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ORIGINAL ARTICLE

Random mucosal rotating flaps for rostral to mid maxillary defect reconstruction: 26 dogs (2000-2019)

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Objectives: To evaluate the feasibility and the complications following single or double random mucosal rotating (transposition or interpolation) flaps for the closure of rostral to mid maxillary defects in dogs.

Materials and Methods: Medical records of dogs treated with single or double random mucosal rotating flaps after maxillectomy for oral lesions or traumatic loss of tissue, were evaluated. Clinical findings, surgery performed, outcome and postoperative complications (major and minor) were extracted.

Results: Twenty-six client-owned dogs were retrospectively included. Dogs underwent maxillectomy for canine acanthomatous ameloblastomas (9), oral squamous cell carcinomas (4), peripheral odontogenic fibromas (4), oral melanomas (3), oral fibrosarcomas (2), dentigerous cysts (2) and oral osteosarcoma (1) and trauma resulting in an oronasal fistula (1). Twenty-three dogs underwent a single transposition or interpolation flap and three dogs were treated with a double transposition flap. Postoperative complications, including dehiscence or flap necrosis, occurred in six dogs.

Clinical Significance: Random mucosal rotating (transposition or interpolation) flaps are versatile when used to close rostral maxillary defects in dogs. Postoperative complications appear to be more likely when these flaps are used to close mid maxillary defects.

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INTRODUCTION

Based on vascularisation, tissue flaps may be classified as either random (i.e. with a random pattern of blood vessels) or axial pattern flaps (i.e. incorporating at least one direct artery and vein). Transposition and interpolation random local flaps are square or rectangular in shape, are very versatile and are frequently used (Pavletic 2018a). They may consist of skin or mucosa or, in selected cases, they may be mucocutaneous (Culp *et al.* 2014, Pavletic 2018b). Transposition flaps are constructed by extending one of the wound margins while the interpolation flaps originate from a site close to the defect, thus requiring a bridging incision or a tubing procedure to reach the defect (Pavletic 2018a).

Rostral to mid maxillary defects in dogs, as a result of an *en bloc* tumour excision or a traumatic tissue loss, may be challenging to close. In addition, the reconstruction of these defects with a simple mucomucosal or mucocutaneous suture apposition may result in a cosmetic change, even if function is still preserved (Culp *et al.* 2014, Pavletic 2018b, Liptak & Lascelles 2022). Random mucosal rotating flaps for the closure of defects resulting from bilateral rostral maxillectomies have been reported by Withrow *et al.* (1985) and Schwarz & Withrow (1990). However, the technique and follow-up were not described in detail.

This retrospective study reports the outcomes and complications of the use of random mucosal transposition flaps (RMTFs)

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and interpolation flaps (RMIFs) for the closure of rostral to mid maxillary defects in a series of dogs.

MATERIALS AND METHODS

Medical record search and data extraction

In January 2020, two independent operators searched in the clinical database of the Veterinary Teaching Hospital of Grugliasco (Turin, Italy) of the University of Turin, among the cases referred from January 2000 to August 2019 using the following keywords: "incisivectomy", "maxillectomy" and "oral mucosal flap".

The inclusion criteria comprised complete medical and surgical records, including the reason for surgical intervention, a description of the technique adopted for the closure of the defect and the following complications.

The data retrieved included age, breed, sex and concomitance of other preoperative pathological conditions. For all dogs, preoperative examination included blood examinations (complete blood count and biochemistry) and a cardiologic evaluation. If the reason for surgery was oncologic, clinical staging included fine needle aspiration of the regional lymph node(s) and cytology, total body computed tomography (CT) or thoracic radiographs in three views, abdominal ultrasound and radiographs of the skull.

A written consent form was signed by the owners before treatment. All dogs underwent surgery in which either an RMTF or an RMIF from the labial and/or cheek region was used.

The flaps were retrospectively characterised, when possible, for length, width, length:width ratio and degree of rotation of the flaps in an attempt to correlate these factors with the surgical outcome. The measurements were based on surgical and histological reports and photographic documentation. When using surgical photographs, measurements were obtained by comparing the flap size with the dimension of surgical instruments.

Anaesthesia and patient preparation

Due to the long study period, different anaesthetic and analgesic protocols were adopted. After premedication and induction, general anaesthesia was maintained with halothane or isoflurane in oxygen. Antibiotic prophylaxis with cefazolin sodium (Cefazolina Dorom; Teva Pharma Italia, Milano, Italy) [20 mg/kg intravenously (iv)] was administered at anaesthesia induction and then every 90 minutes until completion of the surgery.

The hair was clipped on both the lip and cheek regions, and the dog was then positioned in dorsal recumbency with the mouth kept open by a canine mouth gag. The mouth was cleansed with 0.2% chlorhexidine gluconate solution (Sarkiala 2020). The surgical drapes were often fixed at the mucocutaneous margin of the upper lips to allow their manipulation during surgery. The mandible and the tongue were kept out of the surgical field by using an additional drape. A gauze tampon was placed in the pharynx to prevent blood aspiration (Anderson 2018).

