrounding the medial canthus is likely to result in arterial injury as our study found that nearest artery at TT4 was located within the supramuscular plane of OOc.

According to the conventional filler injection technique of the TT, the filler has been usually placed deeply on the preperiosteal plane with bolus technique. Both of the needle entry site and the filler placed target site have been preferred as the same point by inserting the needle perpendicular to the skin. Based on our findings, there was found with small number of nearest artery locating superolateral quadrant all TT landmark when compare with other locations (Figure 42). Moreover, the arteries which located the superolateral region become a peripheral branch, and had a small diameter when compared with the proximal part of the arteries. To recommend the safe injection technique based on our findings, the filler is intended to be deeply injected with bolus injections using a needle over the preperiosteal plane at the TT1, TT2, TT3 and TT4 areas. These areas serve as the filler placed target point because there was no artery lining on the periosteum. Before performed injection, the inferior orbital rim and the inferior orbital fat pad of the individual patient should be palpated and compressed to prevent deposited the filler into the orbit which resulted in the eye bag. Then the needle entry site of this injection should be obliquely accessed at the superolateral quadrant of all landmarks with 30-45° to the skin, and the distances of the needle insertion point should not be exceeded 2 mm of X- and Y-axis from TT1 and TT4 landmarks because the minimal distance was 2.96 mm (Table 17).While the insertion site should not be over 1.5 mm of X- and Y-axis from TT2 and TT3. The tip of needle should be inserted and introduced into the direction of TT1, TT2, TT3 and TT4 until it gently touches the bone, and then the filler is deposited over the periosteum (supraperiosteal plane) of all TT areas. Furthermore, the mold is required to disperse the material along TT and to provide the desired contour.

➢ ***Nearest artery to Mid cheek (MC) injection site***

The filler injection into mid cheek is provide to remodel the cheek by lifting effects of the filler product. Maio et al (2017) mentioned that that the infraorbital artery (IOA) should be cautious during mid cheek injection. [82] Relative to our findings, IOA and it branches was chiefly discovered nearest to MC injection sites. The IOA was the branch of maxillary artery (MA), and it emerged from the infraorbital foramen to supply the anterior face. [60] However, Hwang et al (2011) reported that the main IOA separated into terminal branches including palpebral branch (pIOA), nasal branch (nIOA) and labial branch (laIOA).[62] Nevertheless, our result showed that branch of IOA was also found as the lateral branch, and the proximal part of the lateral branch IOA was found closest to MC landmark (18 of 62 cases, 29%), while the pIOA was secondly found nearest to MC in 14 of 22.6 cases (22.6%). The mean diameter of IOA was found 2.0 mm (min-max: 1.3-2.6 mm) in study of Hwang. However, the arterial diameter investigation in our study was smaller than previous with the 0.79 mm (min-max: 0.34-1.54 mm) of lateral branch of IOA. Differently, Abbate et al (2016) pointed out that the main arterial supply of mid cheek region was the superior branch of TFA [68]. However, the TFA was discovered locating nearest to MC in 12.9%. The location of the nearest artery was found medial (Type V) to MC landmark in most cases (20 of 62, 32.3%). The inferomedial (Type I) location presented in the second place (17.7%). Minimally, the nearest artery placed superior only one case. Dangerously, the nearest artery permanently located at MC injection site in 3 out of 62 cases (4.8%). According to Edizer et al (2009), the IOA positioned 9.6 mm (min-max: 8.5-11.6 mm) underneath infraorbital rim.(58) However, this measurement just only investigates the main arterial branch which it cannot be used to clarified in all IOA branches correlated to MC injection. The exploration of the relationship between nearest artery and the fascial tissue layers found that the submuscular layer (sub-SMAS) of levator labii superioris muscle was almost found (49 of 62 case, 79%). We also found that the proximal IOA ran from deep after exiting the foramen to superficial for supplying the muscles.

In the general technique, the mid cheek is injected directly to MC injection site. The bolus technique is utilized to deposit the filler onto the bone (supraperiosteum).[10] Cotofana et al (2015) suggested that the potential filler injection layers of the mid cheek was subcutaneous and supraperiosteal layer.[96] The recommendation for filler injection based on our finding should be deep injection to create the most satisfying aesthetic outcome. The superior approach should be selected due to there was only one case of nearest artery locating at this location with the distance of 1.80 mm. Therefore, the needle entry site should not exceed 1.5 mm over MC injection site. After that, the needle penetrates the soft tissue until touching the bone. Even though the nearest artery was found at supraperiosteum layer (Type IX), it was not found directly locating over the supraperiosteum at the MC injection location. The needle should be aspirated before injection. Finally, the massage can be performed when the filler was seen with lump texture.

➢ ***Nearest artery to Lateral hollowness (LH) injection site***

The nearby artery of LH was found the TFA in all cases. The TFA was the main arterial supply of the lateral side of the face.[(44)] Pinar et al (2005) described that the TFA was arose from STA in all cases, then it traveled through the parotid gland to the cheek. [(59)] Considering the TFA location, it located inferior to LH landmark in most cases (51.6%) with the distance of 4.40 mm (min-max: 0.70- 12.30 mm). However, the nearest artery was not found placing medial and inferolateral to LH landmark. There was no previous measurement similar to this study. Lee et al (2012) measured the distance between the tragus and the TFA at parotid emerging point, and the distance was 33.2 ± 10.4 mm. In term of facial arterial lining layers, the nearest artery mostly located inside the parotid gland (53.2%). This finding proposes that the extension of parotid gland is located beneath the skin of LH landmark. The TFA was found placing above the masseter muscle in case of missing parotid extension (32.3%). Following the explanation of Cotofana et al (2015), the parotidomasseteric fascia (adherent of layer 3 and 5) was divided and made the space anterior to parotid gland open up to be premasseteric compartment (layer 4) and the TFA was lining in this space. [(96)] In cases of arterial location in the subcutaneous fat, it was TFA perforators which traveled perpendiculary to the cutaneous tissue over the masseter muscle. [(44)]

The injection in this region associated with the temporal- cheek compartment which lying over the parotid gland.[(97)] Based on our findings, the injection site can be initially done with the entry site at either inferolateral or medial to the LH landmark. The retrograde linear treading technique with cannulas should be done along the lateral face within the subcutaneous layer into the superomedial, medial, and inferomedial direction. Although the nearest artery was subcutaneously located in 7 of 62 cases (11.3%), it was not found relative to three suggested areas (superomedial, medial, and inferomedial types).

- ***Nearest artery to Nasolabial fold (NLF) injection sites***

The nasolabial fold is one of the common area for filler augmentation. Therefore, arterial vasculature surrounding this region must be deeply understand. Following our study, we found that the actual arteries of the nasolabial fold injection site are various depending on its compartments. As the results, the inferior margin of NLF (NLF1) is closely associated with facial artery which found in most cases 47 of 62 cases (75.8%). Likely, the most of nearest artery to NLF2 was also the FA (36 of 62 cases, 58.1) Similar to explanation of Lee et al (2015), the involving arteries of nasolabial fold consists of the trunk of the FA and its alar branch. In the study of Pilsl et al (2016), the course of FA was found in 4 types. In Type I (41.7%), the FA traveled from the anterior border of masseter muscle and passed the lateral nose to terminate as AA. For Type II (26.7%), the FA ran to the angle of mouth followed by traveling to dorsum of the nose; hence, there was no AA in this type. In Type III (18.3%), the FA terminated as the SLA, so the arterial supply area superior part was the branch of IOA, MA, and DNA. While the FA gave of ILA and then divided anterior (giving of SLA and LNA) and posterior branches (terminating as AA) in Type IV (IV).[45] Likely, Kim et al. (2014) pointed out that the FA and the angular branch of the FA can be injured during nasolabial fold and nasojugal groove filler injection.(56) However, the nearest artery to NLF3 was IOA in most cases (24 of 62 cases, 38.7%). This finding may closely associate with Type III in the study of Pilsl which the IOA become the main artery supply in the case of FA ending as SLA. Moreover, Lee et al (2015) classified that the FA gave off the SLA and the alar branch in Type I (56.7%). In Type II (21.7%), the FA provided the SLA and then the SLA gave off alar branch, while terminal branch of the FA was the SLA in Type III (15.0%).(50) The IAA which found locating nearest to NLF3 (3 of 62 cases, 4.8%) may correlate to Type II in the study of Lee. Regarding the nearest artery to NLF4, the LNA located nearest to this site in most cases (31 of 62 cases, 50.0%). Because the NLF4 was the area surrounding lateral side of alar, this site may receive blood perfusion from the LNA. [98] Additionally, The IOA which was secondly found located nearest to NLF2, and NLF4 was related to the nasal branch of IOA. Differently, our study found that closest artery to NLF1 was also the SLA in 5 of 62 cases (8.1%). In association with nasolabial fold filler injection procedure, Aloiso (2016) and Hilinski (2009) described that the procedure starts with inserting needle from the inferior end of the fold followed by tracing the needle superiorly, therefore, not only the FA but also the SLA should be concerned.[32-33]

In addition, our study represented that the nearest artery to NLF1 located inferomedial (Type I) to NLF1 in most cases about 27.4% (17 of 62 cases) with the 2.86±1.57 mm of X distance and 3.26±1.71 mm of Y distance. Similarly, the study of Yang et al. (2013) found that the horizontal distance of nasolabial fold at cheilion level was 13.5±5.4 mm.(18) Following the study of Phumyoo et al. (2014), the distance between facial artery and oral commissure was 15.30±3.72 mm.[99] Furthurmore, Qassemyar et al. (2012) reported that mean distance from the oral commissure to the FA was 15.5 mm (range: 9.0-20.2 mm).[19] However, these data focused on only the facial artery and cannot exactly express the relationship between others arteries in the nasolabial fold deformity. Interestingly, this study exhibited that the facial artery located at the inferior margin of NLF (Type IX) in 11 of 62 cases; therefore, the chance of intravascular injection may appear when the filler is directly injected into NLF1 injection site. In the study of relationship between nearest artery and NLF2 landmark, most of nearest artery positioned medial to landmark (19 of 62 cases, 30.6%). However, the nearest artery of NLF2 was found locating the landmark in 12 of 62 (19.4%). Thus, the injection to this site may provide high possibility of arterial devastation. Interestingly, the two locations including medial to NLF3 landmark and at the landmark were equal presence in 16 of 62 cases (25.8%). In medial location, the distance was 2.27 mm (min-max: 1.00- 3.91 mm) Likely, Yang et al. (2013) illustrated that the distance from lateralmost point of the alar to the FA was 3.2±4.5 mm. [18] Moreover, the study of Phumyoo reported that the distance between the FA and nasal alar was 6.66±4.41 mm.18 Therefore, the injection to nasolabial fold at or medial to inferior alar level should be carefully done in order to prevent injury of all involving arteries. To compare with study of Yang et al. (2013), the FA placed medial to nasolabial fold in 42.9% (24 of 56 cases).2 In 11 of 56 cases in their study, the FA traveled medial to NLF at chelion, and then ascended across NLF to locate lateral to NLF at the alar level.[9]

At NLF4 landmark, the nearest artery located lateral to NLF4 in most case (18 of 62 cases, 29.0%) with X distance of 1.61 mm (min-max: 0.93- 5.27 mm). In the serious case, the nearest artery was found placing at the NLF4 injection site in 13 of 62 cases (21.0%). As mentioned above, there are several arterial supplies of each portion of NLF, so its location with correlation to NLF are very significant. In the facial layer examination, the closest artery of all NLF injection sites mainly placed submuscular layer. Distinctly, the NLF1 and NLF2 were related to zygomaticus major and orbicularis oris muscle, while the NLF3 and NL4 were associated with levator labii superioris muscle. The study of relationship between muscle band and the FA in the of Kwak et al (2006) found that the FA traveled along the depressor anguli oris and orbicularis oris muscle in 40 cases (57.1%). In the remaining 30 cases (42.9%), the FA ran below and along the zygomaticus major muscle. [67]

According the general nasolabial fold injection techniques, Lemperle et al. (2010) explained that the filler material should implant approximately 1 mm medial and parallel to the fold.[31] The procedure starts with inserting the 27 G needle from the inferior end of the fold followed by tracing the needle superiorly into the area of connection between nasolabial fold and alar. After completed insertion, the needle is withdrawn as the retrograde linear treading technique. [32-33] However, the injection depth in this area should be deep dermal or dermal subcutaneous junction levels. [10,33] In others recommendations, the nasolabial fold should be divided into upper, middle and lower parts regarding the indication of the plane of injection. The middle and lower portions should be injected into superficial subcutaneous or deep dermal plane to prevent injury of facial artery, while either the deep dermal or perperiosteal plane is suitable for upper part injection. [34] To propose the safe injection technique based on our anatomical findings, we recommend that the filler should be differently injected in each part of NLF using cannula with linear treading technique. The entry point should be produced less than 1 mm inferolateral to inferior margin of NLF. Because the most cases of nearby arteries at this point located inferomedial to NLF1. Then, the cannula should be continually accessed 1 mm lateral to NLF2, after that across approximately 1 mm inferior to NLF3, and then change direction into to medial side with the X distance less than 1 mm from NLF until the tip of cannula reaching the medial of the superior angle of NLF. After that, the cannulas should be retrogradely injected with the retrograde linear trading technique. For the injection depth, the filler should be injected either deep dermal or subdermal layer. The subcutaneous injection in the lower NLF may be not appropriate because the facial artery ran lateral to modiolus and located in subcutaneous layer at NLF1 (21 of 62 cases, 33.9%) and NLF2 area (9.7%). Moreover, the mold or massage are necessary to distribute the filler material along NLF and to produce the smooth contour.

