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PAPER

Indications, outcome and complications with axial pattern skin flaps in dogs and cats: 73 cases

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Objective: To determine the indications, frequency of complications and long term outcome associated with axial pattern flaps used to repair wound defects in dogs and cats.

Methods: Medical records from two independent referral centres for dogs and cats undergoing wound repair with an axial pattern flap were reviewed.

Results: Seventy-three animals were included, 49 dogs: 24 cats. Indications for axial pattern flaps were chronic wounds (43/73; 59%) and closure following tumour resection (30/73; 41%). Axial pattern flaps used were: thoracodorsal, caudal superficial epigastric, reverse saphenous conduit, superficial brachial, deep circumflex iliac, superficial cervical, caudal auricular, lateral thoracic, cranial superficial epigastric, genicular and superficial temporal. Postoperative complications occurred in 64 patients (89%) and 8 patients (11%) had no complications. Complications were: dehiscence, swelling of the flap, necrosis, infection, discharge and seroma. Flap outcome was excellent in 16 patients (23%), good in 29 (41%), fair in 21 (30%) and poor in 5 (7%).

Clinical Significance: There is a high complication rate associated with axial pattern flaps but these are usually easily managed and long term outcome is excellent, in either species.

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INTRODUCTION

Axial pattern flaps (APFs) are widely used in veterinary practice to repair skin defects. They are based on the angiosome (or vascular territory) supplied by a direct cutaneous artery and vein (Trevor *et al.* 1992). All the skin within this angiosome can be lifted from the donor site and will survive provided these vessels remain intact and patent (Pavletic 1981). This reliable blood supply enables the repair of large skin defects in a single procedure, without the need for an adequate vascular bed at the recipient site (Aper & Smeak 2003). An experimental study showed that APFs have approximately twice the surviving area compared to similar sized subdermal plexus flaps (Pavletic 1981). APFs provide full thickness, durable skin coverage with excellent cosmetic results without the need for intensive wound management or a delay procedure prior to transposition (Trevor *et al.* 1992, Sardinas *et al.* 1995, Spodnick *et al.* 1996, Aper & Smeak 2003). APFs require no specialist equipment to be performed and are less technically demanding than microvascular free transfer (Swaim 1990, Cornell *et al.* 1995).

Despite the major advantages of APFs over other reconstructive techniques, complications are described. The incidence of these complications varies, two clinical studies (Trevor *et al.* 1992, Aper & Smeak 2003) showed higher complication rates than described in the experimental studies (Pavletic 1980, 1981, Remedios *et al.* 1989). Complications described in the literature include wound drainage (79%), seroma formation (10–89%), flap oedema (16–80%), bruising, dehiscence (20–50%), distal flap necrosis (20–89%) and infection (16–60%) (Pavletic 1981, Kostolich & Pavletic 1987, Henney & Pavletic 1988, Remedios *et al.* 1989, Trevor *et al.* 1992, Fahie & Smith 1997, Fahie & Smith 1999, Lascelles & White 2001, Aper & Smeak 2003).

APFs have been derived from many direct cutaneous arteries and the area of skin that each supports. These areas appear consistent and well defined in dogs and cats, although there is some variation between the species. A complete list of APFs that are described and used in practice include: caudal auricular (Smith *et al.* 1991), thoracodorsal (Pavletic 1981), superficial brachial (Henney & Pavletic 1988), superficial temporal (Fahie & Smith 1997), superficial cervical (Pavletic 1981) cranial superficial epigastric (Degner *et al.* 1994), caudal superficial epigastric (Pavletic 1980), deep circumflex iliac (Pavletic 1981), genicular (Kostolich & Pavletic 1987), lateral caudal (Saifzadeh *et al.* 2005), lateral thoracic (Anderson *et al.* 2004), facial (Yates *et al.* 2007) and reverse saphenous conduit (Pavletic *et al.* 1983).

Despite their widespread use, published studies of patients having an APF as the sole means of reconstruction, excluding case reports, totals 39 cases (Trevor *et al.* 1992, Aper & Smeak 2003). Specifically, there is limited clinical data on the commonly encountered complications and outcomes following APFs.

The aim of this retrospective study was to report the clinical indications, complications and outcome associated with the use of APFs in wound reconstruction.

MATERIALS AND METHODS

Clinical information was retrieved from the medical records of dogs and cats that had an APF performed at one of the two independent referral hospitals between 1994 and 2010.

