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COMPARATIVE SURGICAL TREATMENT OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS USING THE ULTRASONIC SCALPEL AND THE CONVENTIONAL INCISIONAL TECHNIQUES

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สุนิสา ธันโยดม : การเปรียบเทียบการผ่าตัดรักษาเพดานอ่อนยาวในสุนัขพันธุ์หน้าสั้นโดยการตัดด้วยมีดอัลตราโซนิคกับการผ่าตัดปกติ (COMPARATIVE SURGICAL TREATMENT OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS USING THE ULTRASONIC SCALPEL AND THE CONVENTIONAL INCISIONAL TECHNIQUES) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. น.สพ.ชนินทร์ กัลล์ประวิทธ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ. น.สพ. ดร.วิจิตร บรรลุนารา, หน้า.

กลุ่มอาการทางเดินหายใจอุดกั้นเป็นหนึ่งในภาวะที่เสี่ยงต่อการเสียชีวิตของสุนัขในสายพันธุ์หน้าสั้น การทำศัลยกรรมแก้ไขความผิดปกติชนิดปฐมภูมิซึ่งได้แก่เพดานอ่อนที่ยื่นยาวและรูจมูกที่ตีบแคบต้องทำในทุกราย การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบการผ่าตัดโดยการใช้มีดอัลตราโซนิคกับวิธีการผ่าตัดปกติ ในการแก้ไขเพดานอ่อนที่ยาวผิดปกติของสุนัขพันธุ์หน้าสั้น ในกลุ่มประชากรสุนัขพันธุ์หน้าสั้นที่เข้ามารับการรักษากลุ่มอาการทางเดินหายใจอุดกั้นจำนวน 20 ตัว แบ่งกลุ่มการทดลองออกเป็น 2 กลุ่มด้วยวิธีการสุ่ม กลุ่มวิธีปกติ จำนวน 10 ตัว และกลุ่มใช้มีดอัลตราโซนิค จำนวน 10 ตัว บันทึกเวลาที่ทำศัลยกรรมและปริมาณเลือดออกขณะทำศัลยกรรม ประเมินและให้คะแนนการการหายใจ อาการแทรกซ้อน และความเจ็บปวด ก่อนทำศัลยกรรมและในวันที่ 1 3 7 14 และ 28 หลังทำศัลยกรรม เพดานอ่อนส่วนที่ตัดออกของสุนัขทุกตัวได้รับการตรวจทางจุลพยาธิวิทยา เก็บตัวอย่างเพดานอ่อนบริเวณที่ทำศัลยกรรมหลังทำศัลยกรรม 14 วัน จากกลุ่มวิธีปกติจำนวน 7 ตัวและกลุ่มที่ใช้มีดอัลตราโซนิคจำนวน 8 ตัว ผลการศึกษาพบว่า เวลาในการทำศัลยกรรมของกลุ่มใช้มีดอัลตราโซนิค มีระยะเวลาสั้นกว่ากลุ่มวิธีปกติอย่างมีนัยสำคัญทางสถิติ ($p<0.01$) ปริมาณเลือดออกในกลุ่มวิธีปกติมากกว่าของกลุ่มใช้มีดอัลตราโซนิค อย่างมีนัยสำคัญทางสถิติ ($p<0.05$) กลุ่มมีดอัลตราโซนิคมีค่าคะแนนการหายใจต่ำกว่ากลุ่มวิธีปกติในวันที่ 3 และ 28 หลังการทำศัลยกรรมอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ทั้งสองกลุ่มไม่มีความแตกต่างกันของคะแนนการอักเสบก่อนและหลังการทำศัลยกรรมรวมทั้งคะแนนความเจ็บปวด ผลการตรวจทางจุลพยาธิวิทยาพบว่าคะแนนการเข้ามาของเนื้อเยื่อบุผิวในกลุ่มมีดอัลตราโซนิคสูงกว่ากลุ่มวิธีปกติอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) โดยสรุปการทำศัลยกรรมตัดเพดานอ่อนที่ยื่นยาวในสุนัขพันธุ์หน้าสั้นโดยใช้มีดอัลตราโซนิคใช้เวลาที่สั้นกว่า ไม่มีเลือดออก สุนัขมีการหายใจภายหลังการทำศัลยกรรมดีขึ้น และไม่พบอาการแทรกซ้อนภายหลังการผ่าตัด

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SUNISA THUNYODOM: COMPARATIVE SURGICAL TREATMENT OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS USING THE ULTRASONIC SCALPEL AND THE CONVENTIONAL INCISIONAL TECHNIQUES. ADVISOR: ASSOC. PROF. CHANIN KALPRAVIDH, D.V.M., M.Sc., D.T.B.V.S., CO-ADVISOR: ASSOC. PROF. WIJIT BANLUNARA, D.V.M., Ph.D., D.T.B.V.P., pp.

Brachycephalic airway obstruction syndrome (BAOS) is life threatening condition in brachycephalic dogs. Surgical correction of primary disorders including elongated soft palate and stenotic nares is indicated in all cases. Aim of this study was to compare the use of the ultrasonic scalpel with the conventional incision technique for staphylectomy. Twenty dogs with BAOS enrolled in this study were randomly assigned into conventional (N=10) or ultrasonic group (N=10). Respiratory score was evaluated and recorded prior to surgery. Staphylectomy time and bleeding were recorded. Respiratory, postoperative complication and pain scores were evaluated and recorded at days 1, 3, 7, 14 and 28 after surgery. The excised soft palate from all dogs were histopathologically evaluated. Two weeks after surgery, soft palate biopsies were performed in 7 dogs of the conventional group and 8 dogs of the ultrasonic group. The surgical time of the ultrasonic group was significantly ($p<0.01$) shorter than that of the conventional group. The bleeding volume in the conventional group was significantly ($p<0.05$) more than that of the ultrasonic group. The respiratory scores at days 3 and 28 postoperation of the ultrasonic group were significantly ($p<0.05$) lower than those of the conventional group. Complication and pain scores were not significantly different between groups. Preoperative and postoperative inflammatory scores were not significantly different between groups. The epithelialization score of the ultrasonic group was significantly higher ($p<0.05$) than that of the conventional group. In conclusion, staphylectomy using ultrasonic scalpel provided less surgical time, no bleeding, improved respiratory signs, and insignificantly postoperative complications when compared with the conventional incision technique.

Department:	Veterinary Surgery	Student's Signature	....
Field of Study:	Veterinary Surgery	Advisor's Signature	....
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CHAPTER I
INTRODUCTION

1.1 Importance and rationale

Elongated soft palate is congenital primary malformation of brachycephalic dogs such as Bull dog, French Bulldog and Pug. It is found 86-100 percent of the brachycephalic airway obstruction syndrome (BAOS) (Barnes et al., 2006; Pratschke, 2014). The overlong soft palate extending through the larynx decreases airway diameter causing respiratory problems. From one study, the brachycephalic dogs had shorter survival time than non-brachycephalic dogs and 16.7 % of those died from respiratory failure (O'Neill et al., 2015). Early correction of the primary malformation of BAOS such as stenotic nare and elongated soft palate has favorable long-term outcome. Nowadays, the main techniques used in staphylectomy are conventional incision and carbon dioxide laser. However, these techniques have some disadvantages. The most important disadvantages of the conventional staphylectomy are bleeding, long surgical time (Davidson et al., 2001) and required sewing. Moreover, the suture materials placed in the oral tissue prone to stimulate more inflammatory response than those placed in other areas because of the oral conditions of containing moisture, susceptibility of infection, and contaminating with ingested food and saliva (Kim et al., 2011). Safety precautions are necessary for the use of the carbon dioxide laser.

The ultrasonic energy device is commonly used for soft tissue dissection and vessel sealing. The external generator converts electric energy to ultrasonic energy by a transducer at the hand piece. The mechanical energy from the blade causes denaturation and formation of a sticky protein coagulum which is capable of sealing vessels (Molnar et al., 2004). Ultrasonic scalpel has been used successfully in several surgical procedures, for example lung lobectomy, liver biopsy, ovariectomy, tonsillectomy and uvulopalatoplasty (Wiatrak and Willging, 2002; Molnar et al., 2004; Vasanjee et al., 2006; Halme et al., 2010; Ohlund et al., 2011). Use of the ultrasonic scalpel for staphylectomy in 3 dogs had good outcome (Michelsen, 2011).

The advantages of using the ultrasonic scalpel are less surgical time, less intraoperative hemorrhage (Inaba et al., 2000; Wiatrak and Willging, 2002; Kamal et al., 2006; Peng et al. , 2013) , minimal inflammation, good healing, and minimal postoperative pain (Wiatrak and Willging, 2002). Moreover, the ultrasonic scalpel is easy to use and produces less vision-obscuring smoke. Thus, use of the ultrasonic energy device might be a novel technique for staphylectomy.

1.2 Objectives of study

To compare the use of the ultrasonic scalpel with the conventional incisional technique for resection of the elongated soft palate in brachycephalic dogs with BAOS.

1.3 Research frame

Twenty dogs with BAOS were enrolled in this study and were randomly allocated into the conventional group receiving conventional incisional technique (N=10) or the ultrasonic group receiving the ultrasonic resection technique (N=10). Staphylectomy time and bleeding were recorded. Respiratory scores were evaluated and recorded prior to surgery, with postoperative complication and pain scores at days 1, 3, 7, 14 and 28 after surgery. The excised soft palate from all dogs were histopathologically evaluated. Two weeks after surgery, soft palate biopsies were performed at least in 3 dogs of each group.

