COMPARATIVE CLINICAL OUTCOMES OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS BY SURGICAL TREATMENT USING THE ULTRASONIC SCALPEL AND BIPOLAR SEALING DEVICE TECHNIQUES

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การเปรียบเทียบผลการรักษาภาวะเพดานอ่อนยาวในสุนัขพันธุ์หน้าสั้น โดยการผ่าตัดด้วย มีดอัลตราโซนิคและเครื่องเชื่อมปิดหลอดเลือด

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วริทธิ์ วิจิตรรตนากร : การเปรียบเทียบผลการรักษาภาวะเพดานอ่อนยาวในสุนัขพันธุ์หน้าสั้น โดยการผ่าตัดด้วย มีดอัลตราโซนิคและเครื่องเชื่อมปิดหลอดเลือด. (COMPARATIVE CLINICAL OUTCOMES OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS BY SURGICAL TREATMENT USING THE ULTRASONIC SCALPEL AND BIPOLAR SEALING DEVICE TECHNIQUES) อ.ที่ปรึกษาหลัก : ผศ. นายสัตวแพทย์ ดร.สุมิตร ดุรงค์พงษ์ธร, อ.ที่ปรึกษาร่วม : รศ. นายสัตวแพทย์ ดร.วิจิตร บรรลุนารา

กลุ่มอาการทางเดินหายใจอุดกั้นในสุนัขพันธุ์หน้าสั้นเป็นโรคของระบบทางเดินหายใจที่พบได้มากที่สุดในสุนัขพันธุ์หน้าสั้น การแก้ไขส่วนใหญ่นิยมใช้การทำศัลยกรรมเพื่อแก้ไขรอยโรคปฐมภูมิ ได้แก่ การผ่าตัดเพดานอ่อนยาว และการแก้ไขรูจมูกตีบแคบ การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบผลการรักษาทางศัลยกรรมของภาวะเพดานอ่อนยาวในสุนัขพันธุ์หน้าสั้นโดยการผ่าตัดด้วยมีดอัลตราโซนิค และเครื่องเชื่อมปิดหลอดเลือด โดยแบ่งกลุ่มสุนัขพันธุ์หน้าสั้นออกเป็น 2 กลุ่มด้วยวิธีการสุ่ม กลุ่มที่ใช้มีดอัลตราโซนิคในการผ่าตัดเพดานอ่อน 10 ตัว และกลุ่มที่ใช้เครื่องเชื่อมปิดหลอดเลือดในการผ่าตัดเพดานอ่อน 10 ตัว เก็บข้อมูลเวลาในการทำศัลยกรรม ปริมาณเลือดที่ออกในการทำศัลยกรรม คะแนนความเจ็บปวด และคะแนนการทำงานของระบบทางเดินหายใจก่อนผ่าตัด ในวันที่ 1 7 14 21 และ 28 หลังทำศัลยกรรม เพดานอ่อนของสุนัขทุกตัวจะนำมาวัดระยะความเสียหายของเนื้อเยื่อรอบข้าง และตรวจสอบทางจุลพยาธิวิทยา เก็บตัวอย่างเพดานอ่อนบริเวณที่ทำศัลยกรรมหลังจากทำศัลยกรรม 21 วัน จากสุนัขทุกตัวเพื่อนำมาตรวจสอบทางจุลพยาธิวิทยา ผลการศึกษาพบว่าระยะเวลาในการทำศัลยกรรม ระยะความเสียหายของเนื้อเยื่อรอบข้าง คะแนนการทำงานของระบบทางเดินหายใจ และความเจ็บปวดเปรียบเทียบสองกลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ทั้งสองกลุ่มมีคะแนนการทำงานของระบบทางเดินหายใจลดลงเมื่อเปรียบเทียบกับวันที่ทำศัลยกรรมอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) ผลการตรวจทางจุลพยาธิวิทยาพบว่าคะแนนการอักเสบ และคะแนนการเข้ามาของเนื้อเยื่อบุผิวของทั้งสองกลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ โดยสรุปการผ่าตัดภาวะเพดานอ่อนยาวโดยการใช้มีดอัลตราโซนิคและเครื่องเชื่อมปิดหลอดเลือด ให้ผลการการรักษาที่ดี ใช้เวลาน้อย ไม่มีเลือดออก ไม่มีข้อแทรกซ้อนรุนแรงหลังการผ่าตัด และไม่มีความแตกต่างในด้านของการอักเสบของเนื้อเยื่อภายหลังการทำศัลยกรรม

สาขาวิชา	ศัลยศาสตร์ทางสัตวแพทย์	ลายมือชื่อนิสิต ....
ปีการศึกษา	2561	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
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KEYWORD: Bipolar sealing device Brachycephalic airway obstruction syndrome Brachycephalic dogs Elongated soft palate Ultrasonic scalpel

Varit Wijitratanagorn : COMPARATIVE CLINICAL OUTCOMES OF ELONGATED SOFT PALATE IN BRACHYCEPHALIC DOGS BY SURGICAL TREATMENT USING THE ULTRASONIC SCALPEL AND BIPOLAR SEALING DEVICE TECHNIQUES. Advisor: Asst. Prof. Sumit Durongphongtorn, D.V.M., DVSc. Co-advisor: Assoc. Prof. Wijit Banlunara, D.V.M., Ph.D., D.T.B.V.P.

Brachycephalic airway obstruction syndromes (BAOS) are the most common respiratory problems in brachycephalic dogs. Surgical treatment which are staphylectomy and alaplasty is commonly used for correction primary lesions of BAOS. The purpose of this study is to compare clinical outcome of post staphylectomy using ultrasonic scalpel and bipolar sealing devices. Twenty brachycephalic dogs were included for staphylectomy and randomly separated into two groups. Surgical time, perioperative blood loss, pain score and clinical score of respiratory function were recorded at day 1 7 14 21 and 28 post-operative. The excised soft palate at day 0 and 21 was recorded lateral thermal tissue injury and histopathological evaluation. Surgical time, lateral thermal tissue injury, clinical score of respiratory function and pain score were not significantly difference between groups. Both groups, the clinical score of respiratory function after surgery was significantly ($p<0.05$) lower compared to before surgery. Pre and post-operative inflammatory score and re-epithelialization score were not significantly different between groups. In conclusion, both surgical equipment, ultrasonic scalpel device and bipolar sealing device can be effectively used for staphylectomy with good surgical outcomes and no different inflammation of soft palate.

Field of Study:	Veterinary Surgery	Student's Signature	
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		Co-advisor's Signature	

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Varit Wijitratanagorn

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CHAPTER I
INTRODUCTION

1.1 Importance and rationale

Brachycephalic airway obstruction syndrome (BAOS) are malformations of the upper respiratory tract which results in obstruction of the upper airway (Riecks et al., 2007; Pohl et al., 2016). Severity of respiratory signs in dogs with BAOS was depending on the degree of the respiratory obstruction (Caccamo et al., 2014). To diagnose dogs with BAOS, history taking, physical examination, thoracic radiography, computed tomography, endoscopic examination and functional grading could be performed (Trappler and Moore, 2011; Liu et al., 2016). Treatments of BAOS are medical managements and surgical treatments. Surgical treatments permanently change the abnormal structure of BAOS dogs such as soft palate resection and correction of stenotic nares. However, traditional or conventional technique of surgical treatment can causes bleeding, prolonged surgical time, and suturing is needed, consequence in post-operative respiratory distress, pharyngeal edema, post-operative bleeding, regurgitation, and aspiration pneumonia (Davidson et al., 2001; Michelsen, 2011). Advance surgical equipment takes place in surgical treatment with this two equipments, the ultrasonic dissection device and bipolar sealing device. The cordless ultrasonic dissection device is recommended for coagulation and cutting of tissues. The mean cutting temperature and mean coagulation temperature are 227.1 ± 3.2 and 189.8 ± 3.3°C respectively (Kim et al., 2015). Bipolar sealing device instrument denatures the collagen and elastin within vessel walls to seal vessels up to 7 mm of diameter and tissue bundle (Takada et al., 2005). It is also produced low temperature profile for sealing, temperature that used for sealing isolated vessels and mesentery dissection are 60-95°C and 55-61°C, respectively. Advantage associated with using advance surgical equipment are low complications with less operation time, blood loss, pain, lateral thermal tissue injury (<2 mm), lack of neuromuscular stimulation, less post-operative inflammation at the cut surface

(Takada et al., 2005; Manouras et al., 2008; Melck and Wiseman, 2010; Cortadellas et al., 2011; Michelsen, 2011).

Nowadays there are availabilities of advance surgical equipment for surgical treatments of BAOS in dogs. Therefore, post-operative complications still caused by inflammation of the tissue from heat produced by the advance surgical equipment. Thus, the difference of cutting temperature of both equipments might cause difference degree of inflammation and difference clinical outcomes.

1.2 Objectives of study

To compare between the use of cordless ultrasonic dissection device and bipolar sealing device by determining the degree of inflammation and clinical outcomes of elongated soft palate resection in brachycephalic dogs suffered from brachycephalic airway obstruction syndrome.

1.3 Research frame

Twenty client-owned brachycephalic dogs present with BAOS signs were included in the study. All dogs were randomly divided into two groups depending on the device that used for staphylectomy. Ultrasonic scalpel group (N=10), which an ultrasonic scalpel (Sonicision™) was used and bipolar sealing device group (N=10), which a bipolar sealing device (Ligasure™) was used. Staphylectomy was performed by the same surgeon. Surgical time, bleeding volume and perioperative complications were recorded. Clinical score of respiratory function and pain score was recorded atpre-operative, 1, 7, 14, 21 and 28 days after surgery. Arterial blood gas analysis was collected on the day of surgery and 21 days post-operation to analyse and compared the data with blood gas profile before surgery. The caudal soft palate from all dogs after staphylectomy and 21st days post-operation, ten dogs from each study group were anesthetized and the tissue sample was collected for histopathological evaluation.

1.4 Advantages of study

Could find a new option of surgical equipment for staphylectomy with less post-operative complications.

CHAPTER II
REVIEW OF LITERATURES

2.1 Definition of brachycephalic dogs

There are several methods to define brachycephalic breeds. Skull measurements can be defined dogs as dolichocephalic, mesocephalic and brachycephalic dogs. The craniofacial angle was formed by the angle between the base of the skull and the facial skull is 25°-26° in dolichocephalic dogs, 19°-21° in mesocephalic dogs, and 9°-14° in brachycephalic dogs (Figure 1). A skull width to skull length ratio is 0.81 or greater than 0.81 (Figure 2). Another measurement that can defines brachycephalic dogs is a cranial length to the skull length of 1.60-3.44 (Figure 2) (Meola, 2013).

