Objective: To determine the frequency and extent of complications associated with lateral caudal axial pattern flap in dogs to cover large skin defects on the dorsum, gluteal and perineal area as a result of trauma or surgical tumor removal.

Study Design: Retrospective case series

Animals: 13 client-owned dogs

Methods: Medical records from 8 institutions were reviewed for dogs treated with the lateral caudal flap, also including cases in which, for very large defects, the procedure was combined with other reconstructive techniques. Proportion of the flap length in comparison with the tail length, location of the skin incision (dorsal vs. ventral), cause and size of the wound, and short- and long-term complications were recorded.

Results: Thirteen dogs were included, 11 with tumors and 2 with traumatic skin loss. Percentage of tail used, estimated subjectively, ranged from 33% to 70% (mean, 50.6%). Four dogs had wound complications. Two had minor post-operative wound complications (mild distal dehiscence) that did not require surgical revision, while 2 other dogs required surgical revision. Two cases had distal flap necrosis; the first case was revised surgically while the second dog was managed conservatively. In these cases the flap length used was 80% and 65% of the tail length, respectively. At 30 days, all flaps were completely healed. In some dogs the only visible change was the different direction and color of the hair coat.

Conclusion: Lateral caudal axial pattern flap is a reconstructive option for gluteal, dorsal and perineal skin defects. Distal flap necrosis and dehiscence due to wound infection occurred in 4 dogs that required additional wound care or surgical revision.
Introduction

Surgical reconstruction of large wound defects of the gluteal or perineal regions and base of the tail can be challenging. Ideally, primary closure is recommended if feasible, but some defects may be too large to allow it. (1) Reconstruction can be accomplished by second intention healing, subdermal (local) plexus flap, full thickness skin graft, axial pattern flap, or a combination of procedures. (2)

Second-intention healing is slow and unpredictable, particularly on the proximal tail area due to tail movement, and patients may need frequent bandage changes. (1-3) Local flaps depend on the subdermal plexus vascularization for survival and may undergo necrosis if length to width ratios are challenged. (4) Axial pattern flaps are local skin flap incorporating a direct cutaneous artery and vein (5) allowing for the transfer of a relatively extensive segment of skin in a single stage. (6) They are easy to develop and rotate; in general, their survival rate is between 87 to 100%. (6-9)

The lateral caudal axial pattern flap, that requires sacrifice of the bony structures of the tail, has been used in two case reports and in an experimental study (1-2-10), but to our knowledge no clinical case series has been published so far.

The aim of the present case series is to present both frequency and extent of complications associated with lateral caudal axial pattern flap and provide clinical data regarding its use to reconstruct large defects of the dorsum, gluteal and perineal region in dogs.
Materials and Methods

This study was initiated as an informal request to the Veterinary Society of Surgical Oncology (VSSO) list serve regarding dogs treated with the lateral caudal axial pattern flap from 2005 to 2012 to reconstruct large skin defects of the dorsum, gluteal and perineal area after trauma or tumor removal.

Clinical records of included dogs from contributing institutions were retrospectively evaluated. Data retrieved included age, breed, sex, weight, preoperative diagnostic work-up, percentage of tail used for the lateral caudal axial flap as a proportion of the overall tail length, and cause (tumor excision or traumatic tissue loss) and size of the wound to be covered. Also, location of the skin incision (dorsal vs. ventral) for flap preparation, short- (≤ 15 postoperative days) and long-term (> 15 postoperative days) complications and histopathologic diagnosis with surgical margins evaluation when the flap was used following tumor excision were recorded. Complications were sub-classified as minor when they were managed conservatively, and major when surgical intervention was required. Contributors were also asked to subjectively estimate the percentage of the tail length used for covering the defect. Histopathologic diagnosis was based on original assessment of the attending pathologist at the time of the specimen submission. Complete tumor excision was based on histological evaluation of surgical margins being free of residual tumor. In particular, histologic excision margins were defined as containing no residual tumor at resection margins (R0), no residual tumor but minimal distance between tumor and resection margin (R1), and local macroscopic residual tumor (R2). (11)
Results

Signalment

Thirteen dogs were included in this retrospective study. Breeds included 2 Labrador Retrievers, 2 cross breeds, and 1 each of English Setter, Japanese Akita, Entlebucher Mountain Dog, Staffordshire Bull Terrier, Australian Cattle Dog, Cane Corso, Rhodesian Ridgeback, Siberian Husky and Briard Shepherd dog. Body weight ranged from 13 to 51kg (mean, 31kg). Age at presentation ranged from 4.0 to 16 years (mean, 8 years). There were 9 males, of which 6 were intact and 3 were castrated, and 4 females, of which 3 were spayed and 1 was intact.