1.4 Advantage of study

Staphylectomy using the ultrasonic scalpel incisional technique could be one of the technique of choice for the treatment of the elongated soft palate.

CHAPTER II
REVIEW OF LITERATURES

2.1 Definition of brachycephalic dogs

Skull measurement is used for defining dogs as brachycephalic, dolichocephalic, and mesocephalic. The craniofacial angles are 9°-14°, 19°-21°, and 25°-26° in brachycephalic, mesocephalic and dolichocephalic dogs, respectively (Figure 1). Other measurements are skull width to length ratio and cranial length to the skull length. Skull width to length ratio in brachycephalic dogs is 0.81 or greater (Figure 2). Cranial length to the skull length in brachycephalic dogs is 1.60-3.44 (Figure 2) (Meola, 2013).

Figure 1. Skull measurement. The craniofacial angle formed between the base of the skull and the facial skull (Meola, 2013).

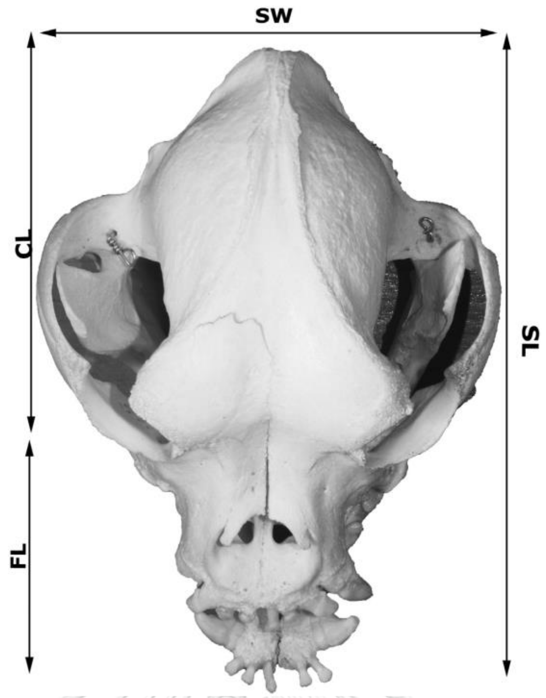

Figure 2. Skull measurement. Skull width to length ratio and cranial length to skull length (Skull width (SW), skull length (SL), cranial length (CL), and facial length (FL) (Meola, 2013)).

2.2 Affected breeds

Commonly affected breeds include Pugs, English and French bulldogs, Boston terriers, Pekingese, Maltese, Shih Tzu, Boxers, Cavalier king Charles spaniels, Yorkshire terriers, Miniature pinscher, and Chihuahuas (Meola, 2013; Monnet, 2013). BAOS is commonly seen in small animal hospitals because brachycephalic dog population has been increasing. (Lewis et al., 2015; Packer et al., 2015). Dogs with BAOS often present the problem at 2 to 4 years of age due to worsening of clinical signs. In most literatures, BAOS has no sex predisposition (Meola, 2013). However, some studies found prevalence of BAOS in male higher than in female (2:1) (Poncet et al., 2005; Poncet et al., 2006), while other reported higher incidence (1.6:1) in female dogs (Torrez and Hunt, 2006). Brachycephalic breed has shorter survival time than non-brachycephalic breed (O'Neill et al., 2015). The median longevity of the brachycephalic dog is 8.6 years old (O'Neill et al., 2015).

2.3 Primary and secondary disorders

Elongated soft palate is one of the congenital primary disorders in brachycephalic dogs and is found in 86-100 percent of the BAOS (Barnes et al., 2006; Pratschke, 2014). Moreover, soft palate in brachycephalic dogs is significantly thicker than in non-brachycephalic dogs, and the thickness of the soft palate is correlated with severity of clinical signs (Grand and Bureau, 2011). Other primary disorders of BAOS are 43-96% of stenotic nares, aberrant nasal conchae, hypoplastic trachea and redundant pharyngeal tissue (Pratschke, 2014). Aberrant nasal conchae can cause obstruction of the nasal meatus (rostral aberrant conchae) or of the nasopharyngeal meatus (caudal aberrant conchae) (Monnet, 2013). Secondary disorders of brachycephalic dogs consist of everted laryngeal saccules, everted tonsils, laryngeal collapse, bronchial collapse, and tracheal collapse. Incidence of the everted saccules and everted tonsils are 53%-66% and 9%-56%, respectively. The everted laryngeal saccule is the first stage of laryngeal collapse (Meola, 2013). Laryngeal collapse is classified into 3 grades (Table 1) (Leonard, 1960).

Table 1. Laryngeal collapse grading

Stage	Macroscopic findings
1	Everted laryngeal saccules
2	Medial displacement of the cuneiform processes of the arytenoid cartilages
3	Collapse of the corniculate processes of the arytenoid cartilages

(Leonard, 1960)

2.3.1 Histopathology of the soft palate

Morphology of the soft palate in dogs were clear stratification of musculoconnective tissue covered by nasopharyngeal and oropharyngeal sides. The nasopharyngeal side is a thin pluristratified squamous epithelium. At the oropharyngeal side, the epithelium is thicker than at nasopharyngeal side. The palatine glands are underneath the nasopharyngeal epithelium while the salivary glands are below the oropharyngeal epithelium. The muscles of soft palate are the paired palatinus, levator veli palatini and tensor veli palatini (Arrighi et al., 2011; Crosse et al., 2015; Pichetto et al., 2015). From previous study, histological examination of the soft palate in brachycephalic dogs was different from mesocephalic dogs. The soft palate of dogs with BAOS was epithelial hyperplasia, intracellular epithelial edema, increased stroma within the lamina propria and edema, myofiber degeneration, and increased proportion of palatine glands and salivary glands (Pichetto et al., 2011; Crosse et al., 2015).

2.3.2 Oral wound healing

Healing of oral wound is characterized by several stages including hemostasis, inflammatory, proliferative, and remodeling phases. The healing of oral wound is faster than skin and has less scar formation. Brand et al. (2014) reported palatal wounds were healed within 14 days and could not be differentiate the origin of wound after 28 days. Key factor that promotes wound healing consists of rapid turnover rate, highly vascularized, and humid environment of the oral mucosa. Histopathological examination of the oral mucosa in guinea pig showed a complete re-epithelialization range of 1-4 weeks (Sinha and Gallagher, 2003).

2.4 Clinical signs

Clinical presentation includes both respiratory and digestive signs. The respiratory signs are loud snoring, inspiratory stertor, stridor, coughing, exercise intolerance, prolonged recovery time after exercise, heat intolerance, variety of sleep problems, and syncope. The digestive signs are vomiting, regurgitation, and ptyalism (Meola, 2013; Roedler et al., 2013). Blood gas analysis in brachycephalic dogs showed significantly lower PaO_2 and higher $PaCO_2$ than in non-brachycephalic dogs, although general blood profiles were normal and packed cell volume were high. (Hoareau et al., 2012). BAOS is progressive disease thus the severity of clinical signs depends on airway closure.

2.5 Pathophysiology

Inspiration starts with contraction of the diaphragm, which produces a negative pressure in the thoracic cavity. Then, external air is drawn from the nose into the lungs. Total airflow resistance is 76.5% at nasal cavities, 4.5% at the larynx, and 19% at the trachea, bronchus, and bronchiole (Monnet, 2013). In brachycephalic dogs, the openings of the nostrils are narrow and overlong soft palate extends through the larynx. Both of anomalies decrease airway diameter resulting in increased airway resistance which is explained by Poiseuille law as $Q = \pi\Delta Pr4/8\eta l$. Therefore, the resistance of airflow is increasing. Rhinomanometric studies confirmed that intranasal resistance is significantly higher in brachycephalic dogs compared with normal dogs (Lippert et al., 2010). Chronic abnormal pressure and airflow dynamics in upper airway can lead to secondary disorders, consisting of everted laryngeal saccules, everted tonsils, laryngeal collapse, bronchial collapse, and tracheal collapse. Moreover, nasal conchae are essential for body temperature regulation by evaporation. In brachycephalic dogs, the short muzzle and abnormal conchae architecture might alter the thermoregulation (Oechtering, 2010), causing severe heat intolerance, exercise intolerance, and prolonged recovery time after minor exercise. Increase inspiratory work lead to increase pressure in the thoracic cavity that can cause excessive vagal stimulation generating vomiting. Furthermore, increase inspiratory work could stimulate the autonomic sympathetic nervous system, which would slow gastric motility and increase gastric emptying time (Monnet, 2013). Gastroesophageal disorders stimulate persistent inflammation at pharyngeal region. Poncet et al. (2005) reported significant correlation between severity of respiratory signs and gastrointestinal signs. From endoscopic examination, inflammation of the upper gastrointestinal tract was found in dogs without digestive signs. In addition, histopathological evaluation of the gastrointestinal tract found inflammatory lesions even in dogs that did not have inflammation found from the endoscopic examination. After correction of BAOS in dogs with gastrointestinal problem, the gastrointestinal sign was improved (Poncet et al., 2006).

2.6 Medical treatment of BAOS

Reduction of stress, management of hyperthermia, oxygen therapy, and fluid therapy could be performed in the emergency case. Endotracheal intubation should be done in severe inspiratory dyspnea dogs. Temporary tracheostomy must be done in the case that the orotracheal tube cannot be inserted. Medication used for sedating patients include acepromazine maleate (0.005-0.02mg/kg intraveneously or subcutaneously), or diazepam (0.2mg/kg intraveneously). Anti-inflammatory drugs include dexamethasone (0.05-0.1mg/kg intraveneous) (Meola, 2013).

