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SHORT CASE SERIES

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# Angularis oris axial pattern flap as a reliable and versatile option for rostral facial reconstruction in cats

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**Abstract**

**Objective:** To evaluate outcomes associated with the use of an angularis oris axial pattern flap (AOAPF) for rostral facial reconstruction in cats.

**Animals:** Nine adult client-owned cats.

**Study Design:** Short case series.

**Methods:** Ten AOAPF were performed in nine cats after resection of a tumor. Wounds were located at the nose, infraorbital, supraorbital, frontal, eye, and ear canal region. Orbital exenteration ($n = 3$), pinnectomy ($n = 2$), nasal planum resection, total ear canal ablation ($n = 2$), and partial eyelid reconstruction ($n = 3$) were performed.

**Results:** Short-term postoperative complications included flap edema ($n = 10$), suture dehiscence ($n = 3$), and distal tip necrosis ($n = 3$). All wounds resulting from minor complications healed by second intention in 5–15 days. Long-term complications included epiphora ($n = 2$), frequent grooming around the eyes ($n = 2$), and enucleation due to corneal ulcer secondary to impaired postoperative eyelid function ($n = 1$). Tumor recurrence occurred in 3 cases.

**Conclusion:** The AOAPF was a versatile and reliable option for rostral facial reconstruction in cats with acceptable long-term outcomes.

## 1 | INTRODUCTION

Surgical resection of tumors from the facial region often results in large wounds involving the nose, nasal planum, cheek, and eyelids.[1,2] Primary closure of the defect in these locations is a challenge due to poor local skin availability and mobility.[1,3] Tension can lead to palpebral and lip impairment, corneal exposure causing ulceration, excessive salivation, negative cosmetic outcomes, and suture dehiscence.[4] Tension-free closure of maxillofacial wounds often requires a random subdermal skin flap or an axial pattern flap to minimize the impairment of facial symmetry and function.[1,2,5] Since this is a difficult region to bandage and contraction can result in functional impairment, second intention healing is considered a poor option for closure.[1,2,6]

The blood supply and abundance of skin in some parts of the head and neck region allow several options for surgical reconstruction, including subdermal, axial or composite flaps, and skin grafts.[1,6] Subdermal plexus flaps can reconstruct most defects of the head; however, limitations of size, partial necrosis, and suture dehiscence are reported, especially for rostral wounds.[6–8] Axial pattern flaps have a high survival rate and allow transfer of larger segments of skin for longer lengths, which makes them a more favorable option for rostral facial reconstruction.[6,9,10]

Common axial pattern flaps reported for the head are the caudal auricular, superficial temporal, and

  

omocervical cutaneous flap.[1,8] The angularis oris axial pattern flap (AOAPF) is based on the cutaneous branch of the facial artery and emerged recently as a promising alternative to other head and neck axial pattern flaps.[11–14] Some advantages of the AOAPF include decreased surgical time and less dissection as its rostral location requires a shorter flap length.[11] Although this flap and outcomes have been well described in dogs, few studies have been published in cats[11–15] and there is no current literature reporting the AOAPF in a series of cats. The objective of this study was to evaluate the clinical outcome and complications of the use of AOAPF for facial reconstruction in cats undergoing tumor excision.

## 2 | MATERIALS AND METHODS

### 2.1 | Patient description

Nine client-owned cats with a tumor on the rostral face that underwent surgical reconstruction at São Paulo State University (Botucatu, Brazil) with an AOAPF from January 2016 to July 2019 were included. There were 7 domestic short hair and 2 Siamese cats. Mean body weight was 3.6 kg (range, 2.4–4.1 kg), and mean age was 9.8 years (range, 5–14 years). There were 5 male and 4 female cats. With exception of the presence of a cutaneous tumor, all cats were considered systemically healthy on preoperative examination, including a complete blood count and serum biochemistry profile in all cases. No evidence of metastatic disease was identified on three-view thoracic radiographic and abdominal ultrasonographic survey. There was no regional lymph node enlargement in any case. Tumor types diagnosed by histopathology were squamous cell carcinoma (SCC) ($n = 8$) and soft tissue sarcoma (STS) ($n = 1$).

