Combined caudal-superficial-epigastric axial pattern flap and full-thickness buccal mucosa graft for single-stage preputial reconstruction in six dogs

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Abstract: OBJECTIVE: To describe the use of a caudal superficial epigastric flap in combination with a full-thickness oral mucosal/submucosal graft for single-stage reconstruction of extensive preputial defects in dogs. MATERIALS AND METHODS: Medical records of dogs with extensive preputial defects either of traumatic origin or derived from tumour excision were reviewed. In all dogs, the prepuce was reconstructed using a full-thickness oral mucosal/submucosal graft combined with a caudal superficial epigastric axial pattern flap during a single surgical procedure. Outcome was assessed by routine clinical examinations for 6 months postoperatively, and through telephone follow-up thereafter. RESULTS: Six dogs were included. The caudal superficial epigastric axial pattern flap healed without complications in all dogs, while the full-thickness oral mucosal/submucosal graft failed in one dog. In this individual the skin flap underwent contracture 30 days after surgery and preputial advancement was required. One dog showed postoperative discomfort during urination, which was successfully managed with a Foley catheter and analgesic administration. Three dogs developed paraphimosis at 30, 80 and 90 days, respectively, and required further surgery. Long-term results were good in all dogs. CLINICAL SIGNIFICANCE: The use of a full-thickness oral mucosal/submucosal graft combined with a caudal superficial epigastric axial pattern flap is feasible for single-stage preputial reconstruction in dogs. Attention should be paid to create a sufficiently large preputial opening, in order to prevent paraphimosis.

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COMBINED CAUDAL-SUPERFICIAL-EPIGASTRIC AXIAL PATTERN FLAP AND FULL-THICKNESS BUCCAL MUCOSA GRAFT FOR SINGLE STAGE PREPUTIAL RECONSTRUCTION IN SIX DOGS

Objective: To describe the use of a caudal superficial epigastric flap in combination with a full-thickness oral mucosal/submucosal graft for single stage reconstruction of extensive preputial defects in dogs.

Methods: Medical records of dogs with extensive preputial defects either of traumatic origin or derived from tumour excision were reviewed. In all dogs, the prepuce was reconstructed using a full-thickness oral mucosal/submucosal graft combined with a caudal superficial epigastric axial pattern flap during a single surgical procedure. Outcome was assessed via routine clinical examinations for six months postoperatively, and by telephone follow-up thereafter.

Results: Six dogs were included. The caudal superficial epigastric axial pattern flap healed without complications in all dogs, while the full-thickness oral mucosal/submucosal graft failed in one dog. Contraction of the skin flap occurred in the latter dog 30 days after surgery, and required a preputial advancement. One dog showed postoperative discomfort during urination, which was successfully managed with a Foley catheter and analgesics administration. Three dogs developed paraphimosis at 30, 80 and 90 days, respectively, and required further surgery. Long-term results were good in all dogs.

Clinical significance: The use of a full-thickness oral mucosal/submucosal graft combined with a caudal superficial epigastric axial pattern flap is feasible for single stage preputial reconstruction in dogs. Attention should be paid to create a sufficiently large preputial opening, in order to prevent paraphimosis.

Introduction

Canine prepuce is a complex structure composed by parietal layers continuous with the skin of the ventral abdomen and a visceral layer, which covers and moistens the penis. A cosmetic and functional preputial reconstruction may thus be difficult to achieve. To date, little attention has been given to such issue in the veterinary literature (Smith & Gourley 1990). The presence of extensive preputial defects ~~determines~~ may result in chronic penile protrusion, which ~~results in~~lead to desiccation and inflammation of the penile surface, leading to self-trauma, balanoposthitis (Boothe 2003), and consequent ulceration, haemorrhage or even partial penile necrosis. Some dogs may show discomfort during urination due to penile and urethral inflammation (Olsen & Salwei 2001, Papazoglo 2001, Boothe 2003, Galanty et al. 2008, Grossman & Baltzer 2012). Medical management of this condition is aimed at decreasing inflammation and providing a moist preputial environment to protect the penis; unfortunately, long-term owner compliance is often poor and surgical intervention may become necessary. In case of extensive preputial tissue loss or resection, for instance after *en bloc* removal of tumours, partial or complete penile amputation with or without scrotal urethrostomy is often required (Papazoglo 2001, Boothe 2003, Galanty et al. 2008, Boothe 2012). A three stage surgical procedure for preputial reconstruction that involves implantation of a mucosal surface near the penis has been described, but such procedure was considered demanding and expensive (Smith & Gourley 1990).