Surgical procedure

The maxillectomy procedures were performed using an oscillating saw and/or an osteotome. The flap was harvested from the ipsilateral and/or contralateral labial and cheek mucosa, depending on the position of the defect and the availability of tissues. For the preparation of an RMTF, a border or a corner was shared with the defect. Two parallel (or slightly converging towards the apex of the flap) mucosal incisions were made with a small blade (n=15 or n=11), starting from the edge of the defect or in its proximity, parallel to the alveolar margin and to the mucocutaneous border of the lip and extending, if necessary, to the cheek. A third caudal transverse incision connected the two previous incisions (Fig 1). If an RMIF was planned, no margin of the defect was shared with the flap. During the RMTF and RMIF preparation, the loss of length derived from rotating the flap over the defect was considered. Furthermore, the flaps were designed to have a base wide enough to ensure tissue survival, especially in case of RMIFs, that generally had to be slightly longer than RMTFs.

After the flap was defined by the incisions, it was carefully undermined starting from the caudal margin towards its base, using fine Metzenbaum scissors. The plane of dissection was in the areolar layer immediately adjacent to the submucosa. Careful haemostasis was performed, avoiding the use of electrocautery in order to minimise tissue trauma. Stay sutures were applied on the free border of the flap to make its manipulation easier. After being completely elevated, the flap was transposed over the defect, directly (RMTF) or after performing a bridging incision (RMIF), which was directed rostrally to reach the defect (Fig 2). According to the most appropriate placement, based on the surgeon's perception, the mucosal surface of the flap was oral or became nasal (Fig 3). It was often useful to first place some single interrupted sutures at crucial points, evaluating how to completely cover the defect. The flap was then definitively sutured in place. A single layer was more often used; however, if feasible, two layers were applied. Interrupted sutures were applied using 3-0 to 4-0 polydioxanone (PDS: Ethicon, Somerville, New Jersey, USA). The donor site was left to heal by second intention in the majority of dogs.

In selected cases, if reinforcement appeared essential (i.e. in case of bilateral rostral maxillectomy), a double layer technique was used (Withrow *et al.* 1985, Schwarz & Withrow 1990). Two RMTFs were prepared, one from each side of the defect. The first flap was folded 180°, in a book fashion, so that its oral mucosa became nasal, and was sutured in place. The second flap was then rotated over the first one, apposing submucosa to submucosa, and sutured to the surrounding mucosa. Conversely, in case of very large defects, each flap was rotated to cover part of the defect, and sutured to each other and to the defect's edges (Fig 4A). In all cases, sutures were applied in a simple interrupted pattern, using 3-0 to 4-0 polydioxanone.

An oesophageal feeding tube was applied when considered appropriate.

Postoperative care and follow-up

All dogs were hospitalised; an Elizabethan collar was applied postoperatively. Broad-spectrum antibiotics were administered for 24 to 48 hours to the majority of the dogs and were empiri-

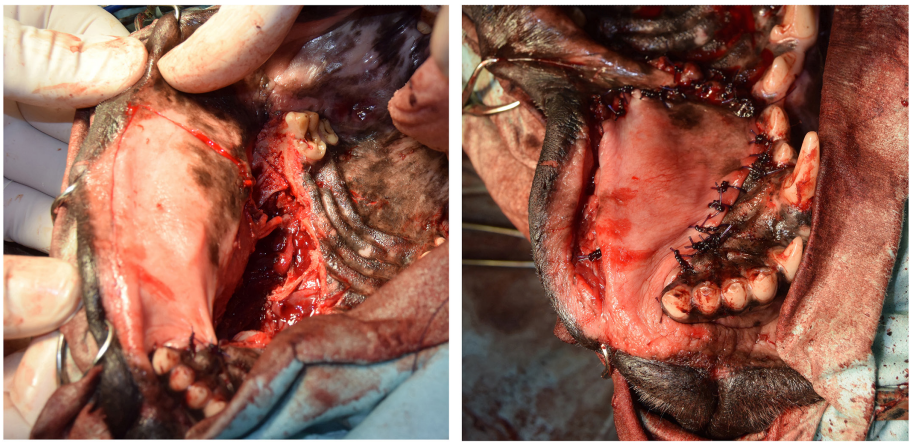

FIG 1. Dog 9. Creation of an RMTF for the closure of a left mid maxillary defect: (A) an RMTF is designed on the lip mucosa adjacent to a maxillary defect, with a rostral pedicle; (B) the flap is elevated, rotated on the defect and sutured in place with absorbable monofilament sutures in a single interrupted pattern; the flap's mucosal caudal and medial margins and the submucosal tissues of the lateral border were sutured in place in order to separate the oral and the nasal cavities. The donor site (internal lip/cheek) healed by second intention (A left, B right)

FIG 2. Dog 10. RMIF surgical technique: (A) a RMIF is designed on the lip mucosa caudal to a large rostral maxillary defect. In order to transpose the flap, a bridging incision is performed between the defect and the flap base (dashed line); (B) the flap is rotated on the defect and sutured in place. The donor area is left unsutured to heal by second intention; (C and D) clinical follow-up 21 days after surgery. Note that lip and cheek are not pulled in medially, and that the reconstruction technique did not alter the muzzle aspect (A top left, B top right, C bottom left, D bottom right)

cally protracted for up to 7 days in only a few of the older cases. Analgesia consisted of opioids (for a maximum of 3 days) and non-steroidal anti-inflammatory drugs (NSAIDs) (for a maximum of 7 days). Crystalloids were administered iv in the immediate postoperative period.

Soft food was offered orally on the first postoperative day unless an oesophageal tube had been inserted. The dogs were discharged after 2 to 5 days with oral medication (NSAIDs) along with the recommendation to use soft food and avoid chew toys for at least 1 month (Liptak & Lascelles 2022).