### 2.2 | Surgical procedure

Anesthesia protocols were tailored to the cat's condition and surgical invasiveness. Preemptive local and regional anesthesia was performed using 0.5% bupivacaine hydrochloride (0.1 ml per site; Cristália, Itapira, SP, Brazil) through uni- or bilateral nerve block (rostral and caudal maxillary ophthalmic, and intraconal nerve block). Intraoperative analgesia was achieved through intravenous constant rate infusion of fentanyl (2.5-15 μg/kg/h; Janssen-Cilag, São Paulo, SP, Brazil) and ketamine (0.6 mg/kg/h; Cristália). Cefazolin (22mg/kg; União Quimica, São Paulo, SP, Brazil) was administered intravenously 30 min prior and every 60 min during surgery. The entire head and neck were clipped and aseptically prepared for surgery. Cats were positioned in lateral recumbency with the affected side up and a cushion elevating the neck. Surgical margins were selected according to preoperative diagnosis and surgical intent and ranged from 0.5 to 1 cm. Flap limits were drawn with a sterile surgical marker (Skins, Batrik Medical Manufacturing, Canada) following the anatomic landmarks previously reported (Figure 1A,B).[11] Briefly, the dorsal border of the flap was created along the ventral aspect of the zygomatic arch until the middle of the wing of the atlas. A parallel line formed the ventral border of the flap along the horizontal ramus of the mandible and extended caudally until the wing of the atlas. Both lines started 1.5 cm dorsal and ventral to the lip commissure. A dorso-ventral line connected both borders caudally. After tumor resection (Figure 1C), the flap margins were adjusted according to the resultant defect size and distance from the flap's base (Figure 1D). To make the flap as long and large as necessary, a nylon thread was used to outline the proposed flap path from its base to the farthest defect edge. The width of the flap was measured using the same principle, but from one edge of the defect to another and then transposing this measure to the flap. The previously drawn flap limits were not exceeded.

The flap was carefully dissected in a caudal-rostral direction, below the panniculus carnosus muscle and avoiding damage to its vascular pedicle. The jugular, maxillary, and linguofacial veins were exposed during dissection and flap elevation but remained intact. Following elevation, the flap was transposed to the desired position over the wound bed (Figure 1E).

A continuous suture pattern was used to close the subcutaneous tissues using a 4-0 or 5-0 poliglecaprone suture (Bioline, Anápolis, GO, Brasil). The epidermal layer was sutured using 3-0 or 4-0 nylon (Bioline) in a simple interrupted pattern (Figure 1F). When a canthoplasty was necessary, the palpebral conjunctiva was sutured to the subcutaneous layer with a simple interrupted pattern using 5-0 poliglecaprone. The flap donor bed was closed primarily in the same way as the flap. No drains were placed, and the wound was left uncovered.

Eight cats had their wound reconstructed with a unilateral angularis oris flap and one with a bilateral flap, resulting in 10 flaps total. Tumor resection required orbital exenteration in three cats (Figure 2A–F), pinnectomy in two (Figure 2D–F), nasal planum resection in two (Figure 2G–I), and one total ear canal ablation. Partial reconstruction of the lower or upper eyelid was performed in three cases (Figure 2J–L).