Data collected included patient signalment, indication for APF, wound location, management prior to referral, type of APF, surgical technique, postoperative management, complications and outcome. There were no additional inclusion criteria and no cases were excluded.

Management prior to referral was categorised into simple closure, complex closure, healing by secondary intention, mass biopsy or other. Simple closure included primary or delayed primary closure and re-suturing of the wound with or without surgical debridement. Complex closure included free skin grafts, local advancement or muscle flaps. Healing by secondary intention (after incisional dehiscence or necrosis) included wounds managed as open wounds with no attempt at closure.

The APFs were performed as described by Hedlund (2007) and all flaps remained attached to the donor site by a skin pedicle. A bridging incision was made for any APFs that were required to cross an area between the donor and recipient site. Chronic axillary wounds were closed with an APF combined with omentalisation as previously described (Lascelles & White 2001).

Analgesia was provided with a combination of opiates and non-steroidal anti-inflammatory drugs as appropriate. Preoperative use of antibiotics was according to the surgeon's preference, given the risk factors for infection present in that patient. Postoperative infections were treated with antibiotics based on culture and sensitivity results. The use of a bandage and a wound drain was according to the surgeon's preference.

Complications were defined as those affecting the APF or donor site within the postoperative period until the animal was discharged from the hospital. Animals were discharged from the hospital when complications had been resolved. Wound swelling was reported as a complication but excluded from comparative statistical analysis. Outcome was defined according to complications and the necessity for a second surgical procedure. Outcome was categorised into four groups: excellent (no complications); good (complications encountered but no second surgery required); fair (complications encountered and a second surgery required); and poor [complications and either multiple surgeries and/or partial (up to 50% necrosis of the APF) or complete (50–100% necrosis of the APF) failure]. For assessment of variables associated with outcome, these outcome categories were grouped into two categories: excellent and good; and fair and poor.

For any patients requiring multiple APFs then only the results for the first APF were included in the study. Cases were not excluded if the medical records were incomplete and any missing data was clearly shown.

Data were entered into a spreadsheet (Excel 2007, Microsoft) and statistical analysis performed (SPSS 18.0, SPSS Inc). Continuous variables were tested for normality using the Kolmogorov-Smirnov test and summarised as mean (±sd) or median (range). Continuous variables were compared between groups using the unpaired t-test, Mann–Whitney U test or one way ANOVA as appropriate. Categorical variables were displayed as frequencies and analysed using the Chi-squared test or Fisher's exact test as appropriate. All variables were examined with the null hypothesis of homogeneity between groups, with the statistical significance set as $P<0{\cdot}05$.

RESULTS

Animals

Medical records from 73 animals were reviewed, comprising 49 dogs and 24 cats. Median age at the time of surgery was 4 years in cats (range 6 months-13 years) and 8 years in dogs (range 1–16 years). Dog breeds included German shepherd dog (8/49; 16%), cross breed (6/49; 12%), boxer (4/49; 8%) and Labrador (4/49; 8%), with 14 other breeds with 3 or fewer individuals (27/49; 55%). Cat breeds included domestic short haired (12/20; 60%), domestic short haired (6/20; 30%), Maine Coon (1/20; 5%) and British blue (1/20; 5%). The breeds of four cats were unknown (4/24; 17%).

Four cats (4/20; 20%) and 15 dogs (31%) were entire males, 9 cats (9/20; 45%) and 7 dogs (14%) were neutered males, 5 cats (5/20; 25%) and 9 dogs (18·4%) were entire females and 2 cats (2/20; 10%) and 18 dogs (37%) were neutered females. The gender of four cats was unknown.

Indications

Indications for APFs were chronic wounds (43/73; 59%) comprising 21 cats (88%) and 22 dogs (45%) and closure following tumour resection (30/73; 41%) comprising 3 cats (13%) and 27 dogs (55%). The specific indications, sites of wounds, previous procedures performed by the referring veterinary surgeon at the wound site and preoperative wound management are summarised in Table 1.

Median time from development of the wound to performing an APF was 27 days [range 0–730, 37 days in cats (0–180), 20 days in dogs (0–730)]. In the case of 11 animals needing mass excision (10 dogs, 1 cat) the APF was performed at the same time as mass removal, i.e. at day 0. The remaining 19 cases requiring an APF after mass excision had a median time from development of wound to performing an APF of 29 days [range 2–730, 39 days in cats (32–45), 25 in dogs (2–730)]. Those requiring an APF after a chronic wound had a median time from development of the wound to performing the APF of 41 days [range 2–709, 51 days in cats (2–180), 36 in dogs (12–709)]. Antibiotics were given preoperatively in 49 patients (49/71; 69%), comprising 20 cats (83%) and 29 dogs (59%).

