PAPER

# Superficial temporal axial pattern flap for facial reconstruction of skin defects in dogs and cats

B. de la Puerta [1,*], P. Buracco [†], J. Ladlow [‡], T. Emmerson [*], S. Del Magno [§], E. Field [¶] and S. Baines [‖]

[*]North Downs Specialist Referrals, The Friesian Buildings 3 and 4, The Brewer Street, Dairy Business Park, Bletchingley RH1 4QP, UK
[†]Department of Veterinary Science, University of Turin, Largo Paolo Braccini, 2 10095 Grugliasco, TO, Italy
[‡]Hamilton Specialist Referrals, Cressex Business Park, Unit 5, Halifax Road, High Wycombe, Buckinghamshire HP12 3SD, UK
[§]Department of Veterinary Medical Sciences, University of Bologna, via Tolara di Sopra 50, 40064 Ozzano dell'Emilia, BO, Italy
[¶]Highcroft Veterinary Referrals, 615 Wells Road, Bristol BS14 9BE, UK
[‖]Willows Veterinary Centre and Referral Service, Highlands Road, Shirley, Solihull B90 4NH, UK

[1]Corresponding author email: bpuerta@ndsr.co.uk

**Objectives:** Report the use, complications and outcome of the superficial temporal axial pattern flap (STA) when used for closure of skin defects localised to the maxillofacial region in dogs and cats.

**Materials and Methods:** Multi-centre retrospective cohort study. Medical records of dogs and cats treated with a STA flap for closure of skin defects were reviewed. Information regarding signalment, reason for axial pattern flap use, flap size, flap healing, postoperative complications including need for surgical revision and overall outcome were collected.

**Results:** Nineteen patients were included: nine dogs and 10 cats. Indications for the STA flap included closure of defects following excision of tumours (18/19, 94.7%) and fungal granuloma resection (1/19, 5.2%). 100% flap survival occurred in 17 of 19 flaps (89.4%). Postoperative complications occurred in eight of 19 flaps (42.1%). A major complication of full thickness partial necrosis of the flap occurred in one of 19 cases (5.2%), where the flap length exceeded recommended guidelines. Minor complications related to the flap were seen in four of 19 cases (21%). This included partial thickness flap necrosis, flap oedema and wound discharge. Complications related to the location of surgery (5/19, 26.3%) included mild ectropion, mild exposure of the eye, reduced ability to blink and subcutaneous emphysema.

**Clinical Significance:** The STA flap is a good option for closure of a skin defect localised to the maxillofacial region. STA flaps were associated with a high percentage of survival and a low incidence of major complications.

*Journal of Small Animal Practice* (2021), 1–8
DOI: 10.1111/jsap.13384

Accepted: 15 May 2021

## INTRODUCTION

Cutaneous maxillofacial defects can result from oncological surgery, trauma, radiation dermatitis, or failure of a previous reconstructive technique (Laing 1990, Probst 1990, Fahie & Smith 1999). Repair of these defects can be challenging due to the relative immobility and lack of redundant skin in this region compared with the occipital region and trunk (Fahie & Smith 1997). Reconstructive techniques that can be used for closure of maxillofacial defects include subdermal plexus flaps, labial advancement flaps, buccal rotation techniques, tissue expanders, microvascular transfer of musculocutaneous free flaps (Pavletic 2010a, Pavletic 2010b) and axial pattern flaps (Degner 2007, Losinski *et al.* 2015, Proot *et al.* 2019). Cosmetic or functional



JSAP JOURNAL OF SMALL ANIMAL PRACTICE

disturbances may result if the wound heals by second intention or a local subdermal flap is used (Fahie & Smith 1997). Axial pattern flaps have increased perfusion compared with subdermal plexus flaps as they incorporate a direct cutaneous artery and vein at the flap base (Pavletic 2010b). This enhanced vascular supply allows formation and transfer of a relatively large flap, when compared to subdermal plexus flaps, for single staged reconstruction (Fahie & Smith 1999). Axial pattern flap options for maxillofacial reconstruction include superficial temporal flap (STA), angularis oris flap, caudal auricular axial pattern flap and omocervical axial pattern flap (Fahie & Smith 1997, Fahie & Smith 1999, Yates *et al*. 2007, Pavletic 2010a, Losinski *et al*. 2015). Although many axial pattern flaps have been described, the clinical outcome for many is not well reported. The caudal auricular axial pattern flap has been shown to be associated with a high rate of complications, with optimal wound healing occurring in only 31% of dogs and 50% of cats in one report (Proot *et al*. 2019). Clinical outcomes for the angularis oris axial pattern flap are limited but in 10 reported cases only two experienced a minor necrosis of the flap (Yates *et al*. 2007, Losinski *et al*. 2015). The use of the omocervical axial pattern flap to close defects of the maxillofacial region would often include extending the flap to the contralateral angiosome, thus increasing the risk of complications (Degner 2007).

The superficial temporal artery supplies the skin of the temporal region and frontalis muscle. The frontalis muscle is a thin muscle located superficial to the temporalis muscle which extends cranially and rostrally from the rostral border of the scutulum to the forehead. An axial pattern flap based on the superficial temporal artery has been used for reconstruction surgery localised to the maxillofacial region (Fahie & Smith 1997, Fahie & Smith 1999).