The dogs were reevaluated daily until discharge and then weekly until clinical healing. The viability of the flap was evaluated with a careful oral inspection, also paying attention to any potential occlusal trauma to the maxillary soft tissues caused by the mandibular teeth. Whenever possible, photographs were taken. Complications were considered minor if characterised by dehiscence without compromising flap viability, and major if flap necrosis occurred, requiring extensive surgical revision. In the follow-up, the dogs were checked for function (i.e. breathing, eating and drinking).

FIG 3. Dog 19. A left RMTF folded 180°, in a book fashion (outlined with a dashed line). Notice that the submucosa of the RMTF remains exposed to the oral cavity and, similarly to the donor area, is left to heal by second intention

RESULTS

Medical record search

Of the 193 cases found during the med, 32 cases were initially selected as an RMTF or an RMIF was used for reconstruction. Six cases were later discarded due to incomplete records regarding the follow-up after discharge. Twenty-six client-owned dogs referred to the Veterinary Teaching Hospital of Grugliasco (Turin, Italy) of the University of Turin from January 2000 to August 2019 were retrospectively included.

Case description

Of the 26 dogs included in this study, there were 10 mixed breed dogs, five Labrador retrievers, three golden retrievers and one each of the following breeds: poodle, West Highland white terrier, German shepherd, miniature schnauzer, standard schnauzer, American Staffordshire, Bernese mountain dog and hovawart. The mean bodyweight was 24.5 kg (range 8 to 45 kg). The mean age at presentation was 8.2 years (range 8 months to 14 years). There were 15 females (six entire, nine spayed) and 11 males (10 entire, one neutered).

The maxillary defects were the result of the excision of 10 oral malignant tumours (four squamous cell carcinomas, three melanomas, two fibrosarcomas and one osteosarcoma), 13 benign oral tumours [nine canine acanthomatous ameloblastomas and four peripheral odontogenic fibromas (POFs)], two dentigerous cysts and one chronic oronasal fistula as a result of a previous traumatic event. Complete data are reported in Table 1.

Surgical technique

Of the 26 dogs included, 23 had a single flap reconstruction as a first approach; in the remaining three dogs, two flaps were used. An RMTF was used in 12 dogs while an RMIF was used in five dogs; in the other nine dogs, this information, other than that a rotated mucosal flap was used, was not recorded. The donor site was left open to heal by second intention in 25 dogs.

Of the 23 defects reconstructed using a single flap, the procedure was performed following a bilateral rostral maxillectomy in eight dogs (dogs 3, 4, 6, 11, 12, 16, 17 and 20), an incisivectomy in eight dogs (dogs 2, 7, 8, 14, 15, 18, 19 and 21) and a unilateral rostral maxillectomy in four dogs (dogs 10, 13, 22 and 23). In dogs 12 and 19, the flap was transposed in a book fashion. A single flap was also used in two dogs which had a rostral/central maxillectomy (dogs 1 and 9). Dog 9, in particular, had a single RMTF created following an excision extending from the third incisor to the ipsilateral third premolar tooth and reaching the median sagittal plane. Dog 1 had a maxillectomy from the right third incisor tooth to the left fourth premolar tooth. A single RMIF was harvested from the right lip and cheek since the tis-

FIG 4. Dog 26. Reconstruction of a large rostral maxillary defect with the use of two RMTFs. (A) The flaps are created, rotated and sutured to the edges of the defect and to each other; (B) postoperative clinical aspect of the dog, with a cutaneous pence realised on the nasal skin (A left, B right)

Table 1. Clinical features of 26 dogs undergoing oral reconstruction with a random mucosal transposition/interpolation flap

Dog	Gender	Age (years)	Breed	Condition	Imaging	Procedure	Type and origin of flaps	RMTF *versus* RMIF
1	FS	4	Mixed breed	Dentigerous cyst	CT	Rostral/ central maxillectomy	Single, contralateral cheek	RMIF
2	F	7	German shepherd	Fibrosarcoma	X-rays+US	I	Single, ipsilateral lip	RMIF
3	M	14	Poodle	Malignant melanoma	X-rays+US	BRM	Single, ipsilateral cheek	No data
4	M	9	West Highland	CAA	X-rays+US	BRM	Single, ipsilateral lip/ cheek	No data
5	FS	6	Mixed breed	Traumatic avulsion	Skull X-rays	Avulsion wound revision	Single, ipsilateral lip	RMIF
6	FS	5.5	Miniature schnauzer	Malignant melanoma	CT	BRM	Single, ipsilateral cheek	RMIF
7	F	11	Mixed breed	POF	X-rays+US	I	Single, ipsilateral lip	No data
8	FS	7	Golden retriever	POF	CT	I	Single, ipsilateral lip	RMTF
9	FS	9	Labrador retriever	OSA	X-rays+US	Rostral/ central maxillectomy	Single, ipsilateral cheek	RMTF
10	FS	5	Golden retriever	CAA	CT	URM	Single, ipsilateral cheek	RMTF
11	F	8	Labrador retriever	Dentigerous cyst	CT	BRM	Single, ipsilateral lip	RMTF
12	M	3	Labrador retriever	CAA	X-rays+US	BRM	Single 180° folding, lip	RMTF
13	M	5	American Staffordshire	POF	CT	URM	Single, ipsilateral lip	RMTF
14	M	7	Bernese mountain dog	SCC	X-rays+US	I	Single, ipsilateral lip	No data
15	FS	14	Mixed breed	CAA	CT	I	Single, ipsilateral lip	RMTF
16	F	9	Mixed breed	CAA	X-rays+US	BRM	Single, ipsilateral lip/ cheek	No data
17	M	12	Mixed breed	SCC	X-rays+US	BRM	Single, ipsilateral lip/ cheek	No data
18	FS	6	Standard schnauzer	CAA	CT	I	Single, ipsilateral lip	RMTF
19	M	8	Mixed breed	CAA	CT	I	Single 180° folding, lip	RMTF
20	M	10	Howavart	Malignant melanoma	CT	BRM	Single, ipsilateral lip	RMTF
21	M	7	Labrador retriever	POF	CT	I	Single, ipsilateral lip	RMIF
22	M	12	Labrador retriever	CAA	X-rays+US	URM	Single, ipsilateral lip	RMTF
23	F	6.5	Mixed breed	CAA	X-rays+US	URM	Single, ipsilateral lip/ cheek	No data
24	FS	9	Mixed breed	Fibrosarcoma	X-rays+US	BRM	Double, overlapping technique, lip	RMTF
25	M	13	Mixed breed	SCC	X-rays+US	I	Double, lip	No data
26	F	0.8	Golden retriever	SCC	CT	BRM	Double, lip	RMTF