5.1.3 *The nearest artery of the lower face injection sites*

- ***Nearest artery to Lip (vermillion and volume)(LV) injection***

The arterial network of the perioral region are important for lip filler injection. Pinar et al (2005) described that the blood perfusion surrounding perioral area derived from two branches of FA including SLA and ILA. However, the upper lip region was supplied by the SLA and its branches including alar (alaSLA) and septal (sepSLA) branch. [48] Correlated to our study, the involving arteries to the lip were FA, SLA, alaSLA, and sepSLA. However, the main SLA located nearest to all LV injection sites. At the point of 2 mm from oral commissure (LV1), the SLA was largely found as closest artery in 45 of 62 case, 72.6%. Additionally, the most SLA located nearest to LV2 landmark (lip vermillion at lateral alar level) in 55 of 62 cases (88.7%). Relative to investigation of Magden et al (2003) they proposed that the SLA was located either at or superior to level of oral commissure. [52] In addition, Lee et al (2014) explained that the SLA traveled above the upper lip vermillion border at the labial commissure level. [50] For LV3 (lip vermillion at midline) injection site, the left SLA was dominant nearby artery in 14 of 31 cases (45.2%). Relative to study of Magden et al (2003), the SLA was found bilaterally in most cases (71%); however, it was additionally observed in unilateral side in 4 cases (21%).[52] Lee et al (2014) classified the distribution patterns of SLA into four different types. In Type I (56.7%), the SLA and alar branch arose from the FA, while the SLA which emerged from FA, and SLA released alar branch was found in Type II (21.7%). For Type III (15.0%), the SLA served as the peripheral branch of FA, and the missing of SLA was grouped in Type IV (6.7%). [50] The terminology used of alar branch are controversial in each study. However, the Lee et al (2014) and Pinar et al (2005) classified the alar branch into superior and inferior alar branches. The inferior alar branch supplied the inferior border of nostril, while the superior alar branch traveled to the superior nostril. [48, 50] Differently, Magden et al (2003) classified the alar branch as the perpendicular branch which directly derived from SLA. However, this branch was named as ascending branch of SLA in the study of Pinar et al (2005). [48,52] However, this study classified this artery following the explanation of Pinar et al (2005). Therefore, inferior alar branch (IAA) was lastly found nearest to LV1 in 7 of 62 cases (11.3%). This finding may associate with Type II of the study of Lee et al (2014) which the IAA derived from SLA before going to the inferior alar region. Moreover, the ascending branch of SLA (aSLA) was secondly found positioning nearest to LV2 (7 of 62, 11.3%), and also found locating nearest to LV3 (2 of 31 cases, 6.5%). However, Pinar et al (2005) divided the aSLA into superficial and deep ascending branches. The deep branch traveled between the submucosa and orbicularis oris muscle, whereas the superficial branch ran superficial to orbicularis oris muscle.[48] Similarly to Magden et al (2003), the aSLA was found existing from SLA in 22 of 28 cases (79%). In 18 of 22 cases (82%), the aSLA was found only on branch, while two and three branches were found in 3 (14%) and 1 cases (4.5%), respectively. [52] In other interested nearest artery to LV3, the septal branch was also found locating nearest to the lip vermillion at the midline in 9 of 31 cases, 29.0%. Correlated to Lee et al, the septal branch ramified from SLA to supply the nasal septum, and it was found in 51 of 60 cases (85.0%). Moreover, they found that it ran beneath orbicularis oris muscle in 63.3%, and lied superficial to orbicularis oris muscle in 21.7%. [50]

The relationship between nearest artery and the LV1-LV3 landmarks was also observed in this study. In most case, the nearest artery to LV1 located in superolateral (Type IV, 28 of 62, 45.2%), while the superior to LV1 was secondly found in 20 of 62, 32.3%. In most cases, the distances were 3.15 mm (range from 1.43- 4.54 mm) along X- axis and 3.92 mm (range from 1.53-7.74 mm). Likely, the study of Lee found that the SLA placed superolateral to oral commissure with the distance of 8.0 ± 2.1 mm. [50] Similar to study of Pinar, the origin of SLA mostly located above the corner of the mouth in 34 of 47 specimens (72.3%); furthermore, it positioned at the level of mount corner in 13 of 47 specimens (27.7%).[48] Additionally, the previous study found that the distance between oral commissure and the SLA was 12.1 mm. [52] However, they has focus only the branch of SLA. In fact, there are several involving branches of LV1. For LV2 landmark, the location of nearest artery related to LV2 landmark was the inferior (Type VIII) in most cases (21 of 62 cases, 33.6%) with the Y distance of 2.02 mm (range from 0.73- 2.02 mm). At LV3, the most of nearest artery located laterally with 1.89 mm (min-max: 0.86- 4.95 mm.). The superomedial and inferolateral location were absent in entire LV injection sites. Regarding the location of artery and the vermillion border in the other study, Lee et al found that the SLA located superior to vermillion border at the level of oral commissure, and also above the border at the midpoint between peak of Cupid's bow and oral commissure. Nevertheless, it traveled below both of the vermillion border below the Cupid's bow and sagittal midline.[50] The location of SLA of at the midline (inferior to vermillion border) in study of Lee et al was similar to our study which the arterial locating inferior to LV3 was secondly found in 8 of 31 cases (29%). To compare the distance from vermillion border to artery of this type, the distance was 1.67 ± 0.73 mm, while the distance of previous study was −0.6 ± 3.0 mm.[50] In term of diameter measurement, the mean diameter of SLA of LV1-LV3, followed in the decreasing order by 1.31 ± 0.57 mm, 1.17 ± 0.43 mm, and 0.93 ± 0.28 mm. To compare with previous study, the mean diameter of origin of SLA was 1.16 (range from 0.60- 2.8 mm). Whereas, the result of Magden et al (2003) found that the external diameter of SLA at vermillion border was 1.5 ± 0.5 mm.

Considering the relationship between nearest artery and fascial tissue layers, the intramuscular layer was mostly found in all LV landmarks. Differently, Lohn et al (2011) described that the SLA traveled along the connection between mucosa and orbularis oris muscle.(49) Relative to this finding, the nearest artery located in the submucosa layer in 6 of 62 cases (9.7) of LV2 landmark and 7 of 31 (22.6) cases at LV3. In term of arterial depth in our study, the depth from the skin to nearest artery of LV1 related to intramuscular layer was 3.85 ± 2.00 mm, while the depth of nearest artery to LV3 in the same facial layer was 4.97 ± 2.75 mm. According to the study of Lee et al, the depth from the vermillion border to SLA at origin was 3.5 ± 1.0 mm, while the depth of SLA at midline was 3.9 ± 1.3 mm. [49] However, the depth of mentioned previous study was not measurement in separate facial layer.

The general lip injection technique are initially performed by inserting the cannulas 2 mm from the oral commissure along the vermillion border, thereafter the linear threading technique is used to inject the filler from medial to lateral. [32,35,52] The superficial injections including the subdermal and superficial cutaneous layer were optioned to avoid injury of FA and SLA.[27, 34] Based on our finding, we may propose the alternative lip vemillion injection technique in order to prevent arterial injury. The entry site shoud be superomedial direction to LV1 because there was no nearest artery lining at this site. Afterwards, the cannula should be traced in the superolateral direction to vermilion border at LV2 landmark, then traced downward into vermillion border at the level superior to LV2 (less than 1 mm from this site) until reaching the midline in either subdermal or superficial subcutaneous plane similar to the general technique. Even though the nearest artery was found located directly at LV3 (4 of 31 cases, 12.9%), However, all cases of this type was located in the subcutaneous tissue layer, and it not correlated with the suggested injection layer in our study. Therefore, our study may also confirmed the safe injection associated with usual techniques.

➢ ***Nearest artery to Chin (CN) injection site***

The chin filler injection is usually performed in order to produce the chin projection. The injection should be done with no risk of complication. Therefore, the nearest artery to inferior border of mandible at midline (CN) was found only submental arterty (SMA). However, the right and left was found positioned nearest to CN landmark in 19 of 31 (61.3%) cases and 12 of 31 (38.7%) cases, respectively. According to Loukas et al (2008), they discovered that both of sublingual and submental artery were blood perfusion of the anterior mandibular region.[100] Moreover, Kim et al (2012) illustrated that submental artery emerged from cervical branch of FA, and then it ran anteriorly in the lower border of mandible above mylohyoid muscle.(101) However, the nearest artery in our study which was only SMA may associated to description of Bavitz et al. Their study found that the SMA was mostly observed in case of small, unimportant or absent sublingual artery.(102) The location of SMA largely was found lateral (Type VI, 90.3%) to CN with X distance of 5.73 (min-max: 1.12- 18.05 mm). Base on this finding, the risk of SMA injury may occur when the injection provides error of distance over than 1 mm from midline. However, mean diameter of SMA was 0.80 ± 0.24 mm. In the examination of Kim et al (2012), the diameter of SMA was decreasing from the level of third molar to first premolar as 1.6 to 0.8 mm. (101) The lining layer of SMA was above the mentalis muscle in most case (12 of 31 cases, 38.7%). In conclude, our study have supported that the filler injection at the midline of chin into the preperiosteal plane is possibly safe because the artery was not found in this layer. In term of subcutaneous and intramuscular injection, the injection should cautiously performed by inserting the needle less than 1 mm from midline.

➢ ***Nearest artery to Jawline (JL) injection site***

The mandibular angle (JL) was set as the landmark for jaw line injection. The most nearest artery to JL was FA in this study (55 of 62 cases, 88.7%). While the masseteric branch of FA (mbFA) was discovered in remaining cases (7 of 62 cases, 11.3%). According to comprehensive review of Yang et al (2015), the arterial supply to masseter muscle which correlated to mandibular angle were both of mbFA and masseteric branch of external carotid artery (mbECA). [103] In addition, Hwang et al (2001) mentioned that the mbECA was the atrial supply of the middle part of masseter muscle. [104] However, masseteric branch locating nearest to JL was only mbFA in this study. The two types of arterial locations including medial (Type V, 54.8%) and inferomedial (Type I, 45.2%) to JL was found in this study. Regarding to its distance, the X distance was 12.21 mm (min-max: 2.56- 23.41 mm) in Type V. In Type I, the distance was 13.12 mm (min- max: 1.38- 29.12 mm) along X- axis, and Y distances was

6.87 mm (min- max: 2.42- 15.22 mm). Yang et al (2015) found that the FA changed inside to outside location at the antergonial notch of mandible, and ran toward the face about 2 cm anterior to the gonion. This finding are similar to the maximal distance of Type V in our study.[103] Fortunately, there was no nearest artery locating at JL landmark; therefore, the needle access from this area may remain safe. The study of Qassemyar et al (2012) found that the mean diameter of FA was 2.78 ± 0.44 mm, while the external diamer in this study was similar to their study (2.56 ± 0.64 mm).[47] Additionally, the nearest artery located posterior to the platysma muscle in all cases. Basically, the needle is used to inject into preperiosteal layer at the inferolateral mandibular border of the mandibular angle. However, this study recommends that the inferoateral approach is safe; nevertheless, the needle should be stayed along the supraperiosteum layer at the area of inferior border of mandible. Finally, retrograde linear threading technique should be done from medial to lateral.