Other treatments compose of short-acting glucocorticoid, reducing physical effort, avoiding hot weather, and controlling weight. The medication for gastritis is a 2-month course including omeprazole (0.7 mg/kg) per oral once a day, cisapride (0.2 mg/kg) per oral every 8 hours, and sucralfate (1g) per oral every 12 hours. However, medical treatment cannot solve the problem (Monnet, 2013).

2.7 Staphylectomy

Early correction of BAOS such as stenotic nares and elongated soft palate are recommended. Correction of primary disorders can reduce secondary disorder such as life-threatening laryngeal collapse. The surgery is recommended in association with spay or castration. Staphylectomy is the preferred procedure to treat the elongated soft palate in brachycephalic dogs. In the operation, the dog is placed in sternal recumbency, and an incision is made at the level of the caudal border of the tonsils. Major postoperative complications include aspiration pneumonia (11%), temporary tracheostomy (3% to 5%), and severe dyspnea or death (3% to 5%) due to edema and swelling of the upper respiratory tract. Minor postoperative complications include vomiting and mucoid regurgitation (18%), nasal discharge (5%), respiratory noise, dehiscence, or regurgitation (3% to 10%) (Ree et al., 2016). Ree et al. (2016) reported 15% of repeated BAOS surgery.

Staphylectomy can be done by several techniques. Conventional technique is performed by sharp dissection and suturing (Davidson et al., 2001). Monopolar electrocautery (Dunie-Merigot et al., 2010), bipolar sealing device (Brdecka et al., 2007;

Cook et al., 2015), carbon dioxide laser (Clark and Sinibaldi, 1994; Davidson et al., 2001; Brdecka et al., 2007; Riecks et al., 2007; Dunie-Merigot et al., 2010), diode laser (Dunie-Merigot et al., 2010), and ultrasonic device (Michelsen, 2011) have also been used for tissue resection. The most important disadvantages of the conventional technique are bleeding, long surgical time (Davidson et al., 2001) and needed suturing. Davidson et al. (2001) reported, even though the conventional technique had clinical outcomes similar to the CO_2 laser technique, the latter used less surgical time than the conventional technique. Surgical times were 5.15 minutes (Davidson et al., 2001) and 8.5 ± 2.9 minutes (Dunie-Merigot et al., 2010) for CO_2 laser, 11.8 ± 2.5 minutes (Dunie-Merigot et al., 2010) for diode laser, and 18 ± 4.6 minutes (Dunie-Merigot et al., 2010) for electrosurgery. The initial reaction of the tissues which is provoked by passing the needle and suture is reflected as an inflammatory response. Assuming the same surgical intervention, tissue type, and other factors such as absence of infection, the tissue reaction will develop during the first two to seven days after suturing the tissue (Javed et al., 2012). The suture material prones to stimulate more inflammatory response in the oral area than in other areas because of the oral conditions of containing moisture, being susceptible to infection, and contaminating with ingested food, saliva, etc. (Kim et al., 2011). Disadvantages of using radiofrequency energy are thermal tissue damage. Even though every device were causes thermal tissue damage, ultrasonic devices use lower temperatures than others. The ultrasonic scalpel uses temperature 60-100°C for tissue resection while the electrosurgery and laser use 150–400°C for tissue resection (Sackman, 2012).

2.8 Ultrasonic energy device

The ultrasonic energy device is commonly used for soft tissue dissection and vessel sealing. This device was introduced to the health care profession in 1992. The external generator converts electric energy to ultrasonic energy by a transducer at the hand piece. Ultrasonic vibration creates longitudinal movement against the inactive part of the blade. The mechanical energy from the blade causes denaturation and formation of a sticky protein coagulum which is capable of sealing vessels (Molnar et al., 2004). Ultrasonic energy device should not be used to seal vessels greater than 4.5 mm in diameter (Bubenik et al., 2005). In dogs, ultrasonic scalpel has been used for several surgical procedures, including jejunotomy (Birch et al., 1999), pulmonary resection (Molnar et al., 2004), ovariohysterectomy (Hancock et al., 2005), vessel coagulation (Bubenik et al., 2005), splenectomy (Royals et al., 2005), tissue biopsy (Barnes et al., 2006), latissimus dorsi muscle incision (Inaba et al., 2000), ovariectomy (Ohlund et al., 2011), laryngeal nerve injury (Lee et al., 2012), and circumcision (Peng et al., 2013). Michelsen (2011) reported good surgical outcome and rapid surgical intervention of staphylectomy with the ultrasonic scalpel in 3 dogs.

Some studies have shown that the ultrasonic scalpel decreases operation time and intraoperative hemorrhage compared to the blunt or the electrosurgical dissection (Inaba et al., 2000; Peng et al., 2013). The ultrasonic scalpel uses temperature (60-$100^{\circ}C$) lower than the electrosurgery and laser (150–$400^{\circ}C$) for tissue resection leading to milder collateral tissues necrosis and short healing time (Sackman, 2012). Lee et al. (2012) used the ultrasonic scalpel at 3 millimeters away from the recurrent laryngeal nerve and reported no nerve damage. The ultrasonic scalpel is easy to use, less vision-obscuring smoke (Inaba et al., 2000), and less postoperative pain compared to the electrocautery and coblator (Wiatrak and Willging, 2002; Parsons et al., 2006).

CHAPTER III
MATERIALS AND METHODS

3.1 Animals

This research was approved by the Animal Care and Use Committee of Chulalongkorn University, Bangkok Thailand (IACUC protocol number 1731028). Twenty dogs with BAOS were enrolled in this study. Breed, sex, age, weight, respiratory and gastrointestinal signs, stenotic nares, elongated soft palate, tracheal hypoplasia, laryngeal collapse grade, and everted tonsils were examined and recorded. Laryngeal collapse was graded into 3 stages (Table 1) (Leonard, 1960). The clinical respiratory scoring and gastrointestinal grading were shown in Tables 2 and 3, respectively (Poncet et al., 2006). For dogs with multiple respiratory signs, the worst clinical sign was used for scoring the respiration. Inclusion criteria were the dogs with the respiratory scores of 2, 3 or 4 and no history of other respiratory diseases. Dogs were randomly assigned to receive the conventional (n = 10) or the ultrasonic scapel technique (n = 10).

Table 2. Respiratory sign scoring scale.

Score	Respiratory signs
0	Absence of clinical signs related to brachycephalic airway obstructive syndrome
1	Non-permanent snoring, snore is not particularly loud
2	Non-permanent loudly snoring, stetor when exciting
3	Permanent loudly snoring, permanent stetor, and sleep apnea
4	Permanent tachypnea, open mouth breathing
5	Cyanosis, agonal breathing

Table 3. Gastrointestinal sign grading scale.

Signs	Never	>Once monthly	Once weekly	Once daily	>Once daily	Constantly
Ptyalism	1	1	2	2	3	3
Regurgitation	1	1	2	3	3	3
Vomiting	1	1	2	3	3	3

Grade : 1 = mild, 2 = moderate, 3 = severe

(Adapted from Poncet et al. (2006))

3.2 Anesthesia and surgical preparation

All dogs received the physical examination and evaluation of complete blood count (CBC) and blood chemistry. Abnormalities were corrected before anesthesia. Food and water were withheld for 12 hours before surgery. Each dog was pre-medicated intramuscularly with acepromazine maleate (0.03 mg/kg) and morphine sulfate (0.5 mg/kg). All dogs were preoxygenated at least 10 minutes before anesthesia induction with propofol (1-4 mg/kg) intravenously to effect, and anesthesia maintenance with isoflurane in oxygen through endotracheal tube. Normal saline solution were administered intravenously (10 ml/kg) throughout the surgical procedure. Intravenous cefazolin (25 mg/kg) and dexamethasone (0.5 mg/kg) were administered preoperatively. The cervical and chest radiography and the laryngoscopy in sternal recumbency were performed immediately after anesthesia induction.

3.3 Surgical procedures

3.3.1 Conventional group

All dogs (n=10) were placed in sternal recumbency. The free end of the soft palate was retracted forwards and held with the Allis tissue forceps. Then, two stay sutures were placed at each corner of the free end of the soft palate; lateral to the caudal aspect of the tonsillar crypt. The soft palate was excised with the metzenbaum scissors in an alternating cut and sew fashion (Figure 3). The nasal and oral mucosal layers were sutured with a taper needle and 4-0 Glycomer 631, synthetic absorbable monofilament suture (taper needle, Biosyn; Medtronic, Boulder United States) in simple continuous pattern.

Figure 3. Dogs were placed in sternal recumbency. The soft palate was excised with the metzenbaum scissors.

3.3.2 Ultrasonic scalpel group

All dogs (n = 10) were placed in sternal recumbency. The free end of the soft palate was retracted forwards and held with the Allis tissue forceps. The soft palate was inserted between the jaws of the shear instrument of the cordless ultrasonic dissection device (Sonicision™ 13 cm device, Medtronic, Boulder United States) (Figure 4) and transected with maximum power laterally from the caudal aspect of the tonsillar crypt (Figure 5).

Figure 4. Sonicision™ 13 cm device, Medtronic.

Figure 5. The soft palate was inserted between the jaw and cut by cordless ultrasonic dissection device.

Staphylectomy time and bleeding were recorded. The surgical time of the conventional staphylectomy was recorded from grasping the elongated soft palate with the Allis tissue forceps until the last stitching. The surgical time of the ultrasonic scalpel staphylectomy was recorded from grasping the elongated soft palate with the Allis tissue forceps until cutting finishes. Intraoperative blood loss was estimated by weighing the used gauze sponges.