Presenting Complaint

The skin defect was the result of tumor removal in 11 dogs and traumatic loss in 2 dogs. (Table 1). Tumors included 5 soft tissue sarcomas, 2 mast cell tumors, 2 hepatoid gland carcinomas, 1 squamous cell carcinoma, and 1 suspected infected perineal adenoma. The completeness of excision was evaluated histologically in all cases. Margins were classified as complete (R0) in 10 dogs and incomplete in 1 dog (R1).

One dog was missing for 3 days and sustained unknown trauma. At presentation, abnormal findings included flaccid tail paralysis, sacrococcygeal luxation, and a large open wound with major soft tissue loss (skin, subcutaneous tissue, and portion of superficial gluteal muscle) over the left gluteal region. The wound was managed with a wet-to-dry bandage for 14 days. The second dog with a traumatic injury resulting from a dogfight presented with a severe degloving injury of the right perineal region and caudal dorsum, as well as rectal perforation. The rectum was debrided and sutured. Before performing the reconstructive surgery the wound was treated conservatively until the wound was free of exudates and covered with healthy granulation tissue.
Preoperative Diagnostic Tests

Cytologic examination by fine-needle aspiration was performed in 4 dogs. Two MCTs, one hepatoid adenocarcinoma, and one perianal adenoma with secondary infection were diagnosed. In 3 dogs preoperative cytology was performed due to the strong suspicious of tumor recurrence considering the clinical history of a previous tumor removed at the same location. Fine-needle aspiration confirmed the recurrence of 1 SCC and 2 STSs. Soft tissue sarcoma was diagnosed based on histopathology of incisional biopsies in 4 dogs.

Preoperative imaging for clinical staging included 3-view thoracic radiographs (n=10) and abdominal ultrasound (n=9). Abdominal ultrasound was not performed in 4 dogs. Thoracic radiographs were unremarkable in all dogs examined. Thoracic radiographs were not performed in 2 dogs with traumatic wounds and 1 dog with an infected perianal adenoma. Abdominal ultrasound was normal in all dogs examined. Computed tomography (CT) of the pelvic region was performed for surgical planning in 3 dogs.

Lateral Caudal axial pattern flap

Patients were anesthetized, positioned in sternal recumbency, and the tail, caudodorsal and caudolateral areas of the body were clipped and prepared for aseptic surgery depending on the location of the lesion. In general, starting from the tail base along its entire length, a sagittal dorsal or ventral tail incision was performed depending on the location of the skin defect to be covered (ventral incision when the defect was in the caudo-ventral perineal region and dorsal incision when the defect was located in the caudo-dorsal and dorsal gluteal region); for tumor excision margins requirements, if needed, a dorsolateral or ventrolateral skin incision was adopted. In particular, tail incision was performed dorso-laterally in 5 dogs, dorsally in 4 dogs, ventrally in 3 dogs and ventrolaterally in 1 dog. Lateral coccygeal arteries and veins were meticulously preserved during these skin incisions by gently and throughly dissecting soft tissue as close as possible to the coccygeal vertebrae. The tail
was usually amputated between the second and third coccygeal vertebra. The percentage of the tail used, estimated subjectively, ranged from 33.0% to 70% (mean, 50.6%). One out of thirteen dogs had a docked tail. In this dog all the tail was used and it was estimated subjectively by the surgeon as being 70% of the total original length as the dog was previously docked for breed standard. The flap was rotated, positioned over the skin defect, and trimmed as needed. In 1 dog, the caudal flap was not wide enough to cover the whole skin defect and a combination of both lateral caudal and caudal superficial epigastric axial pattern flaps was used; the first flap was positioned dorsally while the caudal superficial epigastric axial pattern flap was rotated 90° to reconstruct the ventrolateral aspect of the defect. In another dog, the cranial two-thirds of the defect was reconstructed with an inguinal flank fold flap and the caudal third with the lateral caudal axial flap. A partial sagittal ostectomy of the ischium (Figure 1) and ilium was performed in 2 dogs to achieve deep surgical margins. In one dog, the left coccygeal artery and vein appeared to be damaged by the previous trauma; however, the right coccygeal artery and vein provided sufficient vascularization to the entire tail skin as shown in the following outcome. An active suction drain was placed in 8 dogs, a Penrose drain in 1 dog, and no drain in 4 dogs. The subcutis and skin of the flap were closed routinely (Figure 2). Patients were discharged after active or passive drain removal (2-7 days post-operatively). Flaps were clinically evaluated at drain removal, suture removal (at about 10 post-operative days), and during routine recheck examinations (30-365 days, mean 79 days).

