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Folded-flap palatoplasty and traditional staphylectomy yield similar postoperative soft palate geometry in French Bulldogs undergoing airway surgery

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Objective
To compare CT-derived anatomical geometry of the soft palate and clinical outcome following folded-flap palatoplasty (FFP) or traditional staphylectomy (TS).

Methods
Client-owned French Bulldogs were prospectively enrolled between July 2021 and September 2024. An exercise tolerance test (ETT) and head CT were performed preoperatively and 3 months postoperatively. Dogs were randomized to receive FFP or TS in conjunction with modified multilevel surgery for brachycephalic obstructive airway syndrome (BOAS). Computed tomography measurements were performed and compared between groups. The length of the soft palate was measured from the end of the hard palate to the caudal tip of the soft palate. Soft palate thickness was measured by dividing the length into equal thirds, and measurements were taken of the rostral, middle, and caudal thirds.

Results
Eighteen dogs completed the study (FFP, n = 7; TS, 11). With the use of either surgical technique, soft palates were significantly shorter and significantly thinner postoperatively at the rostral and middle thirds but not at the caudal third when compared to preoperative measurements. Surgical technique was not shown to have a significant effect on the change in palatal length or thickness. There was no significant difference in improvement in ETT scores between the FFP and TS groups.

Conclusions
FFP did not result in a significantly thinner or shorter palate or greater improvement in ETT score when compared to TS. Both techniques resulted in significantly shorter and thinner palates postoperatively.

Clinical Relevance
Equivalent clinical outcome can be expected following FFP or TS combined with modified multilevel surgical techniques for the treatment of BOAS.

Keywords: folded-flap palatoplasty, staphylectomy, brachycephalic, soft palate, airway

Brachycephalic obstructive airway syndrome (BOAS) is a complex and dynamic disease that affects all brachycephalic dog breeds and leads to a variety of respiratory and gastrointestinal clinical signs.[1–4] One of the major components of upper respiratory tract obstruction as a result of BOAS is an elongated soft palate.[1–4] Traditional staphylectomy (TS) is commonly performed to shorten an elongated soft palate in affected dogs.[5] While this procedure removes the redundant caudal portion of the soft palate causing upper airway obstruction, it does not alter the remaining, often hyperplastic, soft palate of brachycephalic dogs.[6,7] Furthermore, it is unlikely to relieve any nasopharyngeal obstruction caused by dorsal compression of a thickened rostral portion of the soft palate.[6,8,9]

An alternative surgical technique for the treatment of elongated and hyperplastic soft palate in BOAS-affected dogs, termed the folded-flap palatoplasty (FFP), has been described.[2,10,11] The FFP technique

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involves resection of the ventral mucosa and a portion of the underlying musculature to create a flap of tissue that is then pulled rostrally and sutured onto itself to create the folded flap of soft palate.[2,10–12] The underlying principle behind this technique is that the palate will not only be shortened but will also be thinned, resulting in decompression of the dorsal nasopharyngeal area.[10,12] A recent study[13] compared the anatomic geometry of the soft palate following FFP or TS in English Bulldogs and found no significant difference in the change in soft palate thickness between the 2 surgical techniques.

With either surgical technique, the goal is to improve respiratory function in BOAS-affected dogs. Whole-body plethysmography (WBP) has been used to objectively quantify respiratory function and is currently considered to be the gold standard.[14,15] However, WBP is principally a research tool and it is not available in most veterinary centers. As a more practical alternative, exercise tolerance testing has been investigated and a 3-minute trot exercise test has been shown to be highly correlated with WBP as allows for an easy and objective measure of BOAS severity.[14]

The objective of this study was to utilize CT and a validated exercise tolerance test (ETT) to compare the soft palate geometry and clinical response in French Bulldogs undergoing FFP or TS for treatment of BOAS.[14] It was hypothesized that French Bulldogs treated with FFP would demonstrate significantly thinner and shorter soft palates and improved ETT scores 3 months following surgery compared to dogs treated with TS.

