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Is the caudal auricular axial pattern flap robust? A multi-centre cohort study of 16 dogs and 12 cats (2005 to 2016)

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Is the caudal auricular axial pattern flap robust?

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1 **Is the caudal auricular axial pattern flap robust?**

2 **A multi-centre cohort study of 16 dogs and 12 cats (2005-2016)**

3

4

5 **ABSTRACT**

6

7 **Objective:**

8 To determine the frequency and type of healing complications arising after the use

9 of the caudal auricular axial pattern flap to close defects on the head in dogs and

10 cats.

11

12 **Study Design**

13

14 Multi-centre retrospective cohort study

15

16 **Material and Methods**

17

18 Centres were recruited via the Association for Veterinary Soft Tissue Surgery (AVSTS)

19 Research Cooperative (ARC). Medical records of 11 centres were reviewed, and data

20 from all dogs and cats treated with a caudal auricular axial pattern flap were

21 retrieved. The following data were recorded: signalment, reason for reconstruction,

22 flap dimensions, anatomic landmarks used, histological diagnosis, flap healing, and

23 whether revision surgery was required.

24

25 **Results**

26 28 cases were included: 16 dogs and 12 cats. Flap length:width ratio was
27 approximately 3:1 and flap length extended to the scapular spine in most cases.
28 Optimal wound healing occurred in 5/16 (31%) dogs and 6/12 (50%) cats. Wound
29 dehiscence without flap necrosis occurred in 1/16 (6%) dogs and 1/12 (8 %) cats.
30 Wound dehiscence with flap necrosis occurred in 10/16 (63%) dogs and 5/12 (42%)
31 cats. Revision surgery was performed in 8/16 (50%) dogs and 3/12 (25%) cats.

32

33

34 **Conclusion and Clinical Relevance**

35

36 The caudal auricular axial pattern flap can provide full thickness skin coverage for
37 large defects on the head in dogs and cats. Partial flap necrosis is a common
38 complication, and revision surgery may be required in order to achieve final wound
39 closure.

40

41

42 **INTRODUCTION**

43

44 Large skin defects in dogs and cats can be challenging to reconstruct and many
45 reconstructive techniques have been developed that allow tension-free closure,
46 including subdermal plexus and axial pattern flaps (Field and others (2015), (Hunt
47 2012, Wardlaw and Lanz 2012). Axial pattern flaps incorporate a direct cutaneous
48 artery and vein, which improves their perfusion and viability. The main advantage of

49 axial pattern flaps is that they are more robust and allow for greater mobilization of
50 a longer flap with higher survival rates compared to a subdermal plexus flap (Pavletic
51 1981, Smith and others 1991).

52

53 Several axial pattern flaps have been described to cover large defects of the head in
54 dogs and cats, and they include the superficial temporal, omocervical, angularis oris,
55 and caudal auricular axial pattern flap (Fahie and Smith 1999, Losinski and others
56 2015, Pavletic 1981, Smith and others 1991). The caudal auricular axial pattern flap
57 was first described by Smith and others (1991) and is based on the
58 sternocleidomastoideus branches of the caudal auricular artery and vein originating
59 between the lateral aspect of the wing of the atlas and the vertical ear canal. These
60 branches course in a caudal and dorsal direction parallel to the central cervical
61 region and supply the cranial aspect of the cervical skin, the platysma muscle, and
62 subcutaneous fat, and eventually anastomose with the superficial cervical artery.
63 Smith and others (1991) described the flap base as the palpable depression between
64 the lateral aspect of the wing of the atlas and the vertical ear canal, centred on the
65 lateral aspect of the wing of the atlas. The flap runs caudally over the central neck,
66 between parallel dorsal and ventral lines extending from the flap base to the spine of
67 the scapula.

68

69 There is limited published information regarding the clinical or experimental use of
70 the caudal auricular axial pattern flap. The available literature includes two
71 experimental studies (Smith and others 1991, Smith and others 1993), which
72 included the clinical use of the flap in two cats, both of which had complete flap

73 survival, and three reports of its clinical use (Field and others 2015, Spodnick and
74 others 1996, Stiles and others 2003). In the Spodnick and others (1996) clinical
75 series, the caudal auricular axial pattern flap was utilized in three cats and no
76 complications or flap necrosis were reported. Stiles and others (2003) used this flap
77 in three cats and one dog following orbital exenteration and described flap necrosis
78 in two cats, both requiring revision surgery. In a more recent study by Field and
79 others (2015) looking at 73 axial pattern flaps in dogs and cats, the caudal auricular
80 axial pattern flap was used in two dogs, but no specific information was reported
81 regarding flap survival or outcome.