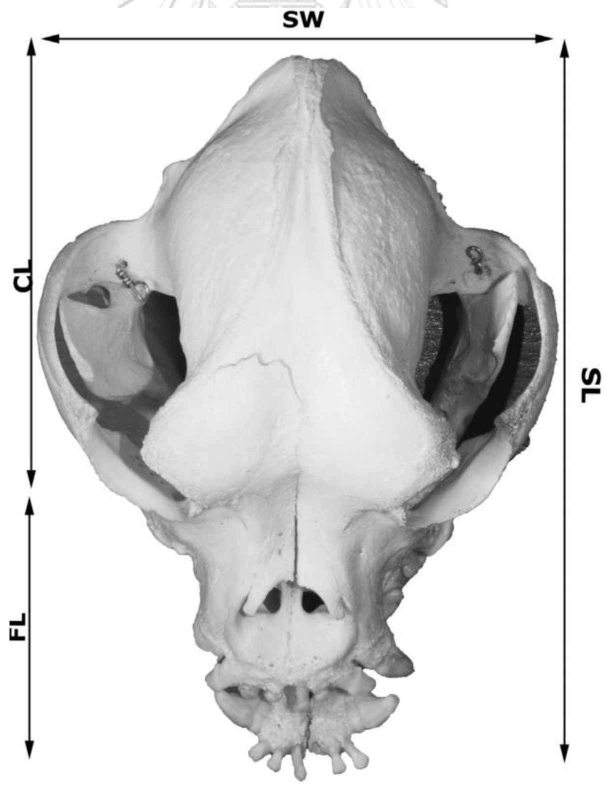

Figure 1. Skull measurement. The craniofacial angle formed by the angle between the base of the skull and the facial skull (Meola, 2013).

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 Brachycephalic breeds

The breed commonly affected consist of English bulldogs, French bulldogs, Pug, Boston terriers, Pekingese, Shih Tzu, Maltese, Boxers, Cavalier King Charles spaniels, Yorkshire terriers, Miniature Pinscher, and Chihuahuas. Most of brachycephalic dogs presents clinical signs since they are 2 to 3 years old. In some cases, less than 6 months brachycephalic puppies show clinical sign of severe laryngeal collapse. In the most recent studies, there are no correlation between sexes and BAOS, however some studies found that male dogs have higher risk compared to female dogs (2:1) (Meola, 2013).

2.3 Anatomical abnormalities

The anatomical abnormalities can be classified into primary lesions and secondary lesions. Elongated soft palate is the most common of the inherited primary disorders in brachycephalic dogs (Brdecka et al., 2008). In most study found 86-100% of brachycephalic dogs have elongation of soft palate and often cause gradually developing clinical signs (Davidson et al., 2001; Trappler and Moore, 2011). Other primary lesions including stenotic nares (42.5-85.2%), hypoplastic trachea, and aberrant nasal conchae (Caccamo et al., 2014). Stenotic nares are also congenital abnormalities of brachycephalic dogs, which can cause airway resistant by medial collapse of alae (Meola, 2013). Secondary lesions including the eversion of tonsils, laryngeal saccules, and laryngeal collapse. Laryngeal collapse can be classified into 3 stages: stage I; there is eversion of laryngeal saccules, stage II; there is medial displacement of the cuneiform processes of the arytenoid cartilages, stage III; there is collapse of the corniculate processes of the arytenoid cartilages (Pink et al., 2006).

2.4 Pathophysiology

In normal dogs, total airflow resistance from nose to lung is 76.5% and doesn’t different between inspiration and expiration. From anatomical abnormalities of brachycephalic dogs, Model of Poiseuille’s law explains the dynamic characteristics of the lung that 50% decreasing of the tube radius leads to 16 times increasing resistant and pressure of flow, the primary lesions which leads to increase the negative pressure during inspiration. Chronic abnormal pressure and airflow dynamics can cause secondary lesions includes the eversion of tonsils, laryngeal saccules, and laryngeal collapse. Laryngeal collapse leads to increasing resistant of the airway, so it leads to causes acute respiratory distress during excitement and exercise (Meola, 2013). Furthermore, brachycephalic dogs have a small size of nasal cavity and have aberrant nasal conchae, resulting airflow obstruction possibly heat production that can cause severe heat and exercise intolerance, prolong recovery time after exercise (Meola, 2013; Oechtering et al., 2016). Brachycephalic dogs can also present gastrointestinal clinical signs related with severity of respiratory signs. In a study, showed all brachycephalic dogs that have respiratory clinical signs had esophageal, gastric or duodenal anomalies (Poncet et al., 2005).

2.5 Clinical signs

Most of brachycephalic dogs presents respiratory and gastrointestinal clinical signs. Respiratory clinical signs include inspiratory stridor, stertor, snoring, gagging, coughing, exercise/heat/stress intolerance, and cyanosis. The severity of clinical signs relies on the degree of respiratory obstruction (Caccamo et al., 2014). Gastrointestinal signs include difficulty in swallowing, aerophagia, vomiting, regurgitation, and hypersalivation (Lecoindre and Richard, 2004). BAOS without managements causes many respiratory and gastrointestinal problems. Therefore, less time of diagnosis and treatments of BAOS will improve the quality of life of BAOS dogs (Trappler and Moore, 2011; Liu et al., 2016).

2.6 Blood gas analysis

Blood gas analysis of brachycephalic dogs showed significantly higher pack cell volume (PCV), $PaCO_2$ and lower PaO_2 compared with normal dogs because of compensatory mechanism of chronic hypoxia in brachycephalic dogs (Hoareau et al., 2012).

2.7 Medical treatment

Medical management includes weight management is recommended in brachycephalic dogs with obesity and severe respiratory problem. Brachycephalic dogs should be getting in cooling place and avoid warm or hot weather. Exercise restriction should be recommended during the warm or hottest time of a day (Trappler and Moore, 2011; Meola, 2013). If dogs have emergency respiratory signs such as acute respiratory distress or severe respiratory dyspnea, oxygen supplementation should be provided with minimal stress. Steroidal anti-inflammatory drugs such as dexamethasone 0.1 mg/kg intravenously should be used. Sedation drugs such as acepromazine maleate 0.02 mg/kg intravenously or subcutaneous injection should be recommended for reduce stress. Temporary tracheostomy must be done with emergency case to bypass upper airway obstruction. Although medical treatments can only be used for palliate patients that are suffering from the clinical signs of BAOS and to stabilize the patients before surgical treatments (Trappler and Moore, 2011).

2.8 Staphylectomy

Surgical treatments which permanently changes the abnormal structure of BAOS and decrease progress of secondary lesions such as soft palate resection and correction of stenotic nares. Early correction of elongated soft palate and stenotic nares such as 3-4 months of age has significant improvement outcomes. Some veterinarian recommended to cut elongated soft palate at the time of spay or castration. Soft palate resection, or staphylectomy is a treatment that is preferable. The objective of staphylectomy is to remove soft palate for reduce airway resistance but do not cut too much to result in nasopharyngeal reflux. Traditional or conventional staphylectomy was performed by sharp incision of a portion of the soft palate by scalpel blade or Metzenbaum scissors and suturing with monofilament absorbable suture with the "cut and over sew" technique (Davidson et al., 2001). Disadvantages of this technique are bleeding, prolonged surgical time, and suturing is needed (Davidson et al., 2001; Michelsen, 2011). Complications of this technique includes post-operative respiratory distress, pharyngeal edema, post-operative bleeding, regurgitation, and aspiration pneumonia (Michelsen, 2011). Other surgical techniques of staphylectomy required advance surgical equipments such as carbon dioxide laser, diode laser, monopolar electrocautery which can save the surgical time and no suture was needed (Davidson et al., 2001; Dunié-Mérigot et al., 2010; Michelsen, 2011; Tambella et al., 2013).

2.9 Ultrasonic energy device

Ultrasonic scalpel was introduced since the 1980s in human surgery, but have been rarely used in veterinary fields because of the cost of equipment (Michelsen, 2011). The Sonicision™ cordless ultrasonic dissection device was recommended for coagulation and cutting of tissues, also sealing vessel with diameter up to 5 mm by converted electrical energy to mechanical energy, resulting in ultrasonic vibration (55.5 kHz) of the active blade that denatures the hydrogen bond in vessel proteins, producing coagulum sealing to the vessel lumen (Spillebeen et al., 2017). The mean cutting temperature and mean coagulation temperature are 227.1 ± 3.2 and 189.8 ± 3.3°C respectively. Benefits of ultrasonic scalpel includes less lateral thermal tissue injury compare with electrocautery, decrease operation time, lack of neuromuscular stimulation, and less smoke production (Melck and Wiseman, 2010; Michelsen, 2011). Disadvantages of Sonicision™ is that Sonicision™ generates more heat comparing to bipolar sealing device, which may result in more inflammation and post-operative complications. In human, ultrasonic scalpel have been used for many surgical procedures such as thyroidectomy (Ecker et al., 2010; Melck and Wiseman, 2010), laparoscopy (Devassy et al., 2015), colorectal laparoscopy (Rimonda et al., 2009), and partial duodenopancreatectomy (Heverhagen et al., 2012). In dogs, ultrasonic scalpel has been use for laparoscopic ovariectomy (Spillebeen et al., 2017), lung biopsy (Molnar et al., 2005), and splenectomy (Royals et al., 2005). Staphylectomy by ultrasonic scalpel has been reported in 2011 by Michelsen. The report discussed about advantage of using ultrasonic scalpel comparing with carbon dioxide laser (Michelsen, 2011).

2.10 Bipolar sealing device

Bipolar sealing device (Ligasure™) has been developed as a replacement of suture ligation, hemoclips, staple devices, and ultrasonic scalpel for sealing vessels and tissue (Takada et al., 2005; Cortadellas et al., 2011). This instrument denatures the collagen and elastin within vessel walls to seal vessels and tissue bundles up to 7 mm of diameter (Takada et al., 2005). A new technology of bipolar sealing device, The Ligasure™ Small Jaw Instrument has been developed to reduce exchange of instrument by providing integrated cutting mechanism separately from sealing. It also produces low temperature profile for sealing, temperature used for sealing isolated vessels and mesentery dissection are 60-95 and 55-61°C respectively. Advantages of the Ligasure™ associated with using bipolar sealing device are less operation time, blood loss, pain, low complications and less lateral thermal tissue injury (<2 mm) (Takada et al., 2005; Manouras et al., 2008; Cortadellas et al., 2011). In human study, bipolar sealing device has been used for many variety surgical procedure such as axillary dissection (Manouras et al., 2008; Cortadellas et al., 2011), thyroidectomy (Kwak et al., 2013; Ruggiero et al., 2014), gynecologic laparoscopy (Demirturk et al., 2007; Law and Lyons, 2013), laparoscopic colectomy (Takada et al., 2005; Campagnacci et al., 2007) and hemorrhoidectomy (Fareed et al., 2009). In veterinary field, bipolar sealing device facilitated multipurpose surgical procedure such as staphylectomy, resulting in better surgical outcome (Brdecka et al., 2008).

