THE STAINS OF VARIOUS LIPSTICKS ON MAXILLARY ANTERIOR CERAMIC VENEERS

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การเปื้อนเปรอะของลิปสติกชนิดต่างๆต่อเซรามิกวีเนียร์บนฟันหน้าบน

น.ส.รติรัตน์ โชติพันธุ์วิทยากุล

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การศึกษาทางคลินิกนี้มีวัตถุประสงค์เพื่อศึกษาความแตกต่างการติดสีของลิปสติกบนตัวฟันระหว่างกลุ่มผู้ป่วยที่ได้รับการบูรณะฟันหน้าด้วยเซรามิกวีเนียร์และกลุ่มผู้ป่วยฟันธรรมชาติ และเปรียบเทียบชนิดของลิปสติกที่มีผลต่อการเกิดคราบลิปสติกบนเซรามิกวีเนียร์และฟันธรรมชาติ โดยทำการศึกษาผู้ป่วยทั้งหมด 30 คน แบ่งออกเป็นสองกลุ่มคือ กลุ่มผู้ป่วยที่ได้รับการบูรณะฟันหน้าด้วยเซรามิกวีเนียร์ (CV) และกลุ่มผู้ป่วยฟันธรรมชาติ (NT) โดยมีผู้ป่วย 15 คนในแต่ละกลุ่ม โดยผู้ป่วยถูกทาลิปสติกทั้งหมด 7 ชนิด ได้แก่ Gloss & Balm, Gloss & Sheer, Cream, Liquid matte, Matte & Frost, Satin และ Matte หลังจากนั้นผู้ป่วยแต่ละคนจะถูกประเมินการติดสีของลิปสติกบริเวณฟันหน้าบนจำนวน 6 ซี่ ในแต่ละกลุ่มจึงมีฟันหน้าบนที่ถูกประเมินจำนวนทั้งหมด 90 ซี่ เพื่อบันทึกความถี่การติดสีของลิปสติกบนตัวฟัน หลังจากทำการบันทึกข้อมูลความถี่การติดสีของลิปสติกบนตัวฟัน ข้อมูลได้รับการวิเคราะห์ด้วย One-way repeated-measures ANOVA (α = .05) ผลการศึกษาแสดงให้เห็นว่าชนิดของลิปสติกมีผลต่อการติดสีบนตัวฟันอย่างมีนัยสำคัญทางสถิติ (P < .001) แต่การติดสีของลิปสติกบนตัวฟันในกลุ่มผู้ป่วยที่ได้รับการบูรณะฟันหน้าด้วยเซรามิกวีเนียร์และกลุ่มผู้ป่วยฟันธรรมชาติไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ (P = .083) จากการศึกษาพบว่าลิปสติกชนิด Gloss & Balm มีการติดสีของลิปสติกบนตัวฟันมากที่สุดทั้งในกลุ่มผู้ป่วยที่ได้รับการบูรณะฟันหน้าด้วยเซรามิกวีเนียร์และกลุ่มผู้ป่วยฟันธรรมชาติ ส่วนลิปสติกชนิด Matte ติดสีบนตัวฟันน้อยที่สุดในผู้ป่วยทั้งสองกลุ่ม จากผลการศึกษาสรุปได้ว่าชนิดของลิปสติกมีผลต่อการติดสีของลิปสติกบนตัวฟันในผู้ป่วยทั้งสองกลุ่ม แต่การติดสีของลิปสติกบนตัวฟันในกลุ่มผู้ป่วยที่ได้รับการบูรณะฟันหน้าด้วยเซรามิกวีเนียร์ไม่แตกต่างจากกลุ่มผู้ป่วยฟันธรรมชาติอย่างมีนัยสำคัญทางสถิติ

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Ratirat Chotipanvidhayakul : THE STAINS OF VARIOUS LIPSTICKS ON MAXILLARY ANTERIOR CERAMIC VENEERS. Advisor: Assoc.Prof. SIRIVIMOL SRISAWASDI, D.D.S., M.S., Ph.D. Co-advisor: Assoc. Prof. Chalermpol Leevailoj, D.D.S., M.S.D.

This clinical study aims to determine differences in lipstick stains between ceramic veneers and natural teeth. Types of lipsticks affected lipstick stains on ceramic veneers and natural teeth were also investigated. A total of 30 patients were divided into two groups: ceramic-veneer (CV) group and natural-teeth (NT) group with 15 patients in each group. Seven lipstick types: Gloss & Balm, Gloss & Sheer, Cream, Liquid matte, Matte & Frost, Satin, and Matte were applied on patients' lips. Six labial surfaces of maxillary anterior teeth were evaluated for the frequency of lipstick staining with each type of lipstick. Thus, 90 maxillary anterior teeth were examined per group. Data were analyzed using one-way repeated measures ANOVA (α = .05). One-way repeated measures ANOVA revealed that types of lipsticks had a statistically significant effect on lipstick stains ($P < .001$). Gloss & Balm lipstick left the highest frequency of lipstick staining in both CV and NT groups. Matte lipstick had the lowest frequency of lipstick staining. However, there was no statistically significant difference between the two groups concerning the lipstick staining ($P = .083$). In conclusion, based on our findings, types of lipstick affected lipstick stains in both groups. Regarding substrates, there was no statistically significant difference between the two groups.

Field of Study:	Esthetic Restorative and Implant Dentistry	Student's Signature .....
Academic Year:	2020	Advisor's Signature .....
		Co-advisor's Signature .....

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CHAPTER I INTRODUCTION

Background and rationale

Nowadays, people put in much effort to look their best, since physical appearance plays an important role in an individual's self-esteem. (1) The desire to be attractive is a key factor in growing demands for esthetic services especially in cases of reconstructing the esthetic zone. One of the most common chief complaints about patients seeking dental treatments is their esthetics of anterior teeth. Patients usually visit the dental office due to having unsatisfied smiles and the desire to improve their appearances. Since ceramic veneers have been proven to provide satisfactory long-term esthetic results, they have been used as a solution to achieve patient esthetic demands. Apart from their lower failure rate than direct restorations, they allowed mimicking of natural tooth appearance, resulting in satisfactory esthetics. (2, 3)

Over the centuries, cosmetic products have been used to enhance a person's appearance. Lipstick is considered as an essential addition in making people feel

presentable, comfortable, and more confident. Women perceive lipstick as an important component in their daily makeup routine. Lipstick has gained popularity as the trend of using lipstick seems to be increasing. It plays a significant role in financial market. The key drivers in the growth of the market include rising awareness, regarding personal grooming and appearance among young female consumers, increasing urbanization, and changing lifestyles. There are several categories of lipsticks available in the market including matte, sheer, satin, powder lipstick, and others. The trend of using lip powder, especially in matte lipstick is gaining popularity among the female population. A variety of lipstick shades are available such as red, nude, brown, purple, maroon, pink, and others. The red color category is the most popular color lipstick estimated to hold the highest revenue share in 2018. The consumer group aged between 20-40 holds the largest lipstick market share. It is due to changes in their lifestyle and rising appearance consciousness. (4, 5)

Under a period of observation, it was found that lipsticks tend to stain on ceramic veneers. However, natural teeth have also been found to have lipstick staining. A survey in 1996 by Shiseido showed that 87% of American women

admitted to leaving traces of lipstick in unwanted areas. (6) Some ingredients in lipstick may have spread to the teeth. Nevertheless, it has been still unknown whether the types of lipstick would affect the staining on ceramic veneers. There was only the study of Abidi et al. and Galvão et al. showed that lipstick with an ultra-fixer stained resin composite more heavily than the lipstick with a common fixer. (7, 8)

Research question

1.) Do lipsticks show higher incidence of staining on ceramic veneers than natural teeth?

2.) Do the types of lipsticks show incidence of staining differently?

Research Objectives

The aims of this present study were to compare the differences of lipstick stains on ceramic veneers and on natural teeth, and to investigate whether the types of lipsticks affect the lipstick stains on ceramic veneers and natural teeth.

Research Hypothesis

1) The frequency of lipstick staining among seven types of lipstick on maxillary anterior ceramic veneers would not differ from natural teeth.

2) There was no difference in frequency of lipstick staining among seven types of lipstick on maxillary anterior ceramic veneers and natural teeth.

Conceptual framework

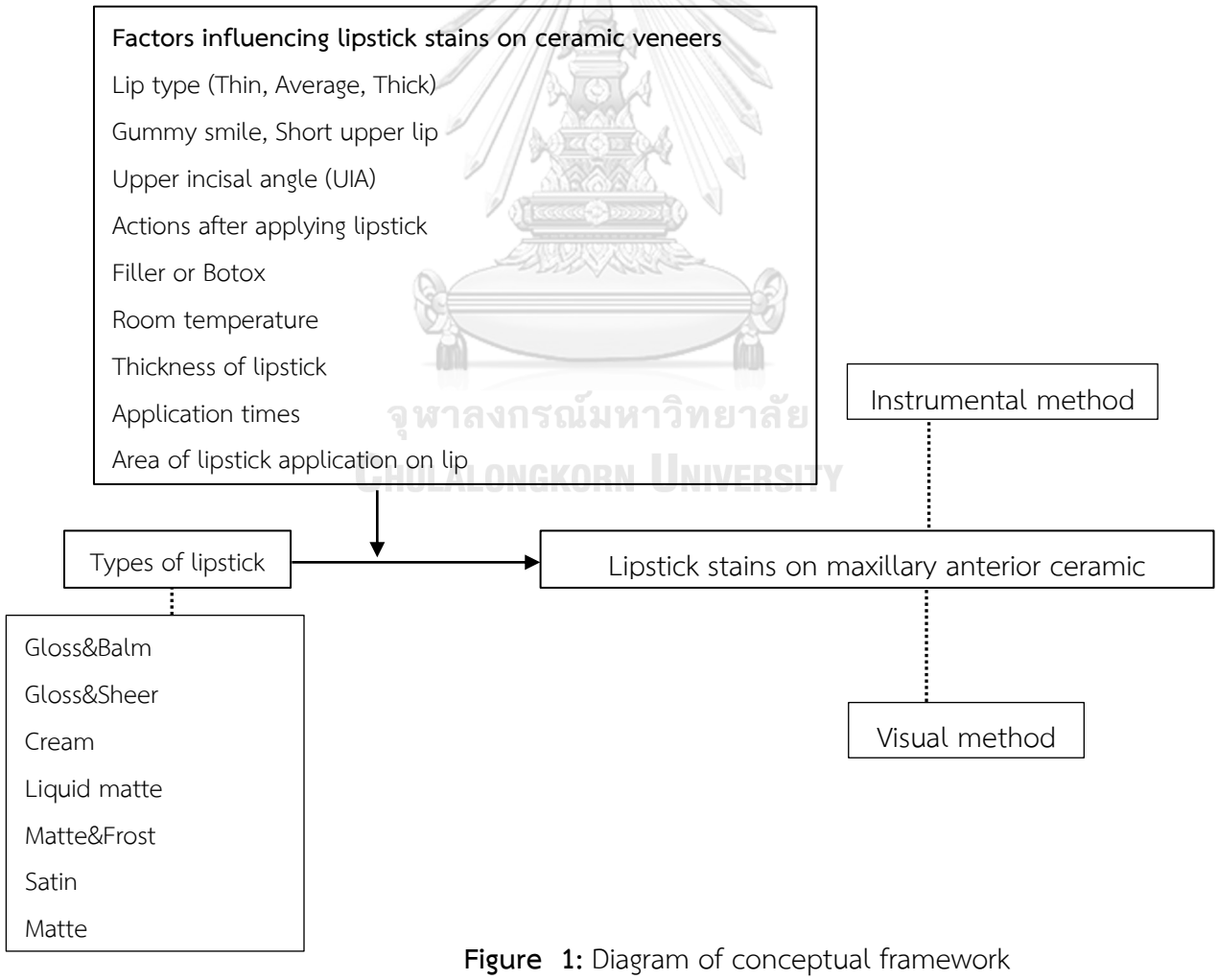

Figure 1: Diagram of conceptual framework

Keywords

ceramic veneers, lipsticks, lipstick stain, lipstick transfer, natural teeth

Limitations

1. This study was performed with one brand lipstick (Chanel, France) so this study might not represent other lipstick's brands in the market.
2. The lipstick stains were evaluated in maxillary anterior ceramic veneers, which were fabricated from one system (IPS e.max, Ivoclar Vivadent, Schaan, Liechtenstein). The pattern of lipstick stains may be different depending on the types of ceramic materials.
3. The situation where the patients were wearing lipstick and doing daily activities/ routines: smiling or speaking, was only a simulation.
4. In this study, lipsticks were applied one layer by a disposable brush applicator to control amount of lipsticks. Therefore, this method may not represent daily lipstick application.