There is limited published information regarding the clinical use of the superficial temporal axial pattern flap. The available publications include two experimental studies (Fahie & Smith 1997, Fahie & Smith 1999), which included its clinical use in one dog and two case reports in which the flap was used in one dog and one cat (Lester & Pratschke 2003, Field *et al*. 2015). In these three clinical cases no complications were reported, with good cosmetic outcome.

The purpose of this retrospective study was to describe the use of the superficial temporal axial pattern flap in a larger cohort of clinical cases and report the frequency of complications and the overall outcome after using this flap for the reconstruction of maxillofacial defects in dogs and cats. We hypothesised that if the limits of the angiosome as described by Fahie & Smith (1997) and Fahie & Smith (1999) are respected the complications would be low and the survival of the flap would be acceptable, but the complication rate would be higher for flaps larger than the described angiosome.

## MATERIALS AND METHODS

This study was approved by the Association for Veterinary Soft Tissue Surgeons (AVSTS) Research Cooperative (ARC) and the Animal Health Trust (UK) Clinical Research Ethics Committee.

Members of AVSTS were invited to participate via the ARC mailing list and the medical records of dogs and cats that were treated with a superficial temporal axial pattern flap for treatment of skin defects between 2004 and 2020 were reviewed. Animals were included in the study if the medical records were complete with sufficient descriptions of the flap dimensions and characteristics to allow the outcome to be reliably assessed for a minimum period of 2 weeks post surgery.

Four different institutions participated in this study, for each institution one operator searched their medical records. Medical records were searched using different software, for the following keywords: axial pattern flap, superficial temporal and facial reconstruction. In three institutions the surgical case logs of each author were searched using Excel (Microsoft Corporation), the fourth institution used their clinical database, Provet Cloud (Three Plus Group).

The following information was collected from the medical records and photographs of the cases: signalment, location of the skin defect, cause of the skin defect, histological diagnosis, time between injury and skin reconstruction (if applicable), flap dimensions (length and width), anatomic landmarks used, use of surgical drains or bandages, preoperative and postoperative antimicrobial administration, postoperative analgesia, preoperative and postoperative chemotherapy administration, oncological outcome (if applicable), presence and type of complications, flap outcome and follow-up time. Flap dimensions were based on an approximate percentage of the flap used in relation to the total length and width described by Fahie & Smith (1997) and Fahie & Smith (1999). Complications were defined as minor if they were managed conservatively and major if they required a further surgical procedure (Emmerson *et al*. 2019).

### Surgical procedures

Patients were anaesthetised and positioned in ventral recumbency. The temporal region was clipped and prepared aseptically. Flaps were raised using anatomical landmarks as previously described (Fahie & Smith 1997, Fahie & Smith 1999). In summary, the landmarks for the base of the superficial temporal flap were the caudal aspect of the zygomatic arch caudally and lateral orbital rim rostrally. The flap width was limited by the eye rostrally and the ear caudally and was therefore equivalent to the length of the zygomatic arch. The recommended maximum length of the flap was to the mid dorsal orbital rim of the contralateral eye although the actual length of the flap varied between cases depending on the length needed to close the defect; in three cases this limit was extended to the contralateral zygomatic arch (Fig 1, 2a). The skin was incised following the described landmarks (Fig 2c) and the thin frontalis muscle was identified superficial to the fascia of the temporalis muscle. The flap was carefully elevated deep to the frontalis muscle towards the flap base (Fig 2d). The flap was transposed as required to reach the recipient site (Fig 2e). In some cases, in an attempt to achieve gross wide resection, enucleation of the eye was performed. The donor site was closed routinely (Fig 2f).

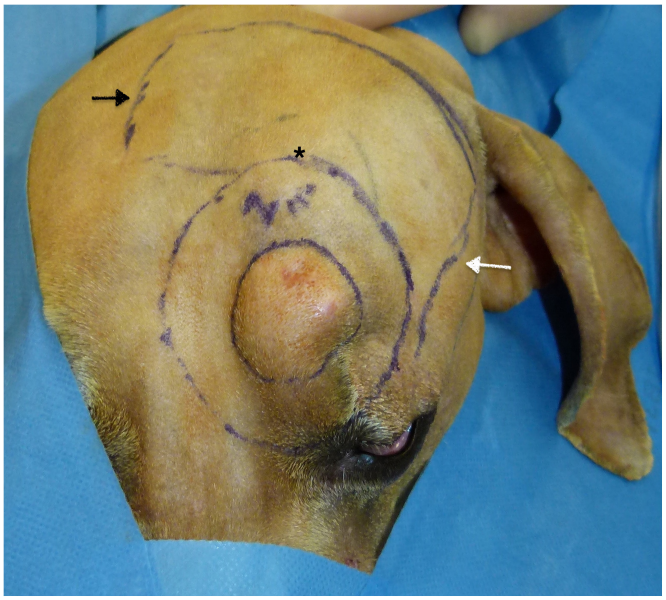

**FIG 1. Frontal view of a 5-year-old golden retriever with a left supraorbital mast cell tumour. A 2 cm lateral margin as well as the angiosome of the flap was drawn. The length of the flap extends past midline but does no reach the maximum length of the mid dorsal orbital rim of the contralateral globe (black arrow). The zygomatic arch has been drawn. Note the extension of the base of the flap from the lateral orbit to the base of the pinna, just dorsal to the zygomatic arch (white arrow). In this case the tumours lateral margin minimally encroaches into the width of the flap (*)**

## RESULTS

Twenty patients were identified for the study, of which 19 met the inclusion criteria. One dog was excluded from this study as information regarding the dimensions of the flap was not available. The superficial temporal flap was used in nine dogs (Table 1) and 10 cats (Table 2).