I Incisivectomy, BRM Bilateral rostral maxillectomy, URM Unilateral rostral maxillectomy, CAA Canine acanthomatous ameloblastoma, POF Peripheral odontogenic fibroma, SCC Oral squamous cell carcinoma, OSA Osteosarcoma; CT Full-body computer tomography scan, X-rays Three views of the thorax and skull radiographs, US Abdominal ultrasound, F Female, SF Spayed female, M Male, NM Neutered male

sues on the left side had been excised to achieve adequate tumour excision margins. In dog 5, a single RMTF was used to close a traumatic oronasal fistula located rostral to the incisor teeth. This dog had experienced an untreated lip avulsion (without any bone involvement) 2 months earlier. After refreshment of the fistula margins, the defect was primarily sutured; however, dehiscence occurred after 5 days. A single RMTF, originating from the lip mucosa lateral to the defect, was rotated approximately 120° to cover it. The flap (with the mucosa facing the oral cavity) was fixed with two horizontal mattress sutures looped around the incisors, the rest of the flap was sutured in a single interrupted pattern (Fig 5).

A double RMTF procedure was performed in three dogs (dogs 24, 25 and 26) to close rostral defects, two of which resulted from a bilateral rostral maxillectomy (dogs 24 and 26) and one from an incisivectomy (dog 25). In dogs 25 and 26, the two RMTFs were sutured together, one rostral to the other, to cover the entire area (Fig 4A). In dog 24, two overlapping flaps were used.

FIG 5. Dog 5. (A) Chronic oronasal fistula due to an untreated traumatic lip avulsion; (B) surgical revision after an unsuccessful previous primary closure; an RMIF was designed to cover the defect; (C) the flap is sutured in place with two mattress sutures (the suture material is passed between the roots of the upper incisor teeth up to the palate, using 18-gauge needles as guide) and simple interrupted sutures; (D) clinical follow-up on day 25 (A top left, B top right, C bottom left, D bottom right)

The flap was ipsilateral to the defect in all cases except in dog 1, as the majority of the ipsilateral mucosa had been excised during the maxillectomy procedure, and except in the revision procedure of dog 20, as the ipsilateral tissues were no longer available.

In three dogs (dogs 1, 6, and 26) an elliptical portion of the dorsal skin of the nasal region was excised in an attempt to limit nose dropping following extensive rostral maxillectomies (Fig. 4b). Dog 1 also required the application of nasal stents to allow re-epithelisation of the nasal openings.

Flap length, width, length: width ratio and degree of flap rotation were available for 15 dogs (Table 2). For dog 16, data were available for both the first procedure and for the revision procedures. The mean and median lengths of the flaps were 6.0 and 5.5 cm, respectively (range 3.0 to 12.0 cm). The mean and median widths of the flaps were 2.8 and 3.0 cm, respectively (range 1.6 to 4.3 cm). The length: width ratio varied from 1.0 to 3.9, with a mean and median of 2.19 and 2.25, respectively. The degree of rotation of the flaps varied from a minimum of 45° to a maximum of 160° (mean 103°, median 87.5°).

No notable intraoperative complications occurred in any of the dogs. Bleeding was effectively controlled during surgery without the occurrence of any life-threatening conditions.

Postoperative care

None of the dogs required intensive postoperative care. All the dogs started to eat independently within 48 hours, except for those in which an oesophageal tube had been inserted (dogs 1, 5 and 9). The tube was removed a week later in dogs 1 and 5. Since dog 9 had surgical complications resulting in feeding problems, the esophagostomy tube was kept in place for 1 month. The median discharge time was 3 days (range 2 to 5 days). Weekly clinical examinations were carried out for a median of 32 days (range 28 to 102 days) based on the progression of the healing process; subsequently clinical follow-ups were based on the nature of the original disease. The surgical margins were histologically confirmed to be clean in 23 out of 25 lesions. Cases 18 and 19 had infiltrated margins at histology.

Postoperative complications

Three dogs (dogs 3, 12 and 19) (11.5%) experienced minor complications consisting of flap dehiscence, and three dogs (dogs 1, 9 and 20) (11.5%) developed extensive flap necrosis (Table 3). The overall median time for the occurrence of the complications was 5.6 days (range 3 to 8 days). All required surgical revision.