CHAPTER II REVIEW OF LITERATURE

Definitions

Lipstick is defined as a cosmetic product which consisted of three main raw materials: oils, waxes, and colors. They can be manufactured from either natural or synthetic materials. Lipsticks have three basic forms; solid, semi-solid, and liquid forms. (9) Veneer is a thin layer of material which is used to place over the teeth to protect or improve the esthetic of the teeth. It is frequently termed as a laminate veneer. (10) Lipstick stains are defined as a visible stain on the anterior maxillary anterior ceramic veneers and maxillary anterior teeth. (Figure 2)

Figure 2: Lipstick stain

Lipsticks

Lipstick ingredients:

The main ingredients found in lipsticks are colors, bases, fragrances, flavoring agents, and additives. Lipsticks contain oils about 40-50 % (by weight), a mixture of waxes approximately 20%, and coloring agents accounting for another 2-10 % (by weight). Fragrances and preservatives are always added to the lipsticks, but they account for one percent or less of the mixture. (11)

A majority lipstick formula is: (9, 12)

1. Colors

They are the main reason for purchasing lipstick. The popular color shades vary from pinks through to true reds. Also, the color shades can be yellow, orange, violet, blue, or colorless. Finely divided metal or pearlescent material is added to several lipsticks; for example, frost lipstick to provide a high degree of gloss to the lips. The colors should be non-toxic and edible.

The lipsticks can be colored by coloring agents, staining dyes, and pigments.

1.1 Staining dyes

Eosin dyes which are tetrabromo derivative of fluorescein acid known as bromic acid or D&C Red No.21 have been used in lip products. Nowadays, bromic acid is mixed with other pigments to achieve a long-lasting effect. There are two types of staining dyes are as follows:

1.1.1 Eosin (water-soluble)

- D&C Red No. 21 C I 45380:2

1.1.2 Bromic acid (halogenated derivatives of fluorescein)

- D&C Red No. 27 C I 45410:1 (Tetrachloro-tetrabromo fluorescein)
- D&C Orange No. 5 CI 45370:1 (Dibromofluorescein)
- D&C Orange No.10 (Di-iodofluorescein)

Eosin and its derivative may cause allergy or

photosensitization. Furthermore, they can change the original color shades of lipstick.

1.2 Pigments

The pigments must meet the basic requirements of FDA and they have been subjected to Food and Drug Administration or FDA approval before using cosmetic products.

FDA classified the certified colors into three categories:

- Food Drug & Cosmetic Colors (FD&C Color)
- Drug & Cosmetic Colors (D&C Color)
- External Drug & Cosmetic Color (Ext. D&C Colors)

Only FD&C and D&C color can be used for lip products. Although there are 87 colors, only a restricted number can be used for lipstick.

Pigments can be divided into three categories:

1.2.1 Inorganic pigments

Titanium dioxide is often added less than 4% to provide whiteish and opacity.

1.2.2 Organic pigments

Red No. 36, D&C Orange No.17 which are non-soluble both in water and oil.

1.2.3 Metallic lake

Generally, the lake of Aluminum is used for transparent lipstick. Examples of the metallic lake are as below:

- Calcium lake of D & C Red No. 7, 31, 34
- Barium lake of D & C Red No. 9, and D & C Orange No. 17
- Aluminum lake of D & C Red No. 2, 3, 19 and FD & C yellow No. 5

2. Bases

The bases consist of oils, fats, and waxes in an appropriate ratio.

2.1 Oils

The roles of oils are a film-forming agent and solvents for the coloring agents that allow them to disperse non-soluble pigments, for example, vegetable oil, mineral oil, synthetic oil.

2.2 Fats

Various fats are used in lipstick such as animal fats, cocoa butter, hydrogenated vegetable oils, and petrolatum. They enable color dispersion and easy to form the shape of lipstick. Moreover, fats can make the lips softer.

2.3 Waxes

Waxes should help lipsticks to keep their forms at room temperature. They give lipstick's shapes and ease of removal from the molds. They also allow lipstick to melt during application and help to keep the color on the lip.

Furthermore, they increase both shiny characteristics and hardness for the lipsticks. The most commonly used wax types for lipsticks are animal waxes, vegetable waxes, mineral or hydrocarbon waxes.

3. Fragrances and flavoring agents

Fragrances can diminish the smell from oils, waxes, pigments, and other ingredients. Lipstick manufacturers try to add fragrances and flavoring agents such as rose, aniseed, cinnamon, clove, lemon, orange, tangerine to make a pleasant sensation. They should be stable, compatible with the base, and not initiate an allergic reaction.

The scents of lipsticks usually originate from flowers, spices, and fruits. The fragrances can come from both natural and synthetic. Hydroxyphenyl butanone, ethyl dimethyl dioxolane acetate, and hexyl acetate/ trans-2-hexanal diethyl acetate are used for raspberry, strawberry, and apple scents respectively.

4. Additives

The aims of adding additives are to improve the stabilization and

efficacy of lipsticks.

4.1 Antioxidants:

Lipsticks consist of some ingredients that may degrade over time due to oxidation reaction. Antioxidants: for example, butylated hydroxyanisole, butylated hydroxytoluene, 2,5, di-tert-butyl hydroquinone, propyl gallate, play an important role in increasing their shelf-life and preventing rancid smell.

4.2 Preservatives

The preservatives such as propyl-h-hydroxybenzoate, are added to lipsticks for antimicrobial effect. Any formula of cosmetic product that incorporates water needs a preservative to inhibit microbial formulation and growth.

4.3 Oil-soluble sunscreen

It believes that oil-soluble sunscreen can prevent sun blisters from the sun’s rays.

Lipstick classifications

Lipsticks can be classified into seven categories based on their compositions.

1. High stain lipstick

High stain lipstick is usually made from castor oil, hydrogenated castor oil, and triglyceride of ricinoleic acid which act as a hardening agent. Moreover, it contains a carnauba wax which is a key ingredient in terms of strengthening the lipstick because of a high melting point (more than 63°C). Lipstick will be softer when a wax dissolve completely in the liquid oil.

2. Creamy lipstick

This type of lipstick contains a high volume of castor oil which is the solvent for Bromo acids.

3. Transparent lipstick

The soluble or stabilized dye is used instead of insoluble opaque pigment or lake; hence light can penetrate. This type of lipstick does not contain any fat. Also, it consists of glycerin-boric acid, water-soluble color, and dye dissolve in sodium stearate and alcohol. The preparation can be performed by the

saponification of stearic acid ester and triethanolamine. After that, adding dye dissolved in glycerin, and glycol.

Also, a water-soluble dye can be used instead of oil-soluble dye to improve better color attachment. Anhydrous lower alcohol such as ethanol or isopropanol which is solvent admixed 2-10 % together with the bases, and other ingredients for better stabilization.

4. Lip salves

The purpose of using lip salves is not for decorative lipstick, but it is used for protecting the lip from cold. They do not contain any staining dye or dye solvent. The main material bases are mineral oil, jelly, or wax. Hydrophilic materials are added to improve color attachment on the surface. Some authors classified lipstick in the same type of lip gloss, but lip salves are packed up in bearing or roll-on.

5. Lip gloss

In the present, lip gloss is usually semi-solid and translucent. The main components are a mixture of pigment, wax, oil, and lanolin materials. When

applying to the lip by finger or roller, it makes the lip soft and shine.

6. Liquid lipstick

The preparation of liquid lipstick aims to form more permanent film than conventional lipstick. Film-forming resin and plasticizer consist of dye soluble in alcohol.

7. Micro-encapsulated lipsticks

It is the lipstick contained the mixture of color and base which are packed in small capsules (microcapsules). These microcapsules are water-soluble. The color will slowly release and dry to form a thick film on the lip after applying lipstick. (13, 14)

Moreover, lipsticks can be categorized by basic characteristics. (15)

1. Sheer lipstick

Sheer lipsticks provide a little spark on their lips. These lipsticks are enriched with moisturizing oils so they would be the best option for dry and chapped lips. However, sheer lipsticks need a touch up every 4-5 hours because they do not stay for long hours.

2. Matte lipstick

Pure color with a smooth and even texture is given by matte lipsticks. These are contrary to sheer or glossy lipsticks which are all about a lustrous look. High color in matte lipsticks is brilliant at covering up pigmented and inconsistent lips.

3. Glossy lipstick

A shiny and watery look from gloss lipsticks can enhance lip dimension which is great for dry and thin lips. Moreover, the advantage part is that they are deeply hydrating as well. The luminosity factor is high in these lipsticks. They provide low to medium coverage and a semi-sheer finish. Gloss lipsticks are available in liquid form as well as gloss-sticks.

4. Creamy/Creme lipstick

These lipsticks contain an abundance of oils and butter and therefore, are excellent for nourishing lips. Creamy lipsticks are easy to apply with a gliding flow. Moreover, they also have a high quantity of wax which helps to increase the

staying power of the lipsticks. The color payoff and coverage are different from shade to shade. Creamy lipsticks tend to melt in hot and humid conditions; therefore they are perfect for colder climates.

5. Stain or Lip tints

Stain lipsticks are the vibrant color lipsticks without touch up that can last throughout the day. The major drawback of applying this stain lipstick is lip dryness. Thus, a balm is suggested to apply before using this lipstick to keep the lip moisturized. Stain lipsticks are usually found in liquid form, these glide onto the lip like a gloss, afterward, a sheer stain is left behind. This provides high color payoff and long-lasting.

6. Liquid matte lipstick

Liquid matte lipsticks are a solution for matte lipsticks which give lipstick a dry feeling to the lips. They are easy to apply like a gloss but provide the characteristic of matte.

7. Matte balms

These are a combination of the benefit of a balm and the coverage and color payoff of a matte lipstick. They are easy to glide onto the lips provided a smooth and long-lasting finish.

8. Balm tints

Lip balms are available in a crayon form. They can moisturize the lips with natural-looking color. Some of them consist of SPF protection to keep lips hydrated. The color of lip balms may last from an hour to a couple of hours depending on brands.

Lipstick manufacturing process

1. Color grinding

The manufacturing process begins with color grinding to consistently disperse color.

2. Mixing

After the pigments are prepared, oils and waxes are mixed in the

stream jacket vessel or water bath under the temperature which is higher than their melting point 2-3°C. Then, the solvent solution and liquid oils are mixed with the color pigments. The mixture passes through the roller or colloid mill until it achieves a uniform consistency. The fragrances are added to the mixture when the temperature is lower than 70 °C then stirring slowly to avoid trapped air bubbles. At this time, vacuum equipment may be used to withdraw the air.

3. Molding

Before molding the lipsticks, the molds which are gold, aluminum, or alloy are cleaned and lubricated with liquid paraffin, or isopropyl myristate. Lipstick is poured up-side-down so that the bottom of the tube is at the top of the mold. Any excess is removed from the mold. When the temperature is cooled down, the lipsticks are separated from the molds.

4. Flaming

After the molding process has been done, the lipsticks are kept for one week before flaming. The lipsticks should be flamed to eliminate small defects and produce a glossy finishing to the surface. The lipsticks are examined for air holes,

mold separation lines, or blemishes.