To the best of our knowledge, a single stage surgical procedure for the reconstruction of extensive preputial defects in dogs has not been reported yet. The aim of this paper is to describe and assess the results of a single stage surgical technique for preputial reconstruction in six dogs, following extensive traumatic tissue loss or wide tumour resection; the surgical procedure that we report consists of a caudal superficial epigastric axial pattern flap combined with a full-thickness oral mucosal/submucosal graft.

Materials and Methods

Medical records of dogs that underwent preputial reconstruction using a caudal superficial epigastric axial pattern flap transposition combined with a full-thickness oral mucosal/submucosal graft following extensive tissue loss caused by tumour removal or trauma were reviewed. Information collected included sex, breed, age and weight of the dogs, presenting complaints, dimension of the preputial defect as assessed by the surgeon, and preoperative diagnostic work-up. Preoperative evaluation included physical examination, complete blood count, serum biochemical profile, and cytology of the preputial mass (in case of suspected tumour); if cytology was highly suggestive of tumour, clinical staging was performed and consisted of thoracic radiographs (3 orthogonal projections), abdominal ultrasonography, and cytology of the inguinal lymph nodes. The latter were also removed at the time of primary tumour excision and submitted for histopathological evaluation. No attempt was made to identify further draining lymph nodes other than the inguinal nodes. Surgical data and follow-up information retrieved from medical records included technical details of the procedures and short- and long-term complications (defined as within and after 30 days postoperatively, respectively). Histological examination of the excised preputial tumours also included evaluation of resection margins. Surgical margins were classified as free from residual tumour (R0, $\geq$1 mm), no residual tumour but minimal distance between tumour and resection margin (R1, $\leq$ 1 mm), microscopic residual tumour at the resection margins (R1-dirt), and local macroscopic residual tumour (R2) (Wittekind et al. 2009).

Postoperative complications were defined as minor when they were managed conservatively and major when further surgery was required. Functional and cosmetic outcome were subjectively evaluated and classified as good, acceptable or poor based on clinician and owner assessment (Table 1).

Surgical procedure

In all dogs, anaesthesia was induced with IV injection of fentanyl (2 μg/kg) and propofol (4 mg/kg) and maintained with isoflurane in oxygen at 0.5 litre per minute. All dogs received cephazolin (22 mg/kg, IV) at the time of induction. Anaesthetised dogs were positioned in dorsal recumbency, and both the ventral abdomen and the oral cavity were aseptically prepared for surgery. Chlorhexidine 2% and alcohol combination and sterile saline were used for preparation of the skin and oral cavity, respectively. The apex and variable portions of the prepuce were reconstructed in five dogs, whilst in one dog (no. 3) the defect was located centrally (Fig. 2). In case of tumour excision, surgical gloves and instruments were changed prior to preputial reconstruction. The exposed penis and the subcutaneous tissues were protected with saline-soaked gauze sponges during surgery. For the full-thickness oral mucosa grafts harvesting, both mucosa and submucosa of the lip and/or cheek were incised with a no. 10 scalpel blade and elevated submucosally using skin hooks or Adson-Brown tissue forceps, and Metzenbaum scissors (Fig. 1-B). The free grafts were collected from the lip and/or cheek on the surgeon's side; no specific anatomic landmark was considered for graft harvesting and its size was decided based on the dimensions of the preputial defect. Major bleeding was managed with vessel ligation, while minor haemorrhage was controlled using electrosurgery. The resulting oral defect was left to heal by second intention. In dog no. 3, the preputial defect was located at the body of the penis and a smaller oral graft was required, as the dorsal part of the preputial mucosa had been preserved during tumour excision (Fig. 2). In dog no. 6, the harvested oral graft was meshed in order to completely cover the preputial defect (Fig. 3). In the remaining cases, the mucosal graft fitted well into the receiving site. In order to obtain grafts consisting of mucosa and submucosa only, both fat and residual muscle tissue were removed before graft placement. The mucosal graft was then apposed circumferentially around the penis (with the mucosal surface facing the penis) and sutured to the residual preputial mucosa with absorbable monofilament sutures (4-0 Monocryl) in a continuous pattern (Fig 1-C). The caudal superficial epigastric axial pattern flap was then created preserving the subcutaneous fat, elevated, and rotated