## DOGS

### Signalment

The median age of the nine dogs was 9.9 years (1–17 years). Dog breeds included were golden retriever (two), Labrador (two), Staffordshire bull terrier (one) and miniature pinscher (one), in addition to three mixed breed dogs. There were six neutered male dogs, two female dogs (one entire and one neutered) and in one dog the sex was not recorded.

### Flap indications and characteristics

The only indication for using the superficial temporal flap in dogs was closure of a surgical defect after tumour resection localised to the maxillofacial region. Tumour types were mast cell tumour (n=3), low-grade soft tissue sarcoma (STS) (n=1), intermediate grade STS (n=1), myxosarcoma (n=1), melanoma (n=1), fibrosarcoma (n=1) and osteosarcoma (n=1). Closure of the defects was performed at the time of surgical resection in eight of the nine dogs. The location of the tumours were upper eyelid (n=2), frontotemporal region (n=4), medial canthus (n=1), nasofrontal region (n=1) and maxilla (n=1).

The surgery was performed by an ECVS Diplomate in eight out of nine dogs; in one dog the surgery was performed by an ECVS resident. The widths of the superficial temporal axial pattern flaps compared with the maximum reported dimensions were 100% in seven dogs, 70% in one dog and 50% in one dog. The lengths of the superficial temporal axial pattern flaps compared with the maximum reported dimensions were 150% in one dog with the flap extending to the contralateral zygomatic arch, 100% in two dogs, 80% in three dogs, 70% in two dogs and 50% in one dog.

Enucleation was performed in three dogs to achieve wide margins: one dog with a mast cell tumour localised to the upper eye lid, one dog with an STS localised in the nasofrontal region and one dog with an osteosarcoma arising from the maxillary bone.

### Preoperative and postoperative care

Nine dogs received perioperative antibiotics with one single dose of 20 mg/kg iv cefuroxime (Zinacef; Glasco Smith Kline) was administered 30 minutes before first incision. Two dogs had postoperative antibiotics; 20 mg/kg amoxicillin/clavulanic acid (Synulox; Zoetis) twice a day per os (PO) for 7 days. No local anaesthetic techniques were used. No active or passive suction drains were used and no bandages were used in the postoperative period. The dog diagnosed with an STS received adjunctive postoperative metronomic chemotherapy, which consisted of 15 mg/m$^2$ cyclophosphamide (reformulated by The Specials Laboratory) once a day PO and 5 mg/kg firocoxib (Previcox; Boehringer Ingelheim) once a day PO, both medications were administered for 6 months.

### Outcome and complications

Flap survival was 100% in eight of nine dogs, with 10% partial thickness necrosis in one dog. No dog had major complications needing revision surgery and five dogs had seven minor complications (55.5%) (Table 1). One dog (11.1%) being treated for a maxillary osteosarcoma, with a flap extending to the base of the contralateral zygomatic arch, suffered a 10% partial thickness necrosis of the tip of the flap. The partial necrosis was treated conservatively and the wound healed by second intention (Fig 3a, b). Two dogs (22.2%) had postoperative wound discharge and empiric therapy with 20 mg/kg cephalexin (Rilexine; Virbac) twice a day PO for 10 days which resulted in resolution of the problem. No culture was performed in these cases. One dog (11.1%) developed oedema that was treated with 0.5 mg/kg prednisolone (Prednidale; Dechra) for once a day PO for 5 days, followed by a tapering dose. The oedema resolved after 12 days with no further complications. Three dogs (33.3%) had complications associated with the periorbital location of the flap. One dog with a mast cell tumour localised to the upper eye lid, in which the flap was sutured directly to the conjunctiva following eye lid resection, suffered a mild ectropion and reduced ability to blink and this dog was treated with eye lubrication (Lubrithal; Dechra) three times a day for