82
83 The aim of this study was to determine how frequently complications arise after use
84 of the caudal auricular axial pattern flap to close defects on the head in dogs and
85 cats.

89 MATERIAL AND METHODS

90
91 This study was approved by the Association for Veterinary Soft Tissue Surgery
92 (AVSTS) Research Cooperative (ARC) and by the Animal Health Trust (UK) Clinical
93 Research Ethics Committee. Centres were invited to participate via ARC's list server
94 and via direct contact with the authors.

95

96 Medical records from contributing institutions were reviewed and data were
97 retrieved for every dog or cat treated with a caudal auricular axial pattern flap
98 between 2005 and 2016 with at least 4 weeks follow-up. Exclusion criteria were
99 previous irradiation of the donor or recipient site. The following data were recorded,
100 where available: breed; sex; neutering status; age; reason for reconstruction; specific
101 location of the defect; histological diagnosis; flap dimensions (cm width and length);
102 anatomic landmarks used; use of surgical drain; flap healing (optimal flap healing
103 defined as flap healing without necrosis or dehiscence; wound dehiscence without
104 flap necrosis; wound dehiscence with flap necrosis); location (flap divided into nine
105 zones; dorsal-middle-ventral thirds, and rostral-middle-caudal thirds, according to
106 the harvested but unrotated flap) and extent of necrosis (cm width and length; and
107 estimate of proportion of flap involved (<10%, 10-<25%, 25-<50%, 50-<75%, 75-
108 100%); and revision surgery performed (yes/no).

109

110 **RESULTS**

111 Data were available for all cases unless otherwise stated.

112

113 *Dogs*

114 Data were available for 17 dogs (Table 1). One dog was excluded as the flap was
115 used to reconstruct a non-healing wound secondary to radiation necrosis after
116 surgical resection and irradiation of a multilobular osteochondrosarcoma. The
117 remaining 16 dogs had caudal auricular axial pattern flap reconstruction after
118 tumour excision. For the six dogs with specific flap dimension data available, the
119 median (range) flap length used was 19.3cm (10.0-27.0cm). The median (range) flap

120 width used was 6.5cm (4.5-10.0cm). For the eight dogs with specific anatomic
121 landmark data available, 5/8 (62.5%) extended caudally to the scapular spine and
122 3/8 (37.5%) did not extend to the scapular spine; and 8/8 involved the central third
123 (dorsoventrally) of the neck skin. Three (18.8%) cases included use of an active
124 suction drain. Histological diagnosis included soft tissue sarcoma (8, of which two
125 were low grade, four were intermediate grade, and two were of unknown grade),
126 squamous cell carcinoma (2), mast cell tumour (3, of which two were grade II and
127 one was unknown grade), and malignant melanoma (3). The most common location
128 of the defect was the orbital area following exenteration (11/16 dogs) followed by
129 defects on the frontal area (2/16), the cheek (2/16), and the ear base (1/16).

130

131 Outcome in dogs is summarised in Table 2. Optimal healing occurred in 5/16 (31.3%)
132 dogs; dehiscence without flap necrosis occurred in 1/16 (6.3%) dogs; and wound
133 dehiscence with flap necrosis occurred in 10/16 (62.5%) dogs. For seven dogs with
134 data available, the median (range) length of the region of necrosis was 4.0cm
135 (2.0cm-10.0cm) and the width of necrosis was 5.0cm (0.5cm-10.0cm). For the seven
136 dogs with data available, the median (range) estimated proportion of flap necrosis
137 was 10-<25% (range <10% to 75-100%). The regions of the flap that underwent
138 necrosis were always at the distal tip (caudal-dorsal, caudal-middle, and caudal-
139 ventral regions of the flap), and with more extensive cases of necrosis, also involved
140 the middle-dorsal, middle-middle, and middle-ventral regions. Revision surgery was
141 performed in 8/16 dogs (50.0%). Of the 10 dogs with wound dehiscence and flap
142 necrosis, 7 (70.0%) underwent revision surgery. The dog that had wound dehiscence
143 without flap necrosis also underwent revision surgery. For the seven dogs with

144 necrosis, the following revisions were performed: debridement and local side-to-side
145 closure (n=2), debridement and closure using either the original flap (n=1) or an
146 extension of the original flap (n=1), debridement and closure using a combination of
147 side-to-side closure and an extension of the original flap (n=1), and debridement and
148 closure using a local subdermal plexus flap harvested from the ventral neck (n=2)
149 (one of which had incomplete closure with the open wound healing by second
150 intention).