3.3.3 Postoperative cares

Morphine sulfate (0.2 mg/kg) were administered subcutaneously after surgery. Firocoxib (5 mg/kg) were administered per oral 8 hours after surgery, then once a day for the first 4 postoperative days. Water and food were given no sooner than 8 hours after surgery.

3.4 Postoperative evaluation

Respiratory, postoperative complication (Table 4) and pain scores were evaluated and recorded at days 1, 3, 7, 14 and 28 after surgery. The pain scoring followed the Colorado State University (CSU) acute pain scale for the dog (Hellyer, 2006) as shown in Figure 6. Laryngoscopy was performed at day 14 post surgery.

Table 4. Postoperative complication scoring scale

Score	Postoperative complications
0	None
1	Coughing, choking
2	Coughing, postoperative bleeding
3	Coughing, postoperative bleeding, aspiration pneumonia
4	Coughing, postoperative bleeding, aspiration pneumonia, dyspnea

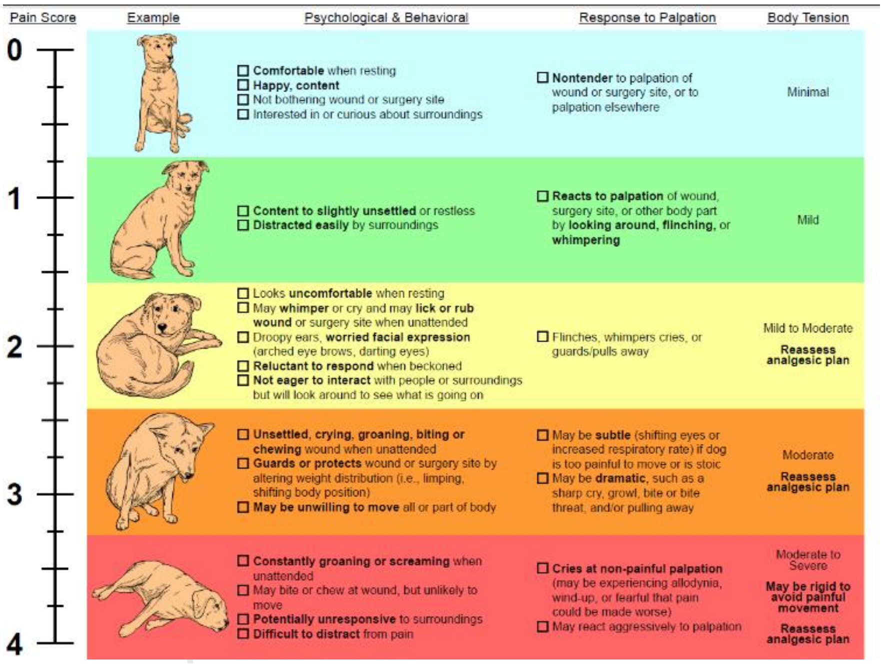

Figure 6. The Colorado State University (CSU) acute pain scale for the dog (Hellyer, 2006).

3.5 Histopathological evaluation

The excised soft palate from all dogs were processed for histopathological evaluation. Two weeks after surgery, soft palate biopsies were performed in 7 dogs of the conventional group and 8 dogs of the ultrasonic group.

Each tissue sample was fixed in 10% neutral-buffered formalin, stained with hematoxylin and eosin, and examined by a pathologist. All tissue samples were scored for the inflammation and the re-epithelialization according to the scoring scales shown in tables 5 and 6.

Table 5. Inflammation scoring scale

Score	Findings
0	No acute inflammation
1	Perivascular scattered acute inflammatory cells
2	Perivascular and submucosal scattered inflammatory cells
3	Submucosal band-like inflammatory cells infiltrate, less than 1/4 of one low power field
4	Submucosal band-like inflammatory cells infiltrate, between 1/4 and 1/2 of one low power field without tissue necrosis
5	Submucosal diffuse inflammatory cells infiltrate, more than 1/2 of one low power field with tissue necrosis

(Sinha and Gallagher, 2003)

Table 6. Re-epithelialization scoring scale

Score	Findings
1	Reepithelialization covering the entire wound, normal thickness
2	Reepithelialization covering the entire wound, irregular thickness
3	Reepithelialization covering more than half of the wound
4	Reepithelialization covering less than half of the wound
5	Reepithelialization at the edge of the wound

(Adapted from Sinha and Gallagher (2003))

3.6 Data analysis

Statistical software (SPSS for windows Version 24; SPSS) was used for data analysis. The surgical time were compared between groups with independent t-test. The respiratory scores were compared between before and after staphylectomy within group with Wilcoxon signed ranks test. The bleeding volumn, respiratory scores, postoperative complication scores, pain scores, inflammatory scores, and the re-epithelialization scores were compared between groups with Mann–Whitney U test. P-values of <0.05 was considered significant.

CHAPTER IV

RESULTS

4.1 Animals

Breed, age, and sex of dogs in the conventional and ultrasonic groups were shown in Table 7.

Table 7. Breed, age, and sex of dogs in the conventional and ultrasonic groups

	Conventional group	Ultrasonic group
Breed (number (%))		
French bulldog	7 (70)	9 (90)
Boston Terrier	1 (10)	0 (0)
Pug	2 (20)	1 (10)
Age (years)		
Mean±SD	4.6 ± 2.59	4.4 ± 2.27
Median [range]	3.5 [1-9]	4.5 [1-8]
Sex (number (%))		
Male	7 (70)	9 (90)
Female	3 (30)	1 (10)

4.2 Anatomical abnormalities

Number of dogs with preoperative and postoperative elongated soft palate, stenotic nares, hypoplastic trachea, everted tonsils, and laryngeal collapse in each group were shown in Table 8.

Table 8. Number and % of dogs with preoperative (Pre-op) and postoperative (Post-op) elongated soft palate, stenotic nares, everted tonsils, and laryngeal collapse in the conventional and ultrasonic groups.

	Conventional group		Ultrasonic group	
	Pre-op	Post-op	Pre-op	Post-op
Elongated soft palate	10 (100)	0 (0)	10 (100)	0 (0)
Stenotic nares	9 (90)	0 (0)	9 (90)	0 (0)
Hypoplastic trachea	0 (0)	0 (0)	0 (0)	0 (0)
Everted tonsil				
None	5 (50)	9 (90)	3 (30)	3 (30)
One site	2 (20)	0 (0)	1 (10)	4 (40)
Two sites	3 (30)	1 (10)	6 (60)	3 (30)
Laryngeal collapse				
None	6 (60)	8 (80)	4 (40)	4 (40)
Stage 1	3 (30)	1 (10)	2 (20)	3 (30)
Stage 2	1 (10)	1 (10)	4 (40)	3 (30)
Stage 3	0 (0)	0 (0)	0 (0)	0 (0)

4.3 Surgical time

The surgical time of the ultrasonic group (mean±SD, 5.74 ± 1.98 mins; range, 3.54 to 9.50 mins) was significantly ($p<0.01$) shorter than that of the conventional group (mean±SD, 27.08 ± 10.57 mins; range, 12.26 to 43.57 mins).

4.4 Bleeding volumn

The bleeding volume (median [range]) in the conventional group (1.95 ml [0.51 to 9.18 ml]) was significantly ($p<0.05$) more than that of the ultrasonic group (0 ml [0 to 0 ml]).

4.5 Respiratory score

4.5.1 Conventional group

The respiratory scores (median [range]) of the conventional group were 3 [2-4], 1 [0-3], 1 [0-3], 1 [0-4], 1 [0-3], and 1 [0-3] at days 0 (preoperative), 1, 3, 7, 14, and 28 postoperation, respectively.

The preoperative respiratory score (day 0) was significantly ($p<0.05$) higher than those at days 1, 3, 7, 14 and 28 postoperation (Figure 7).

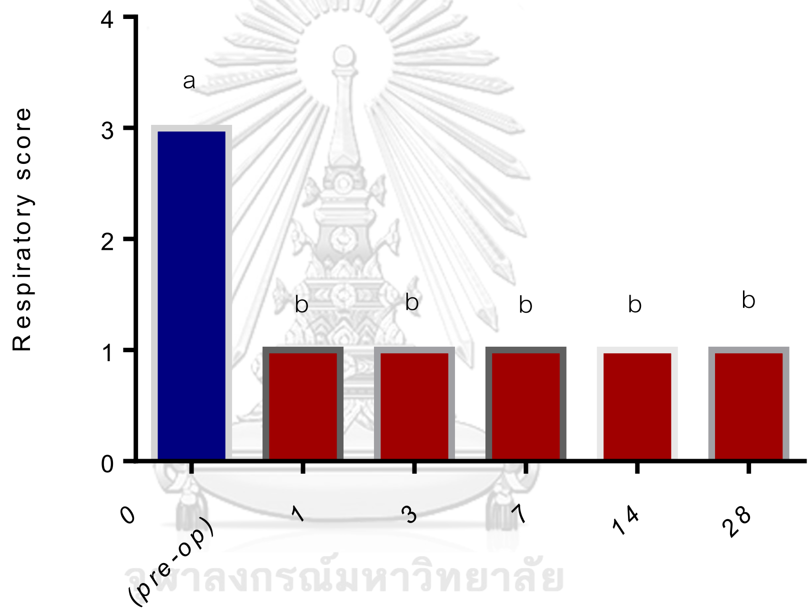

Figure 7. Medians of the preoperative and postoperative respiratory scores of the conventional group, [a, b – the scores with different letters are significantly different ($p<0.05$)].

