Original Article

Efficacy of ultrasonic dissection device in staphylectomy surgery in brachycephalic airway obstructive syndrome (BAOS) dogs

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Abstract

The ultrasonic scalpel instrument was compared with the conventional staphylectomy technique in elongated soft palate surgery in twenty brachycephalic airway obstructive syndrome (BAOS) canines. Patients were randomly divided into the conventional incisional and ultrasonic scalpel group. Operation time (minute), bleeding volume (ml), respiratory distress score, postoperative complications score, pain scores, epithelialization score and inflammatory score were assessed. Two weeks after surgery, soft palates tissues were biopsied from 7 conventional surgery dogs and 8 ultrasonic dissection device applied dogs. The operation time and bleeding volume in the conventional surgery group were significantly higher than that in conventional group (P<0.01 and P<0.001, respectively). In addition, the respiratory distress score was significantly higher in the conventional surgery group compared with the ultrasonic dissection device group on day 3 and day 28 post-operation (P<0.05). There were no significantly different postoperative complication scores, pain scores or inflammatory scores between two groups. The epithelialization score of the UD was significantly higher than that of the conventional group (P<0.05). The ultrasonic dissection device is user friendly, has decreased surgical time, complete hemostasis and provides fewer postoperative complications. The ultrasonic dissection device is recommended in high-risk patients such as those displaying senility, chronic inflammation, or bleeding disorders.

Keywords: BAOS, Dog, Staphylectomy, Ultrasonic

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Introduction

An elongated soft palate is the primary congenital malformation of brachycephalic bred dogs, which are found in 86-100% of brachycephalic airway obstructive syndrome (BAOS) affected dogs (Barnes *et al*., 2006; Pratschke, 2014). The overextended soft palate covers the laryngeal orifice which result in a decreasing of airway diameter leading to respiratory obstructive disorders. Early treatment of the primary defects such as stenotic nares and the elongated soft palate results in long-term health advantages. Nowadays, two of the common techniques used in soft palate resection (staphylectomy) are conventional (dissection and suturing) and carbon dioxide laser resection. However, there are disadvantages to conventional staphylectomy, for example bleeding and delayed surgical time (Davidson *et al*., 2001). Whereas, the high temperature of carbon dioxide lasers causes surrounding tissue burning which may cause harmful effects to user.

An ultrasonic energy device is commonly used in tissue dissection and vessel sealing. The mechanical energy from the ultrasonic blade causes denaturation and the formation of a sticky protein coagulum, which is capable of sealing vessels (Molnar *et al*., 2004). The advantages of using ultrasonic scalpel resection are a decrease surgical time, decreased 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, other benefits are user friendliness and less obscuring of vision compared with thermal dissection devices. The objective of this study is to compare the efficacy of the ultrasonic dissection device with the conventional surgical technique of elongated soft palate resection surgery in the upper airway obstructive syndrome dogs.

Materials and Methods

This study was approved by the Animal Care and Use Committee of Chulalongkorn University, Bangkok Thailand (IACUC protocol number 1731028). Twenty BAOS dogs were enrolled in this study. Breed, gender, age, weight, respiratory scores and anatomical defects such as stenotic nares, elongated soft palate, tracheal hypoplasia, laryngeal collapse grade and everted tonsils were individually noted. Laryngeal collapse grading was classified into 3 levels (Leonard, 1960). The respiratory scores were graded as shown in Table 1. Dogs with a respiratory score of 2, 3, or 4 without a history of respiratory diseases other than BAOS were included in the study and were randomly divided into the conventional surgery group (n=10) and the ultrasonic dissection device application group (n=10).

Table 1 Respiratory scoring scale

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

Physical condition and hematology such as complete blood count (CBC) and blood chemistry panels were evaluated before anesthesia. Food and water were withheld for 12 hours before anesthesia. Patients were pre-medicated with acepromazine maleate (0.03 mg/kg) intramuscularly (IM) and morphine sulfate (0.5 mg/kg) IM. Anesthesia was induced by propofol (1-4 mg/kg) intravenously (IV) and, then maintained by the inhalation of isoflurane with 100% oxygen through endotracheal tube. Intravenous cefazolin (25 mg/kg) and dexamethasone (0.5 mg/kg) were administered at the operation time. Laryngoscopy and cervical and thoracic radiography were performed immediately after anesthesia induction. Rhinoplasty was performed in dogs that had stenotic nares. All surgical procedures, including stenotic nares reconstruction (rhinoplasty) and staphylectomy, were done by the same surgeon.