5. Packaging and labeling

The final steps in the lipstick manufacturing process are packaging and labeling. The lipsticks are packaged into the various package with the requirements of the manufacturers of the brand owner. (12)

Lipstick application

Lipsticks are usually applied to the lip which its color may penetrate a stratum corneum of the epidermis approximately 2/5. The amount of lipstick per one application time is 0.006 grams. (16)

Anatomy and physiological characteristics of the lips

The characteristics of the lip were unique. The lip was completely soft tissue that consisted of muscular membranous, and skin. The histology of the lip was the stratified squamous epithelium. It was divided into three parts: external surface, internal surface, and transitional zone. Skin, with its hair follicles, sebaceous glands, and sweat glands were found in the external surfaces. The internal surface carrying

salivary glands was covered by the labial mucosa, a non-stratified, non-keratinized epithelium. The transitional zone located between the external surface and the internal surface was the red vermillion border of the lip. It did not have hair follicles and sweat glands like normal skin, but sebaceous glands were present in about 50% of adults. Therefore, the source of moisture for the lip was saliva in the oral cavity. Lip was easier to lose water three times than regular skin, so its function acting as a barrier to retain water was lower than facial skin. The deeper part of the lip was the orbicularis oris muscle and loose connective tissue. The labial tissue was very sensitive because it contained a dense population of sensory receptors, including Meissner corpuscles, Merkel cells, and free nerve endings. Lip skin had a faster turnover rate two times higher than adjacent skin. (11)

Lip movement and pronunciation

The lip is one of the speech organs or vocal organs which involves in the production of speech sounds. Teeth's position can also affect the production of

English consonants. There are five valves affected by teeth position: (17)

1. Bilabial sounds

   /B/, /P/, /M/ sounds are produced by contact of the lips. Insufficient lips support can cause defective bilabial sounds.

2. Labiodental sounds

   /F/ and /V/ represent labiodental sounds that are made between upper incisors and the labio-lingual center of the posterior third of the lower lip.

3. Linguodental sounds

   Consonant /Th/ is made closer to the ridge than the tip of the teeth. The labio-lingual position of anterior teeth is provided by these sounds.

4. Linguoalveolar sounds

   The valves are formed by contact of the tip of the tongue with the most anterior part of the palate (the alveolus) of the lingual sided of the anterior teeth to produce alveolar sounds (e.g., /T/, /D/, /S/, /Z/). The sibilant sounds (sharp sounds) are also alveolar sounds (e.g., /S/, /Z/, “sh”, “ch”).

5. Linguopalatal and articulatory characteristics

   The tip of the tongue is in a forward position but does not contact the maxillary anterior teeth. The mandible will move forward and upward, with the teeth almost contact.

Anatomy of smile

A smile is developed by exposing teeth and gingivae created by the lips. Smile characteristics are affected by various factors, for example, age, gender, and orthodontic treatment. There are two types of a smile: a posed or social smile, and an emotional smile. (Ackermen et al.) The social smile is a reproducible smile while the emotional smile varies depending on an emotional display. (18)

Dental ceramic in restorative dentistry

The interest and esthetic demand for non-metallic material had been increased after Charles Land introduced the first feldspathic porcelain crown in 1903.

(19, 20) The properties of ceramics were non-metallic, resistant to degradation, biocompatible restorative materials, and a coefficient of thermal expansion which was similar to the tooth structure. (20) Moreover, they could mimic natural teeth because of their potential to reproduce the depth of translucency, depth of color, and texture. However, they still had limitations of their use due to brittleness, crack propagation, low tensile strength, wear resistance, and marginal accuracy. Hence, they were susceptible to fracture during placement, mastication, and trauma. (20, 21)

Ceramic classifications

Ceramics were classified into four categories according to their composition of glass-to-crystalline-ratio: (22)

- Composition Category 1: Glass-based Systems (mainly silica), Amorphous Glass

The main components of a glass-based system were silicon dioxide (silica or quartz) with various amounts of alumina. Dental ceramics were manufactured from the synthetic forms of aluminosilicate glasses. They were

first used in dentistry to fabricate porcelain dentures. Although these materials provided great esthetic value and high translucency like natural teeth, they had low mechanical properties with low flexural strength from 60 to 70 MPa. They should be used as veneer materials for metal or ceramic substructures, as well as for veneers.

- Composition Category 2: Glass-based Systems with Crystalline Second Phase, Porcelain

Giordano and McLaren subdivided this category into three groups because this category has a broad range of glass-crystalline ratios and crystal types.

  - Subcategory 2.1 Low-to-Moderate Leucite-Containing Feldspathic Glass

Leucite crystals were added to improve strength. They changed the coefficient of thermal expansion (CTE), and inhibited crack propagation. The original materials had low fracture resistance

and abrasive properties relative to enamel because of random distribution and large particle size (several hundred microns). The novel generations of materials had higher flexural strength and less abrasiveness due to finer leucite crystals (10 μm to 20 μm) and even distribution of particles throughout the glass. (23)

- Subcategory 2.2 High-Leucite (Approximately 50%) Containing Glass, Glass-Ceramics

The mechanical and physical properties of this subcategory had improved; for example, increased fracture resistance, improved thermal shock resistance, and resistance to erosion. A secondary heat treatment nucleates and grows crystals improved mechanical and physical properties because of the physical presence of the crystals and the generation of compressive stress around the crystals. The original well-known pressable ceramic system was Empress®(Ivoclar Vivadent). The machinable system of Empress® for both CEREC® and

E4D CAD/CAM system was Empress CAD (Ivoclar). Fracture resistance of both machinable and pressable systems were higher than powder/liquid systems. Furthermore, the use of machinable and pressable systems as posterior inlay and onlay applications and anterior veneer and crown restoration demonstrated excellent clinical results. (22)

- Subcategory 2.3 Lithium-Disilicate Glass-Ceramics

This subcategory was true glass-ceramic with a lithium disilicate crystal content of 70% which was first introduced by Ivoclar as Empress. In 2005, Ivoclar launched IPS e.max press in 2005 which had better physical and mechanical properties than Empress. The flexural strength was improved as results from the increase of crystal contents and refined the size of the crystal. The flexural strength was 360 MPa that is three times higher than Empress. (24) It had better translucency because the increased of crystalline content and low refractive index of the lithium disilicate crystals. With sufficient translucency, it was

used for the highest esthetic restorations. (22)

- Composition Category 3: Interpenetrating Phase Ceramics

In-Ceram was an infused ceramic also called the Interpenetrating phase. It consisted of at least two phases. Interpenetrating phase materials were fabricated by creating a porous matrix. After that, the porosities are filled with second phase material, lanthanum aluminosilicate glass, using capillary action. This category was used as inlays, onlays, anterior/posterior crowns, and bridges. The mechanical and physical properties of this category had been improved due to the individual components. Flexural strength for In-Ceram Spinell, In-Ceram Alumina, In-Ceram Zirconia were 350, 450, 650 MPa respectively. Because of high opacity, In-Ceram Zirconia wasused on posterior teeth. On the other hand, In-Ceram Spinell was more suitable for anterior esthetics. (22)

- Composition Category 4: Polycrystalline Solids

Polycrystalline Solids were formed in solid dense, air-free, glass-free

polycrystalline structures. The first Polycrystalline Solids was Procera AlCeram alumina® (Nobel Biocare). The use of zirconia had increased dramatically. Zirconia existed in three phases: monoclinic, tetragonal, and cubic phase. It was not pure zirconia because small amounts of metal oxides were added to stabilize zirconia in the tetragonal phase at room temperature which called partially stabilized zirconia. The flexural strength was between 900 and 1,100 MPa. (25) The fracture toughness was rage from 8 to 10 MPa $m^{1/2}$. With the apparent physical properties, zirconia could be used for multiple-unit anterior and posterior FPDs. (22)

Ceramic veneers

Ceramic veneers were first introduced by Charles Pincus in 1983. (3) They were considered to be a conservative treatment. Proper selection of ceramic to be used for veneers was very important because it would affect the success rate of restorations. The indications of ceramic veneers were wide range below: (26)

1) Correction of alternations in tooth shape or position

2) Changes in the morphology of teeth with microdontia or tooth

transposition

3) Presence of diastemas and/or poor incisal embrasures

4) Repair of incisal fractures

5) Extensive anterior dental restorations

6) Enamel alterations (abrasion, attrition, abfraction)

7) Change in tooth color

8) Anterior guide rehabilitation

9) Repair of crown and bridge

Material for ceramic veneers fabrication

Several ceramic materials can be used for veneers fabrication and they were classified into four groups according to their compositions. (22)

The feldspathic porcelain was most commonly indicated to fabricate veneers to achieve optimal esthetic results in the case without changing tooth color or improving displeasing shapes or contours and/or lack of size and/or volume, requiring morphologic modifications; diastema closure, anterior tooth alignment, restoring localized enamel malformations, fluorosis with enamel mottling, and misshapen

teeth. (3, 26, 27, 28)

Although the feldspathic porcelain presented high translucency, it had low flexural strength from 60-70 MPa. However, the flexural strength of feldspathic porcelain increased when a good bond with a stiffer tooth substructure was provided. Furthermore, it was easily fracture because it consisted of high glass contents. Dental ceramics had been improved both both in material properties and manufacturing techniques. Lithium disilicate glass ceramic was one such material glass-ceramics, which were both highly esthetic and possess exceptional mechanical properties. (29) It became a popular material that allowed us to fabricate single-tooth restoration, bridge in anterior and premolar region, implant superstructures, hybrid abutment solutions, minimally invasive inlay and onlay (1 mm) and thin veneer (0.3 mm). The restorations were veneered in a highly esthetic manner or, if they were fabricated as monolithic restorations, they were stained. (27) From the study of Sulaiman et al., IPS e.max veneer performed well with a low failure rate in 45 months (monolithic form1.3%, layered form 1.53%). (30)

IPS e.max

Lithium disilicate ($2SiO_2$–Li_2O) dental ceramics were first launched in 1988 for use as a heat-pressed core material branded as IPS™ Empress 2 (Ivoclar Vivadent, Lichtenstein). The new ceramic line from reformulation and refinement of the production process of Empress 2 was released in 2005 under the brand of IPS e.max Press. In 2006, IPS e.max CAD was as a lithium disilicate glass-ceramic, specifically prepared for CAD/CAM use. (29)

IPS e.max was a lithium disilicate glass ceramic which improved physical and optical properties. It became a popular ceramic system because of its superior mechanical properties with high flexural strength (365 MPa) and fracture toughness (2.80 $MPa.m^{1/2}$). (31)

The processing techniques of IPS e.max could be either lost wax hot pressing technique or CAD/CAM milling procedures which were IPS e.max press and IPS e.max CAD. (32)

IPS e.max color stability

Color stability is one of the factors for a long-term success rate of an esthetic

restoration. Both extrinsic and intrinsic color can affect color stability. (33)

IPS e.max veneers fabricated from IPS e.max computer-aided design (CAD), IPS e-max CERAM, and IPS e.max Press with glazing after immersed in the staining solutions for up to 54 hours showed acceptable color change. The non-glazed pressed lithium, disilicate presented unacceptable color change, hence the glaze played an important role in the color stability of IPS e.max press restoration because it was staining resistant. (33, 34)

Measurement of color alteration

The color of dental restorative materials can be measured in reflected light by both a visual (subjective) method and an instrumental (objective) method. In the visual method, the color alteration is assessed by subjective comparison by using color scales, from acrylic resin or ceramic scales (7), whereas the spectrophotometer, calorimeters and computerized image analysis are used for the instrumental method. The CIE L*a*b*(Commission International l´Eclairage) system is used to determining

color change. The color alteration can be calculated by the total color variation ΔE according to the following equation: (35)

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

When the L* parameter represents lightness, *a**, and *b** represent for the green-red and blue-yellow color components. A value of ΔE* of 3.3 is considered as noticeable clinically. (36)

CHAPTER III MATERIALS AND METHODS

Research design

This study was an in vivo study with the aim to determine differences in lipstick stains between ceramic veneers and natural teeth. Types of lipsticks affected lipstick stains on ceramic veneers and natural teeth were also investigated.