APF used and surgical technique

APFs used are shown in Table 2. Ten patients (13·7%) had their wounds omentalised at the time of APF [9 cats (38%), 1 dog (2%)] all of which had thoracodorsal flaps. All cats that had an omentalised APF were treated for chronic axillary wounds.

Postoperative bandages were used in 53 patients [53/72; 74%, 13 cats (54%), 40 dogs (83%)] for a median of 7 days [range 1–56; 3 days in cats (1–21), 10 days in dogs (2–56)]. Wound drains were used in 41 patients [41/72; 57%, 9 cats (38%), 32

Table 1. Specific indications, sites of wounds and previous procedures performed by the referring veterinary surgeon at the wound site and preoperative wound management

Variable			Cats n=24 (%)	Dogs n=49 (%)	Total n=73 (%)
Indications	Wounds	Axilla wound secondary to collar injury	10 (42)	0	10 (14)
		Chronic wound cause unspecified	7 (29)	2 (4)	9 (12)
		Necrotic/infected wound	0	4 (8)	4 (6)
		Necrotising fascititis	0	3 (6)	3 (4)
		Degloving/shear injuries	2 (8)	4 (8)	6 (8)
		Bandage related pressure necrosis		4 (8)	4 (6)
		Skin sloughing/chronic wounds following orthopaedic procedure	1 (4)	2 (4)	3 (4)
		Chronic wounds following dog attack	0	2 (4)	2 (3)
		Acute laceration	0	1 (2)	1 (1)
		Restrictive scar secondary to scalding injury	1 (4)	0	1 (1
	Tumours	Soft tissue sarcoma	3 (13)	12 (25)	15 (21)
		Mast cell tumour	0	6 (12)	6 (8)
		Benign masses	0	4 (8)	4 (6)
		Squamous cell carcinoma	0	1 (2)	1 (1)
		Adenocarcinoma	0	2 (4)	2 (3)
		Haemangiosarcoma	0	1 (2)	1 (1)
		Mass of unknown histology	0	1 (2)	1 (1)
Location of wound			n=19 (%)	n=48 (%)	n=67 (%)
	Proximal forelimb		1 (5)	15 (31)	16 (24)
	Distal forelimb		0	5 (10)	5 (8)
	Proximal hindlimb		1 (5)	11 (23)	12/67(18)
	Distal hindlimb		1 (5)	10 (20)	11 (16)
	Axilla		12 (63)	1 (2)	13 (19)
	Head and Neck		3 (16)	3 (6)	6 (9)
	Thorax		0	2 (4)	2 (3)
	Abdomen		0	1 (2)	1 (2)
	Inguinal		1 (5)	0	1 (2)
Previous procedure			n=20 (%)	n=51 (%)	n=71 (%)
	Simple Closure		2 (10)	30 (59)	32 (45)
	Complex Closure		9 (45)	2 (4)	11 (16)
	Healing by secondary intention		2 (10)	3 (6)	5 (7)
	Mass biopsy		2 (10)	4 (8)	6 (9)
	Other:		2 (10)	3 (6)	5 (7)
	Total ear canal ablation		1		
	Achilles tendon repair		1		
	Placement of external skeletal fixator			1	
	Digit amputations			2	
	No previous procedures		3 (15)	9 (18)	12 (17)
Preoperative management			n=17 (%)	n=46 (%)	n=63 (%)
	Open wound management		3 (18)	5 (11)	8 (13)
	Surgical debridement		4 (24)	4 (9)	8 (13)
	Wet to dry dressings		2 (12)	6 (13)	8 (13)
	Surgical debridement and wet to dry dressings		0	8 (17)	8 (13)
	No management		8 (47)	23 (50)	31 (49)