to reach the preputial defect. The transposition angles ranged from 50° to 90°, depending on which part of the prepuce was involved. No suture was applied between the graft and the deep surface of the caudal superficial epigastric axial pattern flap, in order to avoid accidental damage of the caudal superficial epigastric artery. The deep aspect of the axial pattern flap was then sutured to the submucosal surface of the oral graft. The preputial orifice was created by suturing the apex of the axial pattern flap to the underlying mucosal surface of the oral graft; the diameter of the reconstructed preputial opening was subjectively decided by the surgeon. After placing a Redon active suction drain (Emodren® - Medicalplastic s.r.l.), the lateral borders of the caudal superficial epigastric axial pattern flap were sutured to the receiving site in two layers with an appositional continuous pattern (Fig. 1-D and 1-E). The donor site was routinely closed.

An indwelling urethral catheter was not placed prior to anesthetic recovery in any of the six dogs. All dogs were managed postoperatively with opioids (buprenorphine 20 μg/kg IV q 8 h at the end of the procedure, progressively tapered and discontinued as the dogs recovered) and non-steroidal anti-inflammatory drugs (meloxicam 0.2 mg/kg PO SID for the first day and 0.1 mg/kg SID for 4 days thereafter) in order to control discomfort and reduce inflammation. Cephazolin (20 mg/kg SC BID) was administered for 1-5 days postoperatively; for patients discharged earlier, Cefadroxil (20 mg/kg PO SID) was administered at home till day 5.

General clinical condition, appetite and possible urinary discomfort were monitored postoperatively for the first days. All patients were discharged after drain removal, which occurred when production of fluid was less than 0.2 ml/kg/h (Shaver et al. 2014). Surgical wounds were evaluated daily during hospitalization, and every 3-5 days after discharge until complete healing. The use of an Elizabethan collar was suggested until skin suture removal. Dogs with histologically confirmed malignant tumour were rechecked by the referring veterinarian (physical examination, chest radiographs, abdominal ultrasound) every three months for the first year after surgery, and every 6 months during the second year.

Results

Signalment, clinical findings and diagnosis

Six male dogs (4 intact and 2 castrated) were included. Body weight ranged from 6 to 38 kg (mean 21 kg). (Table 2) Five dogs were referred because of a preputial neoplasm and one dog for a traumatic preputial lesion. Cytology of inguinal lymph nodes did not reveal tumour cells in any of the 5 dogs with a malignant tumour. Histologically, tumour types included: primary cutaneous mast cell tumour (cMCT; Patnaik grade II, Kiupel low grade) in two dogs; recurrence of a cMCT (Patnaik grade II, Kiupel low grade) in one dog; primary squamous cell carcinoma in one dog; and second recurrence of a grade I soft-tissue sarcoma in one dog (Kuntz 1997). Maximum tumour diameter ranged from 2 to 3 cm (Table 2). All surgical margins were classified as R0, as histological evaluation excluded the presence of residual tumour cells. Histological examination of the inguinal lymph nodes confirmed the absence of metastatic disease. Dog no. 6 had an extensive traumatic lesion involving most of the prepuce (including the apex) caused by a bite six months before presentation.

Surgical procedure

Preputial tumours were surgically removed with a peripheral margin of at least 2 cm; deeply, full thickness resection reached the preputial cavity (Fig. 1-A). Bilateral superficial inguinal lymphadenectomy was performed; to complete clinical staging, all nodes were submitted for histological evaluation, even if pre-operative cytological examination had shown no signs of nodal metastasis. The dog with a defect of traumatic origin (no. 6) underwent excision of the whole scar tissue. The preputial defects ranged in size from 4x5 cm to 10x7 cm (Table 2). The caudal epigastric axial pattern flap was created on the right side in three dogs and on the left side in the

remaining three. In dogs with paramedian tumour localisation, the axial pattern flap was elevated from the contralateral side. In all six dogs, only the last two mammary glands were elevated to create the axial pattern flap. All surgeries were performed in less than 90 minutes (range 65-88 minutes; mean 80 minutes). The active suction drain was kept in place for one to four days postoperatively (mean 2 days). All dogs wore an Elizabethan collar during hospitalisation.