Methods

French Bulldogs with clinical signs referable to BOAS that had not undergone airway surgery previously were recruited from the client-owned population at 2 academic institutions. To create a more homogeneous study population, only dogs aged 6 years or younger were enrolled. This age restriction was applied to minimize the influence of age-related changes and comorbid conditions. The study was approved by the University of Guelph Animal Care Committee and the IACUC and Clinical Trials Review Board of the University of California-Davis, and informed written consent was obtained for all dogs enrolled. A randomization process was performed by creating blind envelopes containing randomly assigned cards using Randomizer.org to select dogs to receive FFP or TS in conjunction with modified multilevel surgical procedures for abnormalities associated with BOAS.[3]

Prior to surgery, each dog underwent a physical examination and 3-view thoracic radiographs. Prior to any sedation, a 3-minute ETT was performed per the previously published protocol to assign a BOAS severity grade between 0 and 3.[14] On the day of surgery, dogs were placed under general anesthesia under the supervision of a board-certified veterinary anesthesiologist. Sedation and anesthetic protocols were planned according to the discretion of the attending anesthesiologists. All dogs received antiemetics and prokinetics as part of their premedication protocol. Prior to intubation, an oropharyngeal examination was performed to examine the structures in the oropharynx and record any abnormalities. Dogs were administered doxapram (0.5 to 1 mg/kg, IV), and laryngeal function was evaluated. A noncontrast CT of the head and nasal passages was performed.[7,16–18] Dogs were positioned in sternal recumbency with the mouth maintained in an open position and the tongue in a natural position.[6,7,16–18] The CT studies were uploaded to an imaging analysis software program (Keystone, version 1.0.0.86b24; Asteris) and reviewed by a single blinded, board-certified veterinary radiologist (RA). The length of the soft palate was measured from the end of the hard palate to the caudalmost tip of the soft palate at midline in the sagittal plane. Soft palate thickness was measured by dividing the length into equal thirds, and measurements were taken of the rostral (T1), middle (T2), and caudal (T3) thirds at midline in the sagittal plane **(Figure 1)**.

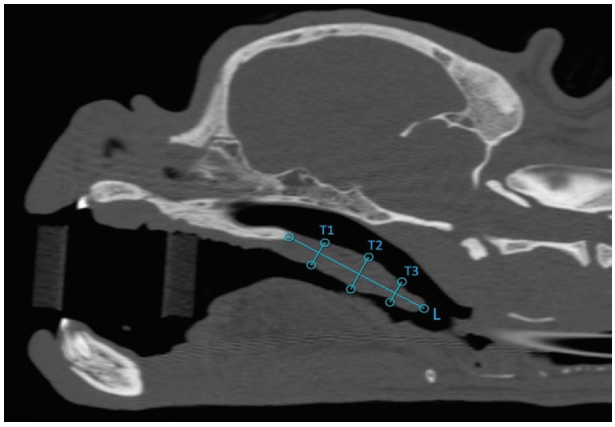


Figure 1—Sagittal plane CT image on sagittal midline of a 10-month-old intact male French Bulldog with brachycephalic obstructive airway syndrome, depicting the measurements of the length (L) and thickness of the rostral (T1), middle (T2), and caudal (T3) thirds of the soft palate, as evaluated for 18 client-owned French Bulldogs before and after surgical treatment with folded-flap palatoplasty versus traditional staphylectomy for brachycephalic obstructive airway syndrome between July 2021 and September 2024. Window width, 2,900 HU; window level, 600 HU; 0.625-mm slice thickness.

Surgery was performed by 2 board-certified small animal veterinary surgeons who both had comparable, extensive experience with both palatal surgical techniques. A TS was performed by placing stay sutures of 3-0 polydioxanone suture on the caudal margin of the soft palate to retract the palate rostrally. The soft palate was sharply transected at the level of the mid to rostral aspect of the tonsillar crypts with Metzenbaum scissors. The oral mucosa was then sutured to the nasopharyngeal mucosa at the level of the palate transection site in 3-0 or 4-0 poliglecaprone-25 suture in a simple continuous pattern.

An FFP was performed by resecting the ventral mucosa of the soft palate extending from the caudal margin up to the pigment line close to the transition of the soft and hard palates with the use of a combination of monopolar electrosurgery and sharp

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dissection.[10] The split thickness of palatal muscle deep to the mucosa was resected to thin the palate before the caudal margin of the palate was folded cranially and sutured into position in direct apposition to the cranial margin of the incised palatal mucosa with 3-0 or 4-0 poliglecaprone-25 suture in a simple interrupted pattern.