Research methodology

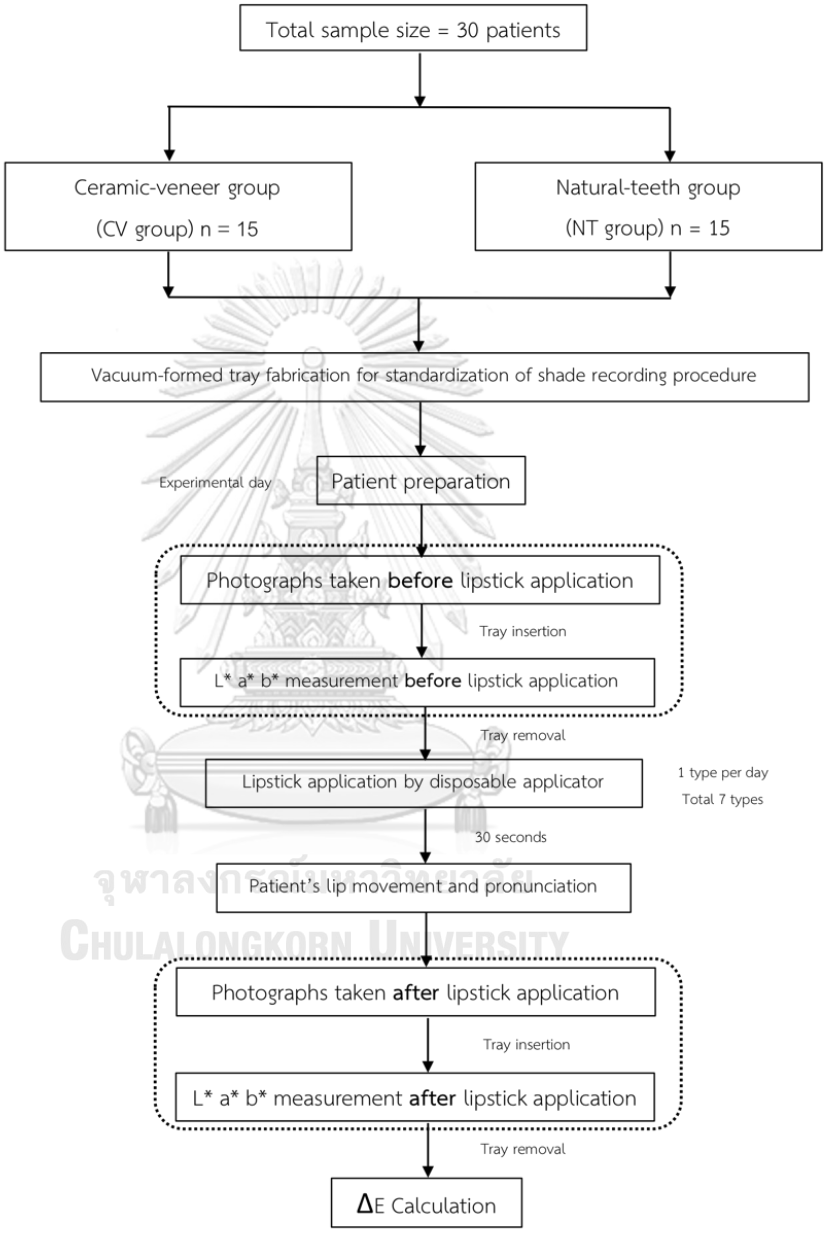

Figure 3: Diagram of study design

Population and sample

This study was conducted with approval of the ethical committee of the Faculty of Dentistry, Chulalongkorn University, Thailand (approval number: HREC-DCU 2019-022). There were no previous studies, therefore, a pilot study was conducted in two patients (one patient was a test group and another a control group.). The total sample size was 30, calculated from the pilot study by using G-Power.

A total of 30 participants were enrolled in this study. The selection criteria for the study population were healthy subjects aged older than 18 years old. The subjects were divided into two groups equally: a ceramic-veneer group (CV group) and a natural-teeth group (NT group) with 15 participants in each group. The CV group (n = 15) included patients with at least six maxillary anterior ceramic veneers fabricated using IPS e.max (Ivoclar Vivadent, Schaan, Liechtenstein) without any chipping, fracture, or dislodgement at the Esthetics Restorative and Implant Dentistry Clinic, Faculty of Dentistry, Chulalongkorn University. The NT group (n = 15) consisted of patients with well-aligned intact maxillary anterior teeth without labial fillings or any macroscopic defects such as abrasion or abfraction. The patients must present

normal occlusion, normal anterior teeth alignment with normal angulation of upper incisor from Steiner's cephalometric norms for Thai population U1-NA = 22°±5.94°.(Figure 4) (37) The exclusion criteria were a history of cleft lip and cleft palate, lip injection, lip surgery, lip pathology or active skin lesions, history of allergy to lip products, and conditions of dry or chapped lip. After informed consent was signed, the data were recorded by single investigator.

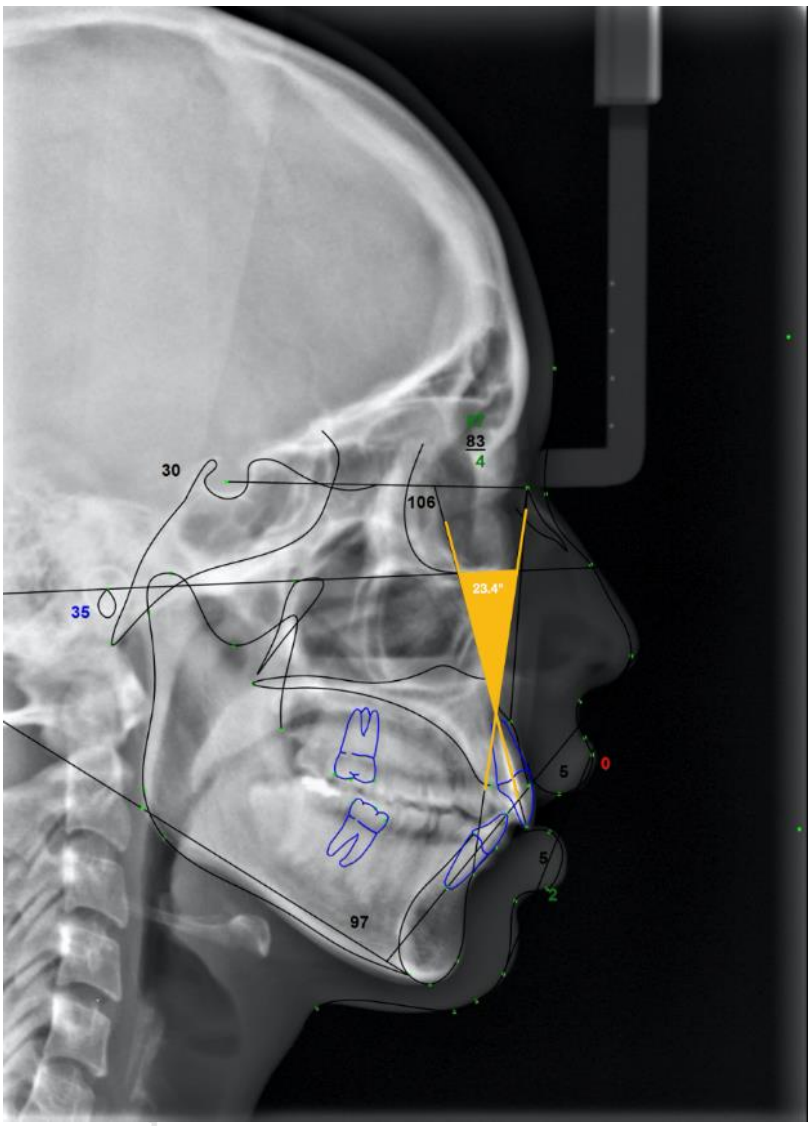

Figure 4: Example figure of normal angulation of upper incisor from Steiner's cephalometric norms for Thai population demonstrated on a lateral cephalometric radiograph.

Intervention

Ceramic-veneer group (CV group): seven types of lipsticks (Chanel, France)

Natural-teeth group (NT group): seven types of lipsticks (Chanel, France)

Outcome Measurement

Variables to be measured

- Frequency of lipstick staining
- L*, a*, b*, and ΔE

Instrument Design

Lipstick samples

In this study, lipstick samples from different types of lipstick from one brand (Chanel, France) were collected. The red shades were selected because the lipstick stains could be detected easily, and they were the most popular shades. (4,5) Seven lipstick types: Gloss & Balm, Gloss & Sheer, Cream, Liquid matte, Matte & Frost, Satin, and Matte, (Chanel, France), were applied to all subjects. Types and compositions of seven lipsticks were described in Table 1. Lipsticks were kept at room temperature and out of direct sunlight in a cool and dry place to avoid heat exposure that may decompose and break down them over time.

