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Folded-flap palatoplasty is not superior to cut-and-sew staphylectomy for the treatment of brachycephalic obstructive airway syndrome in English Bulldogs

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Objective
To determine whether folded-flap palatoplasty (FFP) results in improved respiratory outcomes compared to standard staphylectomy (SS).

Methods
English Bulldogs were randomized to receive FFP or SS in a parallel, equal-allocation, prospective study design at a single institution. Exercise-tolerance testing (ETT), arterial blood gas, head CT, and an owner survey were completed preoperatively and at recheck (approx 30 days postoperatively). Soft palate (SP) length and thickness and pharyngeal air volume were measured on blinded CT images. Linear mixed models and Mann-Whitney *U* tests were performed.

Results
16 dogs completed the study (FFP group, 8; SS group, 8) and 3 did not (excluded due to FFP dehiscence [2] and lack of recheck [1]). Median preoperative ETT grade was not different between groups (SS group, 1 [0 to 3]; FFP group, 1.5 [1 to 3]). Standard staphylectomy resulted in a greater reduction in SP length compared to FFP ($P = .020$; FFP, 5.79 ± 0.50 cm preoperatively, 4.86 ± 0.52 cm at recheck; SS, 6.13 ± 0.53 cm preoperatively, 4.57 ± 0.47 cm at recheck). No other variables differed between groups. At recheck, owners subjectively rated their dogs as improved (FFP group, 5; SS group, 8), unchanged (FFP group, 2), and not rated (FFP group, 1).

Conclusions
Folded-flap palatoplasty did not improve SP thickness, pharyngeal air volume, ETT, arterial blood gas values, or owner survey variables more than SS in these English Bulldogs. Standard staphylectomy resulted in a greater reduction in SP length than FFP.

Clinical Relevance
Standard staphylectomy or FFP can be performed in English Bulldogs. Standard staphylectomy may be preferable due to dehiscence potential with FFP.

Keywords: staphylectomy, palatoplasty, brachycephalic, airway, respiratory

Brachycephalic obstructive airway syndrome (BOAS) is a common diagnosis in English Bulldogs. Although BOAS consists of multiple primary and secondary components, addressing the elongated soft palate is a mainstay of surgical treatment for this condition.[1] A cut-and-sew staphylectomy (standard staphylectomy [SS]) shortens the soft palate to the mid-to-caudal third of the tonsils with apposition of the nasopharyngeal and oropharyngeal mucosal edges with suture.[1] Although this technique resolves the excessive length of the soft palate, the thickness of the remaining soft palate may contribute to residual airway resistance.[2,3] The folded-flap palatoplasty (FFP) aims to address the thickness of the soft palate in addition to the excessive length.[4] This technique involves resecting a portion of the oropharyngeal mucosa and underlying muscle of the soft palate and folding the remaining caudal edge of the soft palate mucosa rostrally, theoretically shortening and reducing the thickness of the soft palate.

Maximizing the effect of surgical treatment is important to provide brachycephalic dogs with an

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improved quality of life while minimizing the risk of the progression of upper airway collapse. Assessment of the severity of BOAS can be performed by several objective and subjective measures. Exercise-tolerance testing, which involves the evaluation of respiratory noise, inspiratory effort, and the presence of dyspnea, cyanosis, and syncope before and after exercise, is sensitive for the diagnosis of BOAS, with a 3-minute trot test having a 93% sensitivity for diagnosis of BOAS.[5] Whole-body barometric plethysmography can also be used to determine the degree to which a dog is affected by BOAS, and this correlates well with exercise-tolerance testing.[5,6] Arterial blood gas values can also be used to assess the clinical severity of BOAS. Brachycephalic dogs have a lower Pa_{O_2} and higher Pa_{CO_2} than nonbrachycephalic dogs, and dogs with moderate BOAS have lower arterial oxygen saturation of hemoglobin (Sa_{O_2}) values than nonbrachycephalic dogs.[7,8] The length and thickness of the soft palate and the cross-sectional area of the pharynx are other objective measures that can be used to compare preoperative and postoperative values in dogs undergoing surgery for BOAS.[9–11] Subjective measures to assess BOAS include owner survey data evaluating both respiratory and gastrointestinal symptoms.[12] Recently, the brachycephalic risk (BRisk) score was developed to predict the risk of postoperative complications in dogs undergoing surgery for BOAS and uses evaluation of breed, history of airway surgery, whether additional procedures are planned, body condition score (BCS), level of respiratory compromise at admission, and rectal temperature at admission.[13] Scores are added for each category, and dogs are assigned to low-risk, medium-to-high–risk, and high-risk groups, indicating the level of risk of postoperative complications (death, euthanasia, oxygen support required for > 48 hours, temporary tracheostomy, or permanent tracheostomy).