In dogs 3 and 12, partial dehiscence occurred 7 days after surgery, resulting in an oronasal communication. In dog 3, the flap was resutured in place and in dog 12, due to flap retraction, a new mucoperiosteal flap was elevated from the palate, rotated by 90° and sutured to the refreshed margins, including those of the previous RMTF. Dog 19 experienced mild dehiscence at the caudal edge of the flap 4 days after the incisivectomy procedure

Table 2. Flap length, width, length:width ratio and degree of flap rotation

Dog	Length (cm)	Width (cm)	Length:width ratio	Degree of rotation
1	12	4	3	60°
2	5	2.5	2	75°
5	3.7	1.6	2.3	120°
6	9.8	2.5	3.9	120°
8	6	2	3	80°
9	7.5	3	2.5	45°
10	6	3	2	160°
11	7.7	3.5	2.2	60°
12	7	3	2.3	90°
15	3	1.8	2.6	90°
18	5	3	1.6	90°
19	4.3	3	1.4	90°
20	7.5	3	2.5	90°
20 (revision surgery)	5	2	2.5	90°
21	4	3	1.3	50°
22	4.5	4.3	1	90°

(Fig 6); 3 days later, the flap was surgically revised, with a successful primary closure.

Dog 1 had nearly 80% flap necrosis 3 days after surgery, involving the portion of the flap that was bent around the canine tooth. Revision surgery was performed with debridement and final closure involving simple apposition of the defect edges to the remaining undermined ipsilateral lip mucosa. Four days later, dehiscence reoccurred, with apparent entire tissue viability. Definitive closure was achieved following resuturing of the edges of the defect.

Dog 9 developed necrosis of the caudal 40% of the flap with the development of an oronasal communication 8 days after surgery. As the dog had an oesophageal feeding tube in place, it was decided to wait for the histopathological evaluation before revision surgery, performed 1 month later. The communication involved the central part of the previous defect, with extension beyond the sagittal plane. For its closure, a new single RMTF was harvested from the cheek. Unfortunately, even this new flap suffered partial necrosis 7 days later, with the development of an oronasal communication of approximately 2.5 cm in the middle palate. A second surgical revision initially refused by the owner, was performed 2 months later. The defect was permanently and successfully closed with an additional single RMTF originating from the cheek.

Patient 20 developed necrosis of the caudal half of the flap. Signs of flap vascular failure were visible 3 days after surgery (Fig 7). Five days later, a 2.5 cm×3 cm oronasal communication was evident in the most rostral part of the palate. The defect was closed with a single RMTF developed from the contralateral lip, with the base rostrolateral to the defect, extending caudally. The flap was medially rotated by 90° and sutured on the debrided edges of the oronasal communication (Fig 8). Seven days later, necrosis of the rostral part of the new flap occurred, leading to a smaller oronasal opening (1.5 cm×1 cm). Another revision surgery was performed, with debridement of the margins and primary suture. The defect then healed with no additional complications.

No dogs treated with the double RMTF technique (dogs 24, 25 and 26) experienced postoperative complications.

No dogs experienced signs of clinically detectable occlusal trauma by the mandibular teeth except for dog 1. After definitive revision, entrapment of the upper lip by the ipsilateral mandibular canine tooth developed. Nevertheless, this complication did not cause any particular discomfort or loss of functionality, as declared by the owners.

DISCUSSION

Large rostral and mid maxillary defects, especially those derived from the *en bloc* excision of bone-infiltrating tumours, may be challenging to close. This case series shows that these defects may be covered with a random rotating mucosal flap composed of labial or cheek mucosa and obtained just lateral to and/or caudal to the defect.

These regions receive rich vascularisation derived from both the facial and the infraorbital arteries (Hanai 1964, Bezuidenhout 2013). The facial artery arises from the external carotid artery near the angle of the mandible. The entire cheek is vascularised by its terminal branches, the superior labial artery, the angularis oris artery and the inferior labial artery, branching from the main vessel rostral to the masseter muscle (Yates *et al.* 2007, Bezuidenhout 2013, Losinski *et al.* 2015). A recent paper has described the vascularisation of the area, highlighting that the rostral portion of the upper lip is vascularised by the infraorbital artery and its terminal branches (Doyle & Degner 2019). The infraorbital artery is the main continuation of the maxillary artery and anastomoses with the superior labial artery, thus creating a large muscolomucosal plexus which allows the design of a peninsular superior labial muscolomucosal flap, the base of which is caudal, at the level of the labial commissure. It should be noted that an important peculiarity of this region is the double vascularisation which permits the mucosa to be independent of the overlying skin (Bryant *et al.* 2003, Doyle & Degner 2019). This abundant vascularisation permits both a great healing potential and a low infection rate (Shatty & Le 2020).