Outcome

During hospitalisation, dog no. 1 showed stranguria and pollakiuria and attempted to lick the genitalia during urination. A decision was made to place a Foley catheter, which was kept for 48 hours till urination became normal. All other dogs had physiological urination, and were discharged two to four days postoperatively, after drain removal.

All the axial pattern flaps healed uneventfully, with no visible sign of necrosis at clinical examination (Fig. 1-F). In dog no. 4, the full-thickness oral graft appeared to have completely failed at day 5. This dog showed dysuria and licking of the prepuce; the graft was removed on day 6 under mild sedation by gentle and minimal traction. After graft removal, signs of discomfort resolved and the resulting preputial defect was left to heal by second intention. Unfortunately, contraction of the skin flap resulted in paraphimosis at day 30 (Fig. 4). Surgical enlargement of the preputial orifice combined with a preputial advancement was performed. Firstly, the preputial orifice was incised ventrally in a craniocaudal direction, and a small wedge was removed from the very cranial part of the opening. A larger orifice was obtained by suturing the mucosa to the skin margins of the wedge (Wilson 1975). The preputial muscles were folded and then sutured over themselves thus obtaining an adequate preputial advancement. Final functional and cosmetic outcome in this dog were considered good.

Two dogs developed paraphimosis at 80 (no. 6) and 90 days (no. 3) postoperatively, and required surgical enlargement of the preputial orifice (as previously described); in both patients, good cosmetic and long-term functional outcome were eventually obtained. The skin flap did not contract

in these two dogs. Urination was assessed as normal in all the dogs from the 3rd day after surgery. The oral mucosa healed completely in 7 to 10 days postoperatively, and no dog showed difficulty when eating or drinking. All dogs had transient contraction of the lip/cheek, which solved spontaneously during the healing process, as confirmed by long-term follow-up examinations.

Dog no. 2 developed moderate inflammation of the preputial opening three months postoperatively due to hair growth into the prepuce. This complication was probably caused by a mild contraction of the oral graft during the healing process, which resulted in the traction of part of the skin flap inside the preputial opening and consequent hair growth inside the prepuce. In this case, conservative treatment with periodic hair clipping was elected, and surgical revision was not necessary. Final functional and cosmetic outcome were considered acceptable.

Long-term follow-up information was obtained via periodic telephone interviews with the referring veterinarian and/or dogs' owners. Minimum follow-up period was 400 days. At the time of writing, all dogs were in good health and had no signs of local and/or distant tumour recurrence and/or urinary problems. Long term cosmetic and functional outcome were considered satisfactory in all cases by owners and surgeons.

Discussion

Extensive preputial defects currently represent a reconstructive challenge, as good cosmetic and functional outcome are difficult to achieve (Smith & Gourley 1990, Boothe 2003, Fossum 2013). Minor defects can be managed with local flaps, bipedicle flaps or preputial advancement combined with preputial muscle shortening (Galanty et al. 2008, Papazoglo 2001, Olsen & Salwei 2001). However, these techniques are less well suited to significant defects of the prepuce, and penile amputation combined with castration and scrotal urethrostomy is often required (Boothe 2003, Galanty et al. 2008, Papazoglo 2001, Boothe 2012).

A three-stage reconstructive technique for extensive preputial defects has been previously reported. The technique involves use of a free mucosal oral graft combined with delayed transposition of a vascularised flap (Smith & Gourley 1990). In that report, the oral graft was firstly sutured to the subcuticular surface of a parapreputial skin flap vascularised by the caudal superficial epigastric artery. The flap was then sutured back to the donor site; six weeks later, the flap/graft was isolated and transposed to cover the penis in a two stage surgical procedure. The oral mucosa, composed of stratified squamous epithelium, provided a suitable covering for the penis (Smith & Gourley 1990). However, ~~such~~ this technique was technically demanding and complete healing took several weeks; reported disadvantages included increased risk associated with multiple surgical procedures and difficulties in flap development, transfer and reconstruction (Smith & Gourley 1990).