2.11 Histopathology of soft palate in brachycephalic dogs

The histology of soft palate in adult mesocephalic dogs were normally classified into musculoconnective tissue that covered by both side of palatine mucosa including nasopharyngeal side and oral side. Epithelium of oral side was lining by pluri-stratified, non-cornified, squamous epithelial composing of a greater number of cell layer than nasopharyngeal side. The palatine glands were presented into both oral and nasopharyngeal side with difference secretory products. The nasopharyngeal side have a moderate number of palatine glands under the nasopharyngeal epithelium. The oral side was contained tubuloalveolar or tubular shape of palatine glands. They were located between epithelial layer and muscular layer. The palatine muscle includes levator veli palatini and palatopharyngeus muscle were homogenous size. Extremely rare of soft plate muscular degeneration was found in mesocephalic dogs (Arrighi et al., 2011).

In brachycephalic dogs, soft palate was different from mesocephalic dogs. Soft palate of brachycephalic dogs has moderate to severe hyperplasia of the superficial epithelium, swelling of keratinocyte with intracellular edema especially at the oral side. Palatine gland hyperplasia was found at the oral and nasopharyngeal side. The ducts of palatine gland were often severely dilated in oral side. Palatine muscle in brachycephalic dogs has variability of muscular fiber size. Hyaline degeneration and Zenker's necrosis were commonly found in palatine muscle (Arrighi et al., 2011; Pichetto et al., 2011).

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 1831013). Twenty client-owned brachycephalic dogs present with BAOS signs were enrolled in the study. Breed, sex, age, weight, body condition score (BCS), respiratory clinical signs such as inspiratory stertor sound, stridor sound, inspiratory dyspnea, gagging or coughing, presence of stenotic nares, elongated soft palate, tracheal hypoplasia, everted laryngeal ventricle, laryngeal oedema, laryngeal collapse, everted tonsils and gastrointestinal signs includes vomiting, regurgitation were recorded for all dogs. Clinical score of respiratory function shown in Table 1 was recorded before surgery and 1, 7, 14, 21, 28 days after surgery respectively (Davidson et al., 2001). If dogs were presented with furthermore clinical signs, the most severe clinical sign was used for scoring the clinical score of respiratory function.

Inclusion criteria of this study includes any age of four breeds of brachycephalic dogs consisting of Pug, Boston terrier, English bulldogs and French bulldogs that have clinical score of respiratory function 1 or more than 1 (Table 1). Brachycephalic dogs with other respiratory diseases such as bronchopneumonia, rhinitis, nasopharyngeal polyp, infectious pneumonia and pulmonary nodules and dogs with previous upper airway surgery were excluded. All brachycephalic dogs were randomly divided into two groups including ultrasonic scalpel group (N=10) and bipolar sealing device group (N=10)

Table 1. Clinical score of respiratory function

Clinical score	Respiratory clinical signs
0	Absence of clinical signs of brachycephalic airway obstruction syndrome
1	Mild coughing, gagging or vomiting while eating or drinking, stertor or stridor with excessive excitement or exercise, tachypnea with excessive excitement or exercise, intermittent snoring
2	Moderate coughing, gagging and vomiting while eating or drinking, stertor or stridor with minimal excitement or exercise, tachypnea with exercise or excitement, snoring
3	Continuous coughing, gagging and vomiting (not associated with eating or drinking alone), stertor or inspiratory stridor at rest, pale or cyanotic mucous membranes with minimal excitement, tachypnea at rest, snoring and hypoxia
4	Agonal breathing, pale or severe cyanosis, seizure, pulmonary arrest.

Adapted from (Davidson et al., 2001)

3.2 Pre-operative assessment

All brachycephalic dogs went through complete physical examination, complete blood count and serum chemistry analysis. Cervical and thoracic radiograph in lateral and ventrodorsal (VD) views were taken before surgery. Arterial blood gas analysis from the femoral artery was performed via heparinized 1 mL polypropylene syringe with 23 G needle. Samples were analyzed within 5 minutes after sampling (Hoareau et al., 2012).

3.3 Anesthetic technique

Food and water were fasted for 8 to 12 hours before surgery. Sedation with acepromazine maleate (0.03 mg/kg), and morphine sulfate (0.5 mg/kg) intramuscularly. re-oxygenation by an oxygen cage for 15 minutes prior to induction, following by induction with 4 mg/kg of propofol intravenously, then laryngeal and oropharyngeal examination were performed via laryngoscopy during induction of anesthesia. Finally, intubation with a cuffed endotracheal tube to maintain the anesthesia with isoflurane inhalation anesthesia. Cefazolin (25 mg/kg) and dexamethasone (0.5 mg/kg) were administered intravenously before surgery.

3.4 Surgical techniques and data records

3.4.1 Ultrasonic scalpel technique

All dogs were positioned in ventral recumbency. The mouth was kept open during surgery. The caudal tip of the soft palate was grasped with Allis tissue forceps and used synthetic monofilament absorbable suture with taper needle (Monosyn®) to performed two stay sutures at edge of caudal soft palate next to tonsillar crypt. Then, staphylectomy was performed by using ultrasonic scalpel (Sonicision™ cordless ultrasonic dissection device, length 13 cm, Medtronic, United States). Maximum power was used to cut the elongated soft palate. The soft palate was inserted between the jaws of the shear instrument which was activated until cutting is complete. The palate was transected laterally from the caudal aspect of the tonsillar crypt.

3.4.2 Bipolar sealing device technique

Dogs in this group were positioned and soft palate was stayed in the same pattern as 3.4.1. Then, staphylectomy was performed by using bipolar sealing device (Ligasure™ Small Jaw Instrument, Medtronic, United States). The soft palate was inserted between the jaws of Ligasure™ Small Jaw Instrument which was activated until cycle is complete then twitch button for slide the blade inside devices to cut tissue. The palate was transected laterally from the caudal aspect of the tonsillar crypt.

Surgical time, perioperative and post-operative complications were recorded. The surgical time of both techniques were recorded from the time that the surgeon starts to grasp the caudal tip of soft palate until the cutting is finished (second). If bleeding occurs, intraoperative blood loss was estimated by weighing gauze sponges (gram).

3.5 Post-operative care, follow up and evaluation

Morphine sulfate (0.2 mg/kg) was administered subcutaneously following the surgery. prednisolone (0.5 mg/kg) was administered once a day orally for 7 days after surgery. Water and food were given at 8 hours after surgery. All dogs were fed soft canned food for 14 days after surgery. The clinical signs were monitored at 1, 7, 14, 21 and 28 days after surgery. At 21 days post-surgery, general anesthetized of dogs were performed for laryngeal and oropharyngeal examination and evaluation of wound.

Clinical score of respiratory function that showed in table 1 was recorded at 1, 7, 14, 21 and 28 days after surgery. Arterial blood gas analysis was collected 21 days post-surgery. Laryngoscopy was performed during induction at 21 days post-surgery. Post-operative complications were recorded. Pain scoring was recorded at pre-operative, 1, 7, 14, 21 and 28 days after surgery.following the Colorado State University (CSU) acute pain scale for dogs (Hellyer et al., 2007).

3.6 Histopathological evaluation

The caudal soft palate tissue after staphylectomy (day 0) was measured lateral thermal tissue injury at middle and both edge of soft palate (mm.). Then, collected tissue was fixed in 10% buffered formalin solution for histopathological evaluation. On the 21st days post-surgery, 6 dogs from each study group were anesthetized and the tissue sample was collected for post-surgical histopathological evaluation by cup biopsy forceps at the middle of the incision line. The tissue sample was fixed with 10% buffered formalin solution, histological processed and stained with hematoxylin and eosin and Milligan's trichrome. The slides evaluated by the pathologist unaware of the surgical technique. All tissue samples were examined and grading for the inflammatory and the re-epithelialization scores as shown in Tables 2 and 3.

Table 2. Histopathologic grading scale of inflammation.

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

Adapted from (Sinha and Gallagher, 2003)

Table 3. Histopathologic grading scale of re-epithelialization.

score	Findings
1	Re-epithelialization covering the entire nasal and oral epithelium, normal thickness
2	Re-epithelialization covering the entire nasal and oral epithelium, irregular thickness
3	Re-epithelialization covering more than half of the nasal and oral epithelium
4	Re-epithelialization covering less than half of the nasal and oral epithelium
5	Re-epithelialization at the edge of the nasal and oral epithelium

Adapted from (Sinha and Gallagher, 2003)

3.7 Statistical analysis

All statistical analyses were performed by commercial software (PRISM® ver. 6.01, GraphPad, Inc). Normal distribution was confirmed by Shapiro-Wilk test. The surgical time and lateral thermal tissue injury area were compared between groups with independent t-test. Blood gas analysis data including pH, pO_2, pCO_2, HCO_3^- and hematocrit were compared within groups by using dependent t-test. Changing of the clinical score of respiratory function within groups were compared with Friedman test followed by Dunn's multiple comparison test. Respiratory function between groups were compared with Mann-Whitney U test. The histopathology scores including inflammatory, re-epithelialization scores, and pain score were analyzed between groups with Mann–Whitney U test. p-values of <0.05 was considered statistical significant.

CHAPTER IV
RESULTS

4.1 Animals

Age, breed, sex and weight of brachycephalic dogs in the ultrasonic scalpel group and bipolar sealing device group were shown in Table 4

Table 4. Age, breed, sex and weight of brachycephalic dogs in the ultrasonic scalpel and bipolar sealing device group.

	Ultrasonic scalpel group	Bipolar sealing device group
Age (Months)		
Mean ± SD	26.3 ± 18.05	30.3 ± 23.51
Breed [number (%)]		
Boston terrier	0 (0 %)	2 (20 %)
English bulldog	1 (10 %)	1 (10 %)
French bulldog	7 (7 %)	5 (50 %)
Pug	2 (2 %)	2 (20 %)
Sex [number (%)]		
Male	8 (80 %)	8 (80 %)
Female	2 (20 %)	2 (20 %)
Weight (Kg)		
Mean ± SD	13.4 ± 5.1	12.22 ± 3.4

4.2 Endoscopic and radiographic examination

The presence of pre-operative and post-operative elongated soft palate, stenotic nares, everted tonsils laryngeal collapse, laryngeal saccules and hypoplastic trachea in two different treatment groups were shown in Table 5.