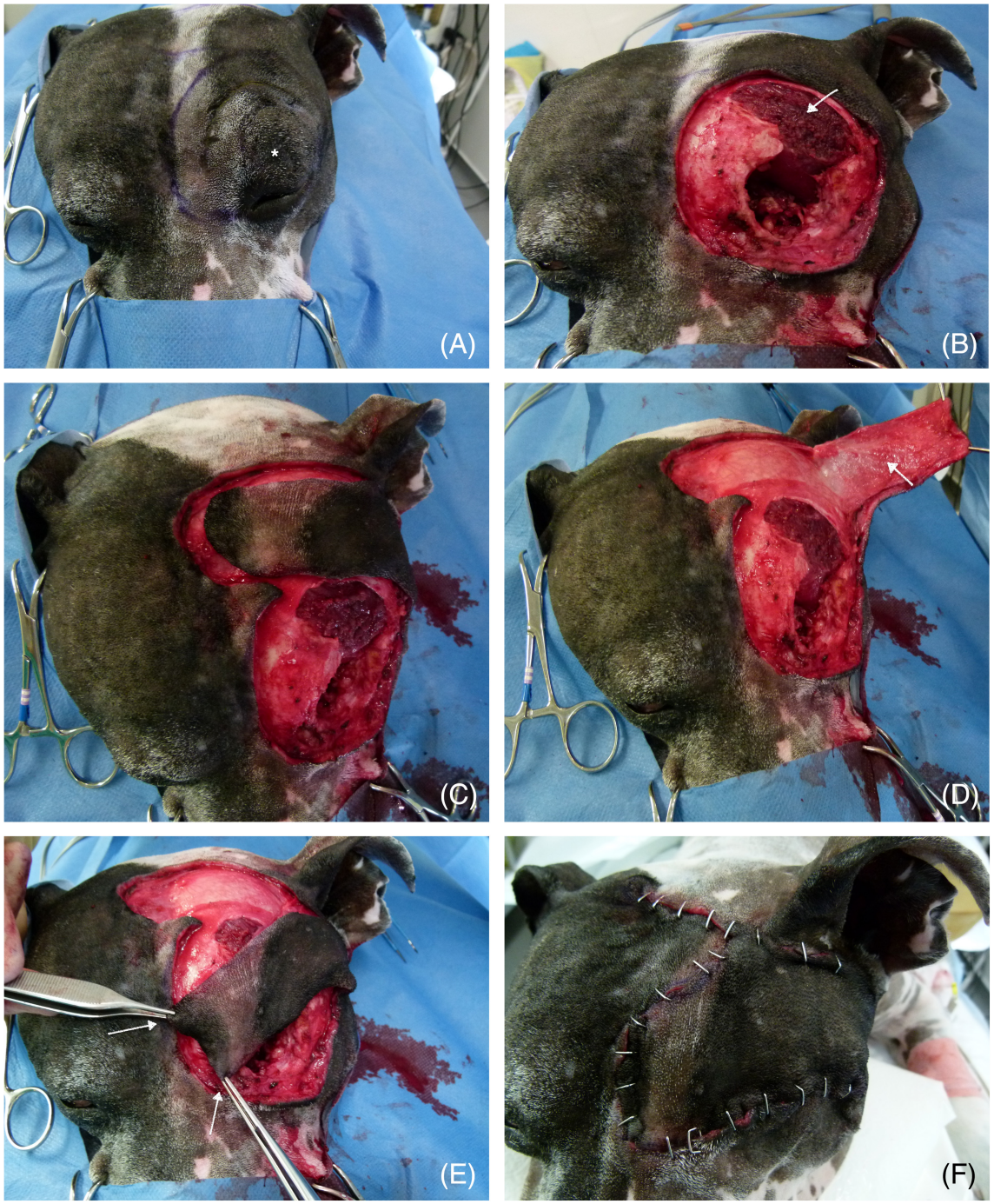


**FIG 2. (a) 11-year-old Staffordshire bull terrier diagnosed with a myxosarcoma (white asterisk) invading the left upper eyelid. A 2 cm lateral margin was obtained, which included enucleation. Flap dimensions have been drawn. (b) Resection of the myxosarcoma obtaining the lateral margins and deep margins which included the temporal fascia (black arrow) and enucleation. (c) The angiosome of the flap was incised following the previous drawn landmarks. (d) The flap has been elevated from the temporalis muscle, making sure we include the frontalis muscle, protecting the superficial temporal artery (white arrow). (e) The flap was transported to cover the recipient bed (white arrows). (f) Final picture of the flap with closure of the donor site using skin staples**

2 weeks. In two other dogs there was a mild exposure of the globe, but no treatment was needed. All these dogs had normal palpebral function. The remaining four dogs were re-examined at 10–14 days postoperatively; good healing with no complications were documented.

Seven out of nine tumours were excised with clean margins of excision. Incomplete excision was identified in two dogs, one with a myxosarcoma and one with a low-grade STS. The dog with the myxosarcoma had an enucleation but the deep margin were incompletely excised and the tumour recurred after 6 months. The dog with the low-grade STS had a tumour extension into the orbit, but enucleation was not performed and the tumour recurred 1 year after surgery. In the group of dogs with clean margins of excision there was no recurrence,

**Table 1. Clinical features of nine dogs undergoing reconstruction using a superficial temporal axial pattern flap**

| | Breed | Age (years) | Sex | Location of defect | Cause | Percentage flap survival | Complications |
|---|---|---|---|---|---|---|---|
| 1 | Labrador retriever | 13 | MN | Fronto temporal | Mast cell tumour | 100 | Discharge slight eye exposure |
| 2 | Golden retriever | 5 | MN | Fronto temporal | Mast cell tumour | 100 | N |
| 3 | Staffordshire terrier | 11 | MN | Upper eye lid | Myxosarcoma | 100 | N |
| 4 | Golden retriever | 3.5 | F | Fronto temporal | Mast cell tumour | 100 | N |
| 5 | Cross breed | 10 | M | Fronto temporal | Soft tissue sarcoma | 100 | Slight eye exposure |
| 6 | Minature pinscher | 15 | MN | Medial Canthus | Melanoma | 100 | N |
| 7 | Labrador retriever | 1 | F | Upper eye lid | Mast cell tumour | 100 | Oedema of the flap<br>Ectropion<br>Decreased palpebral reflex |
| 8 | Cross breed | 17 | MN | Naso frontal | Soft tissue sarcoma | 100 | Discharge |
| 9 | Jack Russell terrier | 14 | – | Maxillary region | Osteosarcoma | 90 | Partial thickness necrosis |