Table 2. APFs used in dogs and cats

Axial pattern flap	Cats n=24 (%)	Dogs n=49 (%)	Total n=73 (%)
Thoracodorsal	17 (71)	19 (39)	36 (49)
Caudal superficial epigastric	3 (13)	10 (20)	13 (18)
Reverse saphenous conduit	1 (4)	9 (18)	10 (14)
Superficial brachial	0	3 (6)	3 (4)
Deep circumflex iliac	1 (4)	2 (4)	3 (4)
Superficial cervical	2 (8)	0	2 (3)
Caudal auricular	0	2 (4)	2 (3)
Lateral thoracic	0	1 (2)	1 (1)
Cranial superficial epigastric	0	1 (2)	1 (1)
Genicular	0	1 (2)	1 (1)
Superficial temporal	0	1 (2)	1 (1)

Table 3. Specific complications following APFs in dogs and cats

Complications	Cats n=20 (%)	Dogs n=44 (%)	Total n=64 (%)
Dehiscence	15 (75)	22 (50)	37 (58)
Swelling of the APF	10 (50)	19 (43)	29 (45)
Necrosis	3 (15)	20 (46)	23 (36)
Infection	8 (40)	12 (27)	20 (31)
Discharge	9 (45)	6 (14)	15 (23)
Seroma	4 (20)	10 (23)	14 (22)

dogs (66·7%)] and removed after a median of 2 days [1–17, 2·84 days in cats (1–9), 3 days in dogs (1–17)]. Postoperative antibiotics were given to 63 patients [63/72; 88%, 21 cats (87·5%), 42 dogs (86%)]. The median duration of hospitalisation was 13·5 days [2–60, 8 days in cats (3–60), 15 days in dogs (2–37)].

Postoperative complications

Postoperative complications occurred in 64 patients [64/72; 89%, 20 cats (83%), 44 dogs (92%)]. Postoperative complications and outcome was not recorded in one dog. Complications are shown in Table 3. Twenty-two patients (31%) required a second surgery [7 cats (30%), 15 dogs (31·9%)], three patients needed more than two surgeries [4%, 2 cats (8·7%) 1 dog (2%)]. The need for additional surgeries was not recorded in two dogs.

The treatment of complications is detailed in Table 4. In the majority of patients, areas of necrotic tissue were surgically debrided and wet to dry dressings were used for further debridement in necrotic or infected wounds. Seromas were generally left to resolve and infected wounds were treated with antibiotics based on culture and sensitivity.

Thirty-eight animals developed an open wound, secondary to dehiscence or necrosis that was left to heal via second intention [57%, 12/22 cats (55%), 26/45 dogs (58%)]. There was one partial failure (1/72; 1%) in 1 dog (2%) and two total failures [2/72; 3%, 1 cat (4%) and 1 dog (2%)]. The cat later had the limb amputated (4%). Two animals (2/72; 3%) died: 1 cat (4%) was found dead and a postmortem was not performed; and 1 dog (2%) died following surgery for gastric dilatation and volvulus in the immediate postoperative period after APF surgery. Two dogs (2/72; 3%) were euthanized postoperatively: one dog (2%) developed systemic inflammatory response syndrome, after mass

Table 4. Treatment of complications in dogs and cats

Treatment of complications	Cats n=20 (%)	Dogs n=44 (%)	Total n=64 (%)
Surgical debridement	7 (35)	12 (27)	19 (30)
Administration of antibiotics	6 (30)	12 (27)	18 (28)
Re-suturing	4 (20)	7 (16)	11 (17)
Wet to dry dressings	0	6 (14)	6 (9)
Seroma drainage	1 (5)	4 (9)	5 (8)
Bandaging	1 (5)	4 (9)	5 (8)
Bandaging with a splint	1 (5)	4 (9)	5 (8)
Drain placement	0	1 (2)	1 (2)
Free skin graft	1 (5)	0	1 (2)
Omentalisation	1 (5)	0	1 (2)

Table 5. APF outcome in dogs and cats

Outcome	Cats n=24 (%)	Dogs n=47 (%)	Total n=71 (%)
Excellent	7 (29)	9 (19)	16 (23)
Good	7 (29)	22 (47)	29 (41)
Fair	7 (29)	14 (30)	21 (30)
Poor	3 (13)	2 (4)	5 (7)

removal and the other was a 16 year old dog (2%) unable to regain normal ambulation after surgery because of orthopaedic disease in other limbs.

Outcome

Flap outcome is shown in Table 5, the outcome of two dogs was not recorded.