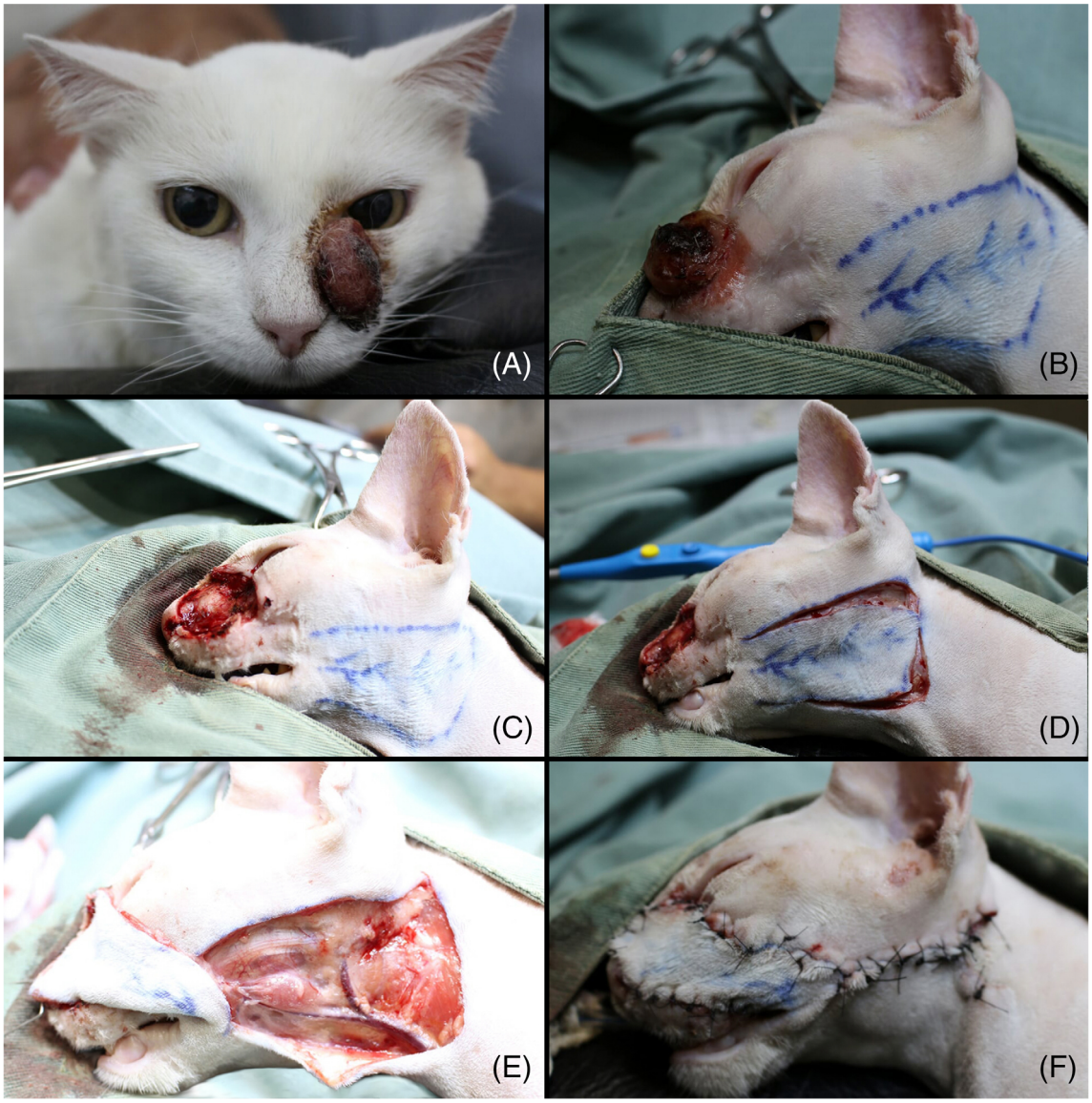


**FIGURE 1** Step-by-step demonstration of a soft tissue sarcoma resection and reconstruction using an angularis oris axial pattern flap (AOAPF) in a cat. (A) Tumor in the infraorbital and medial canthus region of the right rostral face. (B) Surgically prepared field and sterile marked landmarks of the AOAPF. (C) Wound after resection with 1-cm margins including part of the medial canthus. (D) Full-thickness incision of the flap borders. (E) Flap elevation and rotation over the recipient bed. The convergence of the linguofacial and maxillary vein into the jugular vein can be seen. (F) Final appearance after suture placement. The eyelid was reconstructed using the conjunctival mucosa

The AOAPF was able to close all wounds without additional reconstructive techniques. The width of the flap followed the landmarks, while length was equal to or less than the distance between the labial commissure and the wing of the atlas. The arc of rotation of the AOAPF allowed reconstruction of the lateral nasal region (3/10), frontal bone until the midline (6/10), (supra and infra) orbital region (8/10) including the medial canthus (2/10) or upper and lower eyelid (3/10) and ear base (2/10) (Figure 2). In all cases, the flap was able to reconstruct more than one of these described regions. Nonselective dissection of the locoregional lymph node and histopathology was performed in four cats. No sentinel lymph node mapping strategy was utilized.