To overcome such concerns, we decided to adopt a single stage surgical procedure. Dogs' owners were informed of conventional treatment options, consisting of penile amputation combined with a scrotal urethrostomy, but opted for the one-step procedure due to perceived invasiveness of penile amputation. The caudal superficial epigastric axial pattern flap technique has been ~~largely~~ widely employed in veterinary reconstructive surgery, and has shown promising results (Lewin & Smith 2010, Aper & Smeak 2005, Mayhew & Holt 2003). The caudal superficial epigastric artery and vein arise from the external pudendal artery and vein and ~~guarantee~~ give an adequate vascular supply to the flap. In the cases presented in this report, the flap was easily transposed over the apex and/or body of the penis, and no patient showed healing complications or long-term discomfort. Although development of caudal superficial epigastric axial pattern flap usually requires elevation and transposition of the last three mammary glands in dogs (Evans & de Lahunta 2013), in the dogs of this report elevation of the last two glands was sufficient to cover the preputial defects, thus ~~guaranteeing~~ giving adequate vascularisation of the whole transposed flap. In case of lateralised neoplasms, the flap was created from the contralateral side of the tumour, in order to maintain adequate vascular supply without compromising the resection margins.

Free oral mucosal/submucosal grafts have been previously used to augment the dorsal penile mucosa in combination with bilateral advancement flaps (Pope & Swaim 1986). The full-thickness mucosal/submucosal oral mucosa grafts used in the present study permitted to cover the exposed penis in a one-step procedure, and constituted a smooth interface. In five of the six dogs, the graft was outlined in order to surround the penis completely, and was sutured to the preputial mucosa. In the remaining dog (no. 6), the harvested graft was not large enough to cover the penis, and was thus meshed in order to augment its dimensions; this did not appear to interfere with correct healing. Granulation tissue growth into the meshed graft was not thoroughly evaluated since it would have required further anaesthesia; however, palpation of the surgical site two months postoperatively revealed a smooth and uniform interface between the penis and prepuce, and the dog did not show any abnormal clinical signs. Endoscopic examination of the prepuce of dog no. 3 during anaesthesia for an unrelated procedure showed good healing (Fig. 5). Conversely, the oral graft failed in dog no. 4; authors speculate that one important predisposing factor for failure in this dog was that he did not wear the Elizabethan collar consistently after discharge, thus allowing licking of the surgical site. Movement between the graft and the recipient bed has been identified as a cause of full-thickness skin grafts failure (Tong & Simpson 2012, Pope 1990); we thus suspect that graft movement and trauma caused by licking were major causes of graft failure in this case. Further causes of graft failure were not investigated as no other causative clinical conditions (such as local infection or seroma formation) were suspected. Thirty days after the first surgery, this dog underwent surgical revision of the preputial orifice combined with a preputial advancement, in order to completely cover the penis and solve paraphimosis. In this patient, penis exposure was caused by flap contraction during the healing process, which was probably due to mucosal graft failure and consequent lack of mucosal lining.

Paraphimosis also occurred in dogs nos. 3 and 6, and required surgical correction. Stenosis of the preputial orifice was only partial in these two dogs, and preputial lengthening was not required. It is reasonable to assume that lack of experience with this novel surgical procedure accounted, at least

256 in part, for these complications. In dogs no. 3 and 6, which were the first patients enrolled, the
257 reconstructed preputial orifice was too small. Therefore, a larger preputial opening was created in
258 the subsequent cases, in order to prevent postoperative paraphimosis; to reach this aim, it was
259 empirically considered that normal wound contraction would result in a 30-40% reduction in the
260 diameter of the reconstructed preputial orifice.
261 As the mucosal graft donor site was left to heal by secondary intention, all dogs experienced
262 transient lip/check contraction. Nonetheless, in all patients complete healing and re-epithelisation
263 occurred within ten days, no signs of discomfort were noted and cosmetic outcome was not
264 precluded.
265 Histologically, surgical margins of all excised tumours were clean, and no local recurrence occurred
266 in any dog, as confirmed by long-term follow–up examinations. The risk of incomplete tumour
267 excision was discussed with the owners before surgery, particularly for those dogs presenting with
268 tumour recurrence. In all dogs, preoperative tumour staging excluded macroscopic tumour spread,
269 which was subsequently confirmed by histological evaluation