The objective of this study was to evaluate and compare the change in length and thickness of the soft palate, pharyngeal volume, exercise-tolerance testing scores, Pa_{O_2}, Sa_{O_2}, and Pa_{CO_2} preoperatively and 30 days postoperatively in dogs undergoing SS or FFP. The hypothesis was that dogs undergoing FFP would have greater improvement in all variables at 30 days postoperatively compared to dogs undergoing SS.

Methods

This was a single-center, balanced-randomization, blinded, parallel-group study. All procedures were approved by the University of Georgia's Clinical Research Committee (CR-630), and informed client consent was obtained prior to enrollment. English Bulldogs that were presented for initial surgical treatment of BOAS were eligible for inclusion. Dogs were excluded if they had structural heart disease, preexisting aspiration pneumonia, lower airway disease, prior staphylectomy, or required emergency intubation and/or surgery upon arrival. All dogs undergoing BOAS at this institution undergo thoracic radiographs to evaluate for aspiration pneumonia, hiatal hernia, and hypoplastic trachea. Owners filled out a survey asking about their dog's frequency of snoring, inspiratory effort, self-limiting of exercise, difficulty sleeping, collapse, cyanosis, excessive salivation, regurgitation, and vomiting **(Supplementary Material S1)**.[12] All variables were rated as never, less than once a month, once a week, once a day, more than once a day, or constantly. Dogs were assigned a respiratory and digestive grade based on owner survey results[12] and were also assigned a BRisk score.[13] Briefly, all dogs received 0.5 points for being an English Bulldog and 1.5 points for no history of prior airway surgery. Dogs undergoing additional procedures received 1.5 points, and those not undergoing additional procedures received 0 points. One point was assigned to dogs with a BCS ≤ 2.5 or > 3.5, and 0 points were assigned for a BCS > 2.5 and ≤ 3.5. Dogs without stertor or that had stertor only after exercise received 0 points, dogs with stertor at rest received 1.5 points, and dogs that required oxygen and sedation at admission received 2 points. Points were also assigned for rectal temperature on admission, with 1.5 points given for a temperature ≤ 100 °F, 1 point for > 100 °F and ≤ 101 °F, 0.5 points for > 101 °F and ≤ 103 °F, and 0 points for > 103 °F. Dogs with a BRisk score ≤ 3 were considered low risk, dogs with a score > 3 were considered to be at medium to high risk, and dogs with a score > 4 were considered to be at high risk of complications following BOAS surgery.

Dogs then underwent an exercise-tolerance test consisting of a 3-minute trot in a temperature-controlled environment following their initial surgical consult (approx 2 to 4 hours after arriving at the hospital) and were graded as previously described.[5] An arterial blood gas analysis was performed prior to sedation and without preoxygenation with blood samples from the dorsal pedal or femoral artery after application of numbing cream (lidocaine/prilocaine).