Differences between dogs and cats

Results showed statistically significant differences between dogs and cats for gender (P=0·019), age (P=0·039), location of wound (P<0·001), indication for the APF (P<0·001), timing from initial injury until the APF was performed (P=0·037), previous procedures performed at the site (P<0·001), use of concurrent omentalisation (P<0·001), wound drain placement (P=0·018) and duration (P=0·012), use of a bandage postoperatively (P=0·008) and duration (P=0·019). There was significant difference between species for the complications of discharge (P=0·028) and necrosis (P=0·014). See Table 6.

Factors associated with outcome (excellent/good *versus* fair/poor)

Flap outcome was associated with duration of hospitalisation (P=0·006) and leaving the APF to heal by secondary intention after incisional dehiscence or necrosis (P<0·001). See Table 7.

Factors associated with the development of complications

No independent risk factors were associated with complications. See Table 8.

DISCUSSION

In this study we have presented the indications, outcome and complications associated with the use of APFs in 73 cats and dogs. This represents the largest study of this surgical technique.

Table 6. Statistical differences between cats and dogs for all measured variables

Variable	Dogs (n=49)	Cats (n=24)	P value
Gender	Male entire: 15 Male neutered: 7 Entire females: 9 Female neutered: 18	Male entire: 4 Male neutered: 9 Entire females: 5 Female neutered: 2	0·019
Age in years Median (range) in years	4·25 (0·5–13)	8 (1–16)	0·039
Indication	Chronic wounds: 20 Tumour resection: 29	Chronic wounds: 21 Tumour resection: 3	0·000
Location	Proximal forelimb: 15/48 Distal forelimb: 5/48 Proximal hindlimb: 11/48 Distal hindlimb: 10/48 Axilla: 1/48 Head and neck: 3/48 Thorax: 2/48 Abdomen: 1/48	Proximal forelimb: 1/19 Proximal hindlimb: 1/19 Distal hindlimb: 1/19 Axilla: 12/19 Head and neck: 3/19 Inguinal: 1/19	0·000
Timing from initial injury to APF Median (range) in days	20 (0–730)	37 (0–180)	0·037
Previous procedures at site	Simple closure: 30/48 Complex closure: 2/48 Left to heal by secondary intention: 3/48 Mass biopsy: 4/48 No procedures: 9/48	Simple closure: 2/20 Complex closure: 9/20 Left to heal by secondary intention: 2/20 Mass biopsy: 2/20 Other procedures: 2/20 No procedures: 3/20	0·000
Prior surgery at site	36/45	17/20	0·268
Number of prior surgeries	0: 7/45 1: 26/45 2: 7/45 3: 4/45 4: 1/45	0: 3/20 1: 7/20 2: 4/20 3: 2/20 4: 4/20	0·122
Preoperative wound management	Open wound management: 5/46 Surgical debridement: 4/46 Wet to dry dressings: 6/46 Surgical debridement and wet to dry dressings: 8/46 No management: 23/46	Open wound management: 3/17 Surgical debridement: 4/17 Wet to dry dressings: 2/17 Surgical debridement and wet to dry dressings: 0/17 No management: 8/17	0·222
APF used	Thoracodorsal: 19 Caudal Superficial Epigastric: 10 Reverse saphenous conduit: 9 Superficial brachial: 3 Deep circumflex iliac: 2 Caudal auricular: 2 Lateral thoracic: 1 Cranial superficial epigastric: 1 Genicular: 1 Superficial temporal: 1	Thoracodorsal: 17 Caudal Superficial Epigastric: 3 Reverse saphenous conduit: 1 Deep circumflex iliac: 1 Caudal auricular: 2	0·084
Omentalisation	1	9	0·000
Wound drain	32/48	9	0·018
Duration of wound drain Median (range) in days	3 (1–17)	2·84 (1–17)	0·012
Supportive bandage	40/48	13	0·008
Duration of supportive bandage Median (range) in days	10 (2–56)	3 (1–21)	0·019
Preoperative antibiotics	29/47	10	0·062
Postoperative antibiotics	42/48	21	1·000
Length of hospitalisation Median (range) in days	15 (2–37)	8 (3–60)	0·073
Second Surgery	15/47	7/23	0·676
Complications	44/48	20	0·427
Specific Complications: Discharge	6	9	0·028
Necrosis	20	3	0·014
Swelling	19	10	0·813
Seroma	10	4	1·000
Infection	12	8	0·426
Dehiscence	22	15	0·158
Flap outcome	Excellent: 9/47 Good: 22/47 Fair: 14/47 Poor: 2/47	Excellent: 7 Good: 7 Fair: 7 Poor: 3	0·306
Left to heal by secondary intention	26/45	12/22	0·802