Table 5. Number (%) of dogs that presence of pre-operative (pre-op) and post-operative (Day 21) elongated soft palate, stenotic nares, everted tonsils, laryngeal collapse, laryngeal saccules hypoplastic trachea in ultrasonic scalpel group and bipolar sealing device group.

	Ultrasonic scalpel group		Bipolar sealing device group	
	Pre - op	Day 21	Pre - op	Day 21
Elongated soft palate (%)	10 (100)	0 (0)	10 (100)	0 (0)
Stenotic nares	8 (80)	0 (0)	6 (60)	0 (0)
Everted tonsils				
None	1 (10)	1 (10)	2 (20)	1 (10)
Single site	1 (10)	0 (0)	2 (20)	2 (20)
Both sites	8 (80)	9 (90)	6 (60)	7 (70)
Laryngeal collapse				
None	2 (20)	2 (20)	3 (30)	3 (30)
Stage I	3 (30)	3 (30)	4 (40)	4 (40)
Stage II	3 (30)	3 (30)	3 (30)	3 (30)
Stage III	2 (20)	2 (20)	0 (0)	0 (0)
Laryngeal saccules	8 (80)	8 (80)	7 (70)	7 (70)
Hypoplastic trachea	3 (30)	3 (30)	2 (20)	2 (20)

4.3 Surgical time

The mean ± SD of surgical time for staphylectomy was not significantly different (P = 0.13) between ultrasonic scalpel group (232.7 ± 45.62 second) and bipolar sealing device group (288.4 ± 103.9 second).

4.4 Bleeding volume

No perioperative bleeding was presented in all dogs in this previous study.

4.5 Lateral thermal tissue injury

The mean ± SD of lateral thermal tissue injury was not significantly different (P = 0.38) between ultrasonic scalpel group (1.63 ± 0.4 mm.) and bipolar sealing device group (1.78 ± 0.37 mm.)

4.6 Pain score

Post-operative pain score was non-noticeable in all dogs.

4.7 Clinical score of respiratory function

4.7.1 Ultrasonic scalpel group

The median clinical score of respiratory function (range) were 2 (1 - 3), 1 (0 - 1), 1 (0 - 1), 1 (0 - 1), 0 (0 - 1), 0 (0 - 1), 0 (0) at day 0 (pre-operative), 1, 7, 14, 21, 28 respectively. The clinical score of respiratory function before staphylectomy (day 0) was significantly ($p<0.05$) higher compared to day 14, 21 and 28 after staphylectomy (Figure 3).

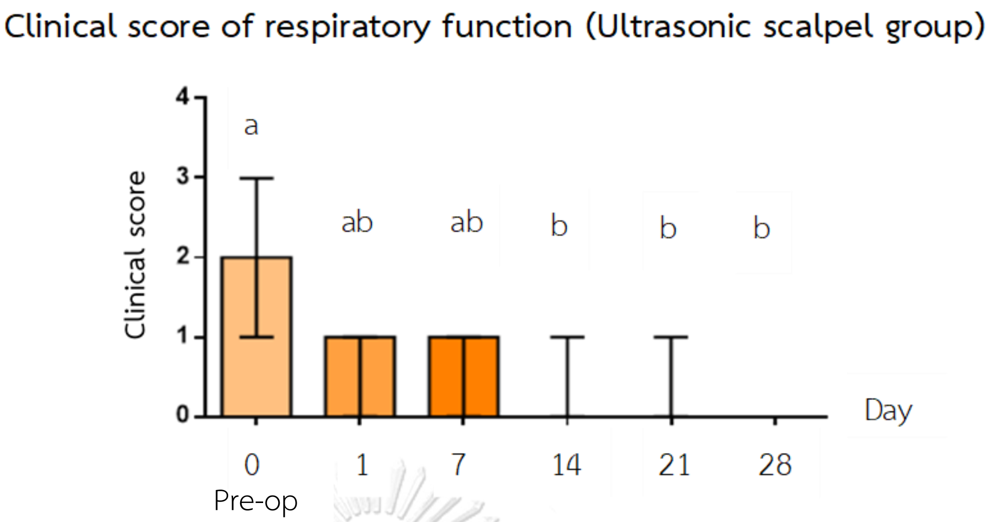

Figure 3. Medians (range) of the clinical score of respiratory function before and after staphylectomy of ultrasonic scalpel group (different alphabet is significantly different (p<0.05))

4.7.2 Bipolar sealing device group

The median clinical score of respiratory function (range) were 2 (1 - 3), 1 (0 - 2), 0.5 (0 - 2), 0 (0 - 1), 0 (0 - 1), 0 (0) at day 0 (pre-operative), 1, 7, 14, 21, 28 respectively. The clinical score of respiratory function before staphylectomy (day 0) was significantly (p<0.05) higher than days 14, 21 and 28 after staphylectomy (Figure 4).

Clinical score of respiratory function (Bipolar sealing device group)

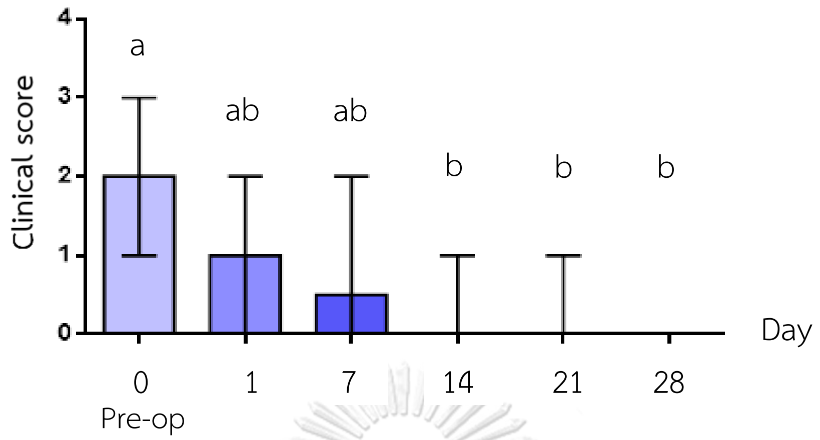

Figure 4. Medians (range) of the clinical score of respiratory function before and after staphylectomy of bipolar sealing device group (different alphabet represents significantly different ($p<0.05$))

4.7.3 Comparative clinical score of respiratory function between ultrasonic scalpel group and bipolar sealing device group

The median (range) clinical score of respiratory function were not significantly different between group before and after staphylectomy (Table 6).

Table 6. Median (range) clinical score of respiratory function of ultrasonic scalpel group and bipolar sealing device group

Day	Ultrasonic scalpel group	Bipolar sealing device group
0 Pre-operation	2 (1 - 3)	2 (1 - 3)
1 Post-operation	1 (0 - 2)	1 (0 - 1)
7 Post-operation	0.5 (0 - 2)	1 (0 - 1)
14 Post-operation	0 (0 - 1)	0 (0 - 1)
21 Post-operation	0 (0 - 1)	0 (0 - 1)
28 Post-operation	0 (0)	0 (0)

(* = $p<0.05$)

4.8 Blood gas analysis

4.8.1 Ultrasonic scalpel group

The pre-operative and post-operative blood gas analysis were presented in Table 7. Pre-operative arterial pH, K^+, hematocrit (Hct) were significantly higher than post-operation ($p<0.05$). Post-operative arterial PCO_2 was significantly higher than pre-operation ($p<0.05$).

Table 7. (Mean ± SD) The pre-operative and post-operative arterial blood gas measurement in ultrasonic scalpel group.

Parameters	Pre-op	Post-op
pH	7.43 ± 0.04	7.4 ± 0.039*
PCO_2 (mmHg)	31.85 ± 5.92	35.72 ± 4.80*
PO_2 (mmHg)	94.1 ± 11.78	156.35 ± 131.25
Sodium (Na^+) (mmol/L)	136.3 ± 5.05	136 ± 5.7
Potassium (K^+) (mmol/L)	3.31 ± 0.39	2.945 ± 0.48*
Chloride (Cl^-) (mmol/L)	106.6 ± 6.10	105.6 ± 9.63
Hct (%)	49.6 ± 4.22	45.7 ± 5.1*
Bicarbonate (HCO_3^-) (mmol/L)	20.74 ± 2.90	21.4 ± 2.54

(* = p<0.05)

4.8.2 Bipolar sealing device group

The pre-operative and post-operative blood gas analysis in bipolar sealing device group were presented in Table 8. Pre-operative arterial pH, $PaCO_2$, PaO_2, sodium (Na^+), potassium (K^+), Chloride (Cl^-), hematocrit (Hct), and bicarbonate (HCO_3^-) were not significantly different between pre-operation and post-operation.

Table 8. (Mean ± SD) The pre-operative and post-operative arterial blood gas measurement in bipolar sealing device group.

Parameters	Pre-op	Post-op
pH	7.45 ± 0.03	7.43 ± 0.06
$PaCO_2$ (mmHg)	31.37 ± 4.69	32.56 ± 5.63
PaO_2 (mmHg)	90.37 ± 5.91	89.89 ± 7.58
Sodium (Na^+) (mmol/L)	137.2 ± 3.58	136.7 ± 3.40
Potassium (K^+) (mmol/L)	3.16 ± 0.41	3.19 ± 0.31
Chloride (Cl^-) (mmol/L)	110.9 ± 5.70	110.1 ± 5.90
Hct (%)	47.9 ± 7.80	45.8 ± 5.20
Bicarbonate (HCO_3^-) (mmol/L)	21.45 ± 2.74	20.81 ± 1.80

(* = p<0.05)

4.9 Histopathological evaluation

4.9.1 Histopathological findings

The microscopic aspect of soft palate assembled from brachycephalic dogs at surgical day were mucosal epithelial hyperplasia with keratinocyte swelling from intracellular edema, mucous gland hyperplasia, and muscle degeneration including hyaline degeneration and Zenker's necrosis. The tissues stained with Milligan's trichrome showed thermal spread caused by coagulation necrosis from instruments and muscle degeneration (Figure 5-7).