All dogs received a standardized anesthetic protocol. Dogs were sedated with dexmedetomidine (5 µg/kg) combined with butorphanol (0.2 mg/kg) given either IM or IV and, once sedated, were given maropitant (1 mg/kg, IV) and metoclopramide (1 mg/kg bolus followed by 1 mg/kg/h, IV, constant rate infusion). Dogs then underwent a CT scan of the head, and dexmedetomidine and butorphanol were repeated as needed to maintain sedation. Flow-by oxygen was provided during the CT scan, and dogs were monitored with doppler noninvasive blood pressure, ECG, and pulse oximetry. For CT, dogs were positioned in sternal recumbency with the maxilla supported by an elevated bar, ensuring that the mandible and tongue rested passively with no pressure on the ventral neck. Scans were performed with a 64-slice helical CT scanner (Somatom Sensation; Siemens Healthineers AG) from the tip of the nose rostrally to the third cervical vertebrae caudally. Noncontrast CT images were acquired with 120 kVp, 35 mA, and a pitch of 0.8 and reconstructed into 0.6-mm– and 2-mm–thick slices with a soft tissue and bone algorithm. Iohexol (Omnipaque 350; GE HealthCare Technologies Inc) was administered IV at 600 mgI/kg by use of a power injector at a rate of 5 mL/s. Postcontrast arterial, venous, and delayed-phase CT images were acquired after contrast injection with the same scan protocol as used in the noncontrast scan. Bolus tracking was performed with a region of interest on the right or left common carotid artery with the trigger set to 60 HU to determine optimal arterial scan initiation. Delayed-phase images were reconstructed in dorsal and sagittal planes with a slice thickness of 0.6 mm.

Following CT, dogs were induced with ketamine (2 mg/kg, IV) and propofol (4 to 6 mg/kg, IV, to effect) and a standardized upper airway examination was performed by 2 board-certified veterinary surgeons with evaluation of laryngeal abduction and sensitivity, palate sensitivity, tongue size, hard palate, soft palate, tonsils, pharynx, epiglottis, piriform recess, laryngeal mucosa, cuneiform processes, corniculate processes, laryngeal ventricles, vocal folds, rima glottidis, and nares.[14] Everted laryngeal saccules, if identified, were sharply excised with scissors, and the dog was then endotracheally intubated. Dogs were maintained on isoflurane in 100% oxygen with doppler noninvasive blood pressure, ECG, pulse oximetry, end-tidal carbon dioxide, and rectal temperature measured throughout the procedure. Dogs received lactated Ringer's solution (2 to 5 mL/kg/h) while under anesthesia.

Dogs were randomly assigned (www.random.org; Randomness and Integrity Services Ltd) with a 1:1 allocation to receive SS or FFP by 1 of 4 board-certified veterinary surgeons. All surgeons were familiar with both surgical techniques, although all had more clinical experience with SS than FFP. Prior to study start, all surgeons performed FFP in a cadaver to ensure the same technique was used throughout the study. Owners were blinded to the treatment group until after the procedure had been performed. The SS was performed as previously described[1] in a cut-and-sew fashion with scissors used for the resection and closed with 4-0 polyglactin 910 in a simple continuous pattern. The FFP was performed as previously described[4] with electrosurgery and closed with 4-0 polyglactin 910 in a simple interrupted pattern. The suture was changed to 3-0 poliglecaprone 25 for both procedures during the study due to dehiscence identified in the FFP group. Vertical wedge resection alaplasty was performed following staphylectomy if indicated and closed with 3-0 poliglecaprone 25 in a simple interrupted pattern. All dogs received dexamethasone sodium phosphate (0.1 mg/kg, IV) prior to extubation. Dogs were recovered from anesthesia and moved into the ICU, with oxygen provided as necessary. The remainder of the in-hospital management was left to the attending clinician's discretion.

Dogs were returned for recheck examination approximately 30 days postoperatively. At this visit, the owners completed the same questionnaire, with the addition of 1 new question asking whether they felt their dog's quality of life was improved, unchanged, or worse compared to prior to surgery. An exercise-tolerance test, arterial blood gas, abbreviated airway examination to evaluate the soft palate for dehiscence, and sedated CT were performed as previously described, with the surgeon blinded to the treatment group.

Statistical analysis

All CT scan images were imported into a commercially available image analysis software (Horos, version 3; Purview) and anonymized to patient data, procedure type (SS or FFP), and whether the scan was pre- or postoperative. Soft palate length was measured from the end of the hard palate to the end of the soft palate by use of the midline point of 0.6-mm–slice, delayed-phase, sagittal reconstructions **(Figure 1)**.