Sample	Types of lipsticks	Brand	Lip editions	Color shades	Lot number	Composition
1	Gloss&Balm	Chanel	Rouge Coco Stylo	222 Fiction	02-0660	Polybutene, Octyldodecanol, Hydrogenated Coconut Oil, Diisostearyl Malate, Jojoba Esters, Dipentaerylthrityl Tetrahydroxystearate/Tetraisostearate, Stearyl Heptanoate, Synthetic Wax, Cera Alba (Bees Wax),Phytosteryl/Octyldodecyl Lauroyl Glutamate, Polyethylene, Stearyl Caprylate, Ethylene/Propylene Copolymer, Synthetic Fluorphlogopite, Disteardimonium Hectorite, Tocopheryl Acetate, Ethyhexyl Palmitate, Propylene Carbonate, Pyrus Malus (Apple) Seed Oil, Parfum (Fragrance), Serica (Silk Powder), C20-24 Alkyl Dimethicone, Tribehenin, Pentaerythrityl Tetra-Di-T-Butyl Hydroxyhydrocinnamate, Polyglycerin-3, Sorbitan Isostearate, Acacia Decurrens Flower Wax, Helianthus Annuus (Hellianthus Annuus (Sunflower) Seed Wax), Alumina, Tocopherol, Palmitoyl Tripeptide-1, Silica [+/- (May contain) CI 12085 (Red 36), CI 15850 (Red 6), Ci 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
2	Gloss&Sheer	Chanel	Rouge Coco Shine	138 Poppy orange	02-0560	Bis-Behenyl/Isostearyl/Phytosteryl dimer dilinoleyl dimer delinoleate, Phytosteryl /Octyldodecyl lauroyl glutamate, Diisostearyl malate, Pentaerythrityl Tetraethylhexanoate, Caphylic/Carpric triglyceride, Squalane, Isotridecyl isononanoate, Synthetic wax, Ethylene/Proprylene Copolymer, Meadowfoam delta-lactone,Sorbitan Isosterate, Lauryl PCA, Synthetic fluorphilogopite, Tocopheryl acetate, Parfum (Fragrance), Alumina, PEG-8, Tocopherol, Ascobyl palmitate, Silica, Ascorbic acid, Citric acid [+/-(May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75740 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI77499 (Iron oxides), IC 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]
3	Cream	Chanel	Rouge Coco	462 Romy	01-0460	Diisostearyl malate, Hydrogenated polydecene, C20-24 alkly dimethicone, Synthetic wax, Octyldodecanolm VP/hexadecane copolymer, Bis-Behenyl/Isostearyl/Photosteryl dimer dilinoleyl dimer dilinoleate, polybutene, Jojoba esters, Ethylene/Propylene copolymer, Polymethylsilsesquioxane, Polyglycerin-3, Disteardimonium hectorite, Synthetic fluorphlogopite, Tocopheryl acetate, PEG-30 Dipolyhydroxystearate, propylene carbonate, Acacia decurrens flower wax, Helianthus annuus cera seed (Helianthus annuus(sunflower) seed wax), Alumina, PEG-8, Parfum (Fragrance), Tocopherol, Silica, Ascorbyl palmitate, Ascorbic acid, Critric acid, [+/-(May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090(Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth oxychloride), CI 77491,CI 77492, CI 77499 (Iron oxides), CI 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]
4	Liquid Matte	Chanel	Rouge Allure Ink	152 Choquant	01-0260	Hydrogenated Polyisobutene, Dimethicone, Disostearyl Malate, Polyethylene, Synthetic Fluorphlogopite, Ethylene/propylene Copolymer, Hydrogenated Polydecene, Simmondsia Chinensis (Jojoba) Seed Oil, Dimethicone Crosspolymer, Isohexadecane, Jojoba Esters, Disteardimonium Hectorite, Tocopheryl Acetate, Phenoxy, Ethanol, Propylene Carbonate, PEG-8, Prunus Amygdalus Dulcis (Sweet Almond) Oil, Hydrogenated Vegetable Oil, Talc, Tocopherol, Potassium Alum, Parfum(fragrance), Camellia Sinensis Leaf Powder, Ascorbyl Palmitate, Kaolin, Caesalpinia Sappan Bark Extract, Ascorbic acid, Citric acid [+/- (May contain CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
5	Matte&Frost	Chanel	Rouge Allure	99 Pirate	01-0760	Pentaerythrityl adipate/Caprate Caprylate/Heptandate, Hydrogenated Polyisobutene, Octyldodecanol, Octyldodecyl Neopentanoate, Synthetic Wax, Polyglyceryl-10 Nonaisostearate, Polyglyceryl-2- Triisostearate, Hydrogenated Coconut Oil, Ethylene/Propylene Copolymer, Disteardimonium Hectorite, Tocopheryl Acetate, Propylene Carbonate, Hydrogenated Castor Oil, Parfum (Fragrance), Alumina, Prunus Amygdalus Dulcis (Sweet Almond)Oil ,Hydrogenated Vegetable Oil, PEG-8, Silica, Talc, Potassium Alum, Tocopherol, Camellia Sinensis Leaf Powder, Kaolin, Ascorbyl Palmitate, Caesalpinia Sappan Bark Extract, Ascorbic Acid, Citric Acid [+/- (May contain CI 12085 (Red 36), CI 15850 (Red 6), Ci 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75470 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]
6	Satin	Chanel	Le Rouge Crayon De Couleur	N°5 Rouge	02-0360	Trimethylsiloxyphenyl Dimethicone, Isononyl Isnonanoate, Isohexadecane, Polyethylene, Hydrogenated Polyisobutene, Dipentaerythrityl Hexahydroxystearate, Octyldodecanol, VP/Hexadecane Copolymer, Hydrogenated Styrene/ Methyl Styrene/ Indene Copolymer, Disteardimonium Hectorite, Propylene Carbonate, Pentaerythrityl Tetra-Di-T-Butyl Hydroxyhydrocinnamate, Tocopherol, BHT [+/-(May contain) CI 12085 (Red 36), CI 15850 (Red 6), CI 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 75740 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI77499 (Iron oxides), IC 77742 (Manganese violet), CI 77891 (Titanium dioxide), Mica]
7	Matte	Chanel	Rouge Allure Velvet	56 Rouge Charnel	02-0860	Dicaprylyl carbonate, Isononyl Isononanoate, Diisostearyl Malate, Synthetic wax, Polymethylsilsesquioxane, Jojoba Esters, Hydrogenated Castor Oil, Ethylene/Propylene Copolymer, Ethyhexyl Palmitate, Aluminum Starch Octenylsuccinate, Butyrospermum ParkII (shea) Butter, Stearalkonium Hectorite, Tribehenin, Tocopheryl Acetate, Propylene Carbonate,Sorbitan Isostearate, Parfum (fragrance), Dimethicone, Tocopherol, Palmitoyl Tripeptide-1,BHT, Citric acid [+/- (May contain CI 12085 (Red 36), CI 15850 (Red 6), Ci 15850 (Red 7 Lake), CI 15985 (Yellow 6 Lake), CI 17200 (Red 33 Lake), CI 19140 (Yellow 5 Lake), CI 42090 (Blue 1 Lake), CI 45380 (Red 22 Lake), CI 45410 (Red 28 Lake), CI 73360 (Red 30 Lake), CI 7547f0 (Carmine), CI 77163 (Bismuth Oxychloride), CI 77491, CI 77492, CI 77499 (Iron Oxides), CI 77742 (Manganese Violet), CI 77891 (Titanium Dioxide), Mica]

Table 1: Materials used in the study

Patient preparation

The patients were not allowed to use any cosmetic product on the lips at least 10 hours beforehand. First, dental plaque and biofilm were removed from their maxillary anterior teeth by using a rubber cup with fine- grit polishing paste. After that, they rinsed their mouths with water and sipped 30 ml water to moisturize their mouths. Next, their lips were dabbed gently with napkins to remove residue of water from these areas. Lastly, they were instructed to do pronunciation exercises of example sentences which represented bilabial (/M/), and labio-dental (/F/, /V/) sounds.

Lipstick stain evaluation criteria

There were two methods to evaluate lipstick stain in this study:

(a) Visual method

The frequency of lipstick staining was recorded on each labial surface of maxillary anterior teeth. Thus, a total of 90 maxillary anterior teeth were analyzed per group. The frequency of lipstick staining ranged from 0 to 6 for each patient. In

the absence of a lipstick stain, it was rated as 0. On the other hand, 1 was given for the area which presented a lipstick stain.

(b) Instrumental method

The spectrophotometer was used for color measurement to collect quantitative data by using the CIE L*a*b* (Commission International l´Eclairage) system. The color differences of maxillary anterior teeth between before and after lipstick application was calculated by the total color variation delta E (**Δ**E) according to the following:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

When the L* parameter represents lightness, and a*, and b* represent green-red and blue-yellow color components. A value of ΔE* of 3.3 is considered as noticeable clinically. (35)

Vacuum-formed trays fabrication

To fabricate an individual positioning device for spectrophotometer, thirty conventional impressions of the entire maxillary arch were made by alginate material (Jeltrate®; Dentsply Caulk). Study casts were fabricated from a type III stone (Comet

3; Lafarge Prestia Co. Ltd.). Clear soft acrylic stents (Sof-Tray®; Ultradent, inc.) for each patient were made on study casts. Then, the labial tray surfaces of maxillary anterior teeth were cut in half diameter of VITA Easyshade compact's tip to standardize a procedure for shade recording. The other areas of the tray were fully scalloped to avoid any tissue contact, as shown in figure 5.

Figure 5: Vacuum-formed tray

Lipstick application and lipstick stain measurement methods

Extra-oral digital photographs in both frontal and lateral views (Nikon D750 and Nikon AF-S VR Micro-Nikkor 105mm f/2.8G) were taken in the studio at both rest and posed smile positions at baseline. The vacuum-formed trays were placed carefully on the maxillary arch. A digital spectrophotometer (VITA Easyshade Compact, DEASYCS220, Zahnfabrik H. Rauter GmbH & Co.KG) was used to measure L*, a*, and b* values as baseline data. Calibration was done according to manufacturer instruction before each measurement. The tip of the VITA Easyshade compact with its 6 mm diameter was positioned perpendicular to the tooth surface and on the vacuum-formed tray to measure at the middle third of each maxillary anterior tooth (Figure 6). Six labial surfaces of maxillary anterior teeth L*, a*, and b* values were measured. Each value representation was collected from the mean of three measured values. After removing the tray, one layer of each lipstick type was applied thoroughly on lips by a disposable brush applicator in a clockwise direction starting from upper lip to lower lip within the vermillion area, and from right to left side of the patient in a rest position by one operator. The applied lipstick was picked

randomly and used only once on a particular subject. A total of seven types of lipsticks were applied on the lip. Before applying the next lipstick, makeup remover and cotton pellets were used to clean the lips thoroughly to prevent staining effect from previously applied lipstick. Between each lipstick application, remnants of previously applied lipstick on maxillary anterior teeth were removed from the substrate's surface with fine-grit polishing paste. Then, the patients were instructed to rinse their mouth. They were required to rest for 30 seconds, and were not allowed to speak or move their lips while waiting. If they had any questions, they could ask the evaluator by writing or typing. Then, the patients pronounced /M/ sound phrase (Mali Mong Maeo Miao Kin Mamuang Man) 10 syllables in 3 seconds, /F/, /V/ phrase (Fueangfa Fumfai Phro Fao Fong Faep Fufong) 10 syllables in 3 seconds, and compressed their lips for 3 seconds. Three extra-oral photographs were taken, and the VITA Easyshade compact was used in the same manner as described previously to measure L*, a*, and b* values after lipstick application (Figure 6).

Figure 6: Lipstick stain evaluation by VITA Easyshade compact

Data collection

Methods of data collection

Outcomes of lipstick stains were evaluated by the frequency of lipstick staining and L*, b*, a*, and ΔE.

Data analysis

Statistical analysis of data

All data were analyzed using the SPSS 22.0 program (SPSS® Inc, Chicago, IL, USA). One-way repeated-measures ANOVA was performed for evaluation association between and within-subjects. Values of $P \leq 0.05$ were accepted as significant.

CHAPTER IV RESULTS

The data were collected from 30 participants: 28 females and two males, between the ages of 23 and 69, with an average age of (± standard deviation) 33±9.4 years old. The ceramic-veneer group was categorized as the patients received maxillary anterior ceramic veneers during the period 2015 to 2020 with an average 3.5 years in function at the Esthetic Restorative and Implant Dentistry Clinic, Faculty of Dentistry, Chulalongkorn University. The study, by visual method, found that Gloss & Balm lipstick showed the highest frequency of lipstick staining in both ceramic-veneer and natural-teeth groups, with an average of 2.87 and 2.53 teeth per person, respectively, whereas Matte lipstick had the lowest frequency of lipstick staining at an average of 0.87 and 0.53 teeth per person, respectively (Table 2).

Table 2: Frequency of lipstick staining in ceramic-veneer group (n=15) and natural-teeth group (n=15)

Types of lipsticks	Lip editions	Ceramic-veneer group Mean (per tooth)	Natural-teeth group Mean (per tooth)
1. Gloss & Balm	Chanel Rouge coco stylo	2.87	2.53
2. Gloss & Sheer	Chanel Rouge coco shine	1.8	1.27
3. Cream	Chanel Rouge coco	1.6	1.07
4. Liquid Matte	Chanel Rouge Allure Ink	2.33	0.93
5. Matte & Frost	Chanel Rouge Allure	1.73	1.4
6. Satin	Chanel Le rouge crayon de couleur	2.07	1
7. Matte	Chanel Rouge Allure Velvet	0.87	0.53

The results, as shown in table 3, found that types of lipstick had a statistically significant effect on lipstick stains ($P < .001$) when a one-way repeated measures ANOVA was performed. However, lipstick staining on the teeth of both groups was not different in terms of statistical significance. ($P = .083$)

Table 3: Repeated Measure ANOVA (Within -Between subjects)

Within subjects	SS	Df	MS	F	Sig
Types of lipsticks	64.142	6	10.694	5.421	0.000**
Types of lipsticks X Substrates	16.124	6	2.687	1.362	0.233
Error (Substrates)	33.429	168	1.973		
Between subjects	SS	Df	MS	F	sig
Substrates	36.043	1	36.043	3.222	0.083
error	313.238	28	11.187		

** p < .001, SS = Sum of Square, MS = Mean Square

As previously mentioned, types of lipsticks had the effect of lipstick stains on the teeth. The use of Wilcoxon-signed rank test, as shown in table 4, found significant differences among types of lipsticks in ceramic-veneer group are shown as follows; lipstick stains of Type I differed from Type II, lipstick stains of Type II differed from Type III, and lipstick stains of Type VII differed from Type I, Type III, Type IV and Type V demonstrating in the statistically significant result. (P < .05) For the natural-teeth group, the results indicated that lipstick stains of Type I differed from Type II, Type III,

Type IV, Type VI, and Type VII, and lipstick stain of Type III differed from Type VII reaching statistical significance. (P < .05)

Table 4: Wilcoxon signed rank test

Types of lipsticks	Substrates	2. Gloss & Sheer	3. Cream	4. Liquid Matte	5. Matte & Frost	6. Satin	7. Matte
1. Gloss & Balm	Veneer group	.023*	1.000	.369	.067	.165	.006*
	Natural teeth group	.034*	.021*	.037*	.060	.033*	.011*
2. Gloss & Sheer	Veneer group		.023*	.418	.837	.653	.109
	Natural teeth group		.558	.535	.763	.477	.259
3. Cream	Veneer group			.369	.067	.165	.006*
	Natural teeth group			.720	.526	.944	.011*
4. Liquid Matte	Veneer group				.058	.571	.004*
	Natural teeth group				.398	.893	.131
5. Matte & Frost	Veneer group					.378	.046*
	Natural teeth group					.322	.088
6. Satin	Veneer group						.059
	Natural teeth group						.400

* The mean difference is significant at .05 level. *P < .05

During clinical observation of lipstick stains, locations of lipstick stains on maxillary anterior teeth of both groups: ceramic-veneer group and natural-teeth group were randomly appeared in all anterior teeth: maxillary canines, maxillary central incisor, and maxillary lateral incisor (Table 5). Kruskal-Wallis test was conducted to examine the differences on location of lipstick stains. No significant difference (Chi square = 1.00, P = 0.317, df = 1) was observed among all anterior teeth. Middle third was the most common area which found lipstick stains in both groups followed by cervical third and incisal third (Table 6). Figure 7 demonstrated different lipstick stains pattern seen on ceramic-veneer group (A-C) and on natural-teeth group (D-F).