4.5.2 Ultrasonic group

The respiratory scores (median [range]) of the ultrasonic group were 3 [1-3], 0.5 [0-2], 0 [0-1], 0.5 [0-1], 0 [0-1], and 0 [0-1] at days 0 (preoperative), 1, 3, 7, 14, and 28 postoperation, respectively.

The preoperative respiratory score (day 0) was significantly higher than those at days 1, 3, 7, 14 and 28 postoperation ($p<0.05$) (Figure 8).

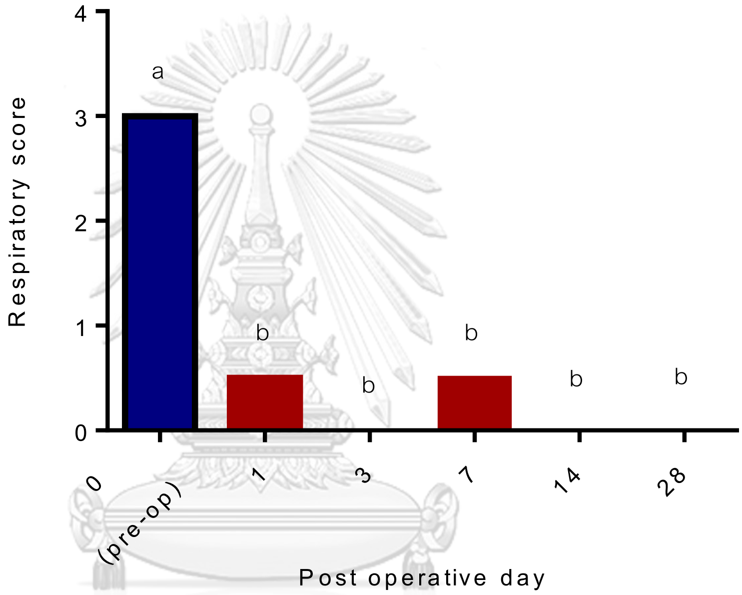

Figure 8. Medians of the preoperative and postoperative respiratory scores of the ultrasonic group, [a, b - the scores with different letters are significantly different ($p<0.05$)].

4.6 Comparison of respiratory scores of the conventional and ultrasonic groups

Medians of the respiratory scores of the ultrasonic group were significantly ($p<0.05$) lower than those of the conventional group at days 3 and 28 postoperation (Table 9, Figure 9).

Table 9. Respiratory scores (medians [range]) of the conventional and ultrasonic groups.

Day	Conventional	Ultrasonic	p-value
0 (preoperative)	3 [2-4]	3 [1-3]	0.149
1	1 [0-3]	0.5 [0-2]	0.377
3	1 [0-3]	0 [0-1]	0.042
7	1 [0-4]	0.5 [0-1]	0.208
14	1 [0-3]	0 [0-1]	0.126
28	1 [0-3]	0 [0-1]	0.022

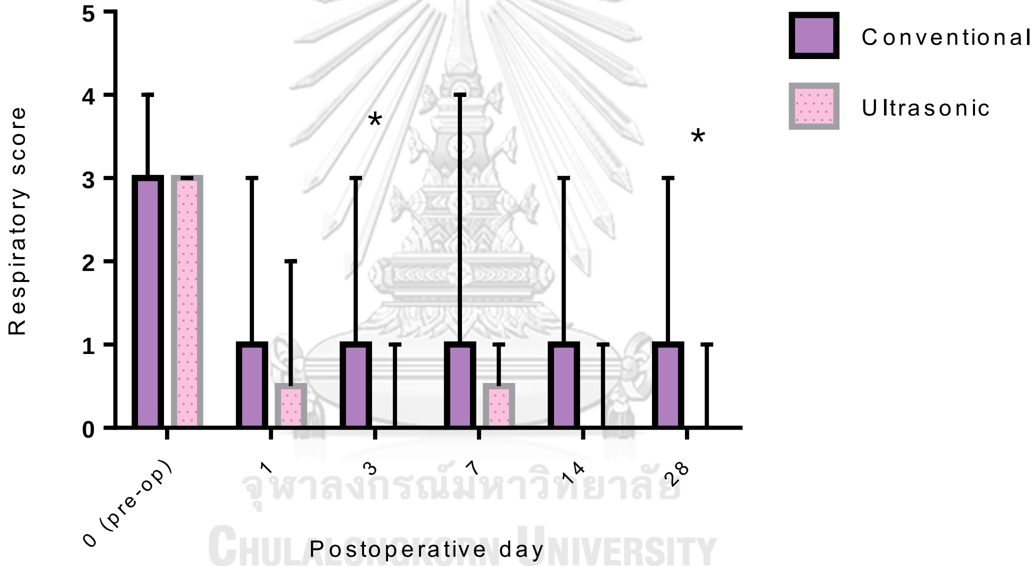

Figure 9. Medians of the respiratory scores of the conventional and ultrasonic groups (* Significantly different (p<0.05) between groups)

4.7 Gastrointestinal grades

Gastrointestinal grade 2 was found preoperatively in 20% of all dogs. Postoperative grading was not performed.

4.8 Pain

Pain scores after surgery were zero in all dogs.

4.9 Complication

The complication scores (median) were not significantly different between groups (Table 10).

Table 10. Complication scores (median [range]) of the conventional and ultrasonic groups.

Post-operation day	Conventional	Ultrasonic	p-value
1	0 [0-1]	0 [0-1]	0.131
3	0 [0-1]	0 [0]	0.067
7	0 [0-1]	0 [0-1]	0.131
14	0 [0-1]	0 [0]	0.067
28	0 [0-1]	0 [0-1]	1.0

4.10 Histology

4.10.1 Inflammation

Inflammatory scores (median) of the soft palate resected at the surgery day and biopsied at day 14 were not significantly different between groups (Table 11, Figure 10).

Histopathological findings of the elongated soft palate resected at the surgery day of the conventional group had no inflammatory cell (Figure 11) while the ultrasonic group had perivascular inflammatory cells (Figure 12).

Table 11. Preoperative inflammatory, postoperative inflammatory, and epithelialization scores (median [range]) of the conventional and ultrasonic groups.

Score	Day	Conventional	Ultrasonic	p-value
Inflammatory	surgery day	0 [0-3]	0 [0-2]	0.551
	14 (postoperation)	3 [1-5]	3.5 [1-5]	0.515
Epithelialization	14 (postoperation)	2 [2-3]	3 [2-5]	0.049

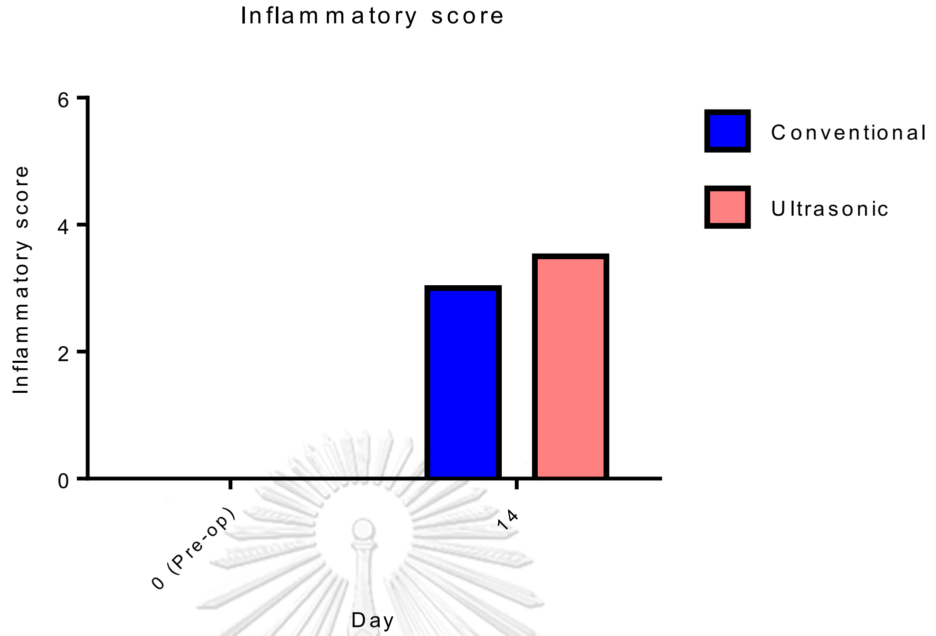

Figure 10. Medians of the preoperative and postoperative inflammatory scores of the conventional and ultrasonic groups

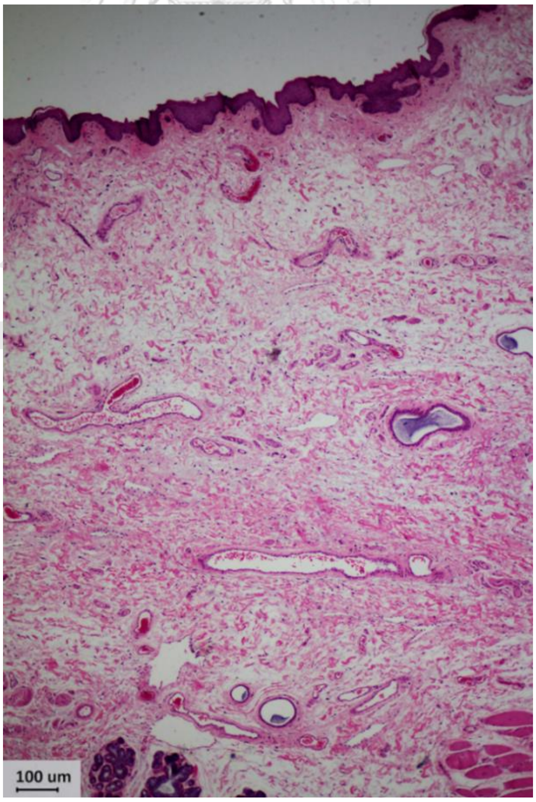

Figure 11. Inflammatory score 0 of the soft palate resected at the surgery day in the conventional group (bar = 100 μm.).