**Table 2. Clinical features of 10 cats undergoing reconstruction using a superficial temporal axial pattern flap**

| | Breed | Age (years) | Sex | Location of defect | Cause | Percentage flap survival | Complications |
|---|---|---|---|---|---|---|---|
| 1 | Domestic short hair | 9 | MN | Upper eye lid | Mast cell tumour | 100 | N |
| 2 | Domestic short hair | 9 | Fn | Upper eye lid | Mast cell tumour | 100 | Slight eye exposure |
| 3 | Domestic short hair | 5 | Fn | Upper eye lid | Squamous cell carcinoma | 100 | N |
| 4 | Domestic short hair | 14 | Fn | Upper eye lid | Sarcoma | 100 | N |
| 5 | Cornish rex | 21 | Mn | Medial Canthus | Squamous cell carcinoma | 100 | Subcutaneous Emphysema |
| 6 | Main Coon | 10 | Mn | Fronto Temporal | Soft tissue sarcoma | 100 | N |
| 7 | Domestic short hair | 12 | FN | Naso maxillary | Chondrosarcoma | 60 | Flap necrosis |
| 8 | Domestic short hair | 14 | – | Lower eye lid | Cutaneous haemangiosarcoma | 100 | N |
| 9 | Domestic short hair | 3 | – | Naso Maxillary | Fungal granuloma | 100 | N |
| 10 | Domestic short hair | 9 | – | Lower eye lid | Squamous cell carcinoma | 100 | N |

with a median follow up time of 2 years (range 6 months to 5 years).

## CATS

### Signalment

The median age of the 10 cats was 10.6 years. Cat breeds included DSH (eight), Maine Coon (one) and Cornish Rex (one). Three cats were neutered males, four cats were neutered females and in three cats the sex was not recorded.

### Flap indication and characteristics

In nine cats, the indication for flap use was reconstruction after tumour excision. The tumour types were squamous cell carcinoma (n=3), mast cell tumour (n=2), low-grade STS (n=2), chondrosarcoma (n=1) and cutaneous haemangiosarcoma (n=1). In one cat, the indication was a fungal granuloma. Closure of all the defects was performed at the time of surgical resection.

The location of the tumours were upper eye lid (n=4), lower eye lid (n=2), medial canthus (n=1), frontotemporal region (n=1) and nasomaxillary region (n=2).

The surgery was performed by an ECVS Diplomate in all but one case and in one cat the surgery was performed by an ECVS resident. The widths of the superficial temporal axial pattern flaps compared with the maximum reported dimensions were 100% in seven cats, 90% in two cats and 60% in one cat. The lengths of the superficial temporal axial pattern flaps compared to the maximum reported dimensions were 150% in two cats, 100% in two cats, 80% in five cats and 70% in one cat.

Enucleation was performed in four cats: one with a mast cell tumour on the upper eye lid (Fig 4a, b); one with an STS on the upper eyelid; one with a squamous cell carcinoma at the medial canthus; and one with a cutaneous haemangiosarcoma on the lower eyelid.

### Preoperative and postoperative care

All 10 cats received perioperative antibiotics; comprising one single dose of 20 mg/kg iv cefuroxime (Zinacef; Glaxo Smith Kline) 30 minutes before first incision. No cat received postoperative antibiotics. No local anaesthetic, active or passive suction drains or bandaging was used in the postoperative period.

One cat with a well-differentiated STS on the upper eye lid was treated with metronomic chemotherapy due to incomplete excision. This comprised 2 mg/m$^2$ chlorambucil (Leukeran; Glaxo SmithKline) for once a day PO, 4 mg/kg thalidomide (reformulated by BOVA) for each other day PO and 0.05 mg/kg meloxicam (Metacam; Boehringer Ingelheim) for once a day PO, these medications were administered for 6 months. One cat with a fungal granuloma was treated with 10 mg/kg itraconazole (Itrafungol; Elanco) for once a day PO for 12 weeks.

### Outcome and complications

Flap survival was 100% in nine cats and 60% in one cat. In this one cat, which had a chondrosarcoma excised from the nasomaxillary region resulting in a large bone defect, a full-width flap