The donor site was left unsutured in all cases but one and was allowed to heal by second intention. It healed in all the dogs

Table 3. Postoperative complications

Dog	Technique	Other procedures	Complication	Time to complication	Revision	Second complication	Time to second complication	Second revision
1	Single RMIF, contralateral cheek	Nasal stenting; pence; esophagostomy tube	80% flap necrosis	3 days	Advancement flap	Dehiscence due to tension	4 days	Direct suture
3	Single RMTF, ipsilateral cheek		Dehiscence due to tension	7 days	Direct suture	No		
9	Single RMTF, ipsilateral cheek	Esophagostomy tube	40% flap necrosis	8 days	Single RMTF, ipsilateral cheek	Dehiscence due to tension	7 days	Single RMTF, ipsilateral cheek
	Single 180° folded RMTF, lip		2 cm dehiscence due to tension	7 days	Palatal mucoperiosteal flap	No		
19	Single 180° folded RMTF, lip		Dehiscence due to tension	4 days	Direct suture	No		
20	Single RMTF, ipsilateral cheek		50% necrosis	3 days	Single RMTF, contralateral cheek	50% flap necrosis	7 days	Direct suture

FIG 6. Dog 19. Dehiscence at the caudal edge of a left RMTF folded 180° in book fashion, 7 days after surgery. Note the initial re-epithelisation of both the donor site and the flap submucosa

within a maximum of 14 days without any interference with both feeding and drinking activities. This technique has the advantage of reducing the risk of occlusal trauma by the mandibular teeth, without causing important physiognomic changes as the cheek/lip is not or is only minimally pulled towards the defect (Figs 2C,D, 4B, 9 and 10). After the first period of healing, the flap becomes more fibrous, leading to greater stability. Moreover, any movement of the flaps initially visible during normal breathing becomes imperceptible a few days after surgery.

The majority of the dogs in this retrospective study (20 of 26, 77%) did not develop any postoperative complications. Altogether, six dogs (23%) developed an oronasal communication due to either flap dehiscence or necrosis.

Simple dehiscence has also been described in the standard advancement flap technique, with a reported incidence of 7% to 33% (Verstraete 2005, Culp *et al*. 2014). It is generally due to excessive tension, irregular edges of the defect or movement of the flap (especially during breathing) (Moores 2009); other factors include wound infection, poor suture technique, and lingual function, potentially leading to suture loosening. Some of these critical aspects were present in the three dogs suffering from this minor complication. The revision surgery was successful in all three dogs at the first attempt.

Flap necrosis due to vascular failure was observed in three dogs. Ischemia is defined as a reduction/interruption of the vascular supply up to tissue necrosis, therefore causing partial or complete failure of the reconstructive procedure (Pavletic 2018a). Potential causes are vascular occlusion (which may be due to excessive tension of the flap and excessive torsion of its pivot point) and/or excessive length in relation to the base of the flap. Normal tissue vascularisation can also be affected by incorrect tissue manipulation and excessive trauma. General surgical principles, such as gentle tissue handling, preservation of the local vascular supply, the creation of flaps with a base wider than the apex without exceeding in length, avoidance of excessive twisting of the flap at its pivot point, avoidance of tension at the suture line, and

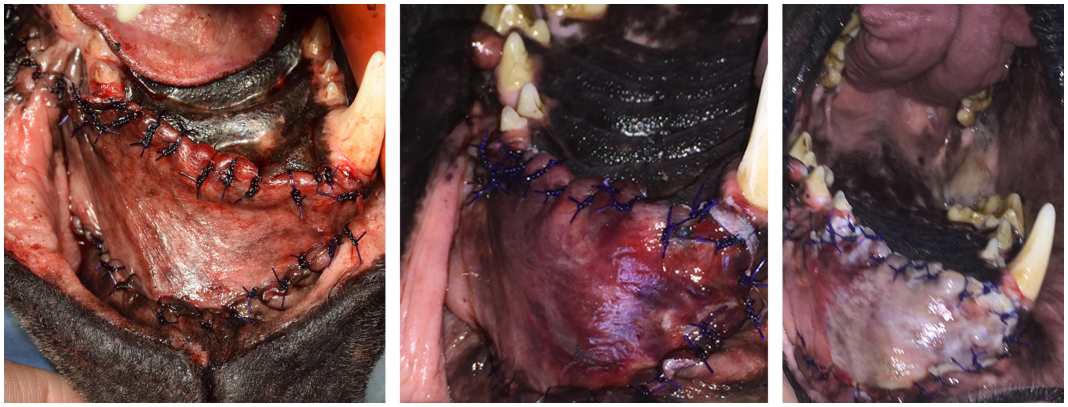

FIG 7. Dog 20. (A) Closure of the defect with an RMTF, immediately after BRM; (B) clinical follow-up 2 days later; (C) clinical follow-up 3 days after surgery; note the whitish devascularised necrotic area with evident demarcation from the healthy tissue (A left, B middle, C right)

elimination of any bony prominence interfering with the placement of the flap, should be followed. In the dogs in this case series, this complication was definitely observed from 2 to 5 days after surgery. However, it could be suspected as early as 24 hours after the procedure, due to discoloration of the distal portion of the flap, which turned from dark red to blue after 3 days and to a well demarcated whitish colour soon thereafter (Fig 7) (Massari & Buracco 2016). The flap of dog 1 probably necrotised and failed because of its high length:width ratio and substantial torsion on its fulcrum around the canine tooth. In the other two cases (dogs 9 and 20), a possible explanation was the excessive length of the flap in relation to its base.

The outcome of the repair of rostral maxillary defects using an RMTF or an RMIF was good, despite the fact that three cases developed flap necrosis and three cases showed minor dehiscence. Even if only three cases were treated with the double RMTF technique, it is interesting to note that none of these dogs suffered from postoperative complications. After bilateral rostral maxillectomy, the use of two flaps in an overlapped fashion has the advantage of providing thicker coverage capable of resisting movement caused by the airflow through the nasal cavities and feeding activity. However, this procedure is not always possible. If two flaps are utilised, each one used to cover part of the defect, they can be rotated, as described here, or advanced and sutured together in a T-shape fashion, as previously described (Liptak & Lascelles 2022). The use of an RMTF and an RMIF to close mid maxillary defects should be additionally evaluated; in fact, both the rostral/central maxillectomies included in this case series experienced extensive flap necrosis, requiring two surgical revisions. Other reconstruction techniques, e.g. angularis oris axial pattern flaps (Bryant *et al.* 2003) or mucosal advancement flaps (Liptak & Lascelles 2022), can be used instead.