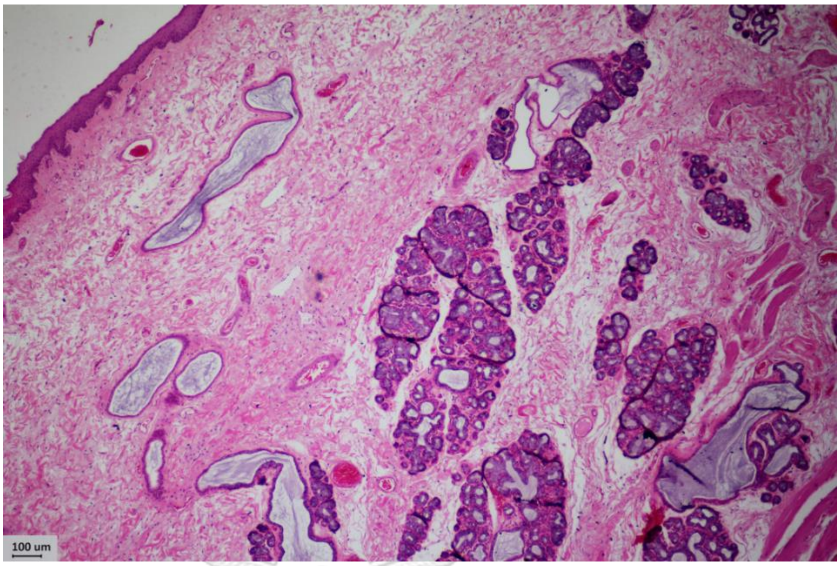

Figure 12. Inflammatory score 1 of the soft palate resected at the surgery day in the ultrasonic group (bar = 100 μm.).

4.10.2 Re-epithelialization

The re-epithelialization score (median) at day 14 of the ultrasonic group was significantly higher ($p<0.05$) than that of the conventional group (Table 11).

Endoscopic examination of the inflammation and wound healing in the conventional group was shown in Figure 13. Histopathological examination at day 14 postoperation showed inflammatory cells infiltrating in the submucosa less than 1/4 of one low power field, irregular thickness of re-epithelialization covering the entire wound (Figures 14 and 15).

Endoscopic examination of the inflammation and wound healing in the ultrasonic group was shown in Figure 16. Histopathological examination at day 14 postoperation showed inflammatory cells infiltrating in the submucosa between 1/4 and 1/2 of one low power field and re-epithelialization covering less than half of the wound (Figures 17 and 18).

Figure 13. Endoscopic picture of the soft palate at the postoperative day 14 of the conventional group.

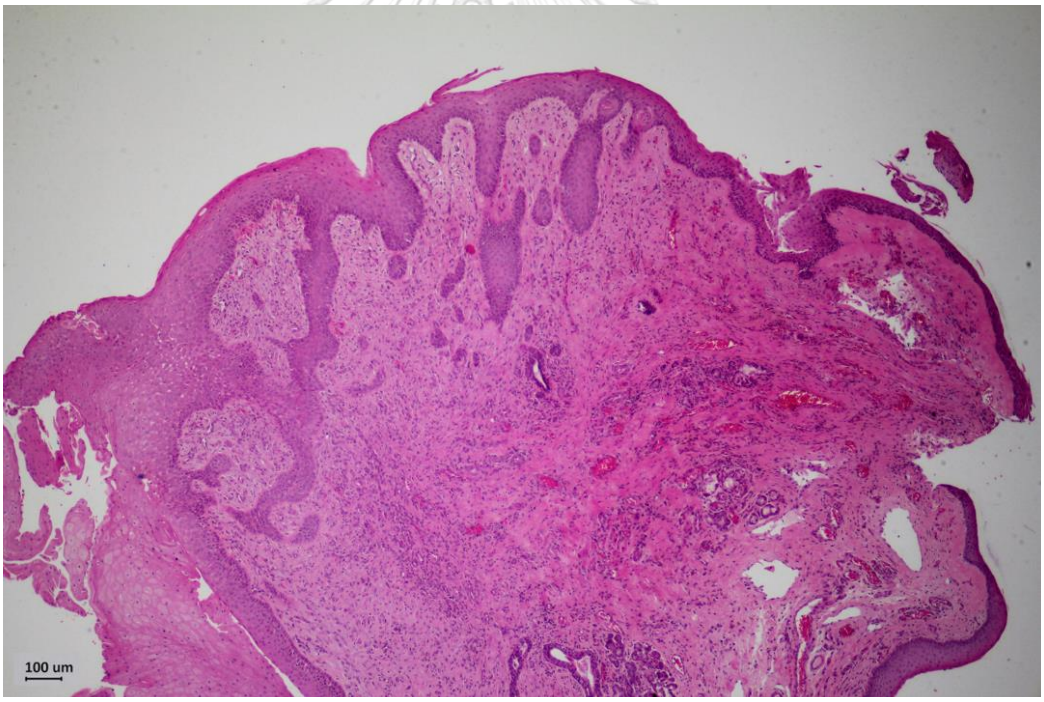

Figure 14. Postoperative re-epithelialization score 2 of the soft palate biopsied at day 14 from the conventional group (bar = 100 μm.).

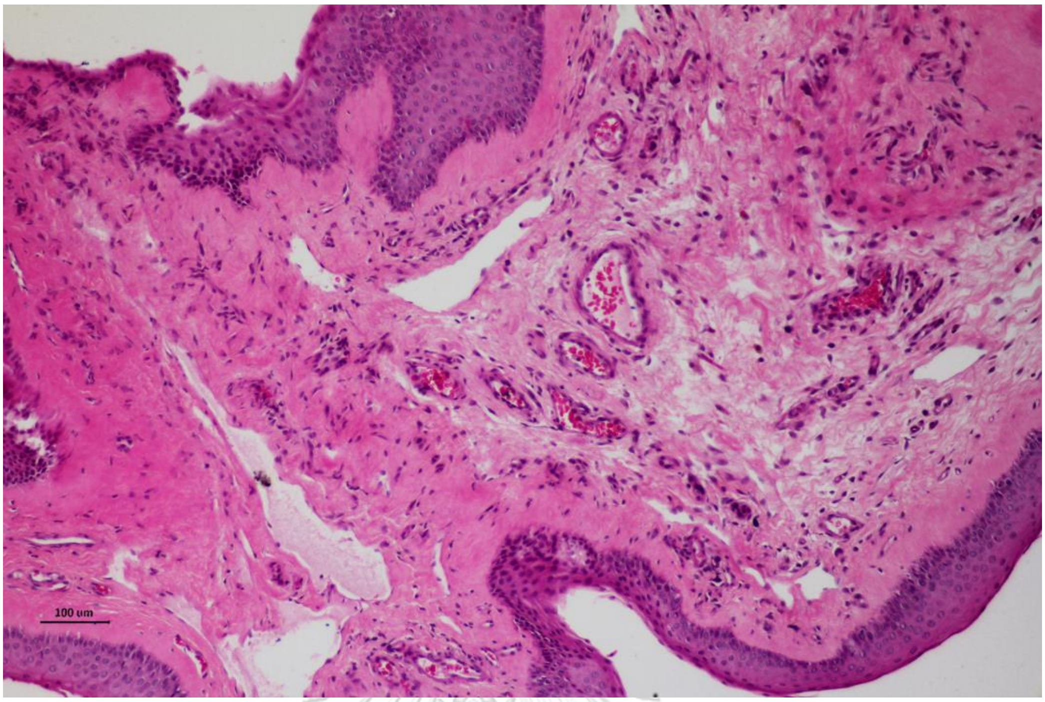

Figure 15. Postoperative inflammatory score 3 of the soft palate biopsied at D14 from the conventional group (bar = 100 μm.).