Surgical Outcome

Short-term post-operative (≤ 15 days) complications were recorded in 4 dogs (30%). Two dogs (15%) had minor post-operative wound complications at the tip of the flap; there was a mild dehiscence (4 cm) in one case and 2 cm² distal flap necrosis in the second one. No surgical revision was needed in any of these 2 dogs and both were treated conservatively. Particularly the one which developed mild wound dehiscence secondary to incisional infection (Pseudomonas aeruginosa and Bacteroides fragilis) was treated conservatively with a tie-over bandage and culture-specific...
antibiotic therapy (enrofloxacin 5mg q 24hrs and metronidazole 10 mg q 12hrs). The second one was
curetted. In both cases the wound healed by second intention without further complications.
Two dogs had major postoperative wound complications requiring surgical revision. Distal flap
necrosis occurred in 1 dog with a traumatic wound and rectal perforation. It was treated by surgical
revision and primary closure. The second dog, that experienced a major wound dehiscence, was
initially managed as an open wound with wet-to-dry bandages, then a surgical revision and definitive
closure was performed after 14 days. No long-term complications were reported.
At 30 days, all flaps had healed and the only visible change was the different direction and color of
the hair coat in those dogs in which a dorsal tail skin incision was performed (Figure 3).

Causes of skin loss, location and wound size, location of the tail skin incision, percentage of the tail
used, and short- and long-term complications are summarized in Table 1.
Regardless of the cause of the skin loss, most defects can be reconstructed using pedicle advancement, transposition, rotation and axial pattern flaps, or combinations of these procedures. The location of the skin defect may influence the reconstructive options. A rotation and transposition skin flap on the dorsum, gluteal and perineal area may be controversial because the defect may extend over the sacro-coccygeal joint with the tail movement potentially resulting in wound dehiscence.

Free skin grafts, which require immobilization for successful reconstruction, could be an option if associated to negative pressure wound therapy that press the graft onto the recipient bed and increase contact area. In this case series negative pressure wound therapy was not applied in any of the dogs. This case series has shown that the lateral caudal axial pattern flap may be a surgical option for the reconstruction of large defects of the dorsum, gluteal and perineal area in dogs. Axial patterns flap include a direct cutaneous artery and vein with the flap area determined by the angiosome of the direct cutaneous artery. The direct cutaneous blood supply allows for the transposition of an extensive area of skin in a single procedure without the need of further procedures. (12) Axial pattern flaps suitable for closure of caudo-dorsal skin defects include the dorsal deep circumflex iliac and caudal superficial epigastric axial pattern flaps. (12-13) However, these flaps may not be suitable for reconstruction of some dorsal skin defects as the latter may be beyond the arc of rotation of these flaps. Moreover, the length of the caudal superficial epigastric axial pattern that would be needed in these cases may exceed its angiosomic limit resulting in distal flap necrosis. (2)

As proposed in a previous experimental study (2) and in 2 case reports (1-10), the lateral caudal axial pattern flap, based on the lateral coccigeal artery, may be a suitable option for the coverage of large gluteal, perineal and dorsal cutaneous wounds, either as a single axial pattern flap or combined with other reconstructive procedures. The vascular supply of the tail originates from the medial sacral artery that continues as median caudal artery and caudal gluteal arteries which give rise to the lateral caudal arteries. (14) The lateral caudal arteries and veins course the length of the tail in a left and
right lateral location, ventral to transverse processes of the caudal vertebrae proximally and then
dorsal to the transverse processes distally. (Figure 4) (1) Tail amputation causes loss of the cutaneous
contribution of the medial caudal artery, but meticulous dissection of the deep caudal fascia preserves
direct cutaneous arterial supply from the lateral caudal arteries. This long, narrow axial pattern flap
has the advantage of being vascularized by 2 direct cutaneous arteries. (1) In 1 dog of this series, the
flap was based on a single lateral coccygeal artery and vein as the contralateral (left) vessel had been
previously compromised by trauma. Despite being based on a single lateral caudal artery, this flap
survived without any wound complication. Hence, flap survival may be possible also when based on
a single lateral caudal artery and vein; however the flap was constructed in a such way to be only
40% of the original length of the tail and this may have contributed, in its survival, besides the fact
the flap was constructed 2 weeks after a conservative management may have favored the delay
phenomenon. In 2 dogs, the lateral caudal axial pattern flap was not large enough to cover the defect
and it was respectively combined with an inguinal fold skin flap or caudal superficial epigastric axial
pattern flap for reconstruction of the defect.