In an attempt to obtain a better functional (i.e. breathing) outcome and avoid excessive nose dropping, an elliptical wedge of skin from the nasal dorsal aspect was excised in three dogs which underwent extensive rostral maxillectomy. However, a more efficient alternative to accomplish this result is a cantilever suture in which a buried 0 UPS monofilament polypropylene mattress suture is passed through the maxillary bone immediately ventral to the nasal bone and the nasal planum (Pavletic 2018c).

Regardless of the surgery undertaken, the majority of the dogs of this case series were able to eat independently. An oesophageal feeding tube was utilised when complications appeared more likely (in fact, in two of these three cases, a flap failure occurred). Feeding the animals bypassing the mouth at least in the first days after surgery may favour the healing process, also avoiding the deposit of food at the level of the sutures. Therefore, given that the placement of an oesophageal feeding tube is easy and presents few complications, it should be prudentially recommended following large excisions or when the vitality of the flaps could be a concern (Kahn 2007).

There were limitations to this study, mainly related to its retrospective nature. In fact, not all the medical records were completed using the same format, and a long-term follow-up was not always available. In addition, photographic records were not available for all the surgical procedures, and it was therefore not possible to calculate flap size, the length:width ratio and the rotation angle for all the flaps. Also, it was not specified in the medical record of nine cases whether an RMTF or an RMIF was performed. However, the bridging incision did not appear to play any significant role in the success rate of the procedure.

A preoperative CT scan is recommended for staging purposes for oncologic patients. A CT scan is important for evaluating the real extension of the tumour and planning adequate tumour excision and reconstruction. Furthermore, to assist the surgical planning, models of the skull can be printed three-dimensionally using the CT images (Culp *et al.* 2014, Winer *et al.* 2017, Huang *et al.* 2022). In this case series, CT was not utilised in 14 of the 26 dogs as the equipment was not available at the Authors' institution at the time or because of owner preference. This important shortcoming may have played a role in surgical planning, particularly in case of benign lesions that could have been treated more conservatively. Dog 1 (an 8 kg dog) was affected by a large odontogenic cyst with extensive bone lysis, involving both the palate and the rostral maxilla (size of the lesion 3.9×2.3 cm at CT). A previous biopsy was not diagnostic, and a rostral/central maxillectomy was then performed. Other treatment options for a dentigerous cyst could have included extraction of the unerupted teeth and other potentially involved teeth, and cystic lining excision by means of lateral maxillary/palatal fenestration, and/or a

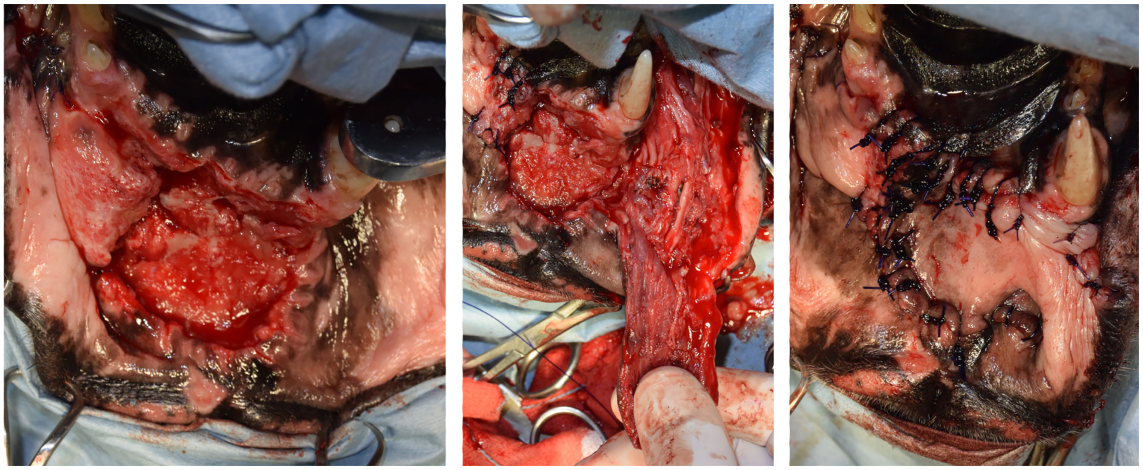

FIG 8. Dog 20, revision surgery. (A) Oronasal communication 5 days after the first surgery; the necrotic areas of the flap are removed; (B) creation of a new RMTF from the contralateral lip; (C) the defect is closed by suturing the flap in position (A left, B middle, C right)

FIG 9. Dog 23. One-year follow-up after URM, showing complete healing of the surgical site

marsupialisation procedure, which has recently been reported for the treatment of large periapical cysts in dogs (Kortegaard *et al*. 2018). The successful management of an extensive mandibular dentigerous cyst with extraction of a few teeth and partial excision of the cystic lining has also been described in another dog (Honzelka *et al*. 2014). The second odontogenic cyst (dog 11), diagnosed as such only after its en bloc excision, had unfortunately previously been histologically diagnosed as a squamous cell carcinoma based on a biopsy. The four POF cases were treated by either a limited incisivectomy (dogs 7, 8 and 21), or a limited unilateral rostral maxillectomy (dog 13), based on the clinical extension of the lesions (Murphy *et al*. 2020, Liptak & Lascelles 2022). Normally, a small POF can be treated simply by extraction of the affected tooth/teeth with minimal alveolar margin removal (Murphy *et al*. 2020).