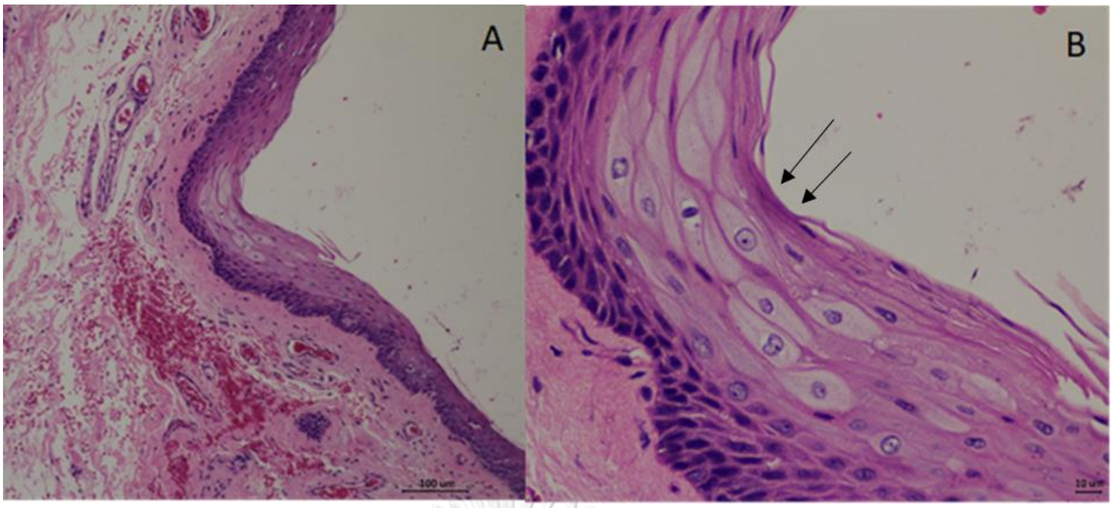

Figure 5. (A) Morphology of oral epithelium of soft palate. (B, arrow) Intracellular edema of epithelium present in oral epithelium. (scale bar: A = 100 μm, B = 10 μm)

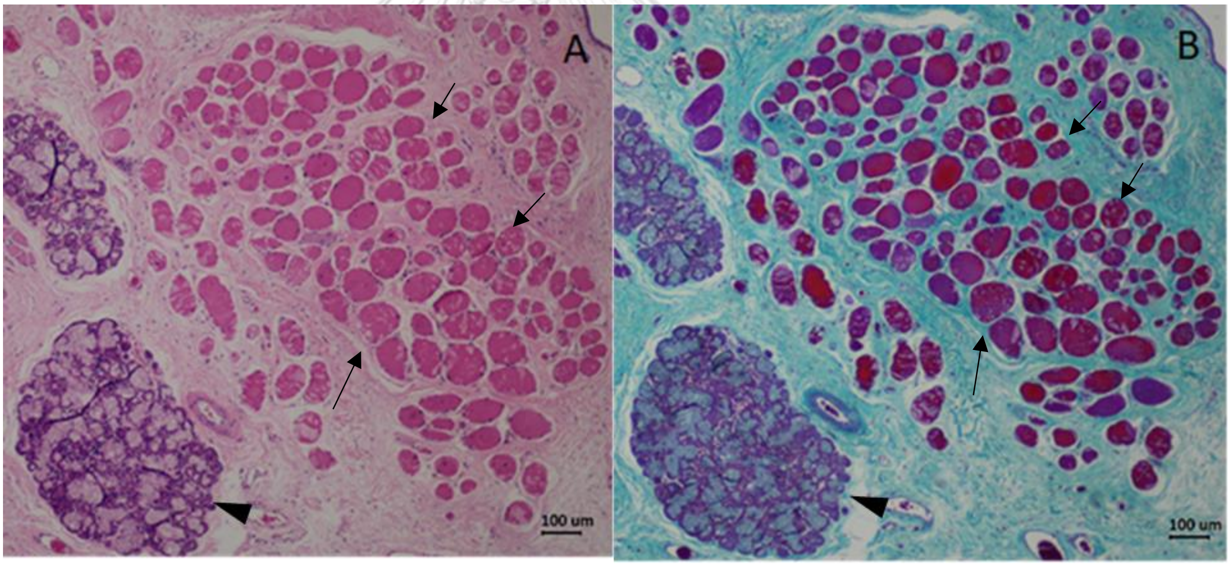

Figure 6. Palatine gland hyperplasia (arrowhead) and muscular degeneration (Zenker's degeneration) (arrow) present in oral side. The tissue stain with hematoxylin and eosin (A) and Zenker's degeneration stained bright red by Milligan's trichrome (B). (scale bar = 100 μm).

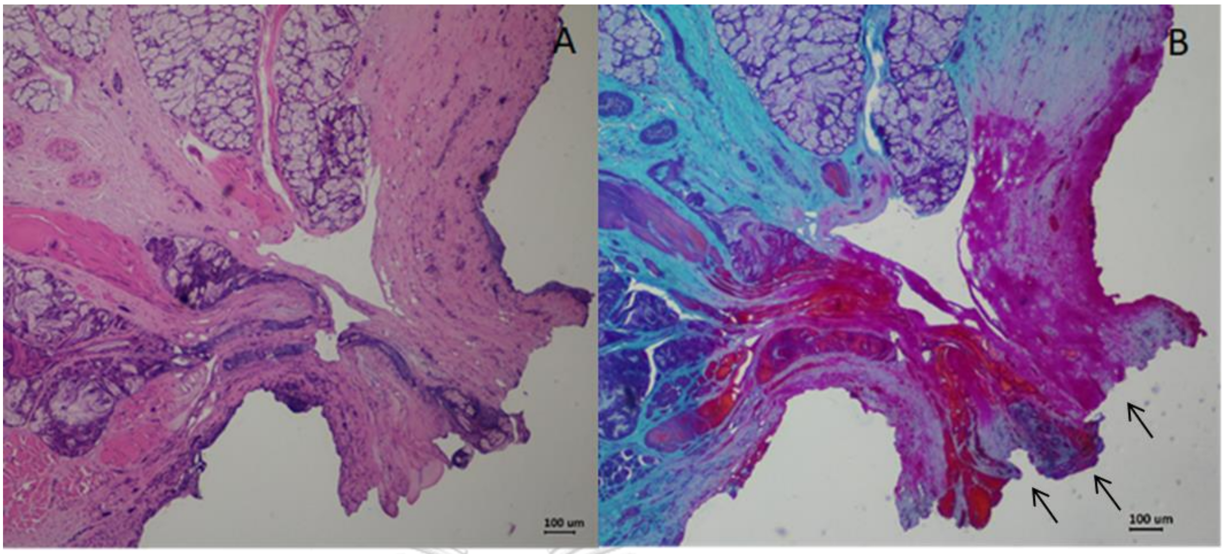

Figure 7. The thermal spread of soft palate shows with hematoxylin and eosin stain (A) and red color by Milligan's trichrome stain (arrow, B). (scale bar = 100 μm)

4.9.2 Inflammatory score

The median (range) inflammatory score of staphylectomy at the day of surgery (day 0) and biopsy day (21 days after staphylectomy) were not significantly different between ultrasonic scalpel group and bipolar sealing device group. (Table 9) (Figure 8-9)

The endoscopic finding of inflammation and wound healing at 21 days post-operation in bipolar sealing device group and ultrasonic scalpel group were shown in Figure 13 and 14 respectively. The microscopic finding of soft palate at the surgical day had perivascular scattered inflammatory cells in ultrasonic scalpel group and no inflammatory cell in bipolar sealing device group (Figure 10-11). The histopathological finding of wound inflammation at 21 days post-operation had perivascular and submucosal scattered inflammatory cells in both groups (Figure 10-11).

Table 9. Median (range) of inflammatory score at surgical day (day 0), post-operative inflammatory score (day 21) and re-epithelialization score of ultrasonic scalpel and bipolar sealing device group.

Histopathology	Day	Ultrasonic scalpel group	Bipolar sealing device group
Inflammatory score	Day 0 (surgical day)	1 (0-2)	0 (0-1)
	Day 21 (biopsy)	2 (1-3)	2 (1-3)
Re-epithelialization score	Day 21 (biopsy)	2 (1-3)	2 (2)

(* = p<0.05)

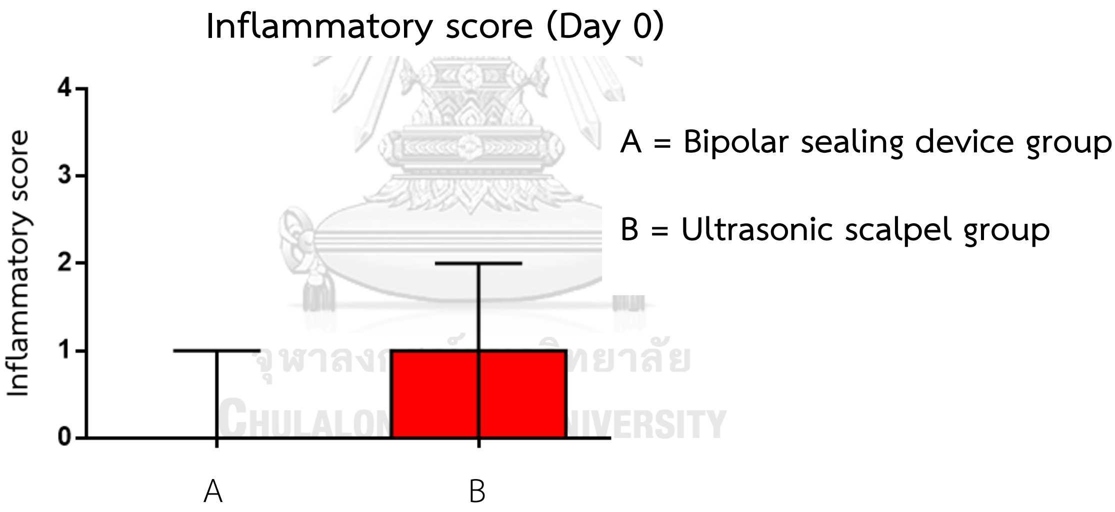

Figure 8. Median with range of inflammatory score of ultrasonic scalpel and bipolar sealing device group at surgical day.