In addition to soft palate surgery, other procedures for modified multilevel surgical treatment of BOAS were performed if abnormalities were visualized at the time of upper airway examination. These procedures included tonsillectomy, laryngeal sacculectomy, nasal vestibuloplasty, and Trader's alaplasty.[3,19,20]

At a minimum of 3 months postoperatively, dogs returned for reevaluation. At this visit, dogs underwent a physical examination and a 3-minute ETT was repeated. Dogs were placed under general anesthesia under the supervision of a board-certified veterinary anesthesiologist. Prior to intubation, an oropharyngeal and laryngeal examination was repeated before and after doxapram stimulation, as performed preoperatively. Intubation was performed with the same size endotracheal tube as preoperatively. The dogs then underwent a noncontrast head CT with the same protocol that was performed preoperatively. All dogs were recovered from anesthesia routinely and discharged later that same day. The CT studies were reviewed by a single blinded, board-certified veterinary radiologist (RA), and length measurements were obtained in the same fashion as described. Thickness measurements were also performed in the same fashion as described; however, the new palatal length was used to divide the palate into equal thirds to obtain the postoperative T1, T2, and T3 values.

Perioperative and postoperative complications and adverse events were described and classified with the use of the definitions proposed by Follette et al.[21]

Statistical analysis

Normality of the data was assessed with the Shapiro-Wilk test, Q-Q plots, and examination of the residuals. A 2-way mixed ANOVA was used to examine the effect of treatment (TS vs FFP) on pre- and postoperative palate length and thickness. Significant main effects were examined with simple pairwise comparisons with Bonferroni adjustment. Differences in pre- and postoperative palatal thickness and length were assessed between groups with a Student *t* test or Welch *t* test, depending on variance. The postoperative change in ETT between groups was examined with the Wilcoxon rank sum test. Significance was set at $P < .05$. Five dogs (TS, n = 1; FFP, 4) did not have an ETT performed at their 3-month postoperative recheck and were excluded from ETT comparative analysis. All statistical analyses were performed in R statistical software.[22]

Results

Eighteen French Bulldogs were enrolled in and completed the study between July 2021 and September 2024. There were 11 intact males, 1 neutered male, 1 intact female, and 5 spayed females included. Median age and weight at the time of presentation were 17 months (IQR, 13.25 to 30.5 months) and 11.6 kg (IQR, 9.95 to 12.75 kg), respectively. Presenting clinical signs included stertorous breathing (n = 18), regurgitation (13), sleep disturbances/sleep apnea (7), exercise intolerance (6), sneezing (1), and collapse (1).

Of the 18 dogs that completed the study, 11 were randomized to receive an FFP and 7 to receive a TS. Seven additional dogs were initially enrolled but were lost to follow-up and did not complete the postoperative follow-up and thus were excluded from the comparative analysis. All 18 dogs underwent a nasal vestibuloplasty and Trader's alaplasty, laryngeal sacculectomy, and bilateral tonsillectomy in addition to palatal surgery. Seven dogs underwent additional procedures (orchiectomy, n = 6; laparoscopic ovariohysterectomy, 1). Median total surgical times for the airway procedures (excluding additional procedures) for the TS and FFP groups were 60 minutes (IQR, 45 to 75 minutes) and 75 minutes (IQR, 45 to 90 minutes), respectively. There was no significant difference between total surgical time between treatment groups ($P = .34$).

Dogs were returned for the recheck visit approximately 3 months postoperatively. The median time to follow-up was 100.5 days (range, 81 to 157 days). Postoperative data were collected for each group, and comparisons between groups were performed **(Table 1)**. Seven of 13 dogs (TS, n = 4; FFP,

Table 1—Preoperative (Pre) and postoperative (Post) mean palatal measurements, with SDs and results of statistical analysis comparing the 2 surgical techniques for 18 dogs that underwent either folded-flap palatoplasty (FFP) or traditional staphylectomy (TS).