Finally, even if this was not a comparative study between the RMTF/RMIF technique, and other surgical procedures, it may be concluded that the use of random mucosal rotating flaps represents a valid option for the reconstruction of rostral maxillary defects in dogs. This technique may also guarantee an early recovery of general functions in the majority of cases, i.e. feeding, drinking and breathing. On the other hand, the use of RMTFs and RMIFs for mid maxillary defects showed significant drawbacks, and it should be chosen with caution. As complications may occur, this should be thoroughly discussed with the owners in advance.

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Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

Author contributions

M. Carroll: Conceptualization (equal); data curation (equal); investigation (equal); methodology (equal); project administration (equal). **E. Morello:** Data curation (equal); methodology (equal). **M. Olimpo:** Conceptualization (equal); data curation (equal); methodology (equal). **D. Giacobino:** Data curation (supporting); formal analysis (supporting); methodology (equal). **P. Buracco:** Conceptualization (equal); data curation (equal); formal analysis (equal); investigation (equal); meth-

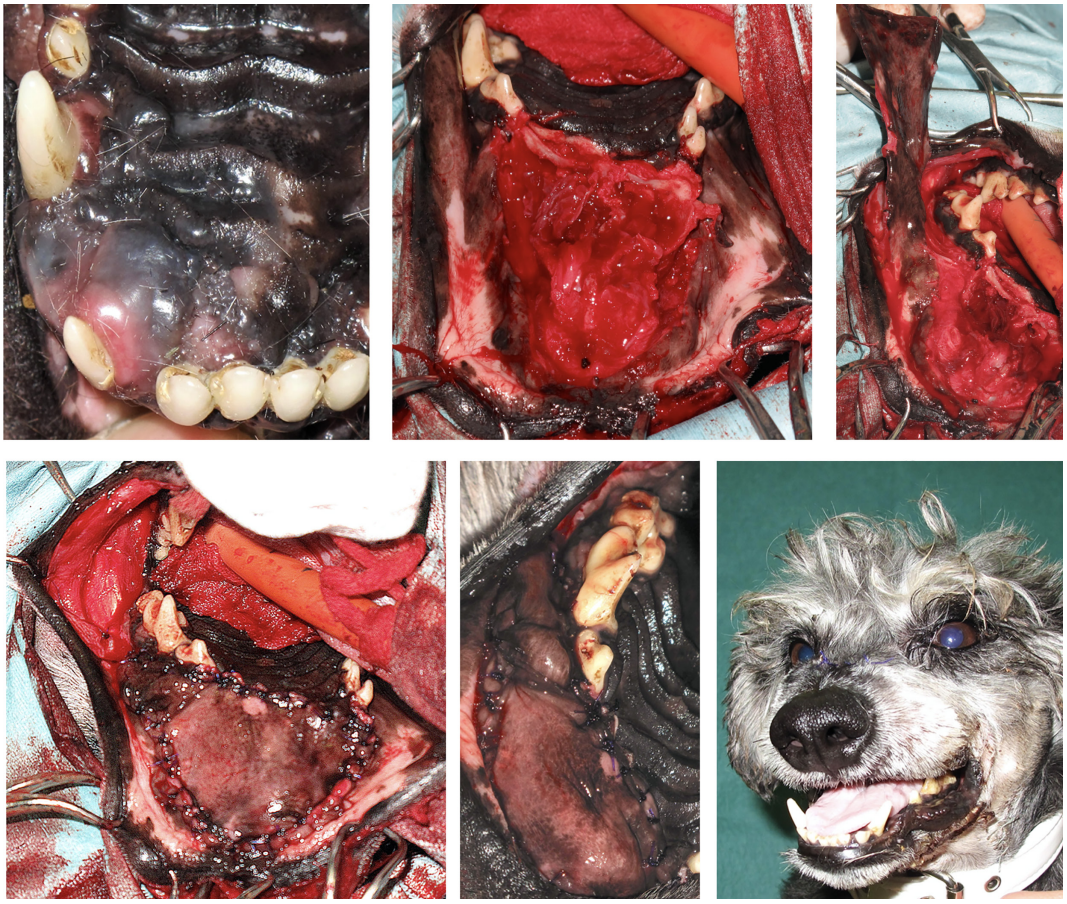

FIG 10. Dog 6. (A) Clinical aspect of an oral melanoma; (B) the defect created after BRM; (C) preparation and elevation of the left RMIF; (D) aspect of the flap sutured in place (the donor site is left unsutured); (E and F) clinical follow-up on day 9 (A top left, B top middle, C top right, D bottom left, E bottom middle, F bottom right)

odology (equal); project administration (equal). **E. Ferraris:** Conceptualization (equal); data curation (equal); investigation (equal); methodology (equal); project administration (equal).

Ethical statement

The study does not fall within the application areas of Italian Legislative Decree 26/2014 which governs the protection of animals used for scientific or educational purposes. Good Clinical Practice guidelines for perioperative standard-of-care management of spontaneously sick dogs (including analgesia) were observed and a written consent form was signed by the owners of dogs before any clinical, diagnostic and surgical manoeuvers.

Data availability statement

Authors declare that data associated with this paper are accessible and available.

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