Table 5: Locations of lipstick stain (n=90)

Substrate	Locations		
	Maxillary Central Incisors	Maxillary Lateral Incisors	Maxillary Canines
Ceramic-veneer group	19	11	13
Natural-teeth group	11	13	14

Table 6: Distributions of lipstick staining

	Locations			
Substrate	Cervical third	Middle third	Incisal third	Total areas of lipstick staining
CV group	107	168	92	367
%	29.2	45.8	25	
NT group	64	104	63	231
%	27.7	45	27.3	

Figure 7: Example patterns of lipstick stains seen on ceramic-veneer group (A-C) and on natural-teeth group (D-F)

Concerning the results from spectrophotometer, delta E (ΔE) values revealed color differences before and after lipstick application. Although a value of delta E which was greater than 3.3 indicated perceptual color difference, there were incidences that delta E values were greater than 3.3 but lipstick stain could not be detected with naked eye. These phenomena were found together with the decreasing of L* values. They were recorded in three teeth from CV group and two teeth from NT group on a variety of lipstick types (Table 7-8). Table 7 showed example of discrepancy between delta E values and frequency of lipstick staining in ceramic-veneer group. It revealed delta E value of 3.33 on maxillary left lateral incisor (22) of patient no.5. However, lipstick staining could not be seen with the naked eye (Figure 8). Apart from this, it was found that more than 50% of lipstick stains did appear on the cervical third and the incisal third in both groups, yet the spectrophotometer could only detect the stains on the middle third area (Table 6).

Table 7: Example table of delta E values (**Δ**E) and frequency of lipstick staining of Liquid matte lipstick of ceramic-veneer group

Teeth	Patient No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	**Δ**E	5.16	4.68	2.44	1.53	1.14	1.06	1.24	5.06	4.64	2.36	3.41	2.38	2.53	1.33	2.22
	Frequency of lipstick staining	1	1	0	1	0	0	0	1	1	0	1	0	0	1	0
12	**Δ**E	3.32	0.12	4.64	1.89	2.89	0.73	1.35	3.16	2.91	2.33	4.83	2.83	2.08	1.68	1.49
	Frequency of lipstick staining	1	0	1	0	0	0	0	0	1	1	1	0	0	0	0
11	**Δ**E	2.53	0.32	11.20	1.67	2.33	1.65	1.19	4.23	1.80	1.85	3.22	3.39	0.59	1.54	2.34
	Frequency of lipstick staining	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0
21	**Δ**E	5.95	1.03	5.47	1.08	1.04	2.45	2.98	5.03	0.78	2.74	2.14	4.36	0.85	2.34	1.80
	Frequency of lipstick staining	1	0	1	1	0	0	0	1	0	1	0	1	0	0	0
22	**Δ**E	5.88	1.20	3.32	2.06	3.33	1.80	1.25	8.39	0.99	1.99	2.02	1.64	2.60	2.53	1.20
	Frequency of lipstick staining	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0
23	**Δ**E	4.84	5.20	2.69	2.53	2.51	1.20	4.78	6.19	0.79	2.32	4.48	1.82	2.28	1.37	0.57
	Frequency of lipstick staining	1	1	0	1	0	0	1	1	0	1	1	0	1	0	0

Table 8: Example table of delta E values (ΔE) and frequency of lipstick staining of Matte & Frost lipstick of natural-teeth group

Teeth	Patient No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	ΔE	2.64	2.58	1.84	2.42	0.88	3.86	2.16	6.04	11.59	2.00	1.82	2.66	1.03	2.08	1.75
	Frequency of lipstick staining	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0
12	ΔE	2.15	1.06	1.84	0.45	0.6	4.55	2.85	4.47	6.75	2.47	2.22	1.22	1.79	1.55	1.82
	Frequency of lipstick staining	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0
11	ΔE	2.67	1.47	4.92	1.55	1.37	2.37	2.94	2.06	2.62	1.04	1.62	1.65	1.43	0.63	0.79
	Frequency of lipstick staining	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0
21	ΔE	1.19	2.29	7.53	1.42	3.82	2.56	1.58	3.32	0.99	2.18	1.13	2.26	0.99	1.19	2.91
	Frequency of lipstick staining	0	0	1	0	1	1	0	1	0	0	1	0	0	0	0
22	ΔE	2.72	2.42	2.43	0.55	2.49	3.02	1.34	3.93	1.23	0.89	2.23	2.35	0.29	0.45	1.70
	Frequency of lipstick staining	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
23	ΔE	0.71	1.95	2.68	2.24	4.15	3.31	1.84	6.08	0.95	2.53	2.60	0.75	0.83	0.38	1.84
	Frequency of lipstick staining	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Figure 8: Example figure of undetected lipstick stain on ceramic veneers with ΔE greater than 3.3

CHAPTER V DISCUSSION AND CONCLUSION

Discussion

Lipstick is one of the most popular makeup products for decades and the trend of using lipstick appears to be increasing. (4) Women wore lipstick to make themselves more attractive and improve their appearances. Lipsticks could draw attention to the faces, especially the area of the mouths.(5) The area of the mouth and eyes of a person are primarily observed by another person in a face-to-face situation. It is generally accepted in today's society that lip fullness is perceived as a key component of an attractive face. The smile plays an important role in indicating facial attractiveness as well as to impress people around us. (38) When lipsticks transfer to teeth, lipstick stains are easy to detect.

Lipsticks could be worn off from lips by talking, smiling, or yawning. They could leave traces on teeth causing a wearer loss of confidence. This issue has raised the urge to investigate whether lipstick transferred and adhered to ceramic veneers differed from natural teeth. The cause of lipstick transferring on teeth was still unclear. Several makeup artists suggested various methods to apply lipstick to avoid

lipstick stains on teeth. Florrie White, a makeup artist explained that excessive application of lipstick may be the main reason of lipstick transfer on teeth. (3 9) However, some types of lipsticks tended to smear on teeth because of their compositions. Stephen Alain Ko, a cosmetic chemist, described that a solvent which played an important role in liquid lipstick ,by helping the formula spread around the lips, may cause it to get on teeth. (40)

However, there was no previous study reporting that which types of lipstick caused lipstick stains on maxillary anterior ceramic veneers, as well as natural teeth. The purposes of this study were to determine differences in lipstick stains between maxillary anterior ceramic veneers compared to natural teeth, and the types of lipsticks that affected the lipstick stains on maxillary anterior ceramic veneers and natural teeth.

Regarding substrates, there was no statistically significant difference between CV group and NT group (Table 3, P = .083). Therefore, the first null hypothesis that lipstick stains among seven types of lipstick on maxillary anterior ceramic veneers would not differ from natural teeth has been accepted. However, the types of

lipsticks had a statistically significant effect on lipstick stains in both groups (Table 3, $P < .001$). This study rejected the second hypothesis. The highest frequency of lipstick staining was observed in Gloss & Balm, while the lowest frequency of lipstick staining was observed in Matte lipstick. (Table 2)

Residual compositions in lipstick such as oils, about 40-50 % (by weight), a mixture of waxes, approximately 20% (11), might leave deposit on the substrate's surface. The morphological change of surface decreased reflected light, resulting in a change in brightness or L* parameter. (41) The spectrophotometer allowed us to determine indistinguishable changes for human eyes. This encouraged the situation when ΔE values were more than 3.3, but lipstick staining did not appear on those areas (Table 7-8) (Figure 8).

Gloss & balm lipstick consists of four solvents in its ingredients: Octyldodecanol, Stearyl Heptanoate, Ethylhexyl Palmitate, and Propylene carbonate. Stearyl Heptanoate is an interesting component since it is the only solvent that can melt on the skin between the temperature of 23-27°C. (42) It may spread to lips and

also teeth to leave lipstick stains. The study also found that Matte lipstick exhibited the least frequency of lipstick staining in both groups.

Several compositions were added with attempts to limit transferring and provide longer wear, for example, a cosmetically metal salt of stearic acid, aluminum starch octenylsuccinate, an oil, a structuring agent, etc. Compositions which form a film after application exhibited such properties. Besides, the use of an oil-soluble film-forming polymer was compatible with the oil or wax phase also provided long-lasting color with reduced transfer properties. The oil-soluble film-forming polymer formed a film after application to the lips included homo- and copolymers of vinylpyrrolidone (VP) and polyvinylpyrrodine (PVP), trimethylsiloxysilicate, polymethylsilsesquioxane, silicone acrylates, and acrylates copolymer. (43) Kanji et al. described that one composition consisting of at least one polymethylsilsesquioxane film former exhibited effectiveness in providing long-wear and water resistance. (44) Matte lipstick contained polymethylsilsesquioxane that improved adhesion of pigments to the skin and wash-off resistance. Apart from adherence to the skin, the oil-soluble film-forming polymer gave a matte look to the

skin. Also, aluminum starch octenylsuccinate found in Matte lipstick can entrap relatively large amounts of oil and reducing the amount of free oil that caused migration or spreading. As previously mentioned, Matte lipstick presented the least frequency of lipstick staining in both CV and NT group could result from their compositions.

Interestingly, it has been reported that the surface energy of skin varied with increasing age.(6) Because of its variations, lipsticks could attach to skin surfaces differently. Concerning substrates, the human's enamel (70°±2°). (45) presented a larger water contact angle than IPS e.max. (45.80 °±0.56°). (46) This aspect might influence lipstick spreading on ceramic veneers greater than natural teeth. Although the outcome of the study indicated that lipstick stains of both groups showed no statistically significant differences, it turned out that those receiving maxillary anterior ceramic veneers tended to have a higher frequency of lipstick staining on their teeth, comparing to natural teeth patients (Table 2).