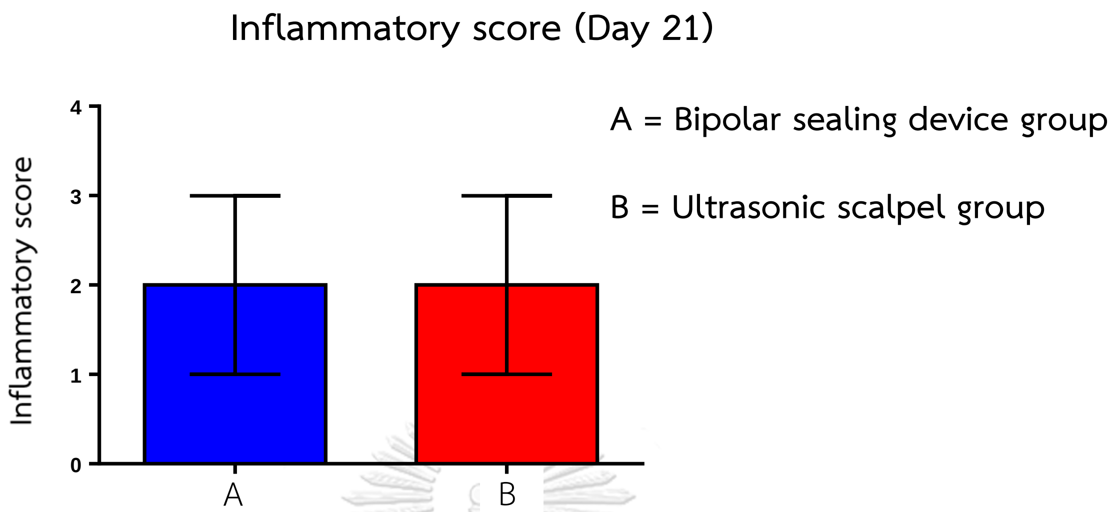

Figure 9. Median with range of post-operative inflammatory of ultrasonic scalpel and bipolar sealing device group (day 21).

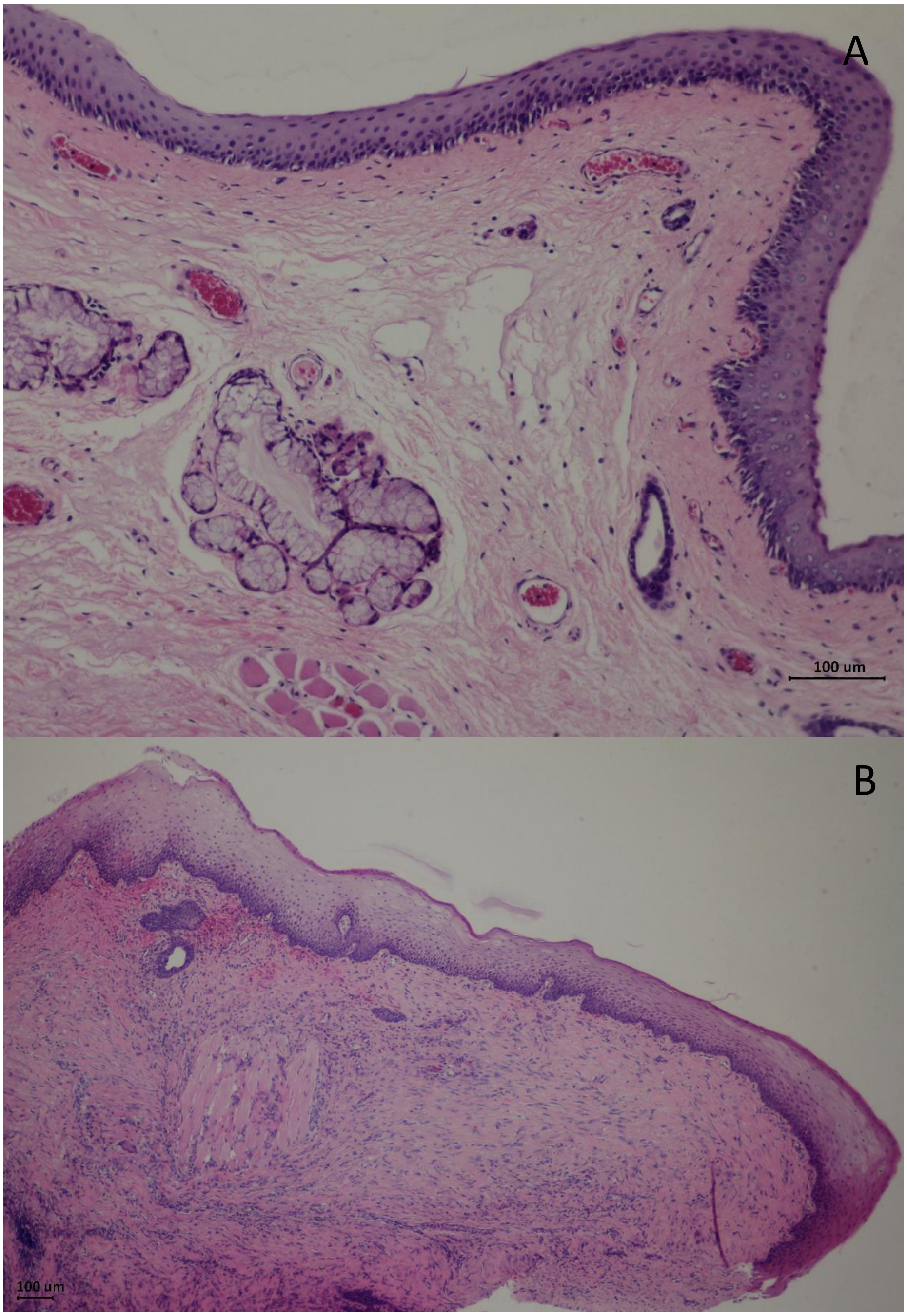

Figure 10. (A) Inflammatory score 0 of soft palate at day 0, (B) post-operative inflammatory score 3 and re-epithelialization score 2 of soft palate at day 21 in bipolar sealing device group. (scale bar = 100 μm)

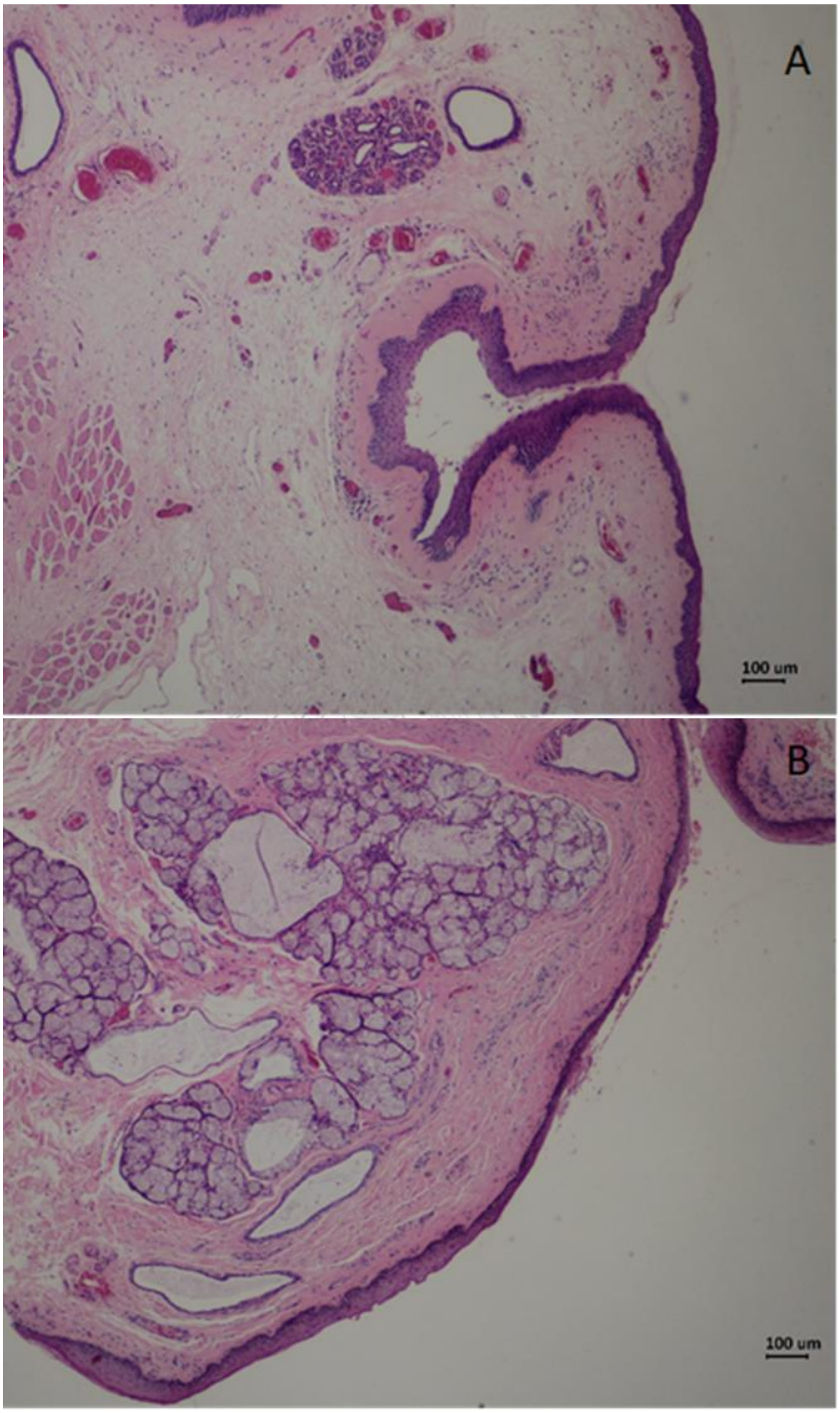

Figure 11. (A) Inflammatory score 1 of soft palate at day 0, (B) post-operative inflammatory score 1 and re-epithelialization score 1 of soft palate at day 21 in ultrasonic scalpel group. (scale bar = 100 μm)

4.9.3 Re-epithelialization score

The median (range) re-epithelialization score of staphylectomy at biopsy day (21 days after staphylectomy) were not significantly different between ultrasonic scalpel group and bipolar sealing device group. (Table 9) (Figure 12)

The microscopic finding of wound healing and re-epithelialization after 21 days post-operative staphylectomy had re-epithelialization covering the entire nasal and oral epithelium but irregular thickness in both groups (Figure 10 - 11).