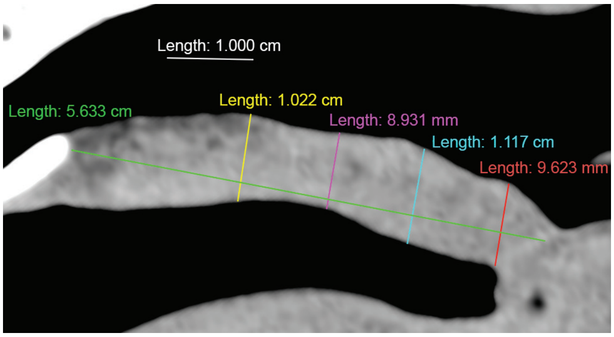

Figure 1—Midline point of a 0.6-mm–slice, delayed-phase, sagittal CT reconstruction demonstrating the measurement of soft palate length (green line) and width at 2 cm (yellow line), 3 cm (magenta line), 4 cm (cyan line), and 5 cm (red line) caudal to the hard palate in an English Bulldog.

The dorsoventral width of the soft palate was measured perpendicular to the line defining its length at 2, 3, 4, and 5 cm (if ≥ 5 cm in length) caudal to the edge of the hard palate.[11] Regions of interest were drawn to isolate the pharynx and 3D segmentation performed to calculate the volume **(Figure 2)**.

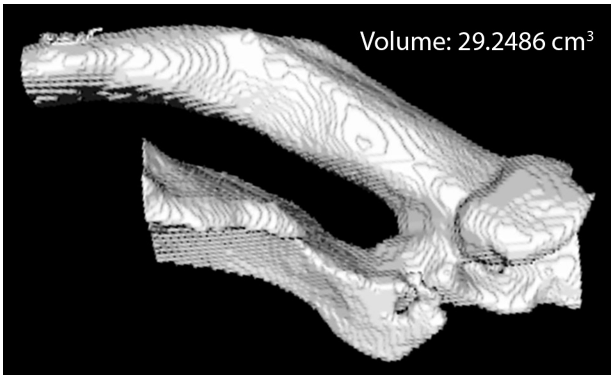

Figure 2—A virtual cast of the pharyngeal air volume following the drawing of regions of interest and 3D segmentation used to isolate the pharynx on a 0.6-mm slice, delayed-phase, transverse CT reconstruction of an English Bulldog. The nasopharynx is located dorsally, the oropharynx is located ventrally, and the laryngopharynx is located to the right side of the image.

The oropharynx was defined rostrally at the level of the isthmus of the fauces, the nasopharynx was defined rostrally at the level of the choanae, and the laryngopharynx was defined caudally to end just rostral to the cricoid cartilage.[15] Skull index was calculated by measuring the length from the inion to the prosthion and width between the zygomatic arches at their widest point with the following formula[16]: Skull Index = (Skull Width X 100)/(Skull Length). All measurements were made by a single investigator (JAG). Due to lack of any objective data regarding changes in studied outcome measures with FFP, pre hoc sample size calculations were unable to be performed and the decision was made to enroll 8 dogs in each group as a pilot study.

Data were analyzed for normality by visual assessment of the histogram plot. Normally distributed data were presented as mean ± SD, and nonnormally distributed data were presented as median (range). Linear mixed models were used to analyze continuous data (soft palate length, soft palate thickness, pharyngeal air volume, Pa_{O_2}, Sa_{O_2}, and Pa_{CO_2}) for differences between SS and FFP. The model was performed with fixed effects of the timing of the variable (preoperative or 30-days postoperative), procedure performed (SS or FFP), and timing/procedure interaction, with dog as the random effect. Model assumptions (normality and homoscedasticity of model residuals) were evaluated via inspection of conditional quantile–quantile plots, histograms, and residual plots. Survey variables were converted to ordinal numbers for analysis (never, 1; less than once a month, 2; once a week, 3; once a day, 4; more than once a day, 5; or constantly, 6). Mann-Whitney *U* tests were used to analyze ordinal data (survey data and exercise-tolerance testing grades) for differences between SS and FFP. Significance was set at $P < .05$. False discovery rates were determined due to multiplicity of testing. All analyses were performed with a commercially available software program (JMP, version 17.0.0; SAS Institute Inc).