151

152 *Cats*

153 Data were available from 12 cats (Table 1). No cases were excluded. The reason for
154 the use of the caudal auricular axial pattern flap was reconstruction after tumour
155 resection in all cats, with the orbital area being the most common location of the
156 defect (10) followed by the temporal region (1) and ear base (1). For eight cats with
157 data available, median (range) flap length was 16.0cm (7.0-18.0cm) and flap width
158 was 5.0cm in all cases. For cases with specific anatomic landmark data available, 7/9
159 (77.8%) extended caudally to the scapular spine and 2/9 (22.2%) did not; all involved
160 the central third (dorsoventrally) of the neck skin. One case (8.3%) had a passive
161 drain placed at surgery. Histological diagnosis was soft tissue sarcoma (7, of which
162 two were low grade, three were intermediate grade, one was high grade, and one
163 was of unknown grade), squamous cell carcinoma (4), and mast cell tumour (1).

164

165 The outcome in cats is summarised in Table 3. There was optimal wound healing in
166 6/12 (50.0%) cats. Wound dehiscence with and without flap necrosis occurred in
167 5/12 (41.7%) and 1/12 (8.3%), respectively. The median (range) length of the region

168 of necrosis was 5.0cm (4.0-8.0cm) and the width was 5.0cm in all five cats. The
169 estimated proportion of the flap undergoing necrosis was 25-50% in all five cats
170 with necrosis. The regions of the flap undergoing necrosis were always the distal tip
171 (the caudal-dorsal, caudal-middle and caudal-ventral regions) and extended to
172 include the middle-dorsal, middle-middle, and middle-ventral regions in cases with
173 more extensive necrosis. Revision surgery was performed in 3/12 (25.0%) cats. Of
174 the five cats with wound dehiscence and flap necrosis, three (60.0%) had revision
175 surgery and two (40.0%) healed by second-intention without the need for further
176 anaesthesia or surgery. The following revision surgeries were performed: surgical
177 debridement and primary closure of the wound (n=1), debridement and closure
178 using advancement of the flap (n=1), and debridement and closure using a local
179 subdermal plexus flap derived from the ventral neck skin (n=1). One cat with wound
180 dehiscence without flap necrosis healed by second intention without revision
181 surgery.

182
183

184 **DISCUSSION**

185

186 The main finding of this retrospective study of 16 dogs and 12 cats treated with a
187 caudal auricular axial pattern flap was the relatively high complication rate. The most
188 common complications were necrosis of various lengths of the distal aspect of the
189 flap, which was reported in 62.5% of dogs and 41.7% of cats and isolated dehiscence
190 of the flap in 6.3% of dogs and 8.3% of cats.

191

192 The mean length of survival of the caudal auricular axial pattern flap was 85% in two
193 experimental studies (Smith and others 1991, Smith and others 1993). In these
194 studies, the flap was created, elevated, and then sutured back in place at the donor
195 site without rotation or transposition. In addition, the authors did not always extend
196 the flap up to the scapular spine. However, 67% of both canine and feline caudal
197 auricular axial pattern flaps underwent necrosis of varying degrees. Furthermore,
198 optimal healing, namely full flap survival with no necrosis or wound dehiscence, was
199 reported in 31.3% of dogs and 50.0% of cats in the present study. In previous
200 experimental and clinical studies, optimal healing was reported in 33% to 100% of
201 dogs and 33% to 75% of cats (Smith and others (1991), (1993), Spodnick and others
202 1996, Stiles and others 2003). These results, in combination with the findings of the
203 study reported herein, suggest that some degree of necrosis of the caudal auricular
204 axial pattern flap is common.