Restoring with ceramic veneers frequently involved adjusting position, shape, color, teeth alignment, and level to patients' original teeth under their familiarity with

perioral muscles movement, which may cause the patients to come across the differences when they applied lipstick, before and after receiving the treatment. (26) Furthermore, the texture of ceramic veneers was unlike that of natural teeth. The stronger surface texture of ceramic veneers may catch lipstick stain greater than natural teeth. In general, chair-side adjustment of ceramic veneers involved selective grinding and finishing or polishing procedures with several polishing systems. These procedures could lead to the removal of the surface glaze and expose of unglazed rough ceramic surface. Ceramic underneath glaze layer was prone to staining and discoloration because it was much rougher than glazed ceramic surface. (47) Moreover, the major concern of glazing was that it could deteriorate during function over time. (48) Even exposure times at several pH levels in saliva were likely to affect ion release as well as surface changes. (49) This might encourage the possibilities that the surface of the ceramic veneers would capture more lipstick stains compared to natural teeth. According to this study, it was observed that old ceramic veneers with certain damages to the glazed surface were more susceptible to lipstick staining. Since glaze played a major role in color stability of IPS e.max press restoration

because it was stain-resistant (33), old ceramic veneers were susceptible to staining over time due to loss of glazed surface. It might increase possibility of lipstick staining on exposure of unglazed ceramic. In addition, the inferior ability of unglazed surface to reflect the light could be explained change of delta E values. (41) The amount of reflected light reduced because of rough ceramic surface underneath glaze layer. Due to the small sample size, the correlation between the color differences and the change in surface could not be entirely established. To make further investigations more insightful, a study on color changes in relation to the loss of glazed surface is recommended.

The role of the lips in expressing emotion or smiling can enhance an individual's beauty. Therefore, smiling was chosen as one of the movements in this study. Smiling is formed by multi-muscular function, not just the lips but also the perioral muscles. (50) When the patient was asked to smile, the upper lip raised by the action of the levator labii superioris and zygomaticus major muscles (51) which could leave lipstick stains on the upper anterior teeth. Ackermen et al. classified two types of a smile: the posed or social smile, and the emotional smile. The social smile

is reproducible smile while the emotional smile varies depending on an emotional display. Thus the social or posed smile was focused on this study because it is repeatable over time. (52) Moreover, the muscle's ability to produce a smile is age-associated change. The study of Desai et al. concluded that the muscles' ability to create a smile decreases with increasing age. Furthermore, there was a decrease of 1.5 to 2 mm in maxillary incisor display during smile with increasing age. (53) Therefore, lipstick staining patterns can also change due to aging.

Lips are parts of the pronunciation mechanisms and facial expressions. Labiodental consonant (/F/) and bilabial sound (/M/) were selected in this study to simulate a speaking situation in daily life related to lips, teeth, vocal cords, and other factors. The static position is typically carried out following the utterance of the letter 'M' when the lips are slightly parted and the teeth are out of occlusion with the perioral muscles relatively relaxed. (54) /F/ sound is achieved by bringing a lower lip against the upper anterior teeth. The incisal edges of the maxillary anterior teeth should lightly contact the lower lip (vermilion border) in the right pronunciation. This sound relates directly to the positioning of the maxillary incisal edges.

There may be some possible limitations in this study. The results from this study might not reflect totally actual conditions. The situation where the patients were wearing lipstick and doing daily activities/ routines: smiling or speaking, was only a simulation. In this study, lipsticks were applied one layer by a disposable brush applicator to control amount of lipsticks. Therefore, this method may not represent daily lipstick application which may differ in method and style among people. Amount of lipstick and application method varies depending on types of lipstick, purpose of use, or wearer's lifestyle, for instance. The lipstick stains were evaluated in maxillary anterior ceramic veneers, which were fabricated from one ceramic system (IPS e.max, Ivoclar Vivadent, Schaan, Liechtenstein). The pattern of lipstick stains may be different depending on the types of ceramic materials. This study was performed with one brand lipstick (Chanel, France), therefore, the results might not represent other lipstick brands in the market. Different results might have been obtained with different lipstick brands and other ceramic systems. Further studies addressing these limitations are recommended, including more lipstick brands and various types of restorative materials or treatment options, such as dental crowns

and resin composite filling. The other suggestion is to study the whole process of ceramic veneers procedure: before and after veneer placement, to minimize confounding factors; for example, muscles related to facial expression, speaking, smiling, and up to the skeletal pattern. Some possible variables might also influence accuracy of the test spectrophotometer. Therefore, distracting factors should be eliminated, for example, scatter background from adjacent teeth or condition of atmospheric light. In addition, smaller diameter of spectrophotometer may be use and lipstick staining could be measured in an overlapping action to cover the entire labial surface. Furthermore, it would be helpful to include multiple investigators in the study.

Conclusion

Based on our findings, there were no statistically significant differences between staining of ceramic veneer and natural teeth groups (P = .083). Therefore, the first null hypothesis that the lipstick stains among seven types of lipstick on maxillary anterior ceramic veneers would not differ from natural teeth has been

accepted. However, the types of lipsticks affected lipstick stains in both groups of substrates ($P < .001$). This study rejected the second hypothesis. The highest frequency of lipstick staining was observed when using Gloss & Balm, while the lowest frequency of lipstick staining was observed in Matte lipstick.

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article including no financial interest in all products used in this study.

APPENDIX

Table 9: Frequency of lipstick staining in veneer group (n=90) and natural teeth group (n=90)

Types of lipsticks	Lip editions	Veneer (Test Group) n = 90	Natural Teeth (Control Group) n = 90
1. Gloss & Balm	Chanel Rouge coco stylo	43	38
2. Gloss & Sheer	Chanel Rouge coco shine	27	19
3. Cream	Chanel Rouge coco	24	16
4. Liquid Matte	Chanel Rouge Allure Ink	35	14
5. Matte & Frost	Chanel Rouge Allure	26	21
6. Satin	Chanel Le rouge crayon de couleur	31	15
7. Matte	Chanel Rouge Allure Velvet	13	8

Table 10: Locations of lipstick stain (n=90)

Types of lipsticks	Substrate	Locations		
		Maxillary Central Incisors	Maxillary Lateral Incisors	Maxillary Canines
1. Gloss & Balm	Veneer	19	11	13
	Natural teeth	11	13	14
2. Gloss & Sheer	Veneer	10	8	9
	Natural teeth	8	5	6
3. Cream	Veneer	9	4	11
	Natural teeth	4	5	7
4. Liquid Matte	Veneer	11	9	15
	Natural teeth	6	3	5
5. Matte & Frost	Veneer	10	4	12
	Natural teeth	10	6	5
6. Satin	Veneer	12	7	12
	Natural teeth	9	4	2
7. Matte	Veneer	6	1	6
	Natural teeth	2	3	3
Total	Veneer	77	44	78
	Natural teeth	50	39	42

Table 11: Total Delta E (ΔE) values (n=90)

Types of lipsticks	Ceramic-veneer Group		Natural-teeth Group	
	ΔE < 3.3	ΔE > 3.3	ΔE < 3.3	ΔE > 3.3
Gloss & Balm	57	33	57	33
Gloss & Sheer	63	27	73	17
Cream	69	21	77	13
Liquid Matte	63	27	77	13
Matte & Frost	55	25	76	14
Satin	65	25	77	13
Matte	78	12	85	5

Table 12: Delta E (ΔE) values of Gloss & Balm in ceramic-veneer group

Gloss&Balm	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	1.559915	5.245209	9.720197	1.963274	0.852448	4.338202	2.182252	2.157416	3.722753	1.135292	3.58236	1.374773	0.485341	2.249444	2.137756
12	1.596176	2.735365	3.198263	1.420876	0.794425	6.924754	4.089281	2.020451	6.7752	2.960105	3.51268	1.092906	1.632313	2.894055	1.240967
11	4.710508	3.103045	10.37058	2.268137	0.715697	9.414764	0.630696	7.333409	8.56952	5.316954	3.43932	0.703957	1.149879	4.668214	1.579733
21	0.412311	2.456058	8.44709	0.707107	2.629111	7.89219	1.05462	7.740514	3.832899	4.016217	3.44658	3.542441	1.112555	1.051454	2.076857
22	1.254769	2.763251	4.88774	3.704952	2.839014	7.55035	1.545603	2.090454	1.347013	1.385641	3.42864	1.456785	1.091889	2.71682	1.748968
23	1.820256	3.834637	7.062971	4.546091	1.142123	3.31126	1.769809	0.917121	2.190383	2.551906	4.09675	0.971254	1.16857	1.132353	0.767391

Table 13: Delta E (ΔE) values of Gloss & Sheer in ceramic-veneer group

Gloss&Sheer	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	7.001766	0.955685	4.956029	3.070288	1.402379	1.49183	2.127597	3.943067	3.387559	2.288862	5.351947	1.276279	1.058825	1.894436	1.438363
12	3.966667	2.062092	5.548473	2.247221	2.45153	4.088738	0.830662	1.027402	3.312099	0.912262	2.973587	1.43527	2.304826	3.60817	1.970899
11	2.785279	1.414999	4.889217	2.720703	3.016621	4.026854	0.94163	2.345208	3.757215	2.912998	2.51175	3.318634	0.422953	2.068548	1.088832
21	2.563635	1.434108	5.364389	1.804008	2.776289	3.818231	1.335415	4.422166	3.041016	0.711805	4.258977	3.308071	1.196755	2.183524	0.354338
22	0.967815	0.890693	4.116903	1.996107	2.941466	6.164144	1.5892	3.360225	2.340703	1.910788	3.47531	0.498888	1.604161	2.630167	2.55908
23	0.968963	2.084866	5.402674	1.067187	1.830604	4.73392	4.28369	1.110055	3.648744	1.20416	1.830604	2.126291	0.2	2.518156	1.771691

Table 14: Delta E (ΔE) values of Cream in ceramic-veneer group

Cream	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	2.734756	3.490304	5.480977	1.782009	0.943398	1.942221	1.63741	2.150969	2.740843	3.704952	2.825479	1.549552	2.340465	6.87063	1.52206
12	1.289272	0.133333	4.632734	1.054619	0.286744	0.94163	1.798147	0.664162	0.882547	5.056789	3.86408	1.392041	1.685889	1.834545	2.573368
11	4.921382	3.107875	7.072168	1.705547	0.61101	1.691153	1.007196	2.157416	3.363365	3.09508	3.918758	1.382429	1.905839	1.933908	1.259188
21	1.977934	1.174261	7.397747	1.293144	0.953939	0.354338	1.191171	1.054619	1.75784	5.249444	3.601389	3.621234	0.124722	1.907878	2.12838
22	3.690378	1.679947	11.03036	2.246231	1.324554	2.735162	1.833333	1.422439	2.046949	2.723152	2.628477	2.60555	0.432049	1.657977	2.416609
23	9.275835	5.685361	8.564851	1.133333	0.839974	1.486981	2.20328	2.269851	0.74087	2.682246	3.546203	2.09258	1.014342	1.520599	1.714319

Table 15: Delta E (ΔE) values of Liquid Matte in ceramic-veneer group

Liquid Matte	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	5.163117	4.676775	2.435615	1.532609	1.139688	1.05725	1.237381	5.056349	4.644112	2.363848	3.410604	2.382809	2.52675	1.334583	2.220611
12	3.316792	0.124722	4.641121	1.894436	2.894823	0.73106	1.354417	3.155595	2.910708	2.325941	4.829309	2.830391	3.83159	1.677962	1.489966
11	2.528065	0.316228	11.20347	1.669664	2.332857	1.64688	1.18603	4.230183	1.801543	1.848723	3.216105	3.387723	0.59442	1.538036	2.335713
21	5.950257	1.033871	5.468394	1.080638	1.036018	2.44858	3.949965	5.02951	0.784573	2.735365	2.143206	4.357624	0.85245	2.343075	1.804008
22	5.88161	1.203698	3.32499	2.060475	3.3315	1.8	1.254326	8.391199	0.994429	1.989975	2.015771	1.640461	2.60128	2.530261	1.195361
23	4.835517	5.195083	2.691138	2.533553	2.506436	1.1879	4.775633	6.187907	0.793025	2.320201	4.482311	1.824524	2.27596	3.907969	0.570575