Results

Sixteen dogs completed the study, with 8 dogs in the SS group and 8 dogs in the FFP group. Three dogs were enrolled in the study but did not finish and were excluded from statistical analysis; 2 dogs were excluded at the 30-day recheck for dehiscence of the FFP, and 1 dog that received FFP was not returned for the 30-day recheck examination. The suture used to close both the FFP and SS was changed from polyglactin 910 to poliglecaprone 25 after the 2 FFP dehiscences, although 3 FFP dogs had successful healing with the polyglactin 910 prior to this change. The 2 dogs that were excluded for FFP dehiscence had flap dehiscence with a central full-thickness defect in the flap **(Figure 3)**, and both dogs underwent surgery to convert to SS by excision of the dehisced flap and closure of the naso- and oropharyngeal mucosa with suture. Both owners rated their dogs as being improved at the recheck examination prior to knowledge of the dehiscence, and neither dog had a change in exercise-tolerance test score.

Fifteen dogs underwent laryngeal sacculectomy, and all dogs had vertical wedge resection alaplasty performed, although 1 dog had this performed only unilaterally due to unilateral stenosis. Eleven dogs underwent additional procedures (6 dogs in the SS group and 5 dogs in the FFP group; sterilization [7], caudectomy [5], surgical treatment of a prolapsed

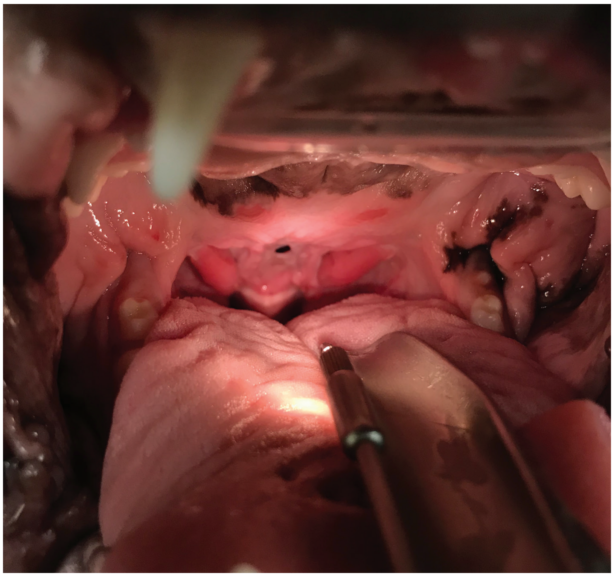

Figure 3—Image from an upper airway examination of a dog that developed folded-flap palatoplasty dehiscence showing dehiscence with a full-thickness central defect of the flap. The flap was excised and the procedure converted to a standard staphylectomy.

gland of the third eyelid [1]), with 2 dogs undergoing more than 1 additional procedure (castration and caudectomy [1] and castration and treatment of prolapsed gland of the third eyelid [1]). No dogs had complications reported during hospitalization. Two dogs (SS group, 1; FFP group, 1) developed aspiration pneumonia 1 day after hospital discharge following a regurgitation event at home; both dogs were rehospitalized, treated, and successfully discharged from the hospital. Neither dog had evidence of a hiatal hernia on thoracic radiographs, and both dogs had an exercise-tolerance testing grade of 1 preoperatively.

Dogs were returned for the recheck visit a median of 29 days (range, 28 to 36 days) following surgery. Baseline and postoperative data were collected for each group, and comparison between groups was performed **(Table 1)**. The only variable that was significantly different between groups was soft palate length, with the SS group having a greater reduction in length of the soft palate than the FFP group ($P = .020$).

On the owner survey at the recheck visit, 13 owners rated their dogs (FFP group, 5; SS group, 8) as improved, 2 owners rated their dogs (FFP group, 2) as unchanged, and 1 owner did not give a rating (FFP group, 1). Both dogs that were rated as being unchanged postoperatively underwent FFP, had improvement by 1 grade in their exercise-tolerance testing grade, and had improvement in Pa_{O_2} (by 12 and 24 mm Hg). One of these dogs had improvement in owner survey scores for snoring and exercise tolerance by 2 scores and vomiting by 1 score, worsened in inspiratory effort by 1 score, and remained the same in all other categories. The second dog had improvement in owner survey scores for snoring by 2 scores but worsened in inspiratory effort, excessive salivation, and vomiting by 1 score and remained the same in all

Table 1—Preoperative and postoperative measurements of variables evaluated in 16 English Bulldogs undergoing folded-flap palatoplasty (n = 8) or standard staphylectomy (8) and results of statistical analysis comparing the 2 procedures via linear mixed model. The *P* value represents the interaction *P* value between pre- and postoperative values and the procedure performed (standard staphylectomy or folded-flap palatoplasty), with a false-discovery rate *P* value performed for multiplicity of testing.