## 2.3 | Postoperative follow-up

Cats were hospitalized for 2–5 days for postoperative care. All cats were treated with oral cephalexin (25 mg/kg twice daily for 7 days; EMS, Hortolândia, SP, Brazil), and ranitidine hydrochloride (2.2 mg/kg twice daily for 7 days; EMS). Piroxicam (0.3 mg/kg once daily for 5 days; EMS) or meloxicam (0.05 mg/kg once daily for

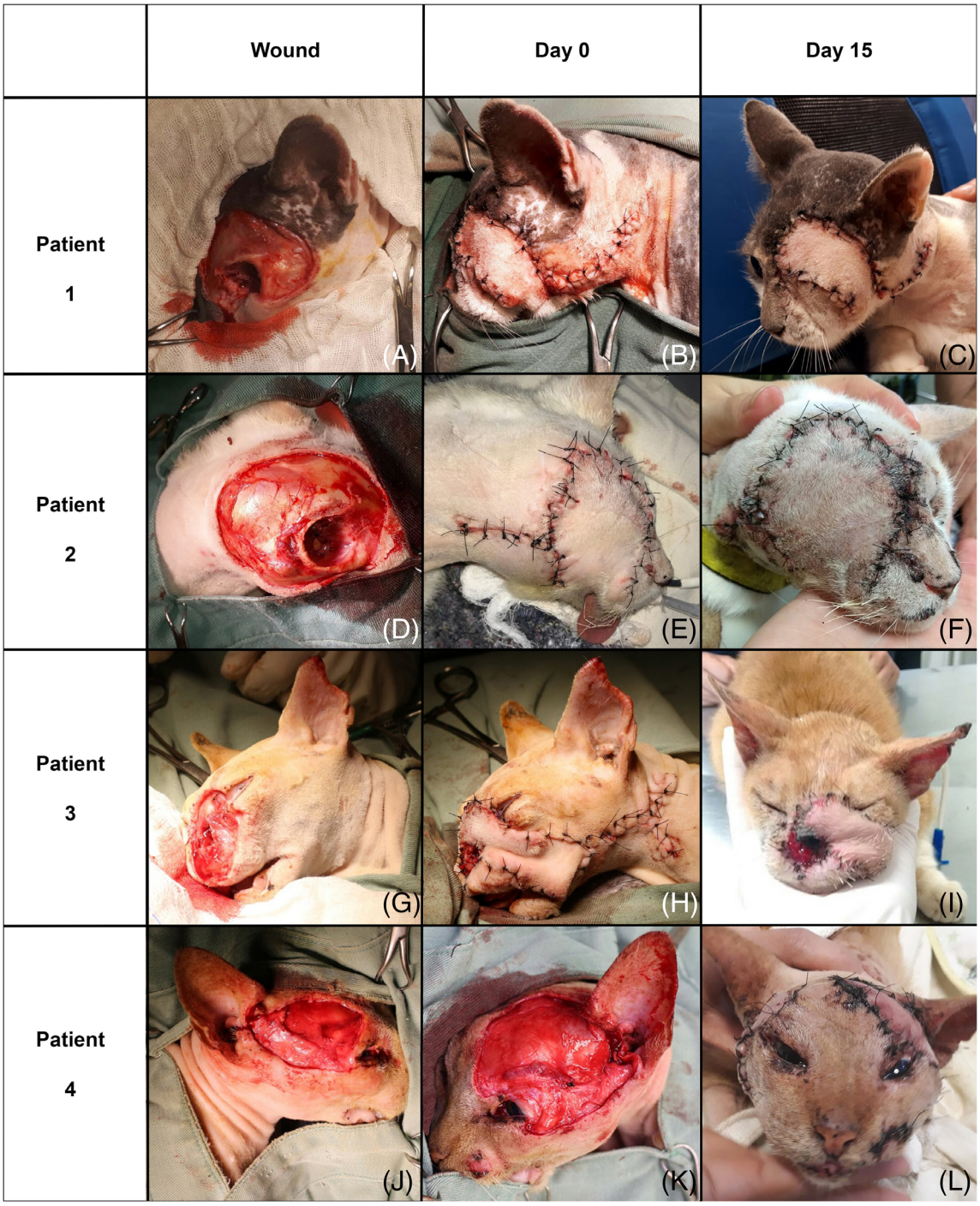


**FIGURE 2** Surgical wound after tumor resection, final aspect after reconstruction with angularis oris axial pattern flap (AOAPF), and appearance at the time of suture removal in four cats with different regions affected. (Cat 1—A–C) Reconstruction of the orbital region after enucleation and surgical resection of a squamous cell carcinoma (SCC). The AOAPF rotated approximately 90° and healed well. (Cat 2—D–F) AOAPF reconstruction of the orbital and supraorbital region. Except for minor distal tip necrosis, the cat recovered well. (Cat 3—G–I) Cat after a large surgical resection of the nose and adjacent skin due to a large SCC. The AOAPF was rotated at >90° angle to cover the infraorbital region, lower eyelid, and nasal bridge. The nose was left to undergo second intention healing. Distal tip necrosis can be seen close to the nasal wound. (Cat 4—J–L) Bilateral resection (J, right side and K, left side) of a large infiltrative SCC affecting both supraorbital regions. Wide, full-thickness resection of the left upper eyelid was required to completely remove the tumor. This cat underwent a bilateral AOAPF. On the left side, complete reconstruction of the upper eyelid was performed using the conjunctival mucosa, however, due to lack of blinking this cat developed corneal ulceration and required enucleation

3 days; Ourofino, Cajamar, SP, Brazi), and dipyrone (15 mg/kg once daily for 4 days; EMS—licensed for cats in Brazil) were administered orally due to its anti-inflammatory and analgesic effects for postoperative pain. Analgesic protocol was complemented with intramuscular methadone (0.2–0.3 mg/kg three times a day; Cristália), tramadol hydrochloride (2–4 mg/kg three times a day; Cristália) or constant rate infusion of ketamine (0.6 mg/kg/h for 4 h; Cristália) as needed, according to the multidimensional pain scale.