➢ ***Nearest artery to Marionette (MN) injection sites***

The marionette line (MN) is one of the lower face aging sign which was found as the labiomental fold lining from oral commissure to the inferior mandibular border. Therefore, the arterial network surrounding the marionette line may be from the arterial supplying branch of the labiomental area. However, this study investigated the nearest artery to MN in two sites: the inferior margin of MN (MN1) and MN itself at the level of mid pupil (MN2). The result found that the associated nearest arteries to all MN landmarks were inferior labial artery (ILA), horizontal labiomental artery (LMA), and main FA. The LMA was mainly found placing closest to MN1 in 38 of 62 cases (61.3%), while it also located nearest to MN2 in most cases (29 of 62 cases (46.8%)). Related to Wu et al (2014), the labiomental region was supplied by the horizontal labiomental

(HLMA) and the vertical labiomental artery (VLMA) except for the ILA. The HLA emerged from the FA while the VLA derived from SMA.[105] Similarly, Ahmadi et al (2012) found that the arterial supply of the lower lip derived from three branches including ILA, HLMA and VLMA.(106) However, the used terminology of HLMA and ILMA seem to be confusion. Therefore, this study classified this branch following the study of Lee et al (2015). The HLMA was defined as the branch of FA which ran in the middle of the lower lip, whereas the ILA traveled along the lower lip border. (54) In the other nearest arteries, the main FA was secondly found nearest to MN1 (37.1%) and MN2 (27.4%) landmarks. It means that the main FA should be concerned during MN filler injection. However, the ILA was also found positioning closest to MN2 in 16 of 62 cases (25.8%) because this point located closer the lower lip than MN1. According to arterial location, the superior (Type VIII) to MN1 was found in most cases (25 of 62 cases, 40.3%) with the distance of 5.91 mm (min-max: 1.09- 15.91 mm) along Y-axis. Differently, the nearest artery of MN2 was mostly placed inferior to landmark (16 of 62 cases, 25.0%) with the Y distance of 3.91 mm (min-max: 0.77-8.79 mm). Interestingly, the artery located directly to MN1 in 7 cases (11.3%) and MN2 in 8 cases (12.9%). Thus, injection at both MN injection sites may probably injure the artery. There was no aforementioned study related to our measurement. Kawai et al (2009) measured the distance between ILA and oral commissure, and the distance was 23.9 mm. [53] However, the measurement cannot show arterial location correlated to marionette line. The external diameter of ILA of MN1 and MN2 landmarks was 1.66 mm and 0.95 ± 0.55 mm, respectively. The study of Pinar et al (2005) found that the external diameter of ILA was 1.31 mm (min-max: 0.5- 1.5 mm). [48] Likely, Kawai et al (2009) found that the mean diameter of ILA was 1.2 mm (range from 1- 1.8 mm). [53]

The arterial lining layer investigation found that the nearest artery located interspace between mucosa and the orbicularis oris and the depressor labii inferioris muscle (submucosa layer) in most cases (both presence in 83.9%). While the intramuscular layer was secondly found equal presence in both MN landmark (12.9%). Similarly, Cotofana et al (2016) found that the ILA positioned in there layers including submucosa (78.1%), intramuscular layer (17.5%), and subcutaneous layer (2.1%). [(107)] However, the nearest arterial lining in subcutaneous layer in our study was found only 1 cases (1.6%). Furthermore, the study of Wu et al (2014) found that the ILA, VLMA and HLMA traveled along the submucosa layer before giving the minute branch.(105) Distinctly, the nearest artery to MN1 in our study was found locating over the bone (supraperiosteal layer) in 2 cases (3.2%).

Commonly, the direct injection into marionette line combined cross- hatching technique was performed to improve this depress area. [(10)]The injection layer should be dermal or subdermal layer. [(9)] Based on our finding, we suggest that the injection medial or inferomedial approach may create low risk of arterial accident . However, the safest injection layer is the dermal injection similar to previous recommendation because there was no arterial lining in this layer.

5.2 The arterial anastomoses of the face

The occurring of severe complications including blindness, skin necrosis, and cerebral infarction are generated by the intravascular injection leading to vascular emboli from the filler material.[(37)] However, the causes of the such complications depends on arterial branches which derive from either direct branch of OA or the anastomotic to branches of OA. In cases of anastomotic routes, Fathi et al (2016) mentioned that the arterial communication between arteries of the face and the branches of OA results in blockage of peripheral branch of the central retinal artery.[84] Therefore, this study have investigated the anastomosis of the nearest arteries of each aforementioned injection sites with the neighboring arteries which arise from both of internal and external carotid artery.

5.2.1 The arterial anastomosis in 20 hemi-faces, anastomosis patterns, number of anastomosis and diameter of anastomotic point

➢ **Upper face**

As mentioned above, the arterial supplies of the upper face region derived from both internal and external carotid system. The main artery supply of the FH and GB injection sites was the STCA which arose directly from OA, while the SOA was the major blood supply of EB and UE injection sites. The communication between SOA and STCA was found 12 of 20 cases (60.0%), and the end- end anastomosis was found in most cases (11 of 12 cases). In addition, our study proposed the number of anastomosis in order to estimate the possible filler emboli pathway following the anastomoses branches. The SOA- STCA anastomotic number was found 1-2 points. Relative to Yu et al (2008), they mentioned that the STCA which significant supplying branch of forehead flap was found connecting with the muscular branch of SOA in their study.[77] Likely, Kleintjes (2007) presented that the STCA was found lateral connecting with SOA at the supraorbital rim in 10 of 43 cases. (59) Additionally, Lopez et al (2008) illustrated that the arterial arcade of upper eyelid was from the communication network of branches of internal carotid system (STC and SOA) and external carotid system (FA and STA).[64] Differently, the related arteries of TP injection sites are STA and ZOA. Although the STA and ZOA were not from the internal carotid circulation, it was found communicating with the internal carotid system in our study.

As our results, the STA communicated with branch of OA including STCA (9 of 20 cases, 45.0%) and SOA (19 of 20 cases, 95.0%); however, it anastomosed with ZOA, braches of STA itself, in 7 of 20 cases (35.0%). Tanya et al (2016) explained that the frSTA has direct communication with the SOA and STCA; thus, it may simplify entry pathway to OA. [77] Moreover, Pinar and Govsa (2006) described that the arterial anastomosis of forehead was from the communication between frSTA and STCA, and from connection of frSTA and SOA. [59] However, the anastomosis between transverse frontal branch of frSTA was discovered connecting with vertical branch of SOA in the middle and upper third of forehead in the study of Kleintjes. [64] Similar to explanation of Choi et al (2017), the upper marginal arcade of the superior palpebral region was contributed from the ZOA, SOA, STCA and superior medial palpebral artery.[89] According to findings in this study and previous study, the embolic channel following injection at temple region may cause of the communication of STA and ZOA with the branches of OA including SOA and STCA. In term of STA and ZOA anastomosis, both arteries ramified of external carotid artery, and anastomosed to each other at the temporal region. Correlated to Pinar and Govsa (2006), the ZOA was found communicating with frSTA along its course.[77] Based on our findings, we assume that the possible pathways of blindness may from individual branches of OA (STCA and SOA), and from the anastomotic routes including SOA – ZOA communication, STA-STCA connection, and STA – SOA anastomosis.

- **Middle face**

The middle face was supplied by various arterial branches. Related to the nearest arteries to each midface injection site, the TFA was found locating nearest to the TT1 and LH injection sites. In our anastomotic study, the TFA was observed anastomosed with FA (12 of 20 cases, 95%), IOA (17 of 20 cases, 85%) and AAfa (one cases, 5%). Moreover, the number anastomosis of TFA with aforementioned arteries was highly found as followed 1-4 sites in TFA- FA communication and 1-3 points in TFA- IOA connection. This result showed that TFA was not found connecting with the branch of internal carotid artery. Therefore, the TFA injury may provide low risk of blindness, but it connection may provide the wide space of the skin necrosis after filler embolus occlusion. Likely, the investigation of Pilsl et al (2016) found that TFA communicated with FA in 9 of 60 facial artery (15%). [45] In addition, Yang et al (2010) represented that the anastomosis between FA and TFA was found in Type A (the superior and inferior emerging branches presenting with the duct-crossing branch) and Type B (superior and inferior emerging branches presenting with missing the duct-crossing branch) TFA. [44] Moreover, the TFA also joined with the IOA and lacrimal artery to supply the periorbital region. [44, 58, 95]

In other anastomoses of the middle face, the IOA and its branches which located nearest to TT2, TT3, MC and NLF3 injection sites connected to several arteries including AAoa (3 of 20 cases, 15%), FA (19 of 20 cases, 95%), and AAfa (2 of 20 cases, 10%) (Table 41). The single anastomosis of IOA was found with AAoa and AAfa, while the amount of anastomosis was 1-3 point in the IOA- FA connection. Regarding to study of Pilsl et al (2016), he exhibited that proximal FA released the vertical branch to communicate with the IOA in 27 of 60 hemi-faces (45%), and the location of connection was over the buccinators and lateral to levator anguli oris muscle. [45, 108] In addition, Mas et al (2014) exhibited that AAfa was found joining with IOA in 5 of 32 cases (15.6%). [108] Therefore, the intra-arterial injection at TT2, TT3, MC and NLF3 may cause of blindness due to the anastomosis of IOA and AAoa.

Interestingly, the AAoa which located nearest to TT4 was also found anastomoses with the AAfa in 9 of 20 cases (45%) in this study. This communication may be one of embolic channel of the filler to reach the central retinal artery. Lasjaunias et al (1979) explained that the AAfa served as the blood perfusion of the medial infraorbital region, and also communicated with peripheral nasal branch of OA.[109] Thus, the injection of area surrounding TT4 area may create the possibility of blindness because of the integration of both carotid systems. Finally, the LNA which was mainly found placing nearest to NLF4 injection site was discovered two communications including with DNA (15 of 20 cases, 75%) and IOA (2 of 20 cases, 10%). Importantly, the connection to DNA is unaccepted condition due to it may be the filler embolic pathway to reach the central retinal artery. Marur et al (2014) illustrated that the DNA was the distal branch of OA, and it piercing the orbital septum becoming anastomotic territories with LNA and IOA. (7) However, Hou et al (2014) reported that the LNA solely communicated with DNA. Based on our findings, the anastomotic pathways which may lead to blindness after midface injection consisted of AAoa- AAfa, AAoa- pIOA, DNA- pIOA, and IOA- DNA communications.

- **Lower face**

The LMA, nearest artery of all MN injection sites, anastomosed with SMA (3 of 20 cases, 15%) and ILA (8 of 20 cases, 25%). Both of End- End type and End- Side types of LMA- ILA communication were found with the anastomotic number of 1- 2 points. Whereas the LMA- SMA anastiomosis was single anastomosis. However, there was no anastomosis between such arteries with the branches of internal carotid system. Correlated to Edizer et al (2002), the horizontal LMA firstly ran transversely, thereafter it changed to vertical to anastomose with the ILA in 2 of 12 cases. [53] According to our results, we suppose that risk of ocular complications may lower than the middle and upper face filler injection.

- **<u>Anastomosis between upper face, middle face, and lower face</u>**

The communication of branches of the upper and middle face in this study was found as followed STA- TFA (35%), TFA- SOA (5%), and TFA- ZOA (30%) communications. Whereas, the communication between middle and lower face was IOA- SLA connection (5%). However, entire anastomoses was found with only the branches of external carotid system. Relative to finding of Pinar and Govsa (2006) and Yang et al (2010), they found that the TFA had communication with the ZOA above the masseteric fascia. (44, 59) The communication between the branches of STA itself has been rarely reported in the previous study. It may has significant in the collateral branches between upper and middle face. In detail of our study, the desSTA traveled inferiorly, and then it joined to the terminal branch of superior trunk of TFA. Similarly, the superior trunk of TFA also released the terminal branch to anastomose with ZOA. Consequently, this occurrence may probably provide the blood supply to each other area when either proximal TFA or ZOA is occluded. To compare with others studies, the result of this study have deeply described in the anastomotic pathway, so the detailed information may assist the clinician in considering the risk of occurring severe complications.

<u>5.2.2 The arterial anastomosis between right and left side of the face, anastomosis patterns, number of anastomosis and diameter of anastomotic point</u>

The anastomoses between right and left hemi-faces were also detailed investigated in this study. On the upper face, the anastomosis between both sides of STCA was discovered in 9 of 10 case (90%). The number of anastomosis was over than 1 site. Therefore, it may increase chance of vascular occlusion via several routes. Likely, Yu et al (2008) and Kleintjesfound (2007) found that the bilateral STCA had their abundant anastomosis territories in the area of midline of the forehead which similar to our study. [81, 83] Moreover, the communication between contralateral STA and STCA was found in 1 cases in this study. It may assume that the temple injection on one side may result in blindness or paramedian forehead necrosis on the opposite side. Therefore, the arterial occlusion after upper face injection may lead to occurring lesion of the contralateral side of the face following our findings.