205

206 The flap dimensions used were not known for all cases in this study, but the majority
207 of the flaps with specific data available in this study extended to the scapular spine.
208 Although this is reported as the appropriate caudal limit of the caudal auricular axial
209 pattern flap, it is interesting to note that the Smith and others (1991) often used
210 shorter flaps than this. Although it is not clear which of their cases involved a shorter
211 flap, the extra length of the flap used may have contributed to tip necrosis in this
212 study.

213

214 It is of interest to note that in this study, the dogs with flap necrosis had a greater
215 variety of necrosis and seemed to have a smaller proportion of necrosis (10-<25%)

216 than the cats with necrosis, all five of which had 25%-<50% necrosis. These data
217 should not be seen as reliable, but could reflect anatomic differences between the
218 species. Future studies are warranted to investigate this further.

219

220 While it is unknown why many of these flap tips had inadequate blood supply for
221 survival and underwent necrosis, the authors speculate that various factors could
222 have been involved, such as: tension (including that caused by seroma fluid, and by
223 patient movement); anatomical variation of vascular anatomy; torsion of the flap
224 pedicle; surgeon's experience or qualification; surgery time (thrombosis and/or
225 infection); location of the tumour; co-morbidities; other unknown factors. With
226 regards to surgeon's experience, it is important to note that all but two procedures
227 were carried out by a boarded surgeon or a supervised resident. Both of the
228 procedures carried out by non-boarded/non-resident surgeons healed either
229 uneventfully or with minor wound dehiscence not requiring revision surgery. Surgery
230 time is another known risk factor for surgical site infection (Brown and others (1997)
231 but unfortunately this was inconsistently recorded in the medical records and could
232 not be evaluated further.

233

234 Revision surgery was felt (by the attending surgical team) to be necessary in 8/11
235 (72.7%) of the dogs with healing complications and 3/6 (50.0%) of the cats with
236 healing complications. There were four dogs and three cats in this study whose
237 wound dehiscence was not felt to warrant revision surgery. Unfortunately, this study
238 design does not allow for detailed understanding of the decisions involved in these
239 cases. Revision surgery was successful in all cases, and mostly involved simply pulling

240 the surrounding skin together (with or without pulling the remaining flap further
241 across, or raising further flap tissue) over the defect left by the necrosis, after
242 debridement. In three cases, revision surgery included a local subdermal plexus flap,
243 which was derived from the ventral neck skin.

244

245 Surgical margins have not been reported in this study as specific data were not
246 available. The decision-making process regarding individual cancer care is complex
247 and this study was not designed to investigate it. Another alternative approach for
248 some of these cases might have been planned marginal excision followed by
249 radiotherapy. This could have resulted in a smaller surgical defect needing only local
250 closure. The surgical teams at the centres involved in this study came to a decision
251 with the owner at the time, taking into account all local factors and balancing
252 logistics, complication risk, overall treatment costs, and prognosis. This includes
253 cases such as Case 23, where this surgical dose was recommended as part of a multi-
254 modal treatment plan. Specific, strong, data regarding these treatment choices for
255 the various cancer types is sparse in the veterinary literature, and further studies are
256 warranted.

257

258 It is important to note that in this study wound dehiscence and flap necrosis did not
259 always require revision surgery, and that all patients healed eventually with one
260 revision surgery. This is consistent with 2 large retrospective studies by Field and
261 others (2015) and Trevor and others (1992) that reported high complication rates
262 but also a high overall success rate. The findings of this study are supportive of these
263 two studies and they reinforce that axial pattern flaps in general and caudal auricular

264 axial pattern flaps specifically may not be as robust and revision surgery should be
265 expected and this should be communicated with the owner.

266

267 This delay in healing could also delay adjuvant treatment if this were indicated,
268 however subsequent review of case data made during the review process for this
269 manuscript showed 0/28 cases underwent adjuvant treatment with chemo- or radio-
270 therapy and 1 case with oral malignant melanoma received adjuvant
271 immunotherapy which was not delayed by the wound healing complications, as
272 expected by the protocol of Piras and others (2017) followed at this centre. The
273 reason for the lack of adjuvant treatment was either that it was not indicated, or
274 that the owner declined it.