[16] The incision was gently cleaned with sterile saline twice daily. E-collars were used until complete incision/wound healing. All cats were evaluated at least once before and at suture removal on the 15th day postoperatively and at least three times during the first 30 days postoperatively. Further evaluation varied according to the occurrence of complications and oncological follow-up. At the time of writing, the owners were contacted by phone for additional long-term information.

Short-term (<30 days postoperatively) and long-term (>30 days postoperatively) complications were recorded. Complications were classified as mild, moderate, or severe according to the criteria proposed by Follet et al.[17] Mild complications were considered those that required only topical or nonsurgical procedures (i.e., wound cleaning and dressing), while moderate and severe complications required antibiotic treatment and surgical re-intervention, respectively. Other clinical findings unrelated to the flap that occurred due to surgical resection of the tumors were also recorded.

Tumor specimens were fixed in 10% formalin and histologically evaluated for definitive diagnosis and histologic margins status.

## 3 | RESULTS

There were no intraoperative complications that required deviation from the operative course. Mild temporary flap edema was present as a skin bulge in all cats but resolved within 5 days and no cat developed seroma or required further treatment. Fifty percent (5/10) of the AOAPFs healed without any mild short-term complications. Distal tip necrosis (3/10, 30%) and suture dehiscence (3/10, 30%) were the only mild complication observed (Figure 3A,B). Distal tip necroses were partial thickness, compatible with vascular necrosis, homogenous in width, and approximately 1 cm in length. Suture dehiscence occurred due to focal areas of skin tension (1) and suture failure (2) in sites close to the nose, ear, and eyes. Both necrosis and suture dehiscence did not expose important structures or impact the outcome, and all resultant wounds were able to heal by second intention in 5–15 days. No animal experienced a moderate or severe short-term complication that required revision surgery.