In the middle face, the anastomoses between dual facial sides were found with the bilateral DNA, LNA, and SLA. Supporting study of Seo et al (2009), they found that the DNA anastomosed to the opposite DNA at the midline of the proximal part of nasal dorsum.[110] Seriously, the DNA derived from the OA, the filler emboli along the DNA can cause the blindness in the contralateral side. For the remaining cases, both side of LNA (5 of 10 cases, 50%), and SLA (9 of 10, 90%) were found communicating together. Similar to Cotofana et al (2017), they found that the SLA ran inside the orbicularis oris muscle, and then its terminal branch anastomosed to the contralateral SLA.[107] Therefore, the contralateral anastomoses may provide the lesion following the vascular complications in the other side.

For the lower face area, the contralateral ILA and LMA which associated to MN injection site were found anastomosing in 8 (80%) and 5 (50%) of 10 cases, respectively. Similar to description of Edizer et al (2003) and Cotofana et al (2017), the ILA traveled in the orbicularis oris muscle, and provide the bilateral anastomosis on the medial face in 2 of 14 cases. [53, 107]

Furthermore, bilateral anastomoses of LMA was found correlating with the explanation of Edizer et al (2003) as well. They found that the LMA travel from lateral to medial direction to joined with LMA on the opposite side. [53] Differently, our study found that the SMA which located nearest to CN anastomosed to the contralateral ILA (10%) and LMA (10%). However, our study was different to others studies because these anastomosis pattern was found only in the ipsilateral side in previous examinations. [53, 100] Even though the anastomotic channel of the artery of lower face may not produce the blindness, it may lead to the pathology on the reverse side.

CHAPTER VI

CONCLUSIONS

This study proposes the exact artery to filler injection sites correlated to facial aging features. Moreover, the nearest arterial location to each injection was investigated in order to present the safe filler injection site. Finally, risk of severe complications was evaluated by both of direct intraarterial injection and by nearest arterial anastomotic pathways.

Considering forehead injection site, the most arterial concern is the supratrochlear artery. For the eyebrow injection site, the most nearest artery is BBSOA. In term of upper eyelid injection site, the main artery is the lateral rim branch of SOA, while the main involving artery to glabellar area is central artery. Therefore, the possibility of severe complication may come from direct branch of OA injection in entire mentioned areas. The major nearest artery of the temple area is from the STA which is arose from external carotid system. The injection of this site may provide the risk of severe complication due to it connects with the branches of internal carotid system including SOA and STCA.To conclude the artery of middle face injection sites, the TT1 and LH injection sites are associated with the TFA, while the TT2, TT3 and MC are related with the IOA. However, these arteries derives from the external carotid system. Nevertheless, the IOA may provide the severe complication by anastomotic pathways of IOA- DNA and IOA- AAoa communication. Regarding the TT4 injection site, the AAoa is closely correlate to this site. Therefore, the possibility of severe complication may cause of direct OA injection. For the nasolabial injection, the FA may concern at the NLF1 and NLF2 injection sites, while the IOA and LNA may be consider at the NLF3 and NLF4 injection sites. Although the all main nearest artery of NLF are from the external carotid system, they had numerous communications to the branch of OA including AAoa and DNA. In the lower face, all lower face injection sites are associate with only the branch of external carotid system. Moreover, they do not directly connect to the branch of internal carotid system.

To summarize our finding, the upper face may provide highest risk of severe complications due to it contained the direct branch of OA. Secondly, the middle face region may encounter with severe adverse events including blindness and cerebral infarction in case of anastomosis between internal and external carotid system. However, the arterial injury of lower face may create least possibility of blindness because of the absent of anastomosis between external and internal carotid system.

REFERENCES

1. Kim YK (A), Jung C, Woo SJ, Park KH. Cerebral Angiographic Findings of Cosmetic Facial Filler-related Ophthalmic and Retinal Artery Occlusion. J Korean Med Sci 2015;30:1847-55.

2. Alessandrini A, Fino P, Giordan N, Amorosi V, Scuderi N. Evaluation of a new hyaluronic acid dermal filler for volume restoration J Cosmet Laser Ther 2015;17:335-42.

3. Fan Y, Jeong JH, You GY, Park JU, Choi TH, Kim S. An Experimental Model Design for Photoaging. J Craniofac Surg 2015;26:e467-71.

4. Ozturk CN, Li Y, Tung R, Parker L, Piliang MP, Zins JE. Complications following injection of soft-tissue fillers. Aesthet Surg J 2013;33:862-77.

5. Sykes JM, Cotofana S, Trevidic P, Solish N, Carruthers J, Carruthers A, et al. Upper Face: Clinical Anatomy and Regional Approaches with Injectable Fillers. Plast Reconstr Surg 2015;136:204S-18S.

6. Kim H-J (B), Seo KK, Lee H-K, Kim J. Clinical anatomy of the face for filler and botulinum toxin injection. 1st ed. Singapore: Springer Science+Business Media Singapore Pte Ltd.; 2015.

7. Marur T, Tuna Y, Demirci S. Facial anatomy. Clin Dermatol 2014 ;32(1):14-23.

8. Lasjaunias P, Berenstein A, Doyon D. Normal functional anatomy of the facial artery. Radiology 1979 ;133:631-8.

9. Graivier MH, Bass LS, Busso M, Jasin ME, Narins RS, Tzikas TL. Calcium hydroxylapatite (Radiesse) for correction of the mid- and lower face: consensus recommendations. Plast Reconstr Surg 2007;120:55S-66S.

10. Bass LS. Injectable Filler Techniques for Facial Rejuvenation, Volumization, and Augmentation. Surg Clin North Am 2015;23:479-88.

11. Surek CC, Beut J, Stephens R, Jelks G, Lamb J. Pertinent anatomy and analysis for midface volumizing procedures. Plast Reconstr Surg 2015;135:818e-29e.

12. Breithaupt AD, Jones DH, Braz A, Narins R, Weinkle S. Anatomical Basis for Safe and Effective Volumization of the Temple. Dermatol Surg 2015;41:S278-83.

13. Hotta TA. Understanding the Anatomy of the Upper Face When Providing Aesthetic Injection Treatments. Plast Surg Nurs 2016;36:104-9.

14. Griepentrog GJ, Lucarelli MJ. Anatomical position of hyaluronic acid gel following injection to the eyebrow. Ophthalmic Plast Reconstr Surg 2013;29:364-6.

15. Wang W, Xie Y, Huang RL, Zhou J, Tanja H, Zhao P, et al. Facial Contouring by Targeted Restoration of Facial Fat Compartment Volume: The Midface. Plast Reconstr Surg 2017;139:563-72.

16. Hill RH, 3rd, Czyz CN, Kandapalli S, Zhang-Nunes SX, Cahill KV, Wulc AE, et al. Evolving Minimally Invasive Techniques for Tear Trough Enhancement. Ophthalmic Plast Reconstr Surg 2015;31:306-9.

17. El-Garem YF. Estimation of bony orbit depth for optimal selection of the injection technique to correct the tear trough and palpebromalar groove. Dermatol Surg 2015;41:94-101.

18. Yang HM (A), Lee JG, Hu KS, Gil YC, Choi YJ, Lee HK, et al. New anatomical insights on the course and branching patterns of the facial artery: clinical implications of injectable treatments to the nasolabial fold and nasojugal groove. Plast Reconstr Surg 2014;133:1077-82.

19. Dallara JM, Baspeyras M, Bui P, Cartier H, Charavel MH, Dumas L. Calcium hydroxylapatite for jawline rejuvenation: consensus recommendations. J Cosmet Dermatol 2014;13:3-14.

20. Haneke E. Adverse effects of fillers and their histopathology. Facial Plast Surg 2014;30:599-614.

21. Park TH, Seo SW, Kim JK, Chang CH. Clinical experience with hyaluronic acid-filler complications. J Plast Reconstr Aesthet Surg 2011;64:892-6.

22. Flynn TC, Sarazin D, Bezzola A, Terrani C, Micheels P. Comparative histology of intradermal implantation of mono and biphasic hyaluronic acid fillers. Dermatol Surg 2011;37:637-43.

23. Iannitti T, Bingol AO, Rottigni V, Palmieri B. A new highly viscoelastic hyaluronic acid gel: rheological properties, biocompatibility and clinical investigation in esthetic and restorative surgery. Int J Pharm 2013;456:583-92.

24. Roh NK, Kim MJ, Lee YW, Choe YB, Ahn KJ. A Split-Face Study of the Effects of a Stabilized Hyaluronic Acid-Based Gel of Nonanimal Origin for Facial Skin Rejuvenation Using a Stamp-Type Multineedle Injector: A Randomized Clinical Trial. Plast Reconstr Surg 2016;137:809-16.

25. Sanchez-Carpintero I, Candelas D, Ruiz-Rodriguez R. [Dermal fillers: types, indications, and complications]. Actas Dermosifiliogr 2010;101:381-93.

26. Hexsel D, Soirefmann M, Porto MD, Siega C, Schilling-Souza J, Brum C. Double-blind, randomized, controlled clinical trial to compare safety and efficacy of a metallic cannula with that of a standard needle for soft tissue augmentation of the nasolabial folds. Dermatol Surg 2012;38:207-14.

27. Tansatit T, Apinuntrum P, Phetudom T. Cadaveric Assessment of Lip Injections: Locating the Serious Threats. Aesthet Surg J 2017;41:430-40.

28. Lee JG (A), Yang HM, Choi YJ, Favero V, Kim YS, Hu KS, et al. Facial arterial depth and relationship with the facial musculature layer. Plast Reconstr Surg 2015;135:437-44.

29. Nettar K, Maas C. Facial filler and neurotoxin complications. Facial plast Surg 2012;28:288-93.

30. De Pasquale A, Russa G, Pulvirenti M, Di Rosa L. Hyaluronic acid filler injections for tear-trough deformity: injection technique and high-frequency ultrasound follow-up evaluation. . Aesthet Surg J 2013;37:587-91.

31. Lemperle G, Knapp TR, Sadick NS, Lemperle SM. ArteFill permanent injectable for soft tissue augmentation: I. Mechanism of action and injection techniques. . Aesthet Surg J 2010;34:264-72.

32. D'Aloiso MC, Senzolo M, Azzena B. Efficacy and Safety of Cross-Linked Carboxymethylcellulose Filler for Rejuvenation of the Lower Face: A 6-Month Prospective Open-Label Study. Dermatol Surg 2016;42:209-17.

33. Hilinski JM, Cohen SR. Soft tissue augmentation with ArteFill. Facial plast Surg 2009;25:114-9.

34. Sieber DA, Scheuer JF, 3rd, Villanueva NL, Pezeshk RA, Rohrich RJ. Review of 3-dimensional Facial Anatomy: Injecting Fillers and Neuromodulators. Plast Reconstr Surg Glob Open 2016;4:e1166.

35. Tzikas TL. Evaluation of the Radiance FN soft tissue filler for facial soft tissue augmentation. Arch Facial Plast Surg 2004;6:234-9.

36. Grunebaum LD, Bogdan Allemann I, Dayan S, Mandy S, Baumann L. The risk of alar necrosis associated with dermal filler injection. Dermatol Surg 2009;35:1635-40.

37. DeLorenzi C. New High Dose Pulsed Hyaluronidase Protocol for Hyaluronic Acid Filler Vascular Adverse Events. Aesthet Surg J 2017.

38. Juhasz ML, Marmur ES. Temporal fossa defects: techniques for injecting hyaluronic acid filler and complications after hyaluronic acid filler injection. J Cosmet Dermatol 2015;14:254-9.

39. Kang BK, Kang IJ, Jeong KH, Shin MK. Treatment of glabella skin necrosis following injection of hyaluronic acid filler using platelet-rich plasma. J Cosmet Laser Ther 2016;18:111-2.

40. Lazzeri D, Agostini T, Figus M, Nardi M, Pantaloni M, Lazzeri S. Blindness following cosmetic injections of the face. Plast Reconstr Surg 2012;129:995-1012.

41. Tansatit T, Moon HJ, Apinuntrum P, Phetudom T. Verification of Embolic Channel Causing Blindness Following Filler Injection. Aesthetic Plast Surg 2015;39:154-61.

42. Lee CM (B), Hong IH, Park SP. Ophthalmic artery obstruction and cerebral infarction following periocular injection of autologous fat. Korean J Ophthalmol 2011 Oct;25:358-61.