Staphylectomy

Conventional surgery group (CS): Patients (n=10) were placed in sternal recumbency on a surgical table. Left and right stay sutures were placed at the free edges of the soft palate, which was lateral to the caudal aspect of the tonsillar crypt. The overextended soft palate was alternately excised using Metzenbaum scissors and then these was a simple continuous pattern sutured using 4-0 synthetic absorbable monofilament suture (taper needle, Biosyn™, Medtronic) in a simple continuous pattern.

Ultrasonic dissection device group (UD): Patients (n=10) were placed in sternal recumbency on a surgical table. The 13 cm cordless ultrasonic dissection device (Sonicision™, Medtronic) gripped the overextended soft palate tissue and transected laterally from the caudal aspect of the tonsillar crypt with maximum power.

Operation time, postoperative complication score and intraoperative blood loss were estimated by weighing used gauzes and were recorded.

Postoperative care and evaluation: Firocoxib (5 mg/kg) was given orally at 8 hours after surgery, then it was given every 24 hours until day 4 after surgery. Water and food were provided at 8 hours after surgery. Respiratory scores, postoperative complication scores

(Table 2) and pain scores were evaluated at days 1, 3, 7, 14 and 28 after surgery. The pain score was assessed according to the Colorado State University (CSU) acute pain scale for dogs (Hellyer and Robinson, 2006). Anatomical healing was reinvestigated using laryngoscopy on day 14 after surgery.

Histopathological evaluation: The excised soft palate tissues from all dogs were kept for histopathological evaluation. Two weeks after the surgery, the soft palate was biopsied from 7 dogs in the CS and 8 dogs of the UD, with the owner's permission. Tissue samples were fixed in 10% neutral-buffered formalin and then stained with hematoxylin and eosin and examined by the same pathologist. All tissue samples were evaluated for the inflammatory scores and the re-epithelialization scores adapted from Sinha and Gallagher (2003). Grading began from no acute inflammation and re-epithelialization covering the entire wound, normal thickness (score = 1) to submucosal diffuse inflammatory cells infiltration, more than 1/2 of one low power field with tissue necrosis and re-epithelialization at the edge of the wound (score = 5).

Table 2 Postoperative complication scoring scale

Score	Postoperative complications
0	No complication
1	Coughing, choking
2	Coughing, postoperative bleeding
3	Coughing, postoperative bleeding, aspiration pneumonia
4	Coughing, postoperative bleeding, aspiration pneumonia, dyspnea

Statistically significance at *P*- value <0. 05 was calculated using SPSS software (SPSS for windows Version 22; SPSS: An IBM Company, USA). The surgical times (minute)(mean±SD) were compared between groups with independent *t*-test. Internal variations in respiratory scores were compared between, before and after staphylectomy using Wilcoxon signed-rank test. The bleeding volume (ml) (median, IQR), respiratory scores, postoperative complication scores, pain scores, inflammatory scores and the re- epithelialization scores were compared between groups with the Mann–Whitney U test.

Results

Breed, age and sex of dogs in the CS and UD are shown in Table 3. The number of dogs having preoperative and postoperative elongated soft palate, stenotic nares, hypoplastic trachea, everted tonsils or laryngeal collapse is shown in Table 4.

The surgical time of the UD (5.74±1.98 min, range 3.54 to 9.50 min) was significantly shorter than that of the CS (27.08±10.57 min, range 12.26 to 43.57 min), *P*<0.01. The bleeding volume (median [interquartile range (IQR)]) in the CS (1.95 ml. [1.19 to 3.06 ml.]) was significantly higher than that of the UD (0 ml. [0 to 0 ml.]), *P*<0.001.