Data were not complete for all variables and the total number is recorded if applicable

Table 7. Statistical differences between outcome for all measured variables

Variable	Excellent/good (n=45)	Fair/poor (n=26)	P value
Species	Dog: 31/45 Cat: 14/45	Dog: 16/26 Cat: 10/26	**0·528**
Gender	Male entire: 10/44 Male neutered: 11/44 Entire females: 9/44 Female neutered: 14/44	Male entire: 8/23 Male neutered: 4/23 Entire females: 5/23 Female neutered: 6/23	**0·761**
Age years **Median (range) in years**	7 (1-13)	9 (1-16)	**0·418**
Indication	Chronic wounds: 25/45 Tumour resection: 20/45	Chronic wounds: 14/26 Tumour resection: 12/26	**0·889**
Location	Proximal forelimb: 10/43 Distal forelimb: 4/43 Proximal hindlimb: 6/43 Distal hindlimb: 7/43 Axilla: 8/43 Head and neck: 5/43 Thorax: 1/43 Abdomen: 1/43 Inguinal: 1/43	Proximal forelimb: 5/22 Proximal hindlimb: 1/22 Proximal hindlimb: 5/22 Distal hindlimb: 4/22 Axilla: 5/22 Head and neck: 1/22 Thorax: 1/22	**0·989**
Timing from initial injury to APF **Median (range) in days**	21·5 days (0-730)	30 (0-709)	**0·407**
Previous procedures at site	Simple closure: 21/44 Complex closure: 7/44 Left to heal by secondary intention: 2/44 Mass biopsy: 5/44 Other procedures: 1/44 No procedures: 8/44	Simple closure: 10/22 Complex closure: 4/22 Left to heal by secondary intention: 2/22 Mass biopsy: 1/22 Other procedures: 1/22 No procedures: 4/22	**0·893**
Prior surgery at site	34/44	17/22	**1·000**
Number of prior surgeries	0: 8/42 1: 21/42 2: 7/42 3: 4/42 4: 2/42	0: 2/21 1: 11/21 2: 3/21 3: 2/21 4: 3/21	**0·656**
Preoperative wound management	Open wound management: 5/43 Surgical debridement: 6/43 Wet to dry dressings: 3/43 Surgical debridement and wet to dry dressings: 7/43 No management: 22/43	Open wound management: 3/19 Surgical debridement: 2/19 Wet to dry dressings: 4/19 Surgical debridement and wet to dry dressings: 1/19 No management: 9/19	**0·451**
APF used	Thoracodorsal: 19/45 Caudal Superficial Epigastric: 9/45 Reverse saphenous conduit: 6/45 Superficial brachial: 3/45 Omocervical: 2/45 Deep circumflex iliac: 2/45 Caudal auricular: 1/45 Lateral thoracic: 1/45 Cranial superficial epigastric: 1/45 Superficial temporal: 1/45	Thoracodorsal: 16/26 Caudal Superficial Epigastric: 3/26 Reverse saphenous conduit: 4/26 Deep circumflex iliac: 1/26 Caudal auricular: 1/26 Genicular: 1/26	**0·707**
Omentalisation	7/45	3/26	**0·736**
Wound drain	27/45	12/25	**0·333**
Duration of wound drain **Median (range) in days**	3 (1-9)	2 (1-17)	**0·260**
Supportive bandage	33/45	18/25	**0·904**
Duration of supportive bandage **Median (range) in days**	6·5 (2-49)	10·5 (1-56)	**0·309**
Preoperative antibiotics	32/45	15/24	**0·465**
Postoperative antibiotics	40/45	21/25	**0·712**
Length of hospitalisation **Median (range) in days**	9·5(2-49)	17 (2-60)	**0·006**
Second Surgery	0/45	25/25	**0·000**
Complications	29/45	26/26	**0·000**
Specific Complications: Discharge	4/45	10/26	**0·003**
Necrosis	9/45	13/26	**0·008**
Swelling	19/45	9/26	**0·527**
Seroma	11/45	3/26	**0·188**
Infection	9/45	11/26	**0·042**
Dehiscence	18/45	18/26	**0·018**
Flap outcome	Excellent: 16/45 Good: 29/45	Fair: 21/26 Poor: 5/26	**0·000**
Left to heal by secondary intention	15/42	23/25	**0·000**

Data were not complete for all variables and the total number is recorded if applicable

Animals in the cohort

Cats tended to have APFs used to reconstruct traumatic wounds, whereas dogs had a greater proportion of flaps used for reconstruction after tumour excision. There are a number of other differences between the species but many of these may be explained by the fact that in cats, the most common indication was the use of a thoracodorsal APF for the management of a chronic axillary wound, nearly all of which were omentalised. This would also be expected to have an influence on the postoperative care, especially use of a drain and bandage.