	FFP		TS			
	Pre	**Post**	**Pre**	**Post**	***P* value**	**No. of cases**
ETT score*	2 (1–3)	1 (0–3)	1.5 (1–3)	1 (0–3)	.4	TS, 6 FFP, 7
Soft palate length (mm)	56.6 (± 6.9)	46.3 (± 6.6)	54.1 (± 7.3)	37.6 (± 7.8)	.2	TS, 7 FFP, 11
Soft palate thickness at T1 (mm)	12.2 (± 1.5)	10.7 (± 1.8)	10.9 (± 2.2)	9.8 (± 2.0)	.7	TS, 7 FFP, 11
Soft palate thickness at T2 (mm)	13.3 (± 2.2)	11.6 (± 2.8)	11.4 (± 1.97)	10.2 (± 2.1)	.6	TS, 7 FFP, 11
Soft palate thickness at T3 (mm)	8.6 (± 1.5)	7.4 (± 2.0)	8.8 (± 1.5)	8.5 (± 1.6)	.5	TS, 7

ETT = Exercise tolerance test. T1 = Rostral third. T2 = Middle third. T3 = Caudal third.
*Data are shown as median (range).

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3) showed improved ETT score, with no significant difference in postoperative ETT improvement between the treatment groups (P = .4).

There were no significant 2-way interactions between treatment (TS and FFP) and time (pre- and postoperatively) for palatal length (F[1,16] = 2.2; P = .2) or thickness at T1 (F[1,16] = 1.2; P = .7), T2 (F[1,16] = 0.24; P = .6), or T3 (F[1,16] = 0.5; P = .5; Table 1). Postoperatively, there was a significant reduction in palatal length (P < .001) and thickness at T1 and T2 but not at T3 when compared to preoperative measurements (T1, P = .001; T2, P = .01; T3, P = .1). Mean palatal length for the combined values of both treatment groups was 55.6 mm (SD, 6.92) preoperatively and 42.9 mm (SD, 8.08) postoperatively. Mean palatal thickness for the combined values of both treatment groups was 11.7 mm (SD, 1.87) preoperatively and 10.3 mm (SD, 1.85) postoperatively for T1, 12.6 mm (SD, 2.28) preoperatively and 11.1 mm (SD, 2.57) postoperatively for T2, and 8.69 mm (SD, 1.45) preoperatively and 7.80 mm (SD, 1.87) postoperatively for T3. No significant difference in reduction was observed between treatment groups (FFP or TS) for any of the variables: length (F[1,16] = 4.3; P = .06), T1 (F[1,16] = 1.7; P = .2), T2 (F[1,16] = 2.7; P = .1), or T3 (F[1,16] = 2.4; P = .1).

Low-grade postoperative complications were seen in 11 of 18 dogs that completed the study. These complications included postoperative regurgitation in 10 dogs (FFP, n = 5; TS, 5), all of which had regurgitation reported preoperatively; nonspecific gastroenteritis was reported in 1 dog (TS group). No evidence of clinical aspiration pneumonia was noted in any dog. One dog in the FFP group experienced a major postoperative complication. This dog went into respiratory arrest a few hours following recovery from general anesthesia. Cardiopulmonary resuscitation was successful, and a temporary tracheostomy was placed. This dog ultimately recovered and was discharged from the hospital 72 hours later. All dogs in this study survived to discharge. At the 3-month recheck, partial flap dehiscence was noted in 1 dog (FFP group); no further complications were noted by owners or detected on physical examination or sedated oropharyngeal examination.

Discussion

The hypothesis that FFP would result in thinner and shorter palates and a greater improvement in clinical outcome was not substantiated by the results of this study. The results of this study suggest that both FFP and TS are viable techniques for surgical treatment of the elongated soft palate in dogs with BOAS. Both techniques resulted in significant reductions in palatal length and thickness and improved ETT scores when compared to preoperative measurements, with no significant differences in outcome between the treatment groups. The findings of this study are consistent with those of a prior study[13] comparing pre- and postoperative palatal length and thickness in English Bulldogs undergoing either FFP or standard staphylectomy. In the prior study,[13] English Bulldogs that underwent FFP did not have significantly thinner palates compared to those that underwent TS, and there was no difference in clinical outcome measures between the 2 treatment groups.