Histopathology indicated clean margin of resection in 4/9 cats. Those with incomplete margins (5/9) were marginal-intent resection of STS (1) and multiple SCC with solar keratosis (4). Recurrence occurred in three of these cats with SCC. All lymph nodes sampled (4/9) were negative for metastatic disease.

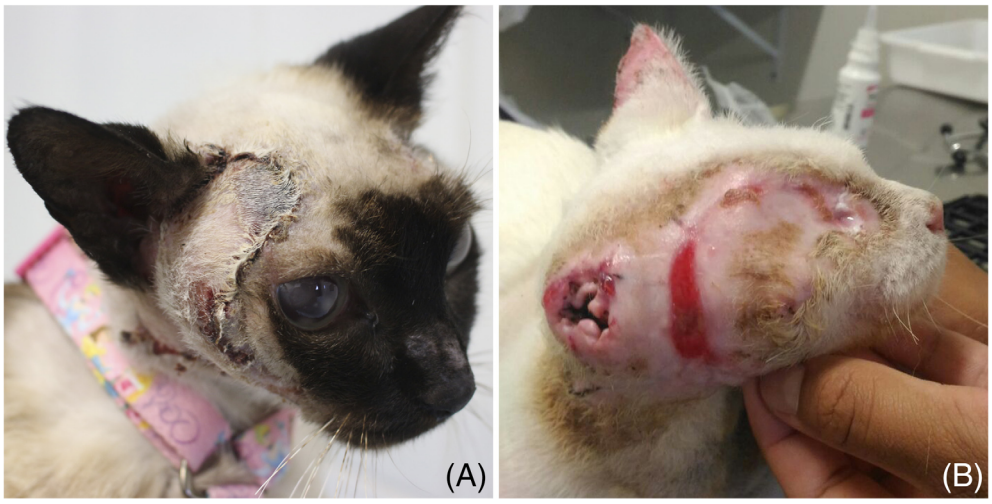


FIGURE 3 Short-term complications associated with the use of the angularis oris axial pattern flap (AOAPF). (A) Distal tip necrosis of the AOAPF in a cat after resection of a supraorbital frontal squamous cell carcinoma (SCC). (B) Suture dehiscence of the middle part of the AOAPF after reconstruction of the orbital and lateral face regions of a cat that underwent exenteration and pinnectomy due to SCC. Both cats were conservatively treated and recovered well after 10–15 days