43. Weinberg MJ, Solish N. Complications of hyaluronic acid fillers. Facial plast Surg 2009;25:324-8.

44. Yang HJ (B), Gil YC, Lee HY. Topographical anatomy of the transverse facial artery. Clin Anat 2010;23:168-78.

45. Pilsl U, Anderhuber F, Neugebauer S. The Facial Artery-The Main Blood Vessel for the Anterior Face? Dermatol Surg 2016;42:203-8.

46. Koh KS, Kim HJ, Oh CS, Chung IH. Branching patterns and symmetry of the course of the facial artery in Koreans. Int J Oral Maxillofac Surg 2003 ;32:414-8.

47. Qassemyar Q, Havet E, Sinna R. Vascular basis of the facial artery perforator flap: analysis of 101 perforator territories. Plast Reconstr Surg 2012;129:421-9.

48. Pinar YA, Bilge O, Govsa F. Anatomic study of the blood supply of perioral region. Clin anat 2005;18:330-9.

49. Lohn JW, Penn JW, Norton J, Butler PE. The course and variation of the facial artery and vein: implications for facial transplantation and facial surgery. Ann Plast Surg 2011;67:184-8.

50. Lee SH (C), Gil YC, Choi YJ, Tansatit T, Kim HJ, Hu KS. Topographic anatomy of the superior labial artery for dermal filler injection. Plast Reconstr Surg 2015 ;135:445-50.

51. Loukas M, Hullett J, Louis RG, Jr., Kapos T, Knight J, Nagy R, et al. A detailed observation of variations of the facial artery, with emphasis on the superior labial artery. Surg Radiol Anat 2006;28:316-24.

52. Magden O, Edizer M, Atabey A, Tayfur V, Ergur I. Cadaveric study of the arterial anatomy of the upper lip. Plast Reconstr Surg 2004;114:355-9.

53. Kawai K, Imanishi N, Nakajima H, Aiso S, Kakibuchi M, Hosokawa K. Arterial anatomy of the lower lip. cand J Plast Reconstr Surg Hand Surg 2004;38:135-9.

54. Lee SH (D), Lee HJ, Kim YS, Kim HJ, Hu KS. What is the difference between the inferior labial artery and the horizontal labiomental artery?. Surg Radiol Anat 2015;37:947-53.

55. Hou D, Fang L, Zhao Z, Zhou C, Yang M. Angular vessels as a new vascular pedicle of an island nasal chondromucosal flap: Anatomical study and clinical application. Exp Ther Med 2013;5:751-6.

56. Kim YS (C), Choi DY, Gil YC, Hu KS, Tansatit T, Kim HJ. The anatomical origin and course of the angular artery regarding its clinical implications. Dermatol Surg 2014;40:1070-6.

57. Lee JG (E), Yang HM, Hu KS, Lee YI, Lee HJ, Choi YJ, et al. Frontal branch of the superficial temporal artery: anatomical study and clinical implications regarding injectable treatments. Surg Radiol Anat 2015;37:61-8.

58. Edizer M, Beden U, Icten N. Morphological parameters of the periorbital arterial arcades and potential clinical significance based on anatomical identification. J Craniofac Surg 2009;20:209-14.

59. Pinar YA, Govsa F. Anatomy of the superficial temporal artery and its branches: its importance for surgery. Surg Radiol Anat 2006;28:248-53.

60. Patel AV, Rashid A, Jakobiec FA, Lefebvre DR, Yoon MK. Orbital Branch of the Infraorbital Artery: Further Characterization of an Important Surgical Landmark. Orbit. 2015;34:212-5.

61. Hayreh SS. Orbital vascular anatomy. Eye 2006;20:1130-44.

62. Hwang K, Kim DH, Huan F, Nam YS, Han SH. The anatomy of the palpebral branch of the infraorbital artery relating to midface lift. J Craniofac Surg 2011 ;22:1489-90.

63. Cong LY, Phothong W, Lee SH, Wanitphakdeedecha R, Koh I, Tansatit T, et al. Topographic Analysis of the Supratrochlear Artery and the Supraorbital Artery:

Implication for Improving the Safety of Forehead Augmentation. Plast Reconstr Surg 2017 ;139:620e-7e.

64. Lopez R, Lauwers F, Paoli JR, Boutault F, Guitard J. The vascular system of the upper eyelid. Anatomical study and clinical interest. Surg Radiol Anat 2008;30:265-9.

65. Kelly CP, Yavuzer R, Keskin M, Bradford M, Govila L, Jackson IT. Functional anastomotic relationship between the supratrochlear and facial arteries: an anatomical study. Plast Reconstr Surg 2008;121:458-65.

66. Kwon SG, Hong JW, Roh TS, Kim YS, Rah DK, Kim SS. Ischemic oculomotor nerve palsy and skin necrosis caused by vascular embolization after hyaluronic acid filler injection: a case report. Ann Plast Surg 2013;71:333-4.

67. Kwak HH, Hu KS, Youn KH, Jin GC, Shim KS, Fontaine C, et al. Topographic relationship between the muscle bands of the zygomaticus major muscle and the facial artery. Surg Radiol Anat 2006;28:477-80.

68. Abbate V, Romano A, AlQahtani A, Manfuso A, Hirt B, Castelnuovo P, et al. Midcheek endoscopic anatomy. Head Neck 2016;38:E268-73.

69. Al-Hoqail RA, Meguid EM. Anatomic dissection of the arterial supply of the lips: an anatomical and analytical approach. J Craniofac Surg 2008;19:785-94.

70. Kim SH (D), Jung WY, Seo YJ, Kim KA, Park KH, Park YG. Accuracy and precision of integumental linear dimensions in a three-dimensional facial imaging system. Korean J Orthod 2015;45:105-12.

71. Lee KW(F), Kim SH, Gil YC, Hu KS, Kim HJ. Validity and reliability of a structured-light 3D scanner and an ultrasound imaging system for measurements of facial skin thickness. Clin Anat 2017.

72. Liu AT, Yu DZ, Chen G, Dang RS, Zhang YF, Zhang WJ, et al. Profiling of innervations of mimetic muscles in fresh human cadavers using a modified Sihler's technique. Muscle Nerve 2010;42:88-94.

73. Won SY, Choi DY, Kwak HH, Kim ST, Kim HJ, Hu KS. Topography of the arteries supplying the masseter muscle: Using dissection and Sihler's method. Clin Anat 2012 ;25:308-13.

74. Smit JM, Ruhe PQ, Acosta R, Kooloos JG, Hartman EH. The nasolabial fold as potential vascular receptor site: an anatomic study. J Reconstr Microsurg 2009;25:539-43.

75. Alghoul M, Bitik O, McBride J, Zins JE. Relationship of the zygomatic facial nerve to the retaining ligaments of the face: the Sub-SMAS danger zone. Plast Reconstr Surg 2013;131:245e-52e.

76. Mu L, Sanders I. Sihler's whole mount nerve staining technique: a review. Biotech Histochem 2010;85:19-42.

77. Khan TT, Colon-Acevedo B, Mettu P, DeLorenzi C, Woodward JA. An Anatomical Analysis of the Supratrochlear Artery: Considerations in Facial Filler Injections and Preventing Vision Loss. Aesthet Surg J 2017; 37:203-8.

78. Kilinc H, Bilen BT. Supraorbital artery island flap for periorbital defects. J Craniofac Surg 2007; 18:1114-9.

79. Ugur MB, Savranlar A, Uzun L, Kucuker H, Cinar F. A reliable surface landmark for localizing supratrochlear artery: medial canthus. Otolaryngol Head Neck Surg 2008; 138:162-5.

80. Hu XZ, Hu JY, Wu PS, Yu SB, Kikkawa DO, Lu W. Posterior Ciliary Artery Occlusion Caused by Hyaluronic Acid Injections Into the Forehead: A Case Report. Medicine 2016; 95:3124.

81. Yu D, Weng R, Wang H, Mu X, Li Q. Anatomical study of forehead flap with its pedicle based on cutaneous branch of supratrochlear artery and its application in nasal reconstruction. Ann Plast Surg 2010; 65:183-7.

82. de Maio M, Swift A, Signorini M, Fagien S, Aesthetic Leaders in Facial Aesthetics Consensus C. Facial Assessment and Injection Guide for Botulinum Toxin and Injectable Hyaluronic Acid Fillers: Focus on the Upper Face. Plast Reconstr Surg 2017; 140:265e-76e.

83. Kleintjes WG. Forehead anatomy: arterial variations and venous link of the midline forehead flap. J Plast Reconstr Aesthet Surg 2007; 60:593-606.

84. Fathi R, Biesman B, Cohen JL. Commentary on: An Anatomical Analysis of the Supratrochlear Artery: Considerations in Facial Filler Injections and Preventing Vision Loss. Aesthet Surg J 2017; 37:209-11.

85. Griepentrog GJ, Lucarelli MJ. Anatomical position of hyaluronic acid gel following injection to the eyebrow. Ophthalmic Plast Reconstr Surg 2013; 29:364-6.

86. Erdogmus S, Govsa F. Anatomy of the supraorbital region and the evaluation of it for the reconstruction of facial defects. J Craniofac Surg 2007; 18:104-12.

87. Skaria AM. The median forehead flap reviewed: a histologic study on vascular anatomy. Eur Arch Otorhinolaryngol 2015; 272:1231-7.

88. Vural E, Batay F, Key JM. Glabellar frown lines as a reliable landmark for the supratrochlear artery. Otolaryngol Head Neck Surg 2000; 123:543-6.

89. Choi DH, Eom JR, Lee JW, Yang JD, Chung HY, Cho BC, et al. Zygomatico-orbital artery: The largest artery in the temporal area. J Plast Reconstr Aesthet Surg 2018; 71:484-9.

90. Riggio E, Spano A, Nava M. The forehead zygomatic-orbital artery-based island flap. Plast Reconstr Surg 2005; 115:226-33.

91. Cotofana S, Fratila AA, Schenck TL, Redka-Swoboda W, Zilinsky I, Pavicic T. The Anatomy of the Aging Face: A Review. Facial plast Surg 2016; 32:253-60.

92. Aveta A, Brunetti B, Tenna S, Segreto F, Persichetti P. Superficial temporal artery perforator flap: Anatomic study of number and reliability of distal branches of the superficial temporal artery and clinical applications in three cases. Microsurgery 2017; 37:924-9.

93. Gruber RP, Levine SM, Levine JP. Facial topography: clinical anatomy of the face. Plast Reconstr Surg 2013; 132:249.

94. Mojallal A, Cotofana S. Anatomy of lower eyelid and eyelid-cheek junction. Ann Chir Plast Esthet 2017; 62:365-74.

95. Schaverien MV, Pessa JE, Saint-Cyr M, Rohrich RJ. The arterial and venous anatomies of the lateral face lift flap and the SMAS. Plast Reconstr Surg 2009; 123:1581-7.

96. Cotofana S, Schenck TL, Trevidic P, Sykes J, Massry GG, Liew S, et al. Midface: Clinical Anatomy and Regional Approaches with Injectable Fillers. Plast Reconstr Surg 2015; 136:219S-34S.

97. Montes JR. Volumetric considerations for lower eyelid and midface rejuvenation. Curr Opin Ophthalmol 2012; 23:443-9.

98. Lombardo GA, Tamburino S, Tracia L, Tarico MS, Perrotta RE. Lateral Nasal Artery Perforator Flaps: Anatomic Study and Clinical Applications. Arch Plast Surg. 2016; 43:77-83.

99. Phumyoo T, Tansatit T, Rachkeaw N. The soft tissue landmarks to avoid injury to the facial artery during filler and neurotoxin injection at the nasolabial region. J Craniofac Surg 2014; 25:1885-9.

100. Loukas M, Kinsella CR, Jr., Kapos T, Tubbs RS, Ramachandra S. Anatomical variation in arterial supply of the mandible with special regard to implant placement. Int J Oral Maxillofac Surg 2008; 37:367-71.

101. Kim DH, Won SY, Choi DY, Kim HS, Jung UW, Kim HJ, et al. Topography of the submental artery that should be considered in bleeding during dentoalveolar surgery. J Craniofac Surg 2012; 23:1453-6.

102. Bavitz JB, Harn SD, Homze EJ. Arterial supply to the floor of the mouth and lingual gingiva. Oral Surg Oral Med Oral Pathol 1994; 77:232-5.

103. Yang HM, Won SY, Kim HJ, Hu KS. Neurovascular structures of the mandibular angle and condyle: a comprehensive anatomical review. Surg Radiol Anat 2015; 37:1109-18.