Indications

Closure of chronic wounds, usually days or weeks after creation of the wound, was the most common indication for APF use. In many of these chronic wounds closure had been attempted previously but had failed, and the flap was used once the wound was in a suitable condition.

APFs used and surgical technique

Although 11 different anatomic types of APFs were used in this study, the thoracodorsal, caudal superficial epigastric and reverse saphenous conduit flap, accounted for approximately 80% of APFs used. This probably reflects their robust nature, and length and the location of the direct cutaneous arteries, making them useful for a wide range of wounds within their arc of transposition. The small numbers within each type of APF prevented the use of multivariate analysis and is an inherent limitation of the study.

Table 8. Statistical differences between measured variables for development of complications

Variable	Complications (n=57)	No complications (n=16)	P value
Species	Cat: 17/57 Dog: 40/57	7/16 9/16	**0·369**
Gender	Male entire: 15/53 Male neutered: 12/53 Entire females: 12/53 Female neutered: 14/53	Male entire: 4/16 Male neutered: 4/16 Entire females: 2/16 Female neutered: 6/16	**0·813**
Age years Median (range) in years	8 (1-16)	5(1-13)	**0·194**
Indication	Chronic wounds: 32/57 Tumour resection: 25/57	Chronic wounds: 9/16 Tumour resection: 7/16	**0·994**
Location	Proximal forelimb: 15/52 Distal forelimb: 5/52 Proximal hindlimb: 8/52 Distal hindlimb: 8/52 Axilla: 9/52 Head and neck: 3/52 Thorax: 2/52 Abdomen: 1/52 Inguinal: 1/52	Proximal forelimb: 1/15 Proximal hindlimb: 4/15 Distal hindlimb: 3/15 Axilla: 4/15 Head and neck: 3/15	**0·333**
Timing from initial injury to APF Median (range) in days	23(0-730)	41(0-205)	**0·531**
Previous procedures at site	Simple closure: 27/52 Complex closure: 8/52 Left to heal by secondary intention: 4/52 Mass biopsy: 4/52 Other procedures: 1/52 No procedures: 8/52	Simple closure: 5/16 Complex closure: 3/16 Left to heal by secondary intention: 1/16 Mass biopsy: 2/16 Other procedures: 1/16 No procedures: 4/16	**0·552**
Prior surgery at site	41/52	12/16	**0·739**
Number of prior surgeries	0: 6/49 1: 26/49 2: 9/49 3: 4/49 4: 4/49	0: 4/16 1: 7/16 2: 2/16 3: 2/16 4: 1/16	**0·731**
Preoperative wound management	Open wound management: 6/48 Surgical debridement: 6/48 Wet to dry dressings: 5/48 Surgical debridement and wet to dry dressings: 7/48 No management: 24/48	Open wound management: 2/15 Surgical debridement: 2/15 Wet to dry dressings: 3/15 Surgical debridement and wet to dry dressings: 1/15 No management: 7/15	**0·892**
APF used	Thoracodorsal: 31/57 Caudal Superficial Epigastric: 9/57 Reverse saphenous conduit: 7/57 Superficial brachial: 3/57 Deep circumflex iliac: 1/57 Caudal auricular: 1/57 Lateral thoracic: 1/57 Omocervical: 1/57 Cranial superficial epigastric: 1/57 Genicular: 1/57 Superficial temporal: 1/57	Thoracodorsal: 5/16 Caudal Superficial Epigastric: 4/16 Reverse saphenous conduit: 3/16 Deep circumflex iliac: 2/16 Omocervical: 1/16 Caudal auricular: 1/16	**0·318**

Table 8. (continued)