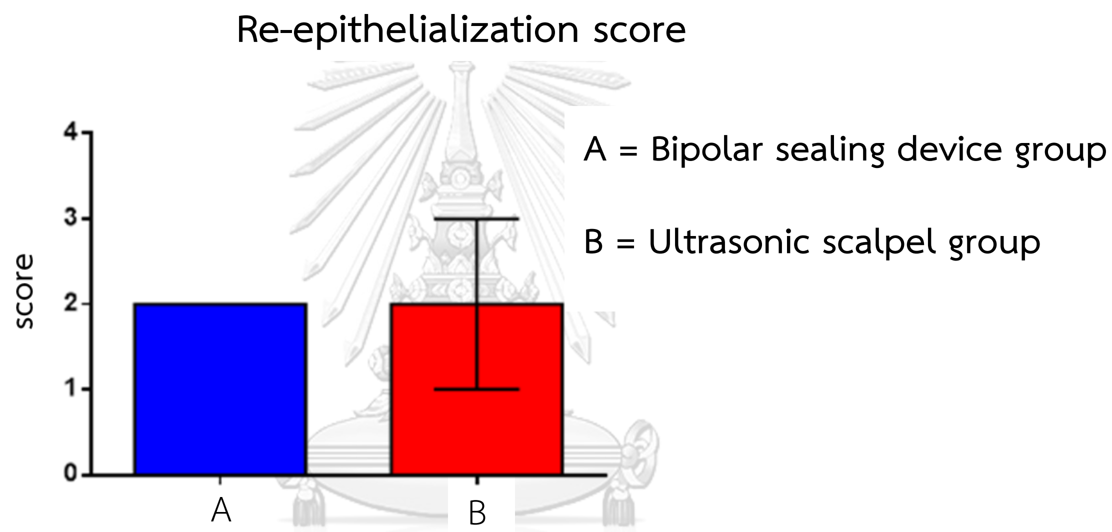

Figure 12. Median (with range of re-epithelialization score of ultrasonic scalpel and bipolar sealing device group

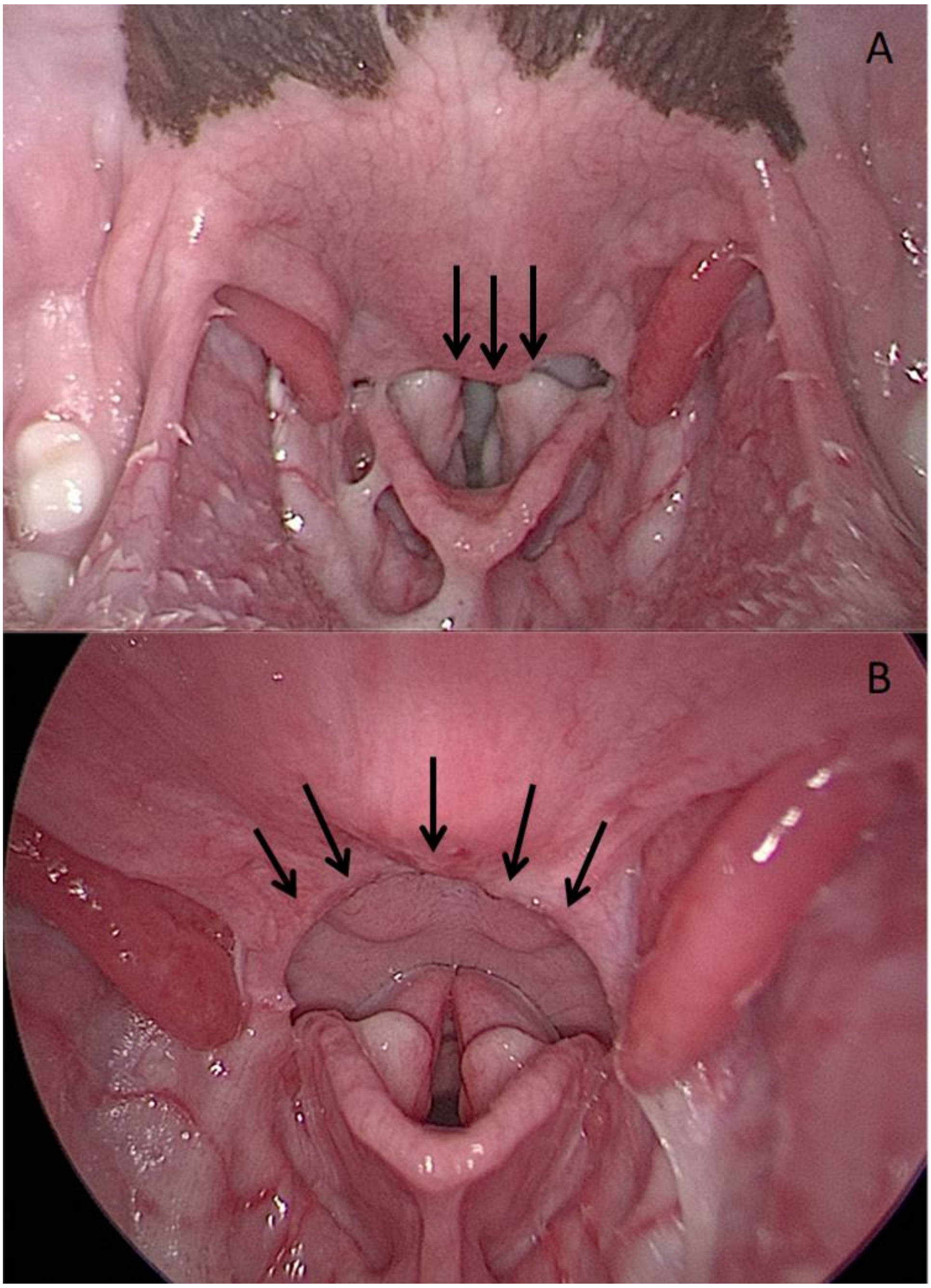

Figure 13. Endoscopic examination of elongated soft palate (arrows) before staphylectomy (A) and 21day after staphylectomy (B) in bipolar sealing device group.

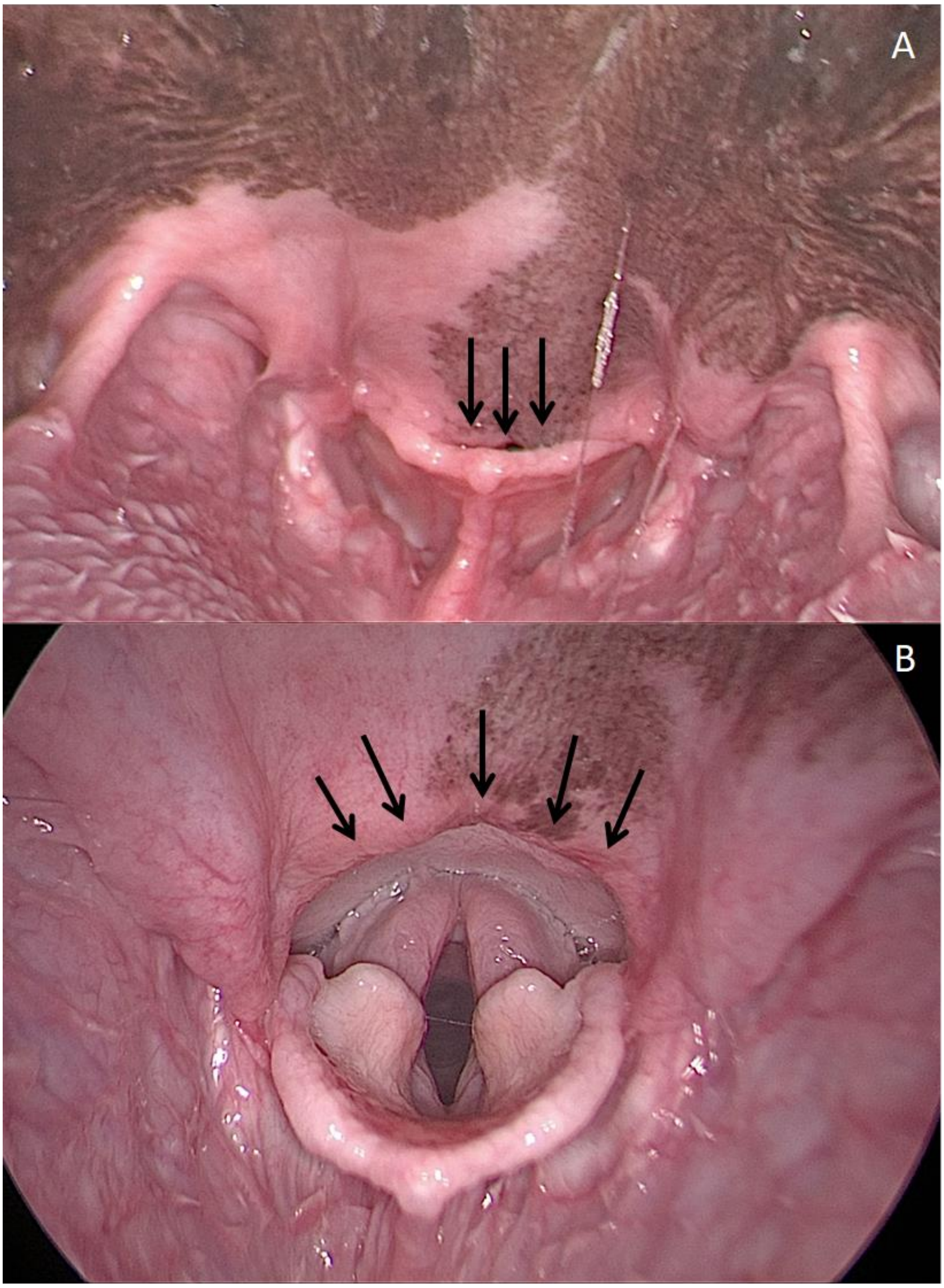

Figure 14. Endoscopic examination of elongated soft palate (arrows) before staphylectomy (A) and 21day after staphylectomy (B) in ultrasonic scalpel group.

CHAPTER IV
DISCUSSION AND CONCLUSION

In this study, the breed that mostly found is French bulldog that similar to previous report (Dunié-Mérigot et al., 2010). The anatomical abnormalities of BAOS consist of primary and secondary lesions. This study, primary lesions was found elongated soft palate (100%), stenotic nares (80%) and hypoplastic trachea (30%) similar to previous study (Riecks et al., 2007; Dunié-Mérigot et al., 2010; Meola, 2013). Secondary lesions which are everted tonsil (90%) and laryngeal collapse stage I (30%), stage II (30%) and stage III (20%) prior surgical procedure was found to be high due to the limitation age of sample dogs. In other studies, have also found high percentage of secondary lesions (Dunié-Mérigot et al., 2010; Meola, 2013).

Comparing surgical time of both surgical equipment groups, ultrasonic scalpel and bipolar sealing device have found that there was no statistical significantly difference. Ultrasonic scalpel device group mean surgical time was 232.7 ± 45.62 second. In previous study of ultrasonic scalpel device surgical time was 300-480 second (Michelsen, 2011). Mean surgical time of bipolar sealing device group was 288.4 ± 103.9 second. Both surgical equipment groups had faster surgical time than conventional technique due to conventional technique was more time consuming from handling suture and control bleeding (Davidson et al., 2001).

There was no perioperative bleeding in both surgical groups. Function of Sonicision™ cordless ultrasonic dissection device is converted electrical energy to mechanical energy, resulting in ultrasonic vibration (55.5 kHz) of the active blade that denatures the hydrogen bond in vessel proteins, producing coagulation and sealing to the vessel lumen (Spillebeen et al., 2017). Function of bipolar sealing device (Ligasure™ Small Jaw Instrument) is denatures the collagen and elastin within vessel walls to seal vessels and tissue bundles up to 7 mm of diameter (Takada et al., 2005).