A significant increase in postoperative respiratory scores compared with preoperative respiratory scores was found in both the CS and UD (*P*<0.05) (Table 5). However, the respiratory score of the UD was significantly lower than those of the CS at day 3 and day 28 post-operation, *P*<0.05.

None of patients was not affected by pain as zero scores of pain were noted after surgery. The complication scores (median [range]) in both groups were (0 [0-1]), *P*<0.05.

Inflammatory scores (median) of the soft palate resected on surgery day and biopsied on day 14 were not significantly different between groups (Table 6). The re-epithelialization score (median) on day 14 of the UD was significantly higher (*P*<0. 05) than that of the CS (Table 6) . Laryngoscopic examination of the wound of the CS and UD are shown in Figure 1a and 2a, respectively.

Table 3 Breed, age, and sex of dogs in the conventional and ultrasonic groups

	Number (%) of dogs		*P*-value
	Conventional group	Ultrasonic group	
Breed			0.43†
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	0.85*
(median [range])	3.5 [1-9]	4.5 [1-8]	
Sex			0.26†
Male	7 (70)	9 (90)	
Female	3 (30)	1 (10)	

† Chi-squared test
* Independent *t*-test

Table 4 Number (%) of dogs with preoperative and postoperative elongated soft palate, stenotic nares, hypoplastic trachea, 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)

Table 5 Respiratory scores (median [IQR]) of the conventional and ultrasonic groups

Day	Conventional	Ultrasonic	*P*-value
0 (preoperative)	3 [3-3]	3 [1.75-3]	0.149
1	1 [0-2.25]	0.5 [0-1.25]	0.377
3	1 [0-2]	0 [0-1]	0.042
7	1 [0-1.25]	0.5 [0-1]	0.208
14	1 [0-1.25]	0 [0-1]	0.126
28	1 [0-1.25]	0 [0-0.25]	0.022

Table 6 Preoperative inflammatory, postoperative inflammatory, and epithelialization scores (median [IQR]) of dogs in the conventional and ultrasonic groups.

Score	Day	Conventional	Ultrasonic	*P*-value
Inflammatory	surgery day	0 [0-1.25]	0 [0-0.25]	0.551
	14 (postoperation)	3 [2-4]	3.5 [2-5]	0.515
Epithelialization	14 (postoperation)	2 [2-2]	3 [2-4]	0.049

Discussion

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). The primary abnormalities of BAOS found in the present study were elongated soft palate (100%) and stenotic nares (90%), which is similar to findings in the previous study (Meola, 2013). Although tracheal hypoplasia has been found in many BAOS patients (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 this study because the predominate breed for tracheal hypoplasia is English bulldog.

According to Poiseuille's law, if the airway decreases to 50%, the resistance to respiration will be increased up to 16 times, which can lead to secondary disease (Meola 2013). There was a 60% incidence of everted tonsils in this study, which was slightly over the study report at 9-56% (Meola 2013). According to Leonard's laryngeal collapse grading system, which reported laryngeal collapse grades I, II and III at 30.7, 48.7 and 20.5%, respectively, in 39 dogs but this study found laryngeal collapse grade I at 25% and grade II at 25% (De Lorenzi *et al*., 2009).

The mean surgical time of the CS was 27.08 ± 10.57 min (range 12.26 to 43.57 min), longer than the time reported by Davidson *et al*. (mean 12.4 min, range 8.58 to 17 min). The mean surgical time of the UD was 5.74 ± 1.98 min (range 3.54 to 9.50 min), similar to that reported by Michelsen (2011) (range 5 to 8 min). The surgical time of the UD was significantly less than that of the CS because there was no need for suturing the incised soft palate margins which were cauterized and sealed while cutting. By other techniques of staphylectomy, surgical times were 5.15 (Davidson *et al*., 2001) and 8.5 ± 2.9 (Dunie-Merigot *et al*., 2010) for CO_2 laser, 11.8 ± 2.5 (Dunie-Merigot *et al*., 2010) for diode laser and 18 ± 4.6 (Dunie-Merigot *et al*., 2010) for electrosurgery.