Variable	Complications (n=57)	No complications (n=16)	P value
Omentalisation	8/57	2/16	1·000
Wound drain	33/56	8/16	0·576
Duration of wound drain Median (range) in days	2 (1-17)	2 (2-9)	0·927
Supportive bandage	43/56	10/16	0·335
Duration of supportive bandage Median (range) in days	7 (1-58)	8 (2-49)	0·899
Preoperative antibiotics	35/55	14/16	0·122
Postoperative antibiotics	48/56	15/16	0·673
Length of hospitalisation Median (range) in days	14·5 (2-60)	7 (3-24)	0·066
Second Surgery	25/54	0/16	0·001
Specific Complications: Discharge	15/57	0/16	0·031
Necrosis	23/57	0/16	0·002
Swelling	22/57	7/16	0·710
Seroma	14/57	0/16	0·030
Infection	20/57	0/16	0·004
Dehiscence	37/57	0/16	0·000
Flap outcome	Excellent: 0/55 Good: 30/55 Fair: 22/55 Poor: 3/55	Excellent: 16/16	0·000
Left to heal by secondary intention	38/54	0/13	0·000

Data were not complete for all variables and the total number is recorded if this applies

The use of a surgical drain, usually an active suction drain, is recommended (Wardlaw & Lanz 2012) for the management of the dead space associated with the donor and recipient site (Remidios *et al.* 1989). However, a drain was only used in just over half the patients. The use of an active drain in some APFs may be difficult due to the location of the APF and the problems encountered in managing potentially bulky drains. There are also species differences, with drains being used and used more commonly and for longer in dogs than cats. Although there was a significant difference in duration of drain placement, the magnitude of the difference was small (0·16 days) and the clinical importance of this finding may be small. The species differences may be explained by the reduced tolerance of cats for drains and the smaller wounds seen in this species. In addition, APFs used to close an omentalised wound may not need an active suction drain with the provision of a physiological drain (Lascelles & White 2001). This clinical decision-making regarding the use of drains appears rational as there was a lower incidence of seroma formation in cats compared to dogs.

The use of a bandage following an APF is a matter of debate. A bandage has the potential to obliterate dead space and limit mobility of the affected part, particularly a limb, which may reduce dynamic tension on the wound in general and on the direct cutaneous vessels in particular (Aper & Smeak 2003). However, a bandage has the potential to apply too great a pressure which may reduce blood flow through the vessels. It may not be possible to apply a bandage to cover the entire flap (e.g. distal thoracic limb using a thoracodorsal APF), consequently the bandage stops part way along the APF, potentially causing a tourniquet effect. In this study we found bandaging was not associated with development of complications or outcome. Bandages were also placed more frequently and for longer in dogs compared to cats, potentially for the same reasons as described for wound drains.

Complications

Overall complications

Complications were encountered in nearly 90% of animals. The effective complication rate depends on the actual complication rate, the diligence with which these are recorded in the medical record and the assessment whether any particular event during the healing process may be considered to be a complication. For instance, postoperative swelling was recorded in nearly half the animals which would not be an unexpected physiological event following disruption to the arterial supply and venous and lymphatic drainage, potentially augmented by a change in the effect of gravity as these flaps are transposed by a great arc. For this reason swelling was not included in complications for comparative statistics. However, irrespective of the above, the flap healed without recourse to further surgical intervention in the majority of patients, the complications encountered were relatively minor and had little effect on the clinical outcome.

Factors associated with complications

The most common complication in this study in both species was incisional dehiscence, which compares to other studies where postoperative wound drainage (Trevor *et al.* 1992) and distal flap necrosis (Aper & Smeak 2003) were the most common complications. This study shows the results for a larger case number for several APFs in both species and thus may account for the differences in these previous studies. Overall there was no difference in the incidence of complications between species. However, discharge and necrosis as individual complications were significantly different between dogs and cats. The higher incidence of discharge may be secondary to the reduced tolerance of cats to drains. The thoracodorsal and caudal superficial epigastric flaps have the ability to extend to a more distal location on the limb in cats compared with dogs (Remedios *et al.* 1989). Therefore, a greater proportion of the limb can be adequately reached with an APF in the cat than the dog without compromising flap viability. This may be a significant factor in the reduced incidence of distal tip flap necrosis seen in this species.

Outcome

Overall outcome

In 93% of patients the outcome was deemed to have been successful, i.e. wound healing was achieved even though an additional surgical procedure was needed in approximately one third of these animals.

In conclusion, this study shows that there is a high complication rate with this procedure but in most cases these complications are relatively minor, easily managed and the long term outcome of these APFs, regardless of the species, is excellent.

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.

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