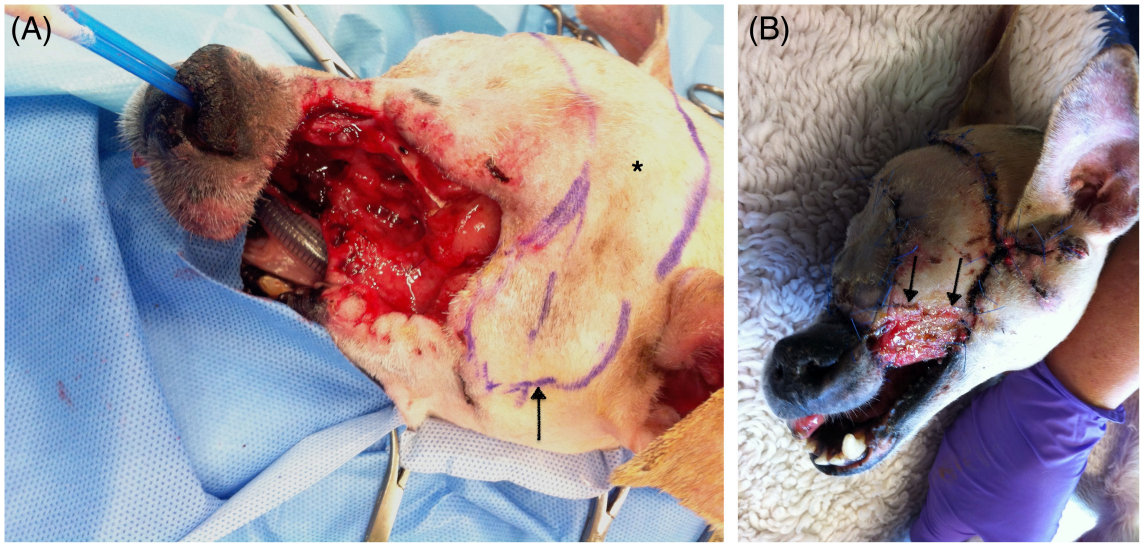


**FIG 3. (a) A 4-year-old Jack Russell Terrier with an osteosarcoma localised to his left maxilla. Picture shows the defect, 15 days post initial surgery, created following resection of the tumour. In this case the length of the temporal flap was extended to the contralateral zygomatic arch (black arrow). The asterisk show the original described maximum length (Picture from Jane Ladlow). (b) This dog suffered partial thickness necrosis of the tip of the flap (black arrows), but there was no loss of coverage of the wound by the flap. The palatine defect was left to heal by second intention. (Picture Jane Ladlow)**

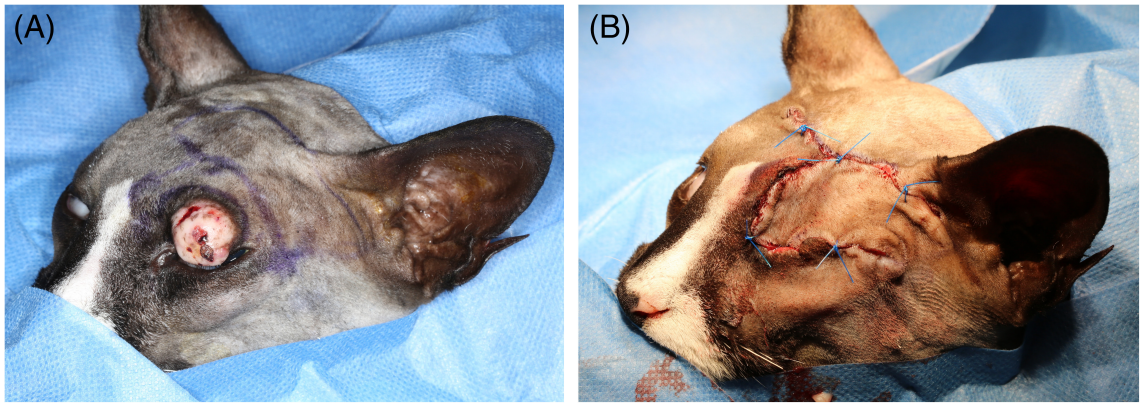


**FIG 4. (a) A 9-year-old cat with a mast cell tumour localised to his left upper eye lid. A 1 cm lateral margin was obtained, for the deep margin the temporal fascia was removed; the margins for the tumour resection and dimensions needed of the flap have been drawn. (b) Final results after the resection of the tumour with enucleation of the globe has been performed**

that extended to the contralateral zygomatic arch was used and full thickness necrosis and dehiscence of 40% of the flap at the tip was noted. This major complication was managed by open wound management and revision surgery using a lip to lid flap. Two minor complications not related to the flap itself occurred in two cats (20%). One cat with a squamous cell carcinoma developed subcutaneous emphysema due to resection of part of the nasal bone but no treatment was needed. The second cat suffered from a mild exposure of the globe that did not need further treatment.

Incomplete excision was found in one cat with squamous cell carcinoma, which had no local recurrence within a year and in one cat with a low-grade STS, which had local recurrence 1 year later. In the seven cats with clean margins of excision there was no recurrence, with a median follow up time of 1.5 years (range from 1 to 4 years). The cat with the fungal granuloma in the maxillary region had clean margins of excision with no recurrence noted 18 months post surgery.

## DISCUSSION

In this clinical retrospective case series, the indications for and outcome of the use of a superficial temporal axial pattern flap for reconstruction of maxillofacial skin defects in nine dogs and 10 cats are presented. The main finding was a high percentage of flap survival and a low rate of flap related complications in comparison with other axial pattern flap studies (Trevor *et al.* 1992, Aper & Smeak 2003, Aper & Smeak 2005, Field *et al.* 2015, Emmerson *et al.* 2019, Proot *et al.* 2019).

In our study there was 100% flap survival in 17 of 19 cases (89.4%). Postoperative complications related to the surgery, including major and minor complications, occurred in eight of 19 (42.1%) animals. Only one animal needed revision surgery and in this case the length of the flap extended further than the recommended maximum length. This is in comparison with other facial flaps where Proot *et al.* (2019) reported a complication rate of 63% for the caudal auricular axial pattern flap,

with 50% of dogs and 25% of cats needing revision surgery. In a study of the angularis oris axial pattern flap, Losinski *et al*. (2015) reported partial dehiscence in three of nine patients. Two of these cases were associated with small areas of necrosis and required minor surgical revisions in each case. Compared with these two axial pattern flaps, the superficial temporal flap is a comparatively robust flap, perhaps because of its relatively small angiosome.