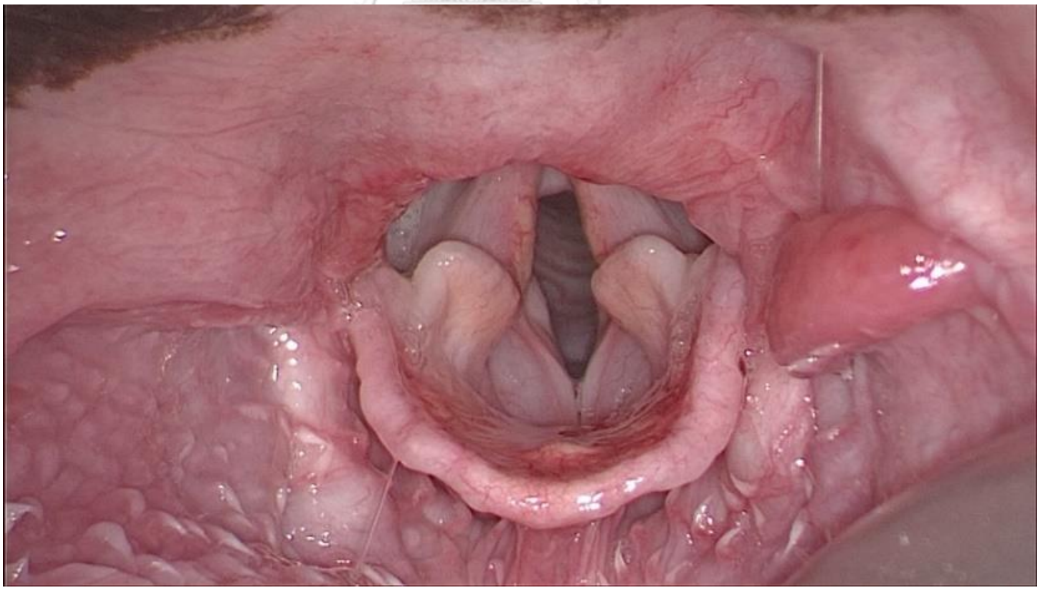

Figure 16. Endoscopic picture of the soft palate at the postoperative day 14 of the ultrasonic group

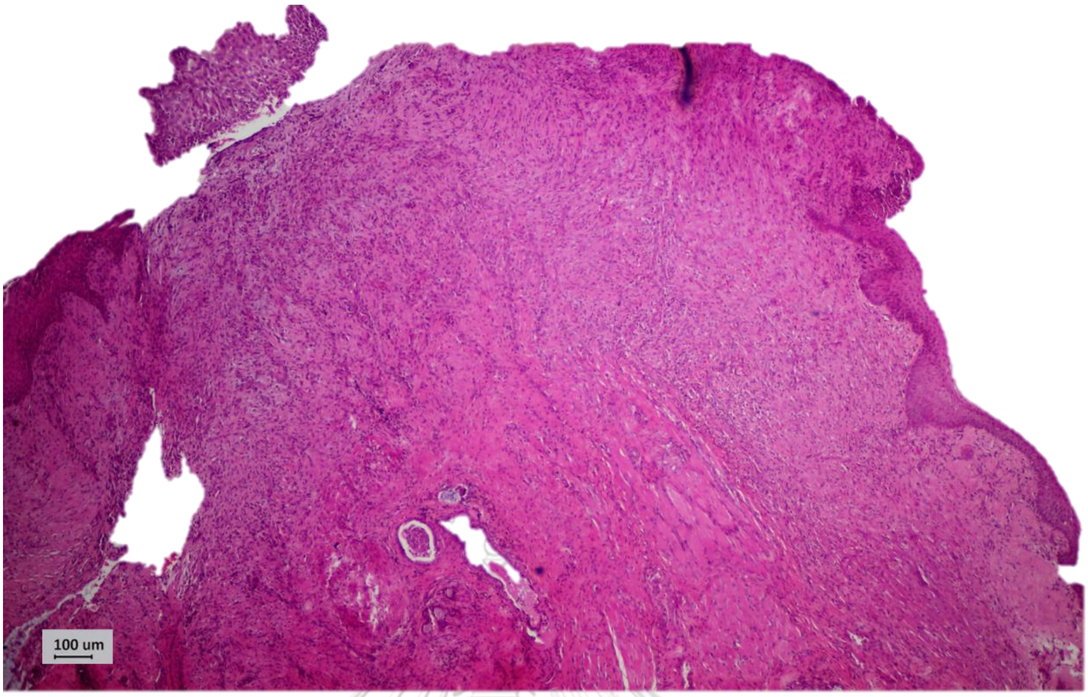

Figure 17. Postoperative re-epithelialization score 4 of the soft palate biopsied at D14 from the ultrasonic group (bar = 100 μm.).

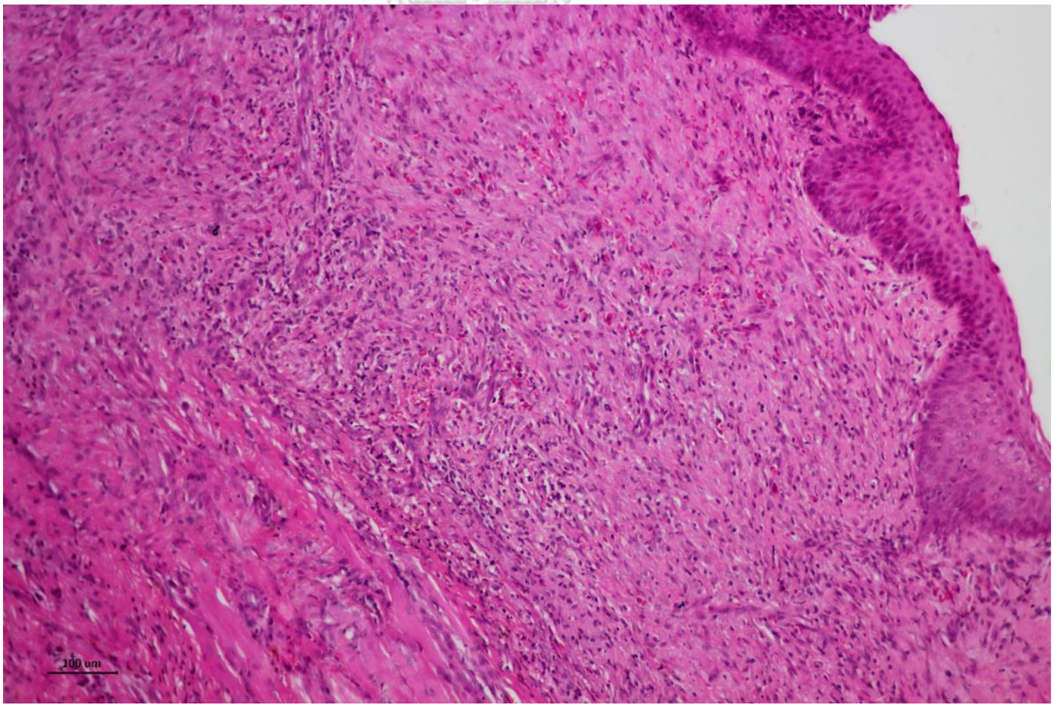

Figure 18. Postoperative inflammatory score 4 of the soft palate biopsied at D14 from the ultrasonic group (bar = 100 μm.).

CHAPTER IV
DISCUSSION AND CONCLUSION

Discussion

Brachycephalic dog population has been increasing (Lewis et al., 2015; Packer et al., 2015). The French bulldog is the breed of dogs mostly found in this study (17/20) similar to other reports (Findji, 2009; Dunie-Merigot et al., 2010). BAOS consists of two groups of disorders, primary and secondary disorders. The primary abnormalities found in the present study were elongated soft palate (100%) and stenotic nares (90%), similar to findings of a previous study (Meola, 2013). Although tracheal hypoplasia was found in many patients with BAOS in many reports (Poncet et al., 2006; Riecks et al., 2007; De Lorenzi et al., 2009; Bernaerts et al., 2010; Planellas et al., 2012), it was not found in the present study. This may be due to the lack of English bulldog in this study which is more commonly affected by tracheal hypoplasia than other breeds.

According to Poiseuille's law, when the airway is 50% narrowed, the resistance of respiration will be increased by 16 times. Then, the secondary abnormalities occur (Meola, 2013). The 60% incidence of everted tonsil was evident in this study, while it was found 9-56% in a previous study (Meola, 2013). According to Leonard’s laryngeal collapse grading system, we found 25% grade I and 25% grade II of the laryngeal collapse, a common secondary change (De Lorenzi et al., 2009). De Lorenzi et al. (2009) reported laryngeal collapse grades I, II, and III of 30.7, 48.7, and 20.5%, respectively, in 39 dogs.

Mean surgical time of the conventional group was 27.08 ± 10.57 minutes (range 12.26 to 43.57 minutes), longer than the time reported by Davidson et al. (mean 12.4 minutes, range 8.58 to 17 minutes). Mean surgical time of the ultrasonic group was 5.74 ± 1.98 minutes (range 3.54 to 9.50 minute), similar to the time reported by Michelsen (2011) (range 5 to 8 minutes). The time of the ultrasonic group was significantly less than that of the conventional group. Use of the ultrasonic technique reduces the time of surgery because there is no need for suturing the incised soft palate margins, because the incised margins is cauterized and sealed as they cut. By other techniques of staphylectomy, surgical times of using CO_2 laser, Diode laser, and electrosurgery were 5.15 minutes (Davidson et al., 2001) 8.5 ± 2.9 minutes (Dunie-Merigot et al., 2010), 11.8 ± 2.5 minutes (Dunie-Merigot et al., 2010), and 18 ± 4.6 minutes (Dunie-Merigot et al., 2010), respectively.

The median bleeding volume of the conventional group was 1.95 ml. (range 0.51 to 9.18 ml.), while bleeding was not found in the ultrasonic group. The ultrasonic device works by converting electrical energy into mechanical vibration of the blade in the range of 55,000 cycles/s and 50 to 85 μm in peak-to-peak amplitude that generates friction between tissues, releasing thermal energy which leads to protein denaturation and tissue coagulation. Vasanjee et al. (2006) found that the ultrasonic device was very effective on controlling hemorrhage, better than ligature technique in the hepatic biopsy. Another study found that ultrasonic energy caused less hemorrhage than laser, monopolar, and bipolar cautery (Lantis et al., 1998). The ultrasonic device can seal 5 mm blood vessels and could be used to cut small bowel mesentery containing multiple blood vessels (Tsirline et al., 2013). In case of old age and chronic inflammation, which are more likely to develop hemorrhage, the ultrasonic device should be used. Michelsen (2011) used the ultrasonic device for soft palate resection in 3 dogs and found postoperative bleeding in 1 of 3, possibly due to the inexperience of the surgeon.