104. Hwang K, Kim YJ, Chung IH, Lee SI. Deep middle masseteric artery (dMMA) attributed to hemorrhage in resection of masseter muscle and mandibular angle. J Craniofac Surg 2001; 12:381-5; discussion 6.

105. Wu D, Wang Y, Song T, Li H, Wu J, Qu W, et al. Aesthetic reconstruction of the upper lip with novel split musculomucosal-pedicle cross-lip flap. Ann Plast Surg 2014; 73:1:S88-91.

106. Ahmadi SK, Rahpeyma A, Rezvani HN. Vermilion lower lip cross flap - An anatomic study on 22 fresh cadavers. Ann Maxillofac Surg 2012; 2:107-10.

107. Cotofana S, Pretterklieber B, Lucius R, Frank K, Haas M, Schenck TL, et al. Distribution Pattern of the Superior and Inferior Labial Arteries: Impact for Safe Upper and Lower Lip Augmentation Procedures. Plast Reconstr Surg 2017; 139:1075-82.

108. Gocmen-Mas N, Edizer M, Keles N, Aksu F, Magden O, Lafci S, et al. Morphometrical aspect on angular branch of facial artery. J Craniofac Surg 2015; 26:933-6.

109. Chand N, Eyre P. Classification and biological distribution of histamine receptor sub-types. Agents Actions 1975; 5:277-95.

110. Seo YJ, Hwang C, Choi S, Oh SH. Midface reconstruction with various flaps based on the angular artery. Int J Oral Maxillofac Surg 2009;67:1226-33.

APPENDICES

1. *The comparative of diameter of nearest artery of Nearest artery to each injection site between gender*

1.1 Forehead (FH) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Left Supratrochlear artery (ltSTCA)	Male	6	0.56	0.30	0.94	0.23	0.200	0.735	0..422	-
	Female	8	0.47	0.24	0.75	0.18	0.200	0.799		
Right Supratrochlear artery (rtSTCA)	Male	9	0.48	0.28	0.66	0.12	0.200	0.799	0.942	-
	Female	7	0.48	0.37	0.70	0.12	0.200	0.190		
Anastomotic branch of right and left supratrochlear artery (Anas. rtSTCA	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.39	0.38	0.40	0.01	-	-		

1.2 Nearest artery to Eyebrow (EB) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Brow branch of supraorbital artery (BBSOA)	Male	10	0.47	0.33	0.69	0.12	0.200	0.637	0.503	-
	Female	19	0.50	0.34	0.72	0.11	0.200	0.227		
Oblique branch of SOA (OBSOA)	Male	1	0.92						0.775	-
	Female	3	0.94	0.37	1.28	0.48	-	0.402		
Zygomaticoorbital artery (ZOA)	Male	3	0.82	0.41	1.06	0.36	-	0.188	-	-
	Female	-	-	-	-	-	-	-		

Frontal branch of superficial temporal artery (frSTA)	Male	1	1.63						0.802	-
	Female	2	1.38	0.93	1.83	0.64	-	-		
Descending temporal branch of frSTA (desSTA)	Male	11	0.56	0.38	0.80	0.16	0.200	0.129	0.095	-
	Female	9	0.47	0.36	0.54	0.06	0.200	0.162		
Supraorbtial artery of lacrimal artery (SOA of LA)	Male	2	0.43	0.34	0.52	0.13	-	-	-	-
	Female	-	-	-	-	-	-	-		
Anastomotic branch of SOA and frSTA (Anas. SOA	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.49	-	-	-	-	-		

1.3 Nearest artery to Upper eyelid (UE) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Frontal branch of superficial temporal artery	Male	-	-	-	-	-	-	-	-	-
	Female	4	1.67	0.98	2.33	0.56	-	0.981		
Supraorbtial artery of lacrimal artery (SOA of LA)	Male	4	0.510.45	0.45	0.59	0.07	-	0.408	0.413	-
	Female	2	0.69	0.55	0.83	0.20	-	-		
Zygomaticoorbital artery (ZOA)	Male	6	0.62	0.33	0.96	0.25	0.200	0.329	0.454	-
	Female	8	0.53	0.42	0.72	0.10	0.200	0.572		
Descending temporal branch of Frontal branch superficial	Male	6	0.72	0.27	2.35	0.80	0.000	0.000	-	0.423
	Female	6	0.48	0.37	0.61	0.10	0.200	0.515		
	Male	10	0.52	0.35	0.77	0.12	0.076	0.238	0.825	-

Brow branch of supraorbital artery	Female	12	0.50	0.34	0.74	0.11	0.200	0.703		
Orbital branch of transverse facial artery (TFA)	Male	2	0.45	0.41	0.49	0.06	-	-	0.348	-
	Female	2	0.52	0.48	0.55	0.05	-	-		

1.4 Nearest artery to Glabella (GB) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Left Supratrochlear artery (STCA)	Male	3	0.58	0.53	0.65	0.06	-	0.637	0.810	-
	Female	6	0.61	0.40	0.85	0.21	0.140	0.071		
Right Supratrochlear	Male	2	0.40	0.35	0.44	0.06	-	-	0.087	-
	Female	1	0.96	-	-	-	-	-		
Left central artery (CA)	Male	5	0.49	0.27	0.73	0.19	0.200	0.656	0.985	-
	Female	5	0.49	0.27	0.63	0.14	0.200	0.462		
Right central artery (CA)	Male	4	0.39	0.30	0.46	0.07	-	0.731	0.484	-
	Female	3	0.46	0.35	0.65	0.17	-	0.174		
Right paracentral artery of (PCA)	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.43	-	-	-	-	-		

1.5 Nearest artery to Temple (TP) injection sites

1.5.1 TP1 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Frontal branch of superficial temporal artery (frSTA)	Male	4	1.35	0.58	1.86	0.56	-	0.597	0.700	-
	Female	7	1.48	0.87	2.18	0.49	0.200	0.686		
Descending temporal branch superficial temporal artery (desSTA)	Male	15	0.50	0.34	0.78	0.13	0.200	0.068	0.947	-
	Female	16	0.51	0.36	0.72	0.11	0.200	0.175		
Zygomaticoorbital artery (ZOA)	Male	8	0.69	0.52	1.07	0.20	0.050	0.053	-	0.862
	Female	7	0.63	0.54	0.86	0.11	0.115	0.021		
Supraorbtial artery from lacrimal artery (SOA of LA)	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.51	0.35	0.66	0.22	-	-		
Brow branch branch of supraorbital artery	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.49	0.40	0.57	0.12	-	-		
Superior branch of transverse facial artery (TFA)	Male	1	0.45	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		

1.5.2 TP2 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Frontal branch of superficial temporal artery (frSTA)	Male	5	1.96	1.57	2.41	0.31	0.200	0.954	0.384	-
	Female	6	1.66	0.95	2.61	0.65	0.200	0.509		
Descending temporal branch superficial temporal	Male	3	0.58	0.44	0.74	0.15	-	0.853	-	0.152
	Female	8	0.45	0.38	0.65	0.09	0.131	0.019		
Zygomaticoorbital artery (ZOA)	Male	18	0.63	0.33	0.99	0.21	0.200	0.396	0.464	-
	Female	18	0.58	0.31	0.98	0.18	0.200	0.730		
Supraorbtial artery from lacrimal artery (SOA of LA)	Male	1	0.34	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Superior branch of transverse facial artery (TFA)	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.52	0.46	0.57	0.52	-	-		
Zygomaticofacial artery (ZFA)	Male	1	0.53	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		

1.6 Nearest artery to tear trough (TT)

1.6.1 TT1 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Transverse facial artery (TFA)	Male	14	0.77	0.23	2.29	0.53	0.017	0.002	-	0.033
	Female	22	0.47	0.05	1.05	0.21	0.200	0.286		
Infraorbital artery (IOA)	Male	1	1.12	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Detoured branch of facial artery (dFA)	Male	3	1.01	0.52	1.54	0.51	-	0.849	0.968	-
	Female	1	0.98	-	-	-	-	-		
Facial artery (FA)	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.90	0.74	1.06	0.23	-	-		
Palpebral branch of maxillary artery	Male	2	0.46	0.42	0.50	0.06	-	-	-	-
	Female	-	-	-	-	-	-	-		
Palpebral branch of TFA (pTFA)	Male	2	0.44	0.36	0.51	0.11	-	-	-	0.481
	Female	4	0.46	0.24	0.55	0.15	-	0.026		
Palpebral branch of IOA (pIOA)	Male	3	0.48	0.44	0.55	0.06	-	0.000	-	-
	Female	-	-	-	-	-	-	-		
Palpebral branch of FA (pFA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.36	-	-	-	-	-		
Palpebral branch of dFA (pdFA)	Male	2	0.64	0.53	0.75	0.16	-	-	0.267	-
	Female	3	0.50	0.44	0.59	0.08	-	0.497		
Palpebral branch of buccal a. (pbFA)	Male	1	0.37	-	-	-	-	-	-	-
	Female	1	0.32	-	-	-	-	-		

1.6.2 TT2 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Transverse facial artery (TFA)	Male	2	0.47	0.43	0.50	0.05	-	-	0.394	-
	Female	1	0.38	-	-	-	-	-		
Infraorbital artery (IOA)	Male	2	0.99	0.92	1.06	-	-	-	1.000	-
	Female	1	0.99	-	-	-	-	-		
Facial artery (FA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.88	-	-	-	-	-		
Palpebral branch of maxillary artery	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.55	0.45	0.65	0.14	-	-		
Palpebral branch of TFA (pTFA)	Male	5	0.53	0.39	0.75	0.14	0.200	0.438	0.502	-
	Female	6	0.48	0.35	0.56	0.09	0.110	0.085		
Palpebral branch of IOA (pIOA)	Male	14	0.53	0.26	0.89	0.18	0.167	0.345	0.593	-
	Female	16	0.50	0.27	0.76	0.13	0.200	0.606		
Palpebral branch of FA (pFA)	Male	3	0.51	0.38	0.66	0.14	-	0.688	-	-
	Female	1	0.43	-	-	-	-	-		
Palpebral branch of dFA (pdFA)	Male	1	0.67	-	-	-	-	-	0.388	-
	Female	3	0.50	0.35	0.61	0.13	-	0.503		
Angular artery of dFA (AAdfA)	Male	1	0.75	-	-	-	-	-	0.339	-
	Female	2	1.24	1.07	1.40	0.23	-	-		
Palpebral branch of AAfa (pAAfa)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.43	-	-	-	-	-		

1.6.3 TT3 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Infraorbital artery (IOA)	Male	2	0.92	0.87	0.96	0.06	-	-	0.405	-
	Female	3	0.65	0.39	1.07	0.37	-	0.233		
Detoured branch of facial artery (dFA)	Male	3	0.81	0.45	1.17	0.36	-	0.969	0.147	-
	Female	3	1.21	1.08	1.36	0.14	-	0.843		
Facial artery (FA)	Male	1	1.51	-	-	-	-	-	-	-
	Female	1	0.86	-	-	-	-	-		
Palpebral branch of maxillary artery	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.65	0.56	0.74	0.13	-	-		
Palpebral branch of TFA (pTFA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.41	-	-	-	-	-		
Palpebral branch of IOA (pIOA)	Male	18	0.52	0.33	0.83	0.16	0.026	0.016	-	0.592
	Female	21	0.49	0.30	0.95	0.17	0.200	0.019		
Palpebral branch of dFA (pdFA)	Male	2	0.48	0.31	0.65	0.24	-	-	0.667	-
	Female	1	0.31	-	-	-	-	-		
Angular artery of IOA (AAioa)	Male	1	0.31	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Angular artery of FA (AAfa)	Male	1	0.74	-	-	-	-	-	-	-
	Female	2	1.02	0.70	1.34	0.45	-	-		

1.6.4 TT4 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Angular artery of OA (AAoa)	Male	15	0.56	0.27	1.13	0.21	0.044	0.092	0.077	-
	Female	12	0.44	0.28	0.60	0.10	0.200	0.822		
Angular artery of IOA (AAioa)	Male	1	0.55	-	-	-	-	-	-	0.655
	Female	3	0.59	0.45	0.87	0.24	-	0.040		
Angular artery of dFA (AAdfA)	Male	4	0.61	0.43	0.83	0.20	-	0.295	0.529	-
	Female	6	0.70	0.35	0.90	0.20	0.099	0.195		
Angular artery of FA (AAfa)	Male	8	0.65	0.27	1.57	0.41	0.200	0.038	-	0.699
	Female	12	0.60	0.43	1.09	0.18	0.014	0.004		
Dorsal nasal artery (DNA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.74	-	-	-	-	-		