The median bleeding volume in the CS was 1.95 ml. (IQR 1.19 to 3.06 ml.), while bleeding was not found in the UD. The ultrasonic device work 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 at 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 can 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 and suggested inexperience of the surgeon might have been the cause.

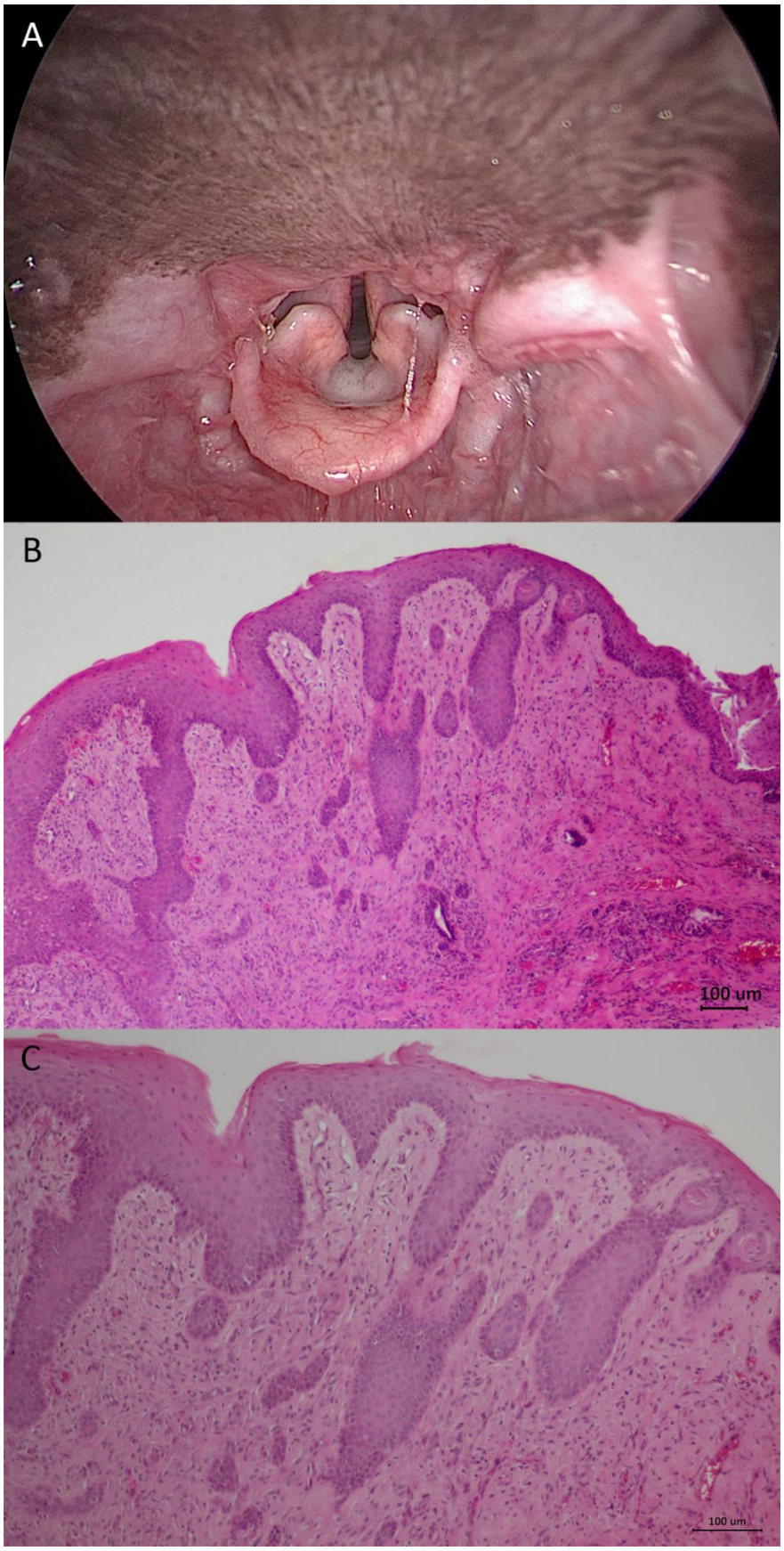

Figure 1 Postoperative day 14 in the conventional surgery group. (A) Endoscopic picture of the soft palate, (B) Reepithelialization covering the entire wound, irregular thickness (bar = 100 µm.), (C) Submucosal band-like inflammatory cells infiltrate, less than 1/4 of one low power field (bar = 100 µm.). Haematoxylin and Eosin (H&E) stained.