The superficial temporal artery is one of the terminal branches of the external carotid artery. It arises rostral to the base of the auricular cartilage in dogs and cats (Evans & Christensen 1979). The course of the artery crosses the caudal aspect of the zygomatic arch, extends slightly dorsal to it and then turns rostrally to parallel the zygomatic arch. Two of its branches, the temporal and rostral auricular arteries, supply both the skin and muscle of the temporal region. Based on the cadaver and angiographic results of the study performed by Fahie *et al*. (1997), these structures are similar and consistent in their location and distribution in dogs and cats and these authors concluded that an axial pattern flap based on the region supplied by the superficial temporal artery and extending dorsad over the cranium had potential clinical application in providing a substantial amount of skin for reconstruction of maxillofacial defects in dogs and cats. In our study there was no obvious difference in dogs and cats in outcome and complications related to the use of the flap supporting the results of the anatomical study.

This flap is useful for reconstruction of defects localised to the periorbital region, including the upper and lower eyelid, the frontal and temporal region close to the globe, as well as the caudal nasal and maxillary area surrounding the orbit. The use of this flap to reconstruct a wound outside of this region has a higher risk of complications due to the requirement for a longer flap. A longer flap could be used to close defects to the occipital region but normally in this region there are other options including primary closure or subdermal flaps.

Two initial experimental studies described the use of the temporal axial pattern flap in dogs and cats (Fahie & Smith 1997, Fahie & Smith 1999). In all cases the base of the flap extended the width of the zygomatic arch. In relation to flap length, the canine cohort was divided in two groups; in one group the length extended to the contralateral mid dorsal orbital rim and in the second group the length of the flap extended to the contralateral zygomatic arch. The flap length survival for the mid orbital group was 91.8%, while in the contralateral zygomatic arch group the flap length survival was 69.5% (Fahie & Smith 1999). In the cats the maximum length was limited to the contralateral mid orbital rim (Fahie & Smith 1997). The authors concluded that flap length should not extend beyond the contralateral mid dorsal orbit due to a higher risk of necrosis.

In our patients in which the flap was 70–100% of the recommended maximum length and did not extend beyond the mid dorsal rim (16 animals) there was 100% flap survival and no flap necrosis. In our patients in which the flap length extended to the contralateral zygomatic arch (three cases), two animals had some degree of flap necrosis. In particular, in one dog there was 10% partial thickness necrosis of the tip that did not need surgical treatment while in the cat there was 40% full thickness necrosis of the flap and a lip to lid procedure was used to close the defect. In the second cat in which the flap extended to the contralateral zygomatic arch there was no necrosis. Following these results, we would recommend not extending the flap to the contralateral zygomatic arch, unless clinically needed. If it was deemed necessary to extend the flap to the contralateral zygomatic arch a delayed phenomenon technique could be used to try and recruit a longer flap and decrease the risk of complications (Pavletic 2010c).

When looking at the results of our study considering flap width, in 14 cases, 100% of the flap width was obtained (as described by Fahie & Smith 1997, Fahie & Smith 1999), 90% of the flap width was used in two cases, 70% in one, 60% in one and 50% in one case. Based on surgeon preference a flap less than the reported width was used, where this flap was adequate to close the defect. In the cases where a flap narrower than 100% of the maximum width was not obtained, the surgeon always ensured incorporation of the superficial temporal vessels. The use of a narrower flap did not seem to affect the viability of the flap in this study.

A small number of minor complications that did not need surgical treatment were noted. Partial thickness necrosis is occasionally reported for axial pattern flaps and will usually heal by second intention. Wound discharge may have been related to surgical site infection, although no samples were taken for culture and this resolved following antibiotic therapy. Flap oedema is occasionally reported (Aper & Smeak 2003, Losinski *et al*. 2015) and usually resolves without treatment. Subcutaneous emphysema was likely due to nasal bone excision but there was no direct complication with the flap.

Cosmetic and functional changes to the eyelids were noted in four cases. The palpebral nerve is incorporated in the rostral auricular plexus and supplies the orbicularis oculi muscle, which is important for palpebral function. During the elevation of the flap a small branch of the rostral auricular plexus is transected. Abnormalities in palpebral function were not noted in the postoperative period in any patient in which enucleation was not performed. Severing the small branch of the plexus did not affect the overall palpebral nerve function. This was also described in the experimental studies performed in cats and in dogs (Fahie & Smith 1997, Fahie & Smith 1999). No animal developed corneal disease and no further surgical treatment was needed. These complications have not been incorporated in the flap complication rate as the flaps did not suffer any complications, but these complications were due to the location of the tumour and the procedure performed.

In 18 of 19 of our cases presented, the flap was used to close wounds resulting from tumour excision. Incomplete margins were described in two dogs with sarcomas, both of which developed local recurrence. In one dog, enucleation was performed but the deep margin over the temporal region was considered incomplete. In the second dog, intra-orbital extension of the tumour was noted, but an enucleation or exenteration was not performed. It is possible that extending the *en bloc* excision to the orbit could have contributed to a more complete tumour removal. Incomplete margins were seen in two cats, one of which developed local recurrence. Although this article did not intend to look at the oncological results of these patients, we could conclude that the superficial temporal axial pattern flap is a good reconstruction option for closure of defects resulting from oncological resection in the orbital region of dogs and cats.