1.7 Nearest artery to mid cheek (MC) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Transverse facial artery (TFA)	Male	2	0.58	0.56	0.59	0.02	-	-	0.145	-
	Female	6	0.45	0.34	0.61	0.10	0.200	0.629		
Labial branch of Infraorbital artery	Male	9	0.87	0.41	1.54	0.37	0.200	0.698	-	0.185
	Female	9	0.71	0.34	1.49	0.40	0.016	0.030		
Detoured branch of facial artery (dFA)	Male	2	1.07	0.71	1.43	0.51	-	-	0.638	-
	Female	2	0.84	0.72	0.96	0.17	-	-		
Facial artery (FA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.98	-	-	-	-	-		
Palpebral branch of maxillary artery	Male	2	0.84	0.69	0.99	0.21	-	-	-	-
	Female	-	-	-	-	-	-	-		
Palpebral branch of TFA (pTFA)	Male	2	0.44	0.38	0.49	0.08	-	-	0.204	-
	Female	3	0.54	0.48	0.62	0.07	-	0.688		
Palpebral branch of IOA (pIOA)	Male	8	0.45	0.28	0.73	0.15	0.200	0.480	0.889	-
	Female	6	0.47	0.30	0.62	0.14	0.200	0.194		
Palpebral branch of FA (pFA)	Male	1	0.62	-	-	-	-	-	0.117	-
	Female	2	0.34	0.31	0.37	0.04	-	-		
Palpebral branch of dFA (pdFA)	Male	-	-	-	-	-	-	-	-	-
	Female	4	0.53	0.33	0.75	0.18	-	0.970		
Palpebral branch of buccal artery	Male	2	0.39	0.35	0.43	0.06	-	-	-	-
	Female	-	-	-	-	-	-	-		
Palpebral branch of AAfa (pAAfa)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.42	-	-	-	-	-		

1.8 Nearest artery to lateral hollowness (LH injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Transverse facial artery (TFA)	Male	28	1.09	0.38	1.74	0.42	0.200	0.173	-	0.832
	Female	34	1.07	0.45	1.94	0.33	0.002	0.003		

1.9 Nearest artery to Nasolabial fold (NLF) injection sites injection site

1.9.1 NLF1 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Detoured branch (dFA)	Male	2	0.72	0.67	0.76	0.06	-	-	0.028	-
	Female	2	1.01	0.99	1.04	0.04	-	-		
Buccal branch of facial artery (bFA)	Male	4	0.59	0.53	0.66	0.06	-	0.780	0.417	-
	Female	2	0.48	0.39	0.57	0.13	-	-		
Facial artery (FA)	Male	20	1.73	0.65	2.44	0.54	0.200	0.250	0.964	-
	Female	27	1.72	0.86	3.01	0.51	0.200	0.322		
Superior labial artery (SLA)	Male	2	1.21	-	-	-	-	-	0.982	-
	Female	3	1.22	0.64	1.72	0.54	-	0.756		

1.9.2 NLF2 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Infraorbital artery (IOA)	Male	13	0.50	0.32	0.73	0.14	0.200	0.395	0.947	-
	Female	6	0.49	0.29	0.62	0.12	0.132	0.376		
Detoured branch (dFA)	Male	2	1.02	1.00	1.03	0.02	-	-	0.074	-
	Female	4	0.76	0.57	0.90	0.14	-	0.761		
Facial artery (FA)	Male	13	1.59	0.85	2.09	0.35	0.077	0.151	0.042	-
	Female	23	1.39	0.96	1.99	0.24	0.058	0.512		
Superior labial artery (SLA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.94	-	-	-	-	-		

1.9.3 NLF3 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Infraorbital artery (IOA)	Male	15	0.62	0.33	1.43	0.27	0.025	0.001	-	0.221
	Female	9	0.52	0.33	1.00	0.21	0.019	0.029		
Detoured branch (dFA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.84	-	-	-	-	-		
Inferior alar artery (IAA)	Male	1	1.04	-	-	-	-	-	0.740	-
	Female	2	1.07	1.03	1.11	0.06	-	-		
Facial artery (FA)	Male	7	1.51	1.18	2.07	0.38	0.107	0.032	-	0.597
	Female	15	1.44	0.86	1.97	0.35	0.200	0.658		
Lateral nasal artery of FA (LNA)	Male	5	1.37	0.94	1.71	0.32	0.200	0.652	0.978	-
	Female	7	1.37	1.05	1.60	0.17	0.159	0.278		

1.9.4 NLF4 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Infraorbital artery (IOA)	Male	8	0.79	0.56	1.37	0.26	0.115	0.030	-	0.089
	Female	12	0.64	0.41	1.23	0.23	0.131	0.033		
Facial artery (FA)	Male	4	1.112	0.98	1.27	0.13	-	0.938	0.840	-
	Female	5	1.15	0.85	1.58	0.29	0.200	0.639		
Angular artery of facial artery (AAfa)	Male	-	-	-	-	-	-	-	-	-
	Female	1	0.41	-	-	-	-	-		
Lateral nasal artery of FA (LNA)	Male	15	1.14	0.73	1.62	0.29	0.200	0.356	0.109	-
	Female	16	0.99	0.65	1.52	0.23	0.200	0.433		
Lateral nasal artery of IOA (ioaLNA)	Male	1	0.58	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		

1.10 Nearest artery to Lip (vermillion and volume) (LV) injection sites

1.10.1 LV1 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Facial artery (FA)	Male	5	1.59	1.27	1.83	0.25	0.200	0.372	0.836	-
	Female	5	1.55	1.17	1.90	0.28	0.200	0.802		
Superior labial artery (SLA)	Male	18	1.39	0.43	2.78	0.57	0.200	0.745	0.421	-
	Female	27	1.25	0.40	2.26	0.57	0.200	0.237		
Inferior alar artery (IAA)	Male	5	1.01	0.65	1.40	0.31	0.200	0.710	0.532	-
	Female	2	1.17	1.11	1.22	0.08	-	-		

1.10.2 LV2 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Superior labial artery (SLA)	Male	23	1.25	0.53	2.19	0.38	0.200	0.897	0.238	-
	Female	32	1.11	0.41	2.17	0.46	0.045	0.196		
Ascending branch of SLA (aSLA)	Male	5	0.76	0.65	0.87	0.08	0.200	0.952	0.907	-
	Female	2	0.71	0.32	1.09	0.54	-	-		

1.10.3 LV3 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Ascending branch of SLA (aSLA)	Male	-	-	-	-	-	-	-	-	-
	Female	2	0.59	0.43	0.75	0.23	-	-		
Septal branch of SLA (sSLA)	Male	6	0.95	0.40	1.91	0.52	0.135	0.274	0.878	-
	Female	3	0.90	0.63	1.06	0.23	-	0.247		
Left superior labial artery. (ltSLA)	Male	5	0.91	0.57	1.33	0.28	0.200	0.772	0.847	-
	Female	9	0.94	0.52	1.45	0.30	0.200	0.897		
Right superior labial artery (rtSLA)	Male	3	1.20	0.46	1.70	0.65	-	0.382	0.983	-
	Female	3	1.21	0.72	1.55	0.43	-	0.421		

1.11 Nearest artery to Chin (CN) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Left submental artery (ltSMA)	Male	8	0.85	0.53	1.12	0.22	0.200	0.375	0.817	-
	Female	4	0.81	0.42	1.35	0.43	-	0.518		
Right submental artery (rtSMA)	Male	6	0.87	0.57	1.14	0.23	0.200	0.356	0.208	-
	Female	13	0.72	0.47	0.96	0.15	0.200	0.876		

1.12 Nearest artery to Jaw line (JL) injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Facial artery (FA)	Male	21	2.63	1.63	3.57	0.54	0.200	0.573	0.512	-
	Female	34	2.52	1.14	4.44	0.70	0.004	0.123		
Masseteric branch of FA (mbFA)	Male	7	0.94	0.70	1.19	0.20	-	-	-	-
	Female	-	-	-	-	-	-	-		

1.13 Nearest artery to marionette (MN) injection site

1.13.1 MN1 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Inferior labial artery (ILA)	Male	-	-	-	-	-	-	-	-	-
	Female	1	1.66	-	-	-	-	-		
Labiomental artery (LMA)	Male	14	1.16	0.34	2.47	0.65	0.200	0.526	-	0.505
	Female	24	0.99	0.47	2.35	0.54	0.002	0.002		
Facial artery (FA)	Male	14	2.23	1.18	3.44	0.59	0.200	0.820	-	0.219
	Female	9	2.04	1.27	3.51	0.65	0.055	0.046		

1.13.2 MN2 injection site

Nearest artery	Sex	n	Diameter (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Inferior labial artery (ILA)	Male	6	0.96	0.43	1.66	0.41	0.200	0.559	-	0.385
	Female	10	0.94	0.32	2.32	0.65	0.001	0.010		
Labiomental artery (LMA)	Male	9	1.07	0.55	1.95	0.45	0.200	0.368	0.924	-
	Female	20	1.08	0.37	0.47	2.22	0.200	0.516		
Facial artery (FA)	Male	13	1.97	0.51	1.05	2.86	0.101	0.578	0.898	-
	Female	4	2.01	1.81	2.25	0.20	-	0.597		

2. ***The comparative of depth of nearest artery of Nearest artery to each injection site between genders***

2.1 Forehead (FH) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous	Male	13	1.24	0.82	1.92	0.38	0.039	0.014	-	0.730
	Female	15	1.21	0.80	1.96	0.40	0.014	0.016		
Supramuscular	Male	1	1.53	-	-	-	-	-	-	0.317
	Female	1	1.53	-	-	-	-	-		
Supraperiosteum	Male	-	-	-	-	-	-	-	-	-
	Female	1	2.25	-	-	-	-	-		

2.2 Eyebrow (EB) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	5	1.26	0.90	1.73	0.40	0.200	0162	0.485	-
	Female	2	1.51	1.25	1.77	0.37	-	-		
Submuscular layer (orbicularis oculi and frontalis	Male	2	2.43	2.00	2.85	0.60	-	-	0.742	-
	Female	3	2.60	2.05	3.00	0.49	-	0.490		
Intramuscular layer (orbicularis oculi and frontalis	Male	3	2.46	1.95	3.20	0.66	-	0.411	-	-
	Female	-	-	-	-	-	-	-		
Supramuscular layer (orbicularis oculi and frontalis	Male	17	1.46	0.75	2.73	0.57	0.200	0.186	-	0.692
	Female	20	1.60	0.87	3.85	0.74	0.005	0.001		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	6	2.69	2.07	3.03	0.34	0.200	0.343		
Parietotemporal fascia	Male	1	2.92	-	-	-	-	-	0.328	-
	Female	3	2.39	2.03	2.75	0.36	-	0.969		

2.3 Upper eyelid (UE) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	2	1.11	0.91	1.31	0.28	-	-	0.680	-
	Female	3	1.26	0.81	1.55	0.40	-	0.316		
Submuscular layer	Male	4	2.95	2.55	3.75	0.54	-	0.069	0.205	-
	Female	5	2.57	2.35	2.85	0.23	0.200	0.252		
Intramuscular layer	Male	4	2.01	1.73	2.35	0.26	-	0.636	-	-
	Female	2	2.67	2.54	2.80	0.18	-	-		
Supramuscular	Male	16	1.60	0.90	2.77	0.60	0.149	0.147	-	0.372
	Female	20	1.41	0.83	2.77	0.52	0.052	0.001		
Supraperiosteum	Male	-	-	-	-	-	-	-	-	-
	Female	2	3.20	2.95	3.44	0.35	-	-		
Parietotemporal fascia	Male	2	2.13	2.01	2.24	0.16	-	-	0.514	0.439
	Female	2	2.43	2.06	2.80	0.52	-	-		

2.4 Glabellar (GB) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	3	1.83	1.24	2.35	0.50	-	0.812	-	0.655
	Female	5	1.64	0.98	3.02	0.75	0.008	0.031		
Intramuscular layer	Male	2	2.86	2.56	3.16	0.42	-	-	-	-
	Female	-	-	-	-	-	-	-		
Supramuscular layer	Male	9	2.04	1.36	3.15	0.50	0.018	0.045	-	0.337
	Female	12	2.32	1.54	3.68	0.61	0.007	0.099		

2.5 Temple (TP) injection sites

2.5.1 TP1 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	8	2.42	1.15	3.91	1.04	0.200	0.466	-	0.066
	Female	3	1.23	0.92	1.84	0.53	-	0.036		
Submuscular layer	Male	6	2.83	1.61	4.36	1.31	-	0.500	0.517	-
	Female	7	2.48	1.74	3.69	0.63	0.200	0.367		
Intramuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	1.58	-	-	-	-	-		
Supramuscular layer	Male	1	2.20	-	--		-	-	-	0.157
	Female	4	2.49	2.34	2.55	0.10	-	0.014		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	2.05	-	-	-	-	-		