Although FFP did not result in significantly thinner soft palates in this cohort of dogs compared to dogs treated with TS, it is possible that this technique could benefit some dogs with excessively thick soft palates. The authors suspect that preoperative head CT might be a useful tool to assess each dog's individual palatal geometry and guide selection of the most appropriate surgical technique. However, further investigation is needed to determine whether there is a critical thickness where FFP would provide additional benefit to dogs undergoing BOAS. An interesting finding of this study was that the soft palate thickness reduced in the TS group postoperatively, despite no surgical thinning being performed. It is speculated that this finding was due to a reduction in oropharyngeal mucosal inflammation and edema after addressing BOAS and reducing stertorous breathing.

Overall, the complication rate of dogs in this study was low. The most common complication was postoperative regurgitation, which was not unexpected because of the frequency in which regurgitation was a presenting clinical sign in this cohort and prevalence of regurgitation in brachycephalic breeds.[23] Additionally, all dogs that experienced regurgitation postoperatively had a history of regurgitation prior to surgery. All dogs were monitored closely in hospital for signs of aspiration pneumonia, and no evidence of clinical aspiration pneumonia was detected in any dogs prior to discharge. Only 1 dog experienced a major immediate postoperative complication, and no fatal complications occurred. A reported complication of the FFP is flap dehiscence,[13,24] which was detected in 1 dog that underwent FFP in the present study. No intervention was performed, as the partial dehiscence did not appear to have any clinical impact for this dog. Flap dehiscence may be an underrepresented complication in the broader population of dogs undergoing FFP, as the majority do not have follow-up airway examinations performed in the immediate postoperative period.

Regardless of the surgical technique used, palatal resection should be carefully planned to remove redundant soft palate to the level of the mid to rostral tonsillar crypt. It is suspected that the equivocal outcomes observed between the groups in this study can be attributed to shortening the palate to this same level with either technique. Although the greater change in soft palate length seen in the TS group compared to the FFP group was not statistically significant, it may suggest that when performing FFP there is a tendency to shorten palates less than when performing TS. Thus, care should be taken to ensure appropriate shortening when performing FFP while being mindful of flap tension to limit dehiscence.

A previous study[25] evaluating CT of the pharynx in closed- versus open-mouthed positions found that an open-mouthed position was superior for evaluation of the pharynx. On the basis of that study, the standard protocol used for CT positioning was that of an open-mouthed position with the tongue in a natural position. Despite efforts to replicate pre- and

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postoperative head positions, variations were seen in head positioning between the dogs and pre- and postoperatively, which may have led to artifactual changes in the geometry of the soft palate. For future studies, the use of conformable mattresses and a protocol to standardize head and tongue positioning more accurately could be considered to minimize variation in CT positioning. Additionally, pre- and postoperative CT studies were performed under general anesthesia with endotracheal intubation, which could have also artifactually affected soft palate geometry. A study[26] evaluating the impact of endotracheal intubation on upper airway measurements in brachycephalic dogs found that intubation did not have a significant impact on soft palate length or rostral and middle soft palate thickness. Thus, the impact of endotracheal intubation on palatal measurements in this study is suspected to be minimal.

The main limitation of this study was the relatively small sample size and potential for type 2 statistical error, possibly diminishing the benefit of the FFP procedure. Seven dogs did not present for their 3-month follow-up appointment and repeat CT. A greater proportion of these dogs were randomized to the FFP treatment group, resulting in uneven numbers of dogs in each treatment group and potentially impacting the results of this study. Additionally, 5 dogs did not receive a postoperative ETT at recheck, which could have skewed ETT score results. Lastly, for the purpose of this study it was elected to measure soft palate thickness at each third of the palate based on the current length. It is recognized that the T1, T2, and T3 measurements do not correspond to the exact same anatomical locations pre- and postoperatively; however, they do correspond to the same relative position on the palate for pre- and postoperative comparison. Performing the measurements in this fashion provided a global evaluation of palatal thickness on the basis of the length of the palate, allowing for 3 points of comparison to assess whether the FFP technique thinned the remaining palate.

In conclusion, the findings of this study suggest that either palatal surgical technique can thin and shorten the soft palate and improve clinical signs of BOAS in French Bulldogs. Both FFP and TS had similar clinical outcomes and low complication rates, underscoring the utility of either technique. Further studies are needed to determine whether there is a critical thickness in which FFP provides additional benefit in brachycephalic dogs undergoing BOAS surgery.

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