Lateral thermal tissue injury of ultrasonic scalpel (1.63 ± 0.4 mm.) and bipolar sealing device group (1.78 ± 0.37 mm.) were not significantly difference. Furthermore, measuring thermal spread by histopathology with Milligan's trichrome stain believed to be more accurate than measuring from gross pathology.

All dogs which have been recruited into this study have history of BAOS clinical signs with no evidence and history of other respiratory disease. In this study have found that post-operative clinical score of respiratory function of staphylectomy in ultrasonic scalpel device group and bipolar sealing device group has decreased since 14 days after surgical procedure which harmonized with previous study of Brdecka et al., 2008; Michelsen, 2011; Cook et al., 2015.

Arterial blood gas analysis before and after surgery have been observe and found that pre-operative arterial pH, $PaCO_2$, PaO_2, sodium (Na^+), potassium (K^+), Chloride (Cl^-), hematocrit (Hct), and bicarbonate (HCO_3^-) of bipolar sealing device group were not significantly different between pre-operation and post-operation. But ultrasonic scalpel group found that Pre-operative arterial pH, K^+, hematocrit (Hct) were significantly higher than post-operation ($p<0.05$). Post-operative arterial $PaCO_2$ was significantly higher than pre-operation ($p<0.05$). Despite, lower pH level after surgery from higher PCO2, all blood gas parameters were in normal range.

Major and minor complications after staphylectomy procedure reported to be low (0 - 6.8% and 0 – 29.5%, respectively) (Cook et al., 2015). There were no major post-operative complications such as temporary tracheostomy and mortality were found in this study. Vomiting, regurgitation and coughing after surgical procedure were observed in some dogs which are minor complications. These minor complications in this study appeared to cause by inflammation after surgery.

Which caused of inflammation from heat that generated by both surgical equipment, despite the difference range of heat that was produced from both surgical equipment, the clinical score of respiratory function and inflammatory score appeared to be the same. So, it was presumed that lower temperature generated from surgical equipment did not produce lower inflammatory level of surrounding tissue. But it might be caused by both equipment can cause less lateral thermal tissue injury, so the remaining tissue was less damage, resulting in inflammatory score and respiratory clinical score were not difference between groups. In both study groups has no significantly difference of the re-epithelialization score due to same healing process which is secondary intention wound healing process.

In conclusion both surgical equipment, bipolar sealing device and ultrasonic scalpel device can be used for staphylectomy with good surgical outcomes, less surgical times, no bleeding, no post-operative major complication and no different inflammation of soft palate.

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APPENDIX

Group	No.	Sex	Age (Months)	Weight (Kg.)	Breeds
Ultrasonic scalpel group	1	Male	36	27.4	English Bulldog
	2	Male	9	12.5	French Bulldog
	3	Female	60	11.9	French Bulldog
	4	Male	7	10.2	French Bulldog
	5	Male	36	12.2	French Bulldog
	6	Male	19	10.2	French Bulldog
	7	Male	12	12.7	French Bulldog
	8	Male	48	14.5	Pug
	9	Female	24	12	Pug
	10	Male	12	10.4	French Bulldog
Bipolar sealing device	1	Male	21	10.7	French Bulldog
	2	Female	84	11.1	Pug
	3	Male	6	20	English Bulldog
	4	Male	24	14.3	Pug
	5	Male	48	7.4	Boston Terrier
	6	Male	24	13.2	French Bulldog
	7	Female	48	9.3	Boston Terrier
	8	Male	12	11.5	French Bulldog
	9	Male	12	11.2	French Bulldog
	10	Male	24	13.5	French Bulldog

Group	No.	Elongated soft palate	Stenotic nares	Hypoplastic trachea
Ultrasonic scalpel group	1	/	/	X
	2	/	/	/
	3	/	x	X
	4	/	/	/
	5	/	/	X
	6	/	/	X
	7	/	X	X
	8	/	/	/
	9	/	/	X
	10	/	/	X
Bipolar sealing device	1	/	/	X
	2	/	/	X
	3	/	X	X
	4	/	/	X
	5	/	/	/
	6	/	/	X
	7	/	X	X
	8	/	/	X
	9	/	/	/
	10	/	X	X

Group	No.	Everted tonsil		Laryngeal collapse stage	
		Pre-op	Post-op (D21)	Pre-op	Post-op (D21)
Ultrasonic scalpel group	1	2 sides	2 sides	1	1
	2	2 sides	2 sides	0	0
	3	none	none	1	1
	4	2 sides	2 sides	2	2
	5	2 sides	2 sides	2	2
	6	2 sides	2 sides	3	3
	7	2 sides	2 sides	1	1
	8	1 side	2 sides	3	3
	9	2 sides	2 sides	2	2
	10	2 sides	2 sides	0	0
Bipolar sealing device	1	2 sides	2 sides	2	2
	2	1 side	1 side	2	2
	3	2 sides	2 sides	0	0
	4	2 sides	2 sides	2	2
	5	1 side	2 sides	1	1
	6	2 sides	2 sides	0	0
	7	none	1 side	1	1
	8	2 sides	2 sides	1	1
	9	2 sides	2 sides	1	1
	10	none	0 sides	0	0

Group	No.	Surgical time (second)	Bleeding (ml.)	Lateral thermal tissue injury (mm.)
Ultrasonic scalpel group	1	200	0	1.79
	2	286	0	1.96
	3	225	0	1.95
	4	195	0	2.31
	5	255	0	1.31
	6	243	0	1.79
	7	180	0	1.05
	8	169	0	1.223
	9	285	0	1.38
	10	289	0	1.5
Bipolar sealing device	1	220	0	1.53
	2	160	0	1.57
	3	350	0	2.53
	4	246	0	2.11
	5	163	0	2.22
	6	229	0	1.7
	7	478	0	1.46
	8	293	0	1.61
	9	396	0	1.64
	10	349	0	1.44

Group	No.	Clinical score of respiratory function					
		D0 (Pre-op)	Day 1	Day 7	Day 14	Day 21	Day 28
Ultrasonic scalpel group	1	2	1	0	0	0	0
	2	2	1	1	0	0	0
	3	2	1	1	0	0	0
	4	2	1	0	0	0	0
	5	3	1	1	0	0	0
	6	3	0	1	0	0	0
	7	1	1	0	0	0	0
	8	2	1	1	1	0	0
	9	2	1	1	1	1	0
	10	2	0	0	0	0	0
Bipolar sealing device	1	2	2	1	1	1	0
	2	2	1	2	1	0	0
	3	1	1	1	0	0	0
	4	2	1	1	0	0	0
	5	1	0	0	0	0	0
	6	2	0	0	0	0	0
	7	1	1	0	0	0	0
	8	3	0	0	0	0	0
	9	2	0	0	0	0	0
	10	2	1	1	0	0	0

Group	No.	Arterial blood gas analysis (Pre-operative)							
		pH	PCO_2	PO_2	Na^+	K^+	Cl^-	Hct	HCO_3^-
Ultrasonic scalpel group	1	7.446	29.4	102.2	143	3.7	108	49	19.8
	2	7.386	39.6	92.9	140	3.8	109	48	23.3
	3	7.389	37.9	91	141	3.34	108	51	22.4
	4	7.468	28.4	86.5	135	3.58	110	43	20.1
	5	7.437	39.8	80.4	138	3.32	110	57	26.3
	6	7.447	28.8	82.4	137	3.56	108	52	19.5
	7	7.509	21.4	105.1	138	3.21	116	55	16.7
	8	7.455	33	72.9	135	3.22	102	46	22.7
	9	7.428	27.7	100.8	127	2.87	94	47	17.9
	10	7.377	32.5	90.7	129	2.53	101	48	18.7
Bipolar sealing device	1	7.459	28.4	93.7	137	3	112	53	19.7
	2	7.431	31.8	93	141	3.59	111	43	20.7
	3	7.47	27.7	89.4	135	3.57	113	35	19.9
	4	7.391	34.1	97.1	139	3.34	114	49	20.2
	5	7.514	20.7	97.3	138	2.79	110	56	16.3
	6	7.45	36.1	87.1	141	3.55	116	55	24.5
	7	7.456	36.4	90	141	3.23	119	43	25.1
	8	7.482	32.6	87.1	136	2.95	107	59	23.9
	9	7.471	33	86.5	134	3.31	109	46	23.5
	10	7.416	32.9	81.5	130	2.3	98	40	20.7

Group	No.	Arterial blood gas analysis (Pre-operative)							
		pH	PCO_2	PO_2	Na^+	K^+	Cl^-	Hct	HCO_3^-
Ultrasonic scalpel group	1	7.371	32.2	251.8	141	3.27	114	42	18.2
	2	7.379	38.1	78.6	139	3.02	108	47	22
	3	7.426	35.8	92.9	137	2.78	104	49	23
	4	7.435	35.9	90.7	136	3.21	105	43	23.6
	5	7.35	46.7	80.5	141	2.93	109	54	25.2
	6	7.367	39.4	78.6	141	3.54	117	54	22.1
	7	7.43	31.4	382	138	3.11	114	44	20.4
	8	7.441	34.4	76.4	135	3.32	106	42	22.9
	9	7.337	32.6	62.1	125	2.3	86	42	17.1
	10	7.42	30.7	87.2	127	1.99	93	40	19.5
Bipolar sealing device	1	7.403	32.2	90.2	139	3.51	118	49	19.7
	2	7.346	46	85	141	3.53	114	46	24.6
	3	7.449	29	84.8	133	3.02	105	34	19.6
	4	7.327	34.7	101.6	138	3.74	114	46	17.7
	5	7.514	25.6	89.9	138	3.22	115	52	20.1
	6	7.455	30.4	84	132	2.94	102	49	20.9
	7	7.398	34.6	83.3	141	3.21	116	47	20.8
	8	7.517	27.3	84	137	2.75	107	50	21.6
	9	7.454	31.8	98	132	3.01	103	41	21.8
	10	7.415	34	81.4	136	2.97	107	44	21.3

Group	No.	Inflammatory score		Re-epithelialization score
		Surgical day (Day 0)	Biopsy day (Day 21)	
Ultrasonic scalpel group	1	1	1	2
	2	1	3	2
	3	1	1	1
	4	1	2	3
	5	2	2	2
	6	0	1	1
	7	0	2	2
	8	1	2	2
	9	0	2	2
	10	1	2	2
Bipolar sealing device	1	1	1	2
	2	1	2	2
	3	0	3	2
	4	0	2	2
	5	0	2	2
	6	0	3	2
	7	0	2	2
	8	1	1	2
	9	0	2	2
	10	0	2	2

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