275

276 Limitations of this study include those inherent to retrospective studies.
277 Perioperative management and the management of flap-related complications were
278 not standardized. The original flap limits and dimensions were infrequently included
279 in the medical records. The degree of flap necrosis (when present) was also
280 infrequently recorded. However, despite these limitations, this study is currently the
281 largest collection of data regarding the clinical use of the caudal auricular axial
282 pattern flap in dogs and cats, and found that this flap can provide full thickness skin
283 coverage for various large skin defects of the head in dogs and cats. Surgeons, and
284 owners, should be aware that flap necrosis should not be seen as an unexpected
285 complication when this flap is used in clinical cases and revision surgery may well be
286 required in order to achieve final wound closure.

287

288 **CONFLICT OF INTEREST**

289 There are no grants, financial support or conflicts of interest to declare

290

291

292

293

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294

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337
338
339

	breed	age (in years)	sex and neutering status	Location of the defect	Cause of defect (ex trauma or neoplasia)	histological diagnosis
1	Labrador Retriever	6.5	MN	left orbital area	neoplasia	intermediate grade soft tissue sarcoma
2	Boxer	10	MN	Dorsal head, temporal region and nuchal crest	neoplasia	intermediate grade mast cell tumor
3	crossbreed	7	MN	left orbital area	neoplasia	undifferentated spindle cell sarcoma, neurofibrosarcoma
4	crossbreed	6	MN	left orbital area	neoplasia	low grade soft tissue sarcoma
5	Yorkshire Terrier	12	FN	Right cheek	neoplasia	aggressive malignant melanoma
6	Labrador Retriever	5	M	left orbital area	neoplasia	intermediate mast cell tumor
7	German Shepherd	9	FN	left cheek	neoplasia	Melanoma
8	crossbreed	9	MN	right frontal area	neoplasia	Squamous cell carcinoma

9	Labrador Retriever	9	FN	left orbital area	neoplasia	soft tissue sarcoma unknown grade
10	Golden Retriever	5	FN	left orbital area	neoplasia	soft tissue sarcoma intermediate grade
11	Labrador Retriever	6	MN	left orbital area	neoplasia	soft tissue sarcoma low grade
12	Cocker Spaniel	1.5	FN	right orbital area	neoplasia	intermediate grade fibrosarcoma
13	Australian Cattle Dog	10	M	Base of right ear	neoplasia	intermediate grade mast cell tumour
14	Crossbreed	6 years	MN	Right orbital area	Neoplasia	Soft tissue sarcoma
15	crossbreed	5	FN	right orbital area	neoplasia	malignant melanoma
16	crossbreed	14	MN	left orbital area	neoplasia	Squamous cell carcinoma
17	domestic short hair	8	FN	defect involving left orbit and left	neoplasia	low grade fibrosarcoma

				temporal region		
18	domestic short hair	4	FN	left orbital area	neoplasia	Soft tissue sarcoma grade II
19	european short hair	7	FN	left Supraorbital/orbit, frontal area	neoplasia	Soft tissue sarcoma, grade II
20	european short hair	8	FN	left orbital area	neoplasia	Squamous cell carcinoma
21	european short hair	8	FN	right orbital after enucleation	neoplasia	recurrence of a grade II soft tissue sarcoma
22	european short hair	10	FN	right temporal region	neoplasia	Mast cell tumour
23	european short hair	15	MN	Region of the ear	neoplasia	Recurrent Grade III fibrosarcoma with lymph node metastasis
24	european short hair	15	FN	right orbital area after exenteration	neoplasia	Squamous cell carcinoma
25	european short hair	9	FN	left orbital area	neoplasia	Squamous cell carcinoma
26	domestic short hair	8	FN	right orbital area	neoplasia	low grade soft tissue sarcoma
27	Domestic Shorthair	8	FN	left orbital area	neoplasia	Spindle Cell Sarcoma

28	Domestic Shorthair	11.5	FS	Right orbit	neoplasia	Squamous cell carcinoma	
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Table 1. Signalment, reason for reconstruction, histological diagnosis, location of defect of all patients.

Review Copy

	No wound breakdown	Wound breakdown no necrosis	Wound breakdown with necrosis	Total
No revision surgery	5	0	3	8
Revision surgery	0	1	7	8
Total	5	1	10	16

Table 2: Showing flap outcome and revision surgery in dogs

Review Copy

	No wound breakdown	Wound breakdown no necrosis	Wound breakdown with necrosis	Total
No revision surgery	6	1	2	9
Revision surgery	0	0	3	3
Total	6	1	5	12

Table 3: Showing flap outcome and revision surgery in cats

Review Copy