Table 16: Delta E (ΔE) values of Matte & Frost in ceramic-veneer group

Matte & Frost	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	4.462311	4.494317	7.01847	2.118241	2.259548	1.04669	1.373964	1.925848	2.980306	3.465865	2.637549	0.484195	1.866964	5.406272	2.137756
12	1.198147	0.627163	2.0822	1.445299	0.947511	2.48238	2.051016	1.725946	2.515287	3.343485	3.389362	0.762306	2.23582	1.344123	1.240967
11	3.405388	2.947315	4.56873	3.841875	0.996661	3.08058	0.555778	3.442706	2.816815	7.569603	0.767391	4.674755	2.69753	0.323179	1.579733
21	2.401388	0.485341	3.5201	1.54991	0.718795	1.29829	2.202019	7.805198	1.498518	5.655381	2.842925	5.191767	1.796911	0.880656	2.076857
22	0.641179	3.252691	1.25211	3.001111	1.182277	1.6928	3.321646	3.810074	1.850826	2.869959	3.667273	1.649916	0.876863	0.343188	1.748968
23	2.351595	2.704112	4.19868	4.211921	0.434614	1.01598	1.167143	4.757334	0.773161	3.310757	1.358512	2.558211	4.43045	0.691215	0.767391

Table 17: Delta E (ΔE) values of Satin in ceramic-veneer group

Satin	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	3.389854	3.631039	6.19058	2.267892	2.259548	2.424642	8.183316	0.67082	2.553647	3.323151	1.048809	2.688246	2.689279	1.760366	0.843933
12	3.62108	1.494434	3.12783	1.169995	0.947511	2.86686	1.279323	1.233784	1.926136	3.883155	2.846831	1.947078	2.154066	1.178983	1.320774
11	4.537988	2.618099	8.68741	2.486854	0.996661	1.915434	1.315295	5.796647	3.368646	2.359614	4.728819	0.349603	0.881287	0.145297	2.17409
21	5.783501	2.609598	7.6184	1.604854	0.718795	2.890213	1.071862	6.095809	3.344315	3.006105	4.939973	2.438807	0.964365	0.778175	1.394035
22	2.587148	3.135637	1.56702	1.796602	1.182277	6.873136	1.369509	4.287061	2.872281	5.755867	2.506215	2.012737	1.907296	1.667333	2.979933
23	5.591362	2.900383	3.95797	1.75119	0.434614	8.63462	2.723929	3.849675	2.196968	10.42572	1.677962	2.121058	2.022375	0.746845	0.354338

Table 18: Delta E (ΔE) values of Matte in ceramic-veneer group

Matte	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
13	2.872862	3.777712	3.17105	0.948889	2.616401	1.482116	3.282614	0.633333	2.367605	1.437977	2.77068	2.75318	3.684502	3.229895	2.2925
12	1.441064	0.120185	1.74992	1.356667	0.622718	0.74087	1.746107	0.366667	0.991632	1.330831	0.888194	1.530069	3.081486	1.320353	0.915909
11	3.230755	0.3	11.4495	2.383333	1.590947	1.808928	1.195361	3.633486	2.838818	2.065053	3.213513	3.039554	2.861818	0.783156	1.119524
21	2.173834	0.433333	4.48628	0.982222	0.221108	1.45831	1.816284	4.542393	0.77603	2.078996	6.382876	5.004664	2.008316	1.970336	1.417745
22	1.996942	0.439697	2.34521	1.336667	0.752034	2.897509	2.348995	4.212943	2.541434	2.698353	1.206464	2.046406	0.687184	0.63421	1.311911
23	0.943398	4.796874	1.89091	2.99	0.574456	5.321967	2.015496	4.091455	2.584355	2.322834	0.538516	1.477987	0.817177	1.255211	2.130206

Table 19: Delta E (ΔE) values of Gloss & Balm in natural-teeth group

Gloss&Balm	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	4.61435	5.963966	2.533333	2.540779	3.573047	3.494281	0.943398	1.294433	5.294651	1.046688	1.621385	2.922898	0.433333	1.463633	2.260039
12	10.40043	5.648205	1.657307	2.705345	3.846066	7.092484	2.944298	2.322116	4.200794	1.108553	2.448129	0.7	1.160938	0.926763	4.3909
11	14.93103	3.946588	3.047403	2.275961	3.434628	8.686708	1.079609	2.090454	4.513067	0.888194	1.782009	1.327487	1.510703	3.360556	2.487748
21	10.38551	6.626043	2.658529	1.815367	2.735162	11.45702	2.445177	8.959353	0.292499	0.562731	2.429678	1.836966	1.479114	3.837534	2.817406
22	8.356169	7.36629	1.488474	1.977091	2.194437	15.7478	1.197219	5.472964	0.682316	0.558768	1.91978	2.145279	1.840894	3.35493	5.20822
23	8.194849	0.841955	2.669374	2.170765	1.45831	12.08364	1.075484	5.617829	5.902165	0.381517	2.361967	1.279323	2.284246	1.00554	5.549074

Table 20: Delta E (ΔE) values of Gloss & Sheer in natural-teeth group

Gloss&Sheer	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.29831	1.615893	2.713342	3.83956	2.078728	3.433495	2.142169	3.032784	5.72771	1.449138	2.551252	2.627631	2.396989	0.469042	2.58908
12	2.01246	2.103172	1.714643	1.771377	3.828693	3.451892	2.61916	2.221861	1.899123	3.545263	2.434475	1.05935	1.610383	0.703167	4.712277
11	0.9481	2.454022	4.59057	1.593738	2.138535	6.573009	1.708476	1.424391	1.668665	1.148429	1.258306	1.449904	2.523446	1.998333	4.713692
21	1.06771	2.381643	7.526324	1.535868	3.512043	8.374963	1.211977	1.367479	1.662996	2.60363	1.706523	0.620931	1.416604	1.580787	3.676955
22	1.54991	2.695057	1.447603	1.973153	1.761628	11.53223	1.01653	1.26535	0.619139	1.075484	2.247468	1.085766	1.872906	2.438123	2.519921
23	3.1	3.693237	2.313967	1.116045	0.312694	5.539454	1.819951	2.339516	1.989137	1.555635	1.974842	1.408703	1.857418	0.770281	0.609189

Table 21*:* Delta E (ΔE) values of Cream in natural-teeth group

Cream	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.504441	7.880285	2.553864	1.169045	0.707892	1.30767	1.492946	5.486347	1.40673	0.749815	2.072572	1.836966	1.891795	2.700412	4.049829
12	7.664855	2.517936	1.949929	2.843316	2.9524	2.20227	2.664583	3.644631	2.304344	1.449521	2.615339	1.780761	3.223697	1.678955	2.329998
11	11.04229	2.840579	1.876758	0.767391	1.990533	0.65574	1.498518	2.61916	1.0873	1.277585	3.940812	0.974109	0.928559	2.15226	2.987753
21	9.832712	3.005735	1.786679	2.239047	4.495059	2.50754	2.845269	2.127858	0.951023	0.321455	2.932007	1.810157	2.414999	1.342469	2.124199
22	5.829999	3.070288	2.456284	1.294862	2.39583	1.63197	0.889444	2.718047	2.661244	2.815236	1.45564	2.102115	0.525991	2.916238	2.014393
23	6.371551	8.115417	2.646801	1.715615	1.608312	2.47229	2.437212	3.563082	2.976015	2.272541	1.75784	2.370654	1.139688	2.179704	0.223607

Table 22: Delta E (ΔE) values of Liquid Matte in natural-teeth group

Liquid Matte	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.289347	3.767699	2.696912	1.262273	3.018646	0.713364	1.546681	1.855023	1.667999	1.524248	2.64617	1.931321	1.382831	1.529343	0.64377
12	3.562459	0.378594	3.006105	1.401983	1.078064	1.515109	0.731057	2.552123	0.571548	1.043498	3.03114	2.346392	1.623097	0.924362	2.87943
11	9.426322	0.886316	7.984081	1.213352	0.694422	1.367479	2.556473	0.943398	2.008039	2.643441	6.30679	2.922328	2.059126	1.187902	0.77817
21	11.25951	1.23783	8.16551	2.491987	1.617955	2.264705	2.624669	2.136716	1.20185	0.980363	3.72812	2.867635	1.215639	1.065625	2.31445
22	4.562894	1.211977	1.715291	1.349074	0.654896	1.552417	2.644491	3.8704	1.944794	0.454606	2.46419	1.751507	2.882129	1.031719	1.64283
23	13.54474	0.694422	1.104536	0.870504	0.731817	2.105548	2.052099	5.509386	2.341415	2.746715	17.2193	2.346155	2.280595	1.960159	2.3029

Table 23: Delta E (ΔE) values of Matte & Frost in natural-teeth group

Matte & Frost	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.63923	2.57962	1.841195	2.423038	0.877496	3.86221	2.159218	6.038856	11.5944	2.004717	1.815106	2.6602	1.034945	2.079797	1.74547
12	2.14631	1.06145	1.836361	0.449691	0.644636	4.549969	2.849171	4.468905	6.750967	2.466441	2.220756	1.219289	1.794436	1.54704	1.819341
11	2.66875	1.47045	4.917429	1.554206	1.374773	2.372762	2.935605	2.061553	2.624669	1.043498	1.617857	1.64587	1.42595	0.628932	0.785988
21	1.18556	2.28668	7.531416	1.417745	3.822303	2.558863	1.580787	3.322148	0.993311	2.175367	1.127212	2.261268	0.987702	1.185561	2.906315
22	2.72315	2.41891	2.426245	0.546707	2.485961	3.017541	1.337494	3.925557	1.231079	0.892562	2.233604	2.349468	0.292499	0.449691	1.695091
23	0.71336	1.94622	2.681832	2.235571	4.149431	3.305383	1.840894	6.084589	0.948683	2.526966	2.604464	0.749815	0.827983	0.384419	1.843306

Table 24: Delta E (ΔE) values of Satin in natural-teeth group

Satin	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.824103	3.388051	2.190383	2.755399	1.610024	4.088738	2.063977	2.751363	1.736216	1.560983	1.211519	1.0873	1.462494	0.693622	2.816223
12	2.791455	2.300483	2.148384	2.437895	2.255118	4.413741	0.722649	2.369716	2.655184	1.167143	2.347812	1.204159	2.676233	0.996661	2.626574
11	2.401388	3.225764	5.45456	1.507389	0.912262	4.219663	1.224291	3.913651	2.918523	0.307318	5.414487	2.28959	1.943079	2.1145	1.287116
21	1.130388	2.862788	5.288247	1.576917	1.289272	4.845846	2.827052	5.00999	1.774824	0.381517	2.968164	2.832549	1.553848	3.320643	1.004435
22	1.122002	3.44093	2.759026	2.40578	2.352776	3.968487	2.196968	2.290318	0.720339	2.615339	2.491318	0.778888	1.337078	0.839312	1.873203
23	1.394035	3.237798	1.99137	1.248555	1.273229	3.208842	2.667083	3.03553	1.516575	1.671327	2.778889	2.517936	1.477987	0.46428	2.876147

Table 25: Delta E (ΔE) values of Matte in natural-teeth group

Matte	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
13	2.422579	0.74685	0.849837	1.739093	2.762044	1.7873	2.070695	3.284644	2.306994	0.438432	1.922094	1.827567	2.551252	1.897367	2.06801
12	4.133468	2.00666	1.581139	0.632816	1.307245	2.63101	1.641815	1.10755	2.76506	2.895399	2.900192	2.335713	2.434475	2.736583	2.84273
11	8.535547	2.34141	3.235395	1.652271	1.41028	1.07755	2.428992	1.338739	0.825967	0.963212	1.271919	2.150969	1.258306	0.822598	2.767068
21	6.661832	2.18785	2.664374	0.622718	3.627978	2.62403	1.967796	2.863758	0.903081	1.266228	2.076589	1.726268	1.706523	0.650641	1.472715
22	3.420364	2.27889	2.979374	1.268858	2.875568	2.07552	2.90555	1.732372	2.34426	1.822696	2.801587	1.104033	2.247468	1.440679	1.90817
23	2.395134	1.48885	1.926136	1.715938	2.525426	0.96032	1.567021	2.548638	0.820569	0.754983	2.278645	0.691215	1.974842	0.274874	0.517473

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