	Folded-flap palatoplasty		**Standard staphylectomy**		***P* value**	**FDR *P* value**
Age (y)	1.8 ± 1.3		1.9 ± 1.1			
Sex						
Female	3 (1 intact)		3 (1 intact)			
Male	5 (5 intact)		5 (2 intact)			
Weight (kg)	26.3 ± 6.2		23.8 ± 3.7			
Body condition score						
< 2.5	0		0			
2.5–3.5	2		5			
> 3.5	6		3			
Skull index	87.4 ± 2.7		89.4 ± 4.4			
BRisk score	3.5 (2.5–5.5)		3.25 (0.5–4.5)			
	Pre	**Post**	**Pre**	**Post**		
Snoring	5.5 (4–6)	3.5 (3–5)	5 (3–6)	4 (1–5)	.273	.623
Inspiratory effort	3.5 (1–6)	2.5 (1–4)	3 (1–5)	2 (1–5)	.747	.934
Self-limiting of exercise	1 (1–6)	2 (1–4)	3 (1–6)	1 (1–3)	.193	.623
Difficulty sleeping	2 (1–5)	1 (1–2)	1 (1–5)	1 (1–1)	.298	.623
Collapse	1 (1–1)	1 (1–1)	1 (1–2)	1 (1–1)	.382	.623
Cyanosis	1 (1–2)	1 (1–1)	1 (1–1)	1 (1–1)	.382	.623
Excessive salivation	4 (1–5)	2.5 (1–5)	3 (1–5)	1 (1–6)	.958	.958
Regurgitation	2.5 (1–5)	1 (1–5)	2 (1–5)	2 (1–3)	.866	.958
Vomiting	2.5 (1–3)	1 (1–3)	1 (1–2)	1 (1–2)	.090	.623
Respiratory grade	2.5 (1–3)	2 (1–3)	2.5 (1–3)	2 (1–2)	.902	.958
Digestive grade	2 (2–3)	2 (1–3)	2 (1–3)	2 (1–3)	.405	.623
Exercise-tolerance test grade	1.5 (1–3)	1 (0–2)	1 (0–3)	0.5 (1–2)	.256	.623
Soft palate length (cm)	5.79 ± 0.50[a]	4.86 ± 0.52	6.13 ± 0.53[b]	4.57 ± 0.47	.001	.020
Soft palate thickness at 2 cm* (mm)	8.24 ± 1.57	8.10 ± 1.39	8.96 ± 1.42	8.89 ± 1.24	.921	.958
Soft palate thickness at 3 cm* (mm)	8.06 ± 1.61	7.79 ± 1.52	8.09 ± 1.81	8.19 ± 0.91	.700	.933
Soft palate thickness at 4 cm* (mm)	8.04 ± 1.12	7.08 ± 1.91	8.06 ± 2.71	6.98 ± 3.22	.385	.623
Soft palate thickness at 5 cm* (mm)	6.79 ± 1.13	[c]	7.75 ± 3.31	[d]		
Pharyngeal air volume (cm^3)	41.19 ± 15.17	42.98 ± 11.16	38.81 ± 11.77	44.54 ± 12.32	.491	.701
Pa_{O_2} (mm Hg)	89.66 ± 4.77	90.26 ± 13.75	89.70 ± 9.38	84.30 ± 16.80	.387	.623
Sa_{O_2} (%)	97.54 ± 0.56	97.26 ± 1.24	97.48 ± 0.85	96.36 ± 2.45	.346	.623
Pa_{CO_2} (mm Hg)	30.68 ± 1.37	31.03 ± 4.48	31.75 ± 2.10	28.84 ± 2.09	.197	.623

Nonnormally distributed data are reported as median (range). Normally distributed data are reported as mean ± SD.