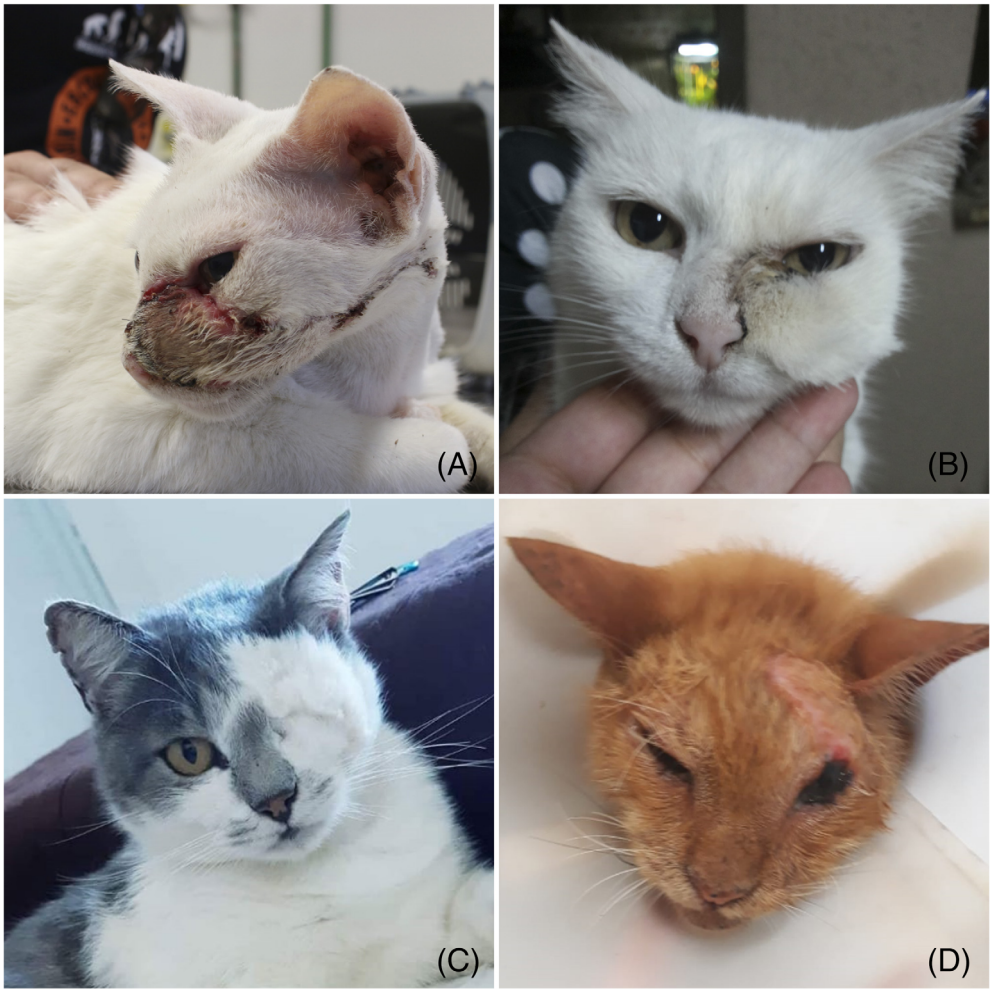


**FIGURE 4** The cosmetic appearance of 4 cats several months after angularis oris axial pattern flap (AOAPF) surgery. (A) Cat 1 (Figure 2) after the skin sutures were removed. (B) The same cat 260 days after surgery. Note complete healing of the surgical wound, but epiphora can be seen near the medial canthus. (C) Cat 6 months after the surgical procedure. Different hair color and orientation could be seen. (D) Cat 4 (Figure 2) after 30 days following surgical reconstruction. Complete epithelialization of the wound on the left eye could be seen, but this cat was unable to blink and required enucleation

All cats were still alive at the time of writing. The follow-up time varied between 60–980 days (median of 388 days) with all cats having an evaluation at least 30 days postoperatively. All surgical sites were completely healed at the 30th day postoperatively. Epiphora occurred in cats (2/9) that had undergone medial canthus resection (Figure 4A,B). A mild long-term complication was that long hair growth occurred in the opposite direction in all cats, necessitating frequent trimming around the eyes to avoid corneal injuries (2/9) (Figure 4B,C). One severe long-term complication required enucleation 40 days after the reconstructive surgery in a cat that underwent a full-thickness resection of the upper eyelid (Figure 2J–L). The flap healed well, but the cat was unable to blink and developed a severe corneal ulceration (Figure 4D).

## 4 | DISCUSSION

In this series of cats, the AOAPF was a versatile option for rostral facial reconstruction allowing reconstruction of defects involving hard-to-close sites, including temporal, nasal, ear, infraorbital, supraorbital, and orbital regions.[18,19] Repairing large facial defects is a challenging procedure in cats compared to dogs, due to their lack of facial skin elasticity and limited lip and jowl skin.[8,14] The AOAPF overcame these challenges in several situations, including bilateral application. We also found the AOAPF useful for closing wounds from marginal-intent resection of STS and SCC, as the large size of the resulting defect and primary closure would impair eyelid and nasal function. It is important to note that wounds at the caudal aspect of the head are not good candidates for AOAPF reconstruction since its rostral vascular pedicle would preclude mobilization of a large amount of skin.