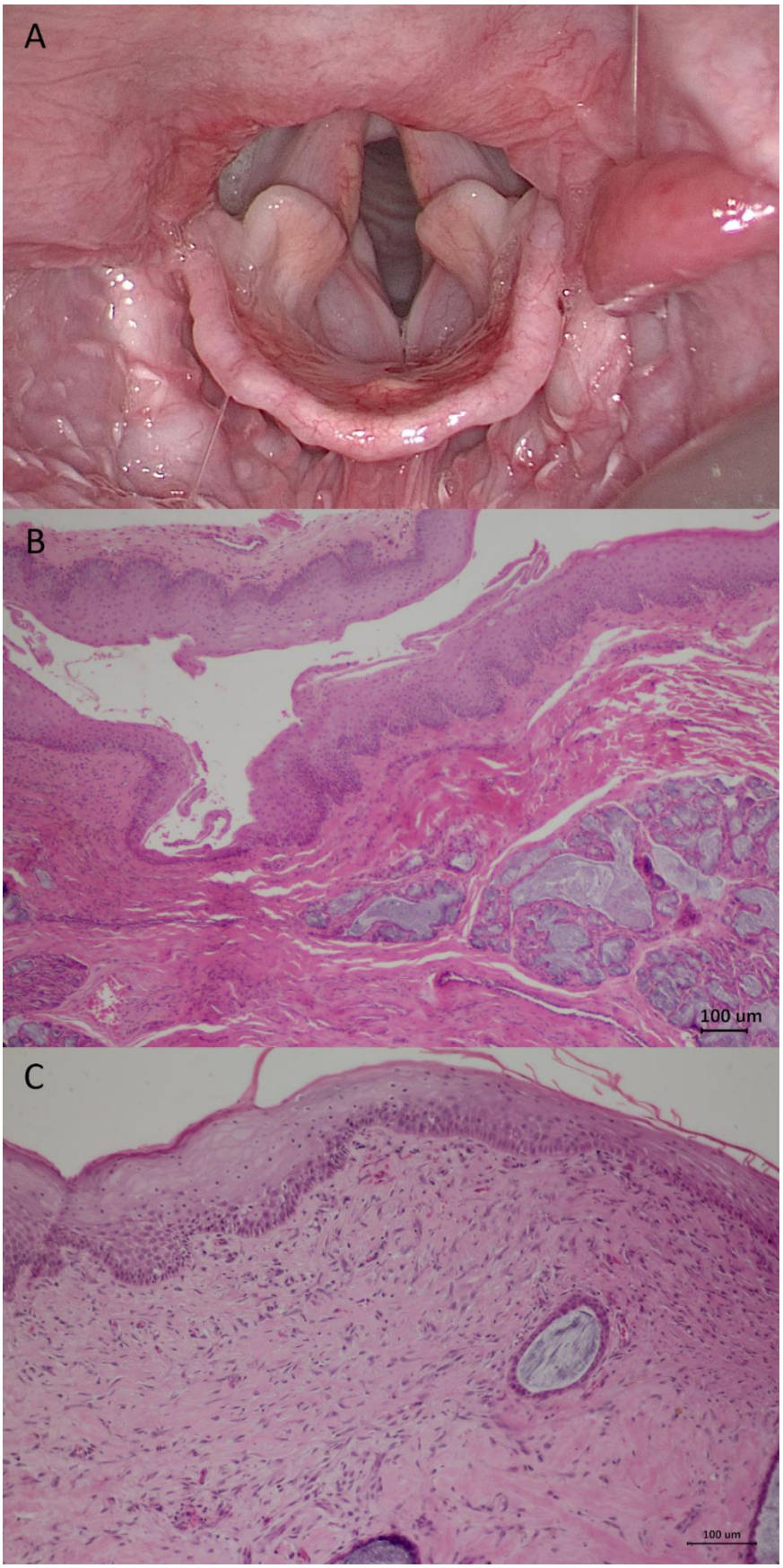

Figure 2 Postoperative day 14 in ultrasonic dissection device group. (A) Endoscopic picture of the soft palate, (B) Reepithelialization covering more than half of the wound (bar = 100 µm.), (C) Submucosal band-like inflammatory cells infiltrate, between 1/4 and 1/2 of one low power field without tissue necrosis (bar = 100 µm.). Haematoxylin and Eosin (H&E) stained.

All dogs in this study had clinical signs of BAOS without other respiratory problems. The respiratory score improved after surgery in all patients, which was the same as Brdecka *et al*. (2008) and Dunie-Merigot *et al*. (2010) studies. In this study, the ultrasonic group had a better the respiratory score than that of the conventional group on all postoperative evaluation days. The respiratory score (median [IQR]) of the ultrasonic group on day 3 post-operation (0 [0-1]) was significantly lower than that of the conventional group (1 [0-2]). This might be due to less tissue edema in the UD from minimal tissue handling, less hemorrhage and operation time which were consistent with the study by Michelsen (2011). who also reported that staphylectomy using an ultrasonic device did not cause postoperative respiratory complications despite the lack of preoperative corticosteroid drugs to prevent postoperative swelling. The significantly lower respiratory score (median [IQR]) in the UD compared with CS on day 28 after surgery may have been due to the remaining of a suture as a foreign body reaction. Second intention healing in ultrasonic dissection group resulted in a prolonged inflammatory phase. The respiratory score of the ultrasonic group on day 7 after surgery was higher than the score on day 3 after surgery because firocoxib was withdrawn on day 4 after surgery. Non-steroidal anti-inflammatory (NSAID) drugs were recommend given until day 7th after surgery in elongated soft palate resection with the ultrasonic device.