An asterisk indicates the distance from the caudal edge of the hard palate at which the measurement was taken.

BRisk = Brachycephalic risk. FDR = False discovery rate. Pre = Preoperative. Post = Postoperative. Sa_{O_2} = Arterial oxygen saturation of hemoglobin.

[a]2 dogs had a soft palate touching the larynx. [b]6 dogs had a soft palate touching the larynx. [c]Only 2 dogs had a measurement at this level postoperatively. [d]No dogs had a measurement at this level postoperatively.

other categories. The 2 dogs that developed aspiration pneumonia following a regurgitation event after hospital discharge both had an exercise-tolerance testing grade of 1 postoperatively and both owners rated their dog as improved at recheck examination. One dog had no change in the regurgitation score on owner survey (rated as less than once a month preoperatively and at recheck), and the other dog had improvement in the regurgitation score on owner survey (rated as more than once a day preoperatively and as never at recheck).

Discussion

Based on the dogs of this study, there was no evidence that FFP was of greater benefit than SS, as there was no difference in the change in soft palate thickness, pharyngeal air volume, exercise-tolerance testing scores, Pa_{O_2}, Sa_{O_2}, Pa_{CO_2}, or owner survey variables from preoperative to 30-day postoperative assessments between dogs undergoing FFP or SS. The only variable that was significantly different between FFP and SS was soft palate length, in which the SS group had a greater reduction than the FFP group. Thus, the hypothesis that dogs undergoing FFP would have greater improvement in all variables at 30 days postoperatively compared to dogs undergoing SS was rejected.

The FFP procedure is proposed to both shorten and thin the soft palate,[4] but there was no difference in the change in soft palate thickness between dogs undergoing FFP and SS. It may be that in dogs with excessively thick soft palates, FFP could provide more benefit than SS. Four dogs in this study had at least 1 soft palate thickness measurement > 1 cm; how the soft palates of the dogs included in this study relate to the soft palate thickness of a broader population of brachycephalic dogs and the thickness at which FFP may be more beneficial than SS has not been determined and should be investigated. Additionally, the median preoperative exercise-tolerance test score was grade 1, which may have contributed to the lack of difference between groups due to lack of clinical severity. Although more clinically affected dogs were attempted to be enrolled, dogs requiring emergency intubation and surgery were excluded from enrollment due to the need to obtain an arterial blood gas sample in an awake dog without oxygen supplementation and to obtain a sedated, nonintubated CT for the study. It is possible that more clinically affected dogs may have had thicker soft palates that would have allowed for identification of a difference between the surgical procedures. The mean age of dogs was < 2 years, and older dogs are known to have more hyperplastic airway tissues that could have altered soft palate and pharyngeal measurements, had more older dogs been enrolled.[3,17]

There was no significant difference in arterial blood gas values pre- and postoperatively for either group. This may have been due to obtaining the sample in unsedated dogs. Some dogs were more resistant to restraint than others, and the ease of obtaining the sample was variable between dogs and time points (pre- and postoperative), which may have led to a negative change in these values affecting statistical analysis. It is also possible that mixed venous/arterial samples were obtained; although in each case, the anesthesia personnel obtaining the sample evaluated for pulsatile, bright red blood flow to ensure arterial sampling.

The BRisk score was not different between groups. Performing additional procedures increases the BRisk score, but the number of dogs undergoing additional procedures was similar between groups (SS group, 6; FFP group, 5). Additionally, no dogs had any complications for which the BRisk score was a predictor (oxygen support for > 48 hours postoperatively, temporary tracheostomy during hospitalization, permanent tracheostomy, and death), making evaluation of this score difficult in this population of dogs.[13]