The caudal auricular, superficial temporal and omocervical flaps have been described for facial reconstruction in domestic felines.[1,3,19,20] Due to the cervical or caudal location of these flap's base, a longer length is necessary when closing facial defects, increasing the probability of distal tip necrosis.[19] The main advantages of the AOAPF over those located on the cervical region are the rostral site of its vascular pedicle, caudal orientation,

and large amount of skin perfused.[11,14] These features make the AOAPF an optimal choice for rostral facial reconstruction in cats, as it simplifies the procedure, decreases subcutaneous dissection, and requires a shorter flap, while still covering the defect.[11,14,21]

Inclusion of the cutaneous panniculus carnosus muscle was a fundamental step to ensure AOAPF survival due to the subcutaneous and deep plexus that supply the direct cutaneous vessels.[8,11] Careful dissection and delicate flap undermining prevented damage to subjacent structures, including the auriculopalpebral and auriculotemporal nerves, parotid gland duct, and facial vessels.[13] The caudal orientation of the AOAPF is also a crucial element for flap survival.[21] Closure of the secondary defect at the donor bed was straightforward due to the skin elasticity in that region and the lack of vital structures nearby.[1]

Variation between species and individuals was expected, despite the landmarks having been well-established in both dogs and cats.[11,13,19] In dogs, the flap length is limited to twice the base width.[8] On the other hand, the angularis oris artery can be found more ventrally and caudally in cats than dogs, but no situation required exceeding the wing of the atlas in this case series.[11,13,14]

The surgical procedures resulted in good outcomes, similar to previous case reports[11,14] and only one severe complication was observed. Mild complications, including flap edema, distal tip necrosis, and suture dehiscence, were self-limiting and attributed to the lack of bandaging, possible self-trauma, and vascular impairment.[13] The use of a drain is controversial, as seroma is seldom observed in the facial region and cat behavior would make management difficult.[11,13] We chose to avoid drain placement and seromas did not occur in our cat population, confirming that it was unnecessary in these cases. Abnormal hair growth was a long-term concern but was easily managed by the owners. Overall, mild complications following AOAPF in cats were similar to those seen for other axial pattern flaps.[10]

A severe complication occurred when the AOAPF was used for eyelid reconstruction in one cat which underwent the wide full-thickness resection of the upper eyelid during tumor removal. The AOAPF was able to close the defect; however, the blinking was compromised. Impairment of blinking and potential need for enucleation should be discussed with the owner when using the AOAPF for large eyelid reconstruction.

While curative-intent wide resection is ideal in all cases, in five cats marginal excision was performed, either due to an inability to achieve curative-intent margins or due to owner preference. Due to the location, even marginal surgery resulted in large defects and an AOAPF was elected to reconstruct the surgical wound bed. Marginal resection resulted in incomplete margins in all these cats. Local recurrence was present in three cats at a median of 3 months. In order to decrease the risk of seeding the AOAPF donor bed with neoplastic cells, clean gloves and instruments were used for this aspect of the procedure. In these cats, marginal resection was performed to improve their quality of life as the morbidity of the tumor was significant. The owners were aware of the high risk of local recurrence and elected a conservative excision with knowledge of these risks. Despite the lack of clean margins and recurrence in three cats, these cats recovered their normal behavior according to the owners, and the surgical procedure was associated with minimal morbidity. No tumor recurrence arose from the AOAPF donor scar during the follow-up period.

There are several limitations with this retrospective case series. First, an extensive survival analysis and tumor-related outcomes were not described here as it was beyond the scope of this case series. Also, lymph node staging was only obtained in four cats. Some cats could not be evaluated in person for long-term outcomes; therefore, conclusions were based on phone consultation with the owners. Furthermore, the small number of animals presented here can lead to limited conclusions.

Based on our findings in this series of nine cats, we believe that the AOAPF is a reliable and versatile option for rostral facial reconstruction in cats, as it is in dogs. Surgeons should be encouraged to use this technique as it is easy to perform, results in good outcomes, and has few complications.

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## AUTHORS CONTRIBUTIONS

VGPA and JGQ conceived the study and executed pre- and post-operative management, surgical procedures, data interpretation, and manuscript composition. MLO contributed to study design, data interpretation and manuscript composition. All authors wrote, revised, and approved the final version of this original article.

## CONFLICT OF INTEREST

The authors declare no conflict of interest to this report.

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