In this study, laryngeal saccule and everted tonsils spontaneously resolved in some dogs 14 days after staphylectomy and alarplasty which reduced the pressure in the larynx resulting in decreased 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 necessarily in all cases because some dogs spontaneously improved without surgery. Moreover, Poncet *et al*. (2006) found that the respiratory signs of some dogs without ventriculectomy were better than those with ventriculectomy.

There were no significant differences in postoperative complications between the UD and CS. 100% of patients survived without temporary tracheostomy being requested. Cook *et al*. (2015) reported 0-6.8% major complication after staphylectomy. Postoperative complications in the present study were coughing and gagging which might be due to inflammation from endotracheal intubation or surgery.

The histopathology of the soft palate tissues that were resected intraoperatively found severe mucosal hyperplasia, hydropic degeneration of keratinocytes, edema of lamina propria, mucous gland hyperplasia and hyaline degeneration similar to previous reports (Pichetto *et al*., 2011; Crosse *et al*., 2015). The inflammatory score (median [IQR]) was not significantly different between groups, but the score on day 14 of the UD (3.5 [2-5]) was higher than that of the CS (3 [2- 4]). This might be due to the ultrasonic dissection device causing more tissue damage than sharp scissors cutting. The ultrasonic device produced 150°C of thermal energy damage during resection which may have caused tissue coagulative necrosis. In addition, the tissue samples from the CS was collected from the middle of the wound instead of at the surgery knotting area, where the inflammation most likely occurred. However, there was no significant difference between groups.

The median [IQR] re-epithelialization score of the CS (2 [2-2]) was significantly less than that of the UD (3 [2-4]). This was consistent with the inflammatory score. A high inflammatory score could cause delay in 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 on day 14 of both groups were similar. The wounds healed completely approximately 2 weeks after surgery. A short-term absorbable suture with 50% tensile strength 6-7 days may appropriate for the conventional technique and the stitches can be removed on 14 days after surgery.

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