Parietotemporal fascia	Male	13	1.88	0.90	3.57	0.85	0.200	0.210	0.140	-
	Female	17	2.37	0.90	4.30	0.89	0.071	0.320		
Loose areolar tissue between superifial temporal artery and superficial part	-	-	-	-	-	-	-	-	-	-
	1	2.54	-	-	-	-	-	-		

2.5.2 TP2 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	6	2.39	1.64	4.07	0.96	0.195	0.155	0.626	-
	Female	7	2.34	1.19	4.24	1.06	0.145	0.355		
Submuscular layer	Male	3	2.56	1.44	3.55	1.06	-	0.807	0.870	0.655
	Female	1	2.33	-	-	-	-	-		
Supramuscular layer	Male	3	2.54	1.01	3.88	1.45	-	0.774	0.944	-
	Female	3	2.48	2.18	2.82	0.32	-	0.794		
Parietotemporal fascia	Male	16	3.03	1.44	4.60	1.00	0.200	0.729	-	0.374
	Female	21	2.83	1.16	5.79	1.15	0.009	0.036		
Loose areolar tissue between superifial temporal artery and superficial part of	Male	2	3.31	3.20	3.43	0.16	-	-	-	-
	Female	-	-	-	-	-	-	-		

2.6 Tear trough (TT) injection sites

2.6.1 TT1 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous	Male	5	3.47	1.55	6.10	1.77	0.200	0.832	0.432	-
	Female	3	2.43	1.48	4.15	1.49	-	0.122		
Submuscular	Male	20	7.27	1.67	14.14	3.36	0.200	0.586	0.562	-
	Female	28	6.72	1.20	12.65	3.05	0.200	0821		
Intramuscular	Male	1	2.22	-	-	-	-	-	-	-
	Female	1	5.78	-	-	-	-	-		
Supramuscular	Male	1	6.65	-	-	-	-	-	-	-
	Female	2	6.31	4.49	8.13	2.57	-	-		
Supraperiosteum layer	Male	1	7.49	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		

2.6.2 TT2 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Submuscular layer	Male	23	3.30	1.13	7.24	1.71	0.038	0.020	-	0.952
	Female	26	3.41	1.19	11.17	2.18	0.008	0.000		
Intramuscular layer	Male	2	2.59	1.51	3.67	1.53	-	-	-	-
	Female	-	-	-	-	-	-	-		
Supramuscular layer	Male	3	3.57	1.86	5.44	1.80	-	0.852	0.793	-
	Female	7	3.20	1.30	7.36	2.02	0.200	0.082		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	4.67	-	-	-	-	-		

2.6.3 TT3 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	2	2.12	1.73	2.51	0.55	-	-	-	-
	Female	-	-	-	-	-	-	-		
Submuscular layer	Male	15	3.35	1.74	8.45	1.69	0.200	0.003	-	0.421
	Female	22	2.83	1.02	5.62	0.98	0.200	0.384		
Intramuscular layer	Male	2	2.02	1.98	2.06	0.06	-	-	0.436	0.121
	Female	2	3.06	2.21	3.91	1.20	-	-		
Supramuscular layer	Male	7	2.54	1.05	3.67	0.86	0.200	0.777	-	0.908
	Female	8	3.49	1.16	10.68	3.01	0.001	0.001		
Supraperiosteum layer	Male	2	6.30	3.32	9.27	4.21	-	-	0.414	0.439
	Female	2	2.55	1.51	3.59	1.47	-	-		

2.6.4 TT4 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	1	1.45	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Submuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	2.60	-	-	-	-	-		
Intramuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	2	1.46	0.89	2.04	0.81	-	-		
Supramuscular layer	Male	24	1.61	0.75	3.09	0.56	0.097	0.098	-	0.304
	Female	29	1.49	0.75	3.25	0.57	0.124	0.003		

Supraperiosteum layer	Male	3	4.00	3.12	4.75	0.82	-	0.751	0.090	0.083
	Female	2	2.25	1.79	2.72	0.66	-	-		

2.7 Mid cheek (MC) injection sites

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	-	-	-	-	-	-	-	-	-
	Female	2	1.36	1.05	1.66	0.43	-	-		
Submuscular layer	Male	22	7.11	2.66	13.39	3.32	0.190	0.092	0.367	-
	Female	27	6.32	2.15	11.52	2.79	0.200	0.241		
Intramuscular layer (orbicularis oculi)	Male	1	2.01	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Supramuscular layer	Male	4	4.20	1.80	6.76	2.59	-	0.151	0.413	-
	Female	4	2.92	2.06	4.59	1.15	-	0.170		
Supraperiosteum layer	Male	1	3.11	-	-	-	-	-	-	-
	Female	1	5.05	-	-	-	-	-		

2.8 Lateral hollowness (LH) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous	Male	5	6.80	3.55	12.49	3.56	0.200	0.380	0.601	-
	Female	2	5.31	5.13	5.49	0.25	-	-		
Submuscular (origin of zygomaticus major m.)	Male	-	-	-	-	-	-	-	-	-
	Female	2	8.86	8.10	9.61	1.07	-	-		
Supramuscular (masseter m.)	Male	8	6.89	4.54	9.54	1.91	0.200	0.368	0.986	-
	Female	12	6.90	4.32	9.47	1.62	0.200	0.828		
Parotid gland	Male	13	8.70	4.58	11.45	2.10	0.117	0.096	0.226	-
	Female	20	7.62	4.19	13.66	2.65	0.200	0.204		

2.9 Nasolabial fold (NLF) injection sites

2.9.1 NLF1 injection sites

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous	Male	8	4.12	2.16	10.55	2.85	0.034	0.004	-	0.885
	Female	13	4.87	1.50	14.13	3.71	0.015	0.015		
Submuscular layer	Male	11	6.88	4.31	10.17	2.10	0.200	0.245	0.133	-
	Female	13	5.49	2.10	10.46	2.22	0.200	0.721		
Intramuscular	Male	6	5.88	2.01	10.46	3.61	0.200	0.637	-	0.886
	Female	7	5.53	2.24	11.62	4.03	0.026	0.040		
Supramuscular	Male	3	5.46	5.04	6.14	0.59	-	0.258	0.141	.180
	Female	1	7.09	-	-	-	-	-		

2.9.2 NLF2 injection sites

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous (nasolabial fat)	Male	3	4.28	2.24	6.84	2.34	-	0.635	0.220	-
	Female	3	7.02	4.39	7.45	2.58	-	0.634		
Submuscular (insertion of zygomaticus major, zygomaticus minor	Male	16	7.61	2.24	14.22	3.01	0.200	0.589	0.489	-
	Female	11	6.73	1.56	13.02	3.50	0.200	0.913		
Intramuscular layer (insertion of zygomaticus major, zygomaticus minor	Male	3	3.05	2.35	3.76	0.71	-	0.977	-	0.732
	Female	7	3.83	2.06	7.78	2.54	0.003	0.003		
Supramuscular layer (insertion of zygomaticus major,	Male	6	3.88	2.90	5.73	1.04	0.200	0.268	0.789	-
	Female	13	3.60	1.08	9.03	2.40	0.200	0.153		

2.9.3 NLF3 injection sites

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Submuscular layer	Male	17	7.31	3.61	11.02	2.46	0.049	0.049	-	0.015
	Female	15	5.12	1.91	8.86	2.44	0.196	0.097		
Intramuscular layer	Male	4	3.06	1.54	4.01	1.14	-	0.423	0.355	-
	Female	7	3.73	2.07	5.64	1.11	0.200	0.886		
Supramuscular layer	Male	5	4.58	1.68	6.43	1.79	0.200	0.470	0.008	-
	Female	11	2.55	1.19	3.67	0.90	0.200	0.295		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	10.30	-	-	-	-	-		
Infraorbital fat	Male	2	14.02	13.42	14.62	0.85	-	-	-	-
	Female	-	-	-	-	-	-	-		

2.9.4 NLF4 injection sites

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	1	2.89	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Submuscular layer	Male	16	6.97	3.14	14.53	3.19	0.200	0.157	-	0.187
	Female	16	5.58	2.56	14.03	3.06	0.011	0.003		
Intramuscular layer	Male	2	1.94	1.90	1.97	0.05	-	-	0.312	0.564
	Female	3	3.30	1.56	4.25	1.51	-	0.095		
Supramuscular layer	Male	8	2.98	1.66	4.34	0.99	0.200	0.549	-	0.105
	Female	12	2.32	1.64	3.59	0.72	0.024	0.026		
Infraorbital fat	Male	2	11.00	3.92	18.07	10.01	-	-	0.607	1.000
	Female	2	6.72	6.40	7.04	0.45	-	-		

2.10 Lip (vermillion and volume)(LV) injection site

2.10.1 LV1 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Submuscular (submucosa)	Male	3	6.49	3.27	9.87	3.26	-	0.961	-	-
	Female	-	-	-	-	-	-	-		
Intramuscular (orbicularis oris)	Male	25	3.65	1.71	10.50	1.93	0.052	0.000	-	0.323
	Female	33	4.01	1.87	9.90	2.06	0.000	0.000		
Supramuscular (orbicularis oris)	Male	-	-	-	-	-	-	-	-	-
	Female	1	2.19	-	-	-	-	-		

2.10.2 LV2 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous	Male	1	2.75	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Intramuscular	Male	23	3.25	1.99	7.07	1.21	0.073	0.003	-	0.022
	Female	31	4.76	1.56	11.92	2.85	0.002	0.000		
Supramuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	1.18	-	-	-	-	-		
Submucosa	Male	4	6.92	2.72	12.33	4.71	-	0.314	0.299	-
	Female	2	3.87	2.94	4.80	1.32	-	-		

2.10.3 LV3 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	1	4.51	-	-	-	-	-	-	-
	Female	1	3.33	-	-	-	-	-		
Intramuscular layer	Male	8	4.18	2.27	10.30	2.68	0.021	0.006	-	0.116
	Female	11	5.55	2.62	10.45	2.71	0.200	0.127		
Supramuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	2.75	-	-	-	-	-		
Submucosa	Male	5	4.78	3.21	7.58	1.64	0.200	0.340	0.484	-
	Female	4	5.96	2.44	8.88	2.79	-	0.547		

2.11 Chin (CN) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	4	1.49	0.94	2.44	0.63	-	0.353	0.303	-
	Female	5	2.02	0.98	2.68	0.69	0.200	0.333		
Submuscular layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	7.95	-	-	-	-	-		
Intramuscular layer	Male	3	3.65	2.72	5.36	1.33	-	0.090	-	0.300
	Female	6	3.00	2.08	5.39	1.26	0.199	0.046		
Supramuscular layer	Male	7	4.39	2.35	8.58	1.91	0.021	0.045	-	0.465
	Female	5	4.73	1.21	6.87	2.10	0.200	0.504		

2.12 Jaw line (JL) injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Submuscular layer	Male	28	4.94	2.55	13.17	2.71	0.000	0.000	-	0.078
	Female	34	5.69	1.27	10.85	2.69	0.002	0.002		

2.13 Marionette (MN) injection site

2.12.1 MN1 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Submuscular layer	Male	26	4.16	1.82	7.66	1.58	0.167	0.122	-	0.437
	Female	26	3.97	1.25	11.53	2.15	0.024	0.001		
Intramuscular layer	Male	2	3.38	2.21	4.55	1.65	-	-	0.505	-
	Female	6	4.24	2.37	6.55	1.46	0.200	0.850		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	2	4.47	3.64	5.29	1.17	-	-		

2.12.2 MN2 injection site

Layers	Sex	n	Depth (mm)				Test of normality		Test statistics	
			Mean	Min	Max	SD	Kolmokorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)	T-Test	Mann-Whitney U
Subcutaneous layer	Male	1	2.84	-	-	-	-	-	-	-
	Female	-	-	-	-	-	-	-		
Submuscular layer	Male	26	4.65	1.81	9.71	1.76	0.200	0.070	-	0.096
	Female	26	3.87	2.07	8.11	1.41	0.200	0.018		
Intramuscular layer	Male	1	3.34	-	-	-	-	-	-	0.275
	Female	7	3.78	2.58	8.92	2.28	0.000	0.000		
Supraperiosteum layer	Male	-	-	-	-	-	-	-	-	-
	Female	1	5.33	-	-	-	-	-		

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