Two dogs initially enrolled in this study were excluded at the 30-day recheck examination due to dehiscence of the FFP. The suture used to close the flap was changed from polyglactin 910 to poliglecaprone 25, and no further dehiscences occurred, although this may not have been the reason for dehiscence in these dogs, as 3 dogs had successful FFP healing with polyglactin 910. Dehiscence is likely a multifactorial process, and tension, motion, suture selection, thermal injury, and vascular compromise may have all played a role in these dehiscences.[18,19] Dehiscence is a previously reported complication of the FFP,[18–20] and the dehiscences in this study are similar to what has been previously reported.[18] Both dogs in this study had flap dehiscence with a central defect and were converted to SS by resecting the flap and suturing the nasopharyngeal and oropharyngeal mucosa. Both dogs recovered without complication following the second procedure. Despite dehiscence of the FFP in these 2 dogs, both owners rated their dog as being improved at the recheck visit, although neither dog had a change in their exercise-tolerance testing score, which was completed prior to knowledge of the dehiscence. These owners may have felt their dog was improved due to the relatively thin nature of the dehisced flap and a central defect that likely facilitated air passage into the larynx. Owners also may have been biased in a way similar to the placebo effect and more likely to rate their dog as improved due to the costs and emotional toll of surgery. Additionally, owners were informed of which procedure their dog underwent immediately postoperatively, which could have affected their ratings at the recheck examination. Owners were not provided with their previous survey responses at the recheck visit. Because the recheck visit was approximately 30 days from the surgery, there may not have been enough time for a never rating to be differentiated from a less than-once-a-month rating. Dogs with FFP dehiscence were excluded from further analysis because the purpose of this study was to determine the outcomes with successful FFP. Future studies should evaluate the clinical implications of FFP dehiscence. No dehiscences were identified in dogs undergoing SS, indicating that factors inherent to the FFP procedure such as tension, vascular compromise of the flap, and use of electrosurgery may be more likely to cause dehiscence in this procedure. In a retrospective evaluation comparing SS to FFP, no differences in the occurrence of complications were noted between groups, but dogs in the FFP group had longer anesthesia and surgery times.[21] As this was a retrospective study, dogs were not subjected to a recheck airway examination to evaluate for palatal dehiscence. The incidence of dehiscence of SS is unknown. It may be that SS is less likely to cause clinical signs following dehiscence due to the nature of this procedure shortening the palate with no tissue remaining to flap back down to the larynx, meaning a sedated airway examination is rarely repeated within 1 month of surgery to evaluate for this complication.

Limitations of this study included the overall small case numbers and, as previously stated, lack of inclusion of dogs with excessively thick soft palates or dogs that were more severely affected. This was a randomized prospective trial exclusive to English Bulldogs. It is possible other brachycephalic breeds may be more likely to have excessively thick soft palates. Another limitation was that the CT scans were performed under sedation. This was chosen to avoid interference of an endotracheal tube with airway measurements. All dogs were positioned in the same manner and with their maxilla resting on a horizontal bar and their mandible hanging passively. However, it is possible that dogs had a different depth of sedation during their pre- and postoperative CTs, which may have affected pharyngeal air volume measurements due to a difference in how far their mandible dropped. Despite this, measurements were taken at the beginning of the oropharynx, which should limit the influence of mandibular position by excluding the oral cavity from measurements. The number of dogs in which the soft palate touched the larynx was different between groups (SS group, 6; FFP group, 2), although the soft palate commonly touches the epiglottis in dogs.[15] The extent to which this may have affected the results of this study was unknown, but future studies may consider preoperative palate length as a component of randomization into groups. All surgeons performing the palate procedures were familiar with both SS and FFP, although all surgeons had more clinical experience with

FFP. Surgeons completed an FFP in a cadaver dog prior to study start to ensure all surgeons used the same technique. However, the decreased experience with FFP compared to SS could have affected the results. Because dogs were prospectively enrolled, the anesthetic protocol was standardized for all dogs in this study, helping to limit differences between dogs related to anesthetic factors. A previous study[22] found that use of metoclopramide combined with an antacid, reduced use of opioids, and recovery in an ICU led to a reduced incidence of postoperative regurgitation, aspiration pneumonia, and respiratory distress. The institution at which this study was performed routinely uses metoclopramide and maropitant and restricts opioid usage as much as possible in dogs undergoing surgery for BOAS, but an antacid and recovery in an ICU are not routine in this institution. Only 2 dogs developed aspiration pneumonia following a regurgitation event at home shortly after hospital discharge.

In conclusion, FFP was not more beneficial than SS in the English Bulldogs of this study and dogs in the SS group had a greater reduction in soft palate length than those in the FFP group.

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Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org.