The limitations of this study include those inherent to retrospective studies. Estimation of the flap dimensions (width and length) were based on medical records and photographs of the cases. Being a retrospective study, obtaining the exact length and width in centimetres was not possible in all cases due to limitations of the medical records; because of this the dimensions of the flap were based on a percentage in relation to the maximum length and width of the original description. This data collection could lead to errors regarding the dimensions of the flap, but this would be unlikely to affect the results of the study.

Perioperative management and the management of flap complications were not standardised. No statistical analysis was performed due to the low number of cases. In this study 89.4% of cases had a 100% flap survival with a low number of complications. Due to the low number of cases, it cannot be concluded that the information reported is representative of all superficial temporal axial pattern flaps. All the cases included in this study except one were oncological cases, but there is no reason that traumatic wounds could not be closed with a superficial temporal flap after appropriate treatment.

In conclusion, the superficial temporal axial pattern flap can be used for single staged cutaneous maxillofacial reconstruction. Flap survival occurred in all cases in which the maximum length of the flap was not extended beyond the mid dorsal orbital rim of the contralateral eye and the rate of flap complications was low. This article provides further evidence that the length of the flap should be limited to the mid dorsal orbital rim of the contralateral eye to limit flap necrosis.

## Acknowledgements

The authors would like to thank the AVSTS Research Cooperative (ARC) for facilitating this multi-centre clinical research project.

## 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.

## References

Aper, R. L. & Smeak, D. D. (2003) Complications and outcome after thoracodorsal axial pattern flap reconstruction of forelimb skin defects in 10 dogs (1989-2001). *Veterinary Surgery* **32**, 378-384

Aper, R. L. & Smeak, D. D. (2005) Clinical evaluation of caudal superficial epigastric flap reconstruction of skin defects in 10 dogs (1989-2001). *Journal of the American Animal Hospital Association* **41**, 185-192

Degner, D. A. (2007) Facial reconstructive surgery. *Clinical Techniques in Small Animal Practice* **22**, 82-88

Emmerson, T., De la Puerta, B. & Polton, G. (2019) Genicular artery axial pattern flap for reconstruction of skin defects in 22 dogs. *Journal of Small Animal Practice* **60**, 529-533

Evans, H. E. & Christensen, G. C. (1979) Millers Anatomy of the Dog. 2nd edn. W.B. Saunders, Philadephia. pp 654-664

Fahie, M. A. & Smith, M. M. (1997) Axial pattern flap based on the superficial temporal artery in cats: an experimental study. *Veterinary Surgery* **26**, 86-89

Fahie, M. A., Smith, B. J., Ballard, J. B., *et al*. (1997) Regional peripheral vascular supply based on the superficial temporal artery in dogs and cats. *Anatomia, Histologia, Embryologia* **27**, 205-208

Fahie, M. A. & Smith, M. M. (1999) Axial pattern flap based on the cutaneous branch of the superficial temporal artery in dogs: an experimental study and case report. *Veterinary Surgery* **28**, 141-147

Field, E. J., Kelly, G., Pleuvry, D., *et al*. (2015) Indications, outcome and complications with axial pattern skin flaps in dogs and cats: 73 cases. *Journal of Small Animal Practice* **56**, 698-706

Laing, E. J. (1990) Problems in wound healing associated with chemotherapy and radiation therapy. In: Problems in Veterinary Medicine. Ed W. A. Lindsay. Lippincott, Philadelphia, PA. pp 433-441

Lester, S. & Pratschke, K. (2003) Central hemimaxillectomy and reconstruction using a superficial temporal artery axial pattern flap in a domestic short hair cat. *Journal of Feline Medicine and Surgery* **5**, 241-244

Losinski, S. L., Stanley, B. J., Schallberger, S. P., *et al*. (2015) Versatility of the angularis oris axial pattern flap for facial reconstruction. *Veterinary Surgery* **44**, 930-938

Pavletic, M. M. (2010a) Facial reconstruction. In: Atlas of Small Animal Wound Management and Reconstructive Surgery, Vol. **2010**. Lippincott, Philadelphia, PA. pp 434-480

Pavletic, M. M. (2010b) Axial pattern skin flaps. In: Atlas of Small Animal Wound Management and Reconstructive Surgery, Vol. **2010**. Lippincott, Philadelphia, PA. pp 357-402

Pavletic, M. M. (2010c) Distant flap techniques. In: Atlas of Small Animal Wound Management and Reconstructive Surgery, Vol. **2010**. Lippincott, Philadelphia, PA. pp 337-343

Probst C.W. (1990) Grafting techniques and failures in small animal surgery. Placeholder TextProblems in Veterinary Medicine Philadelphia, PA Lippincott pp. 413-423

Proot, J. L. J., Jeffery, N., Culp, W. T. N., *et al*. (2019) Is the caudal auricular axial pattern flap robust? A multi-centre cohort study of 16 dogs and 12 cats (2005 to 2016). *Journal of Small Animal Practice* **60**, 102-106

Yates, G., Landon, B. & Edwards, G. (2007) Investigation and clinical application of a novel axial pattern flap for nasal and facial reconstruction in the dog. *Australian Veterinary Journal* **80**, 113-118

Trevor, P. B., Smith, M. M., Waldron, D. R., *et al*. (1992) Clinical evaluation of axial pattern flaps in dogs and cats: 19 cases (1981-1990). *Journal of the American Veterinary Medical Association* **201**, 608-612