Complications observed in this cases series include necrosis of the distal aspect of the flap,
dehiscence and infection. Distal flap necrosis occurred in 2 dogs, one managed conservatively and
one by surgical revision; the percentage of the tail length used for the flap in these cases was 65%
and 80%, respectively. In another dog, mild wound dehiscence occurred secondary to incisional
infection. As previously reported, (15-18) increasing the flap length may result in loss of distal
perfusion and subsequent necrosis. Saijzadeh et al (2005) suggested that, for clinical purposes, the
maximum length of the coccygeal axial pattern flap should not exceed 78% of the tail length to
minimize the risk of distal flap necrosis. (2) These authors reported a mean failure of 22% of the total
flap area. (2) Based on the results of the present case series, it could be recommended that the lateral
caudal axial pattern flap should not exceed 60% of the tail length to minimize the risk of distal flap
necrosis even if one dog had no wound complication despite 70% of the tail length was used. It is
possible that some breed and/or specific tail conformations, may influence the amount of the usable
Nevertheless, as already reported in a previous experimental study, (2) authors may conclude that the lateral caudal axial pattern flap alone, based on the lateral coccygeal artery, or combined with other regional flaps depending on the size of the defect to be covered, offers a reasonable

Post-operative seroma formation has been reported as a complication following reconstruction with axial pattern flaps. (6,13) Seroma was not recorded as a complication in the present study, but this may have been due to the post-operative use of drains in most dogs and shortness of the tail length used. The use of soft, padded, tie-over bandage to obliterate dead space and avoid self-mutilation has been reported as an alternative to drain placement to avoid seroma formation (2) but in this case series no dogs had tie over bandage placement during the postoperative period.

This study has several important limitations due to its retrospective nature. The first one involves the fact that, being cases coming from different investigators and institutions, there was no a standardized approach. Second, the small number of dogs enrolled limited the statistical analysis. Third, the percentage of tail used for the lateral caudal axial pattern flap was measured subjectively by each contributor, thus not being an accurate estimation of the actual percentage of the tail length used. Another potential limitation of the study was that cases were gathered after an informal request to the Veterinary Society of Surgical Oncology (VSSO) list serve. This sampling method relies on self reporting and it may bias the estimation regarding successful take, flap survival proportion and complication because clinicians usually may prefer to report only successful cases. All these elements may have resulted in some bias, especially in the evaluation of the percentage of the usable skin and complications associated.

Nevertheless, as already reported in a previous experimental study, (2) authors may conclude that the lateral caudal axial pattern flap alone, based on the lateral coccygeal artery, or combined with other regional flaps depending on the size of the defect to be covered, offers a reasonable
reconstructive option for the coverage of skin defect in the gluteal, perineal and dorsal areas after either wide tumor excision or traumatic skin losses.

References

1 Smith MM, Carrig CB, Waldron DR et al: Direct cutaneous arterial supply to the tail in dogs.

14 Evans HE. The Heart and Arteries, In Evans Miller’s Anatomy of the Dog, Third Ed, Saunders, 1993, pp 678-679

15 Pavletic MM. Caudal superficial epigastric arterial pedicle grafts in the dog Vet Surg 1980; 9:103-107


**Figure 1:**

- a) Preoperative image of 10 years old Rhodesian Ridgeback with a soft tissue sarcoma showing the extension of the tumor (dotted line) located cranial to the ischiatic tuberosity.
- b) Intraoperative image
after tumor excision and ostectomy of ischiatric tuberosity. Blue arrow indicates body of ischium.

Yellow arrow indicates superficial gluteal muscle. c) Intraoperative image showing positioning of a Jackson-Pratt drain, anal purse-string suture (green arrow) and the extension of the coccygeal axial pattern flap before being sutured to close the defect.

**Figure 2:** Immediate postoperative image after closure of the defect

**Figure 3:** Recheck at 45 days showing complete healing of the wound and different hair direction of the coccygeal flap.

**Figure 4:** Radiographs of tail vascolaritation after contrast study. Note the lateral coccygeal arteries.

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<th>Table 1: Clinical history, surgical approach and complications summary</th>
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* dog with one caudal plexus preserved; ** dog with shorter tail

MCT= Mast Cell Tumor; SCC= Squamous Cell Carcinoma; FSA= Fibrosarcoma; PNST= Peripheral Nerve Sheet Tumor