All dogs in this study had clinical signs of BAOS without other respiratory problems. The median respiratory score of day 1 postoperation was 1, range 0 to 3 which was significantly lower than the preoperative respiratory score (median [range], 3 [1-4]). This agrees with the findings of Brdecka et al. (2008) and Dunie-Merigot et al. (2010). In the present study, the ultrasonic group had better respiratory scores than the conventional group at all postoperative evaluation days but significant only at day 3 and day 28. The respiratory score of the ultrasonic group at day 3 postoperation (median [range], 0 [0-1]) was significantly lower than that of the conventional group (median [range], 1 [0-3]). This might be due to less tissue edema in the ultrasonic group from minimal tissue handling, less hemorrhage and operation time which were consistent with the study of Michelsen (2011). The latter reported that using ultrasonic device for staphylectomy did not cause postoperative respiratory complication despite the lack of preoperative corticosteroid drugs to reduce postoperative swelling. The respiratory score of the ultrasonic group at day 28 postoperation (median [range], 0 [0-1]) was significantly lower than that of the conventional group (median [range], 1 [0-3]). This might be due to the remaining of a suture as a foreign body in the conventional group. Wound in the ultrasonic group was healed by second intention resulting in a prolong inflammatory phase. After surgery, respiratory score of the ultrasonic group at day 7 was higher than the score at day 3 because of NSAIDs withdrawal at day 4. Therefore, elongated soft palate surgery with ultrasonic device may require postoperatively 7 days of NSAIDs.

In this study, laryngeal saccule and everted tonsil were spontaneously resolved in some dogs 14 days after staphylectomy and alarplasty resulting from a reduction of the pressure in the larynx resulting in a decrease in the inflammation. This was consistent with the findings of Cook et al. (2015) and Riecks et al. (2007). Both reported that the correction of everted laryngeal saccules and tonsils was not neccessary in all cases, because some dogs were spontaneously improved without surgery. Moreover, Poncet et al. (2006) reported that respiratory signs of some dogs without ventriculectomy were better than those with ventriculectomy.

There were no significant differences in postoperative complications between the ultrasonic and conventional groups. No death and temporary tracheostomy were found. Cook et al. (2015) reported 0-6.8% major complication after staphylectomy. Our postoperative complications found were coughing and gagging which might be due to inflammation from endotracheal intubation or surgery.

The histopathological findings of the soft palate in brachycephalic dogs at the surgical day were severe mucosal hyperplasia, hydropic degeneration of keratinocyte, edema of lamina propria, mucous gland hyperplasia, and hyaline degeneration similar to previous studies (Pichetto et al., 2011; Crosse et al., 2015). The inflammatory score was not significantly different between groups. The inflammatory score at day 14 of the ultrasonic group (median [range], 3.5 [1-5]) was higher than that of the conventional group (median [range], 3 [1-5]). This might be due to thermal energy damage from the ultrasonic device. The active blade temperature of 150°C during activation could cause coagulation necrosis in tissue. Therefore, the tissue damage in ultrasonic group was more than the conventional group using a sharp scissors instrument. In addition, the tissue sample of the conventional group was collected at the middle of the wound in stead of at the surgery knotting area where the inflammation most likely occurred. However, there was no significant difference between both groups.

The re-epithelialization score of the conventional group (median [range], 2 [2-3]) was significantly less than that of the ultrasonic group (median [range], 3 [2-5]). This was consistent with the inflammatory score. High inflammatory score could cause delay wound healing (Barnes et al., 2006). Sinha and Gallagher (2003) reported that epithelialization of the tissue incised by a sharp instrument was faster than that by the ultrasonic device. However, wound healing and the respiratory scores at day 14 of both groups were normal. The wound was completely healed 2 weeks after surgery. So, for the conventional technique a short-term absorbable suture which has 50% tensile strange at 6-7 days should be used and stitchs are removed 14 days after surgery.

Conclusion

Staphylectomy using ultrasonic scalpel provided less surgical time, no bleeding, better respiratory score, and indifferent postoperative complications when compared with the conventional incision technique

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APPENDIX

Group	No.	Gender	Age (years)	Weight (kg.)	Breed
Conventional	1	Female	9	14	Boston Terrier
	2	Male	3	12.9	French Bulldog
	3	Male	1	10	French Bulldog
	4	Male	4	13.5	French Bulldog
	5	Female	7	13.8	Pug
	6	Male	3	18.28	French Bulldog
	7	Female	3	13.3	French Bulldog
	8	Male	3	9.1	French Bulldog
	9	Male	8	11.1	Pug
	10	Male	5	12.1	French Bulldog
Ultrasonic	11	Male	2	18.3	French Bulldog
	12	Female	5	12	French Bulldog
	13	Male	4	10.8	French Bulldog
	14	Male	6	14	French Bulldog
	15	Male	7	12	French Bulldog
	16	Male	5	13	French Bulldog
	17	Male	8	15.6	French Bulldog
	18	Male	4	10.1	Pug
	19	Male	1	9.8	French Bulldog
	20	Male	2	14	French Bulldog

Group	No.	Time (min.)	Bleed (ml.)
Conventional	1	16.43	0.51
	2	27.5	9.18
	3	18.46	2.72
	4	32.01	4.09
	5	43.57	2.3
	6	33.09	0.86
	7	41.52	1.3
	8	26.45	2.55
	9	12.26	1.48
	10	19.53	1.6
Ultrasonic	11	7.3	0
	12	9.5	0
	13	8.24	0
	14	3.54	0
	15	4.59	0
	16	6.13	0
	17	5.05	0
	18	4.24	0
	19	4.57	0
	20	4.29	0

Group	No.	Stenotic nare	Elongated soft palate	Hypoplastic trachea
Conventional	1	/	/	X
	2	/	/	X
	3	/	/	X
	4	/	/	X
	5	/	/	X
	6	/	/	X
	7	X	/	X
	8	/	/	X
	9	/	/	X
	10	/	/	X
Ultrasonic	11	/	/	X
	12	/	/	X
	13	/	/	X
	14	/	/	X
	15	/	/	X
	16	/	/	X
	17	/	/	X
	18	/	/	X
	19	/	/	X
	20	X	/	X

Group	No.	Laryngeal collapse stage		Everted tonsil	
		Pre-op	Post-op D14	Pre-op	Post-op D14
Conventional	1	none	none	none	none
	2	none	none	none	none
	3	none	none	2 sides	2 sides
	4	none	none	none	none
	5	1	1	2 sides	none
	6	none	none	none	none
	7	none	none	none	none
	8	1	none	1 side	none
	9	1	none	1 side	none
	10	2	2	2 sides	none
Ultrasonic	11	none	none	2 sides	2 sides
	12	2	2	2 sides	2 sides
	13	2	1	2 sides	1 side
	14	none	none	2 sides	2 sides
	15	2	2	2 sides	1 side
	16	1	1	2 sides	1 side
	17	none	none	1 side	1 side
	18	2	2	none	none
	19	1	1	none	none
	20	none	none	none	none

Group	No.	Respiratory score					
		Pre-op	Post-op D1	Post-op D3	Post-op D7	Post-op D14	Post-op D28
Conventional	1	3	2	0	2	1	1
	2	3	0	2	0	0	2
	3	3	0	0	0	0	0
	4	3	1	1	1	1	1
	5	3	3	3	4	3	1
	6	3	3	1	1	2	0
	7	2	0	1	0	0	0
	8	3	1	1	1	1	1
	9	3	2	2	1	1	1
	10	4	0	0	1	0	3
Ultrasonic	11	2	1	1	1	0	0
	12	3	0	0	1	1	1
	13	3	1	0	1	1	1
	14	3	1	0	0	1	0
	15	3	0	0	0	0	0
	16	3	0	0	1	0	0
	17	1	2	1	1	0	0
	18	3	0	0	0	0	0
	19	3	0	0	0	0	0
	20	1	2	1	0	0	0

Group	No.	Complication score				
		Post-op D1	Post-op D3	Post-op D7	Post-op D14	Post-op D28
Conventional	1	0	1	1	1	0
	2	0	0	1	1	0
	3	0	0	0	0	0
	4	1	0	0	0	0
	5	1	1	1	0	0
	6	0	0	0	0	0
	7	1	1	1	1	1
	8	0	0	0	0	0
	9	1	0	0	0	0
	10	0	0	0	0	0
Ultrasonic	11	0	0	0	0	0
	12	0	0	0	0	0
	13	0	0	0	0	0
	14	0	0	0	0	0
	15	0	0	0	0	0
	16	0	0	0	0	0
	17	0	0	0	0	0
	18	1	0	0	0	1
	19	0	0	0	0	0
	20	0	0	1	0	0

Group	No.	Inflammatory score		Epithelialization score
		Surgical day	Post-op D14	Post-op D14
Conventional	1	0	4	2
	2	2	N/A	N/A
	3	0	N/A	N/A
	4	0	2	2
	5	0	1	2
	6	0	3	2
	7	3	2	2
	8	0	3	2
	9	0	5	3
	10	1	N/A	N/A
Ultrasonic	11	0	5	4
	12	0	N/A	N/A
	13	0	2	3
	14	0	3	2
	15	0	1	2
	16	0	5	3
	17	1	4	4
	18	2	5	5
	19	0	2	2
	20	0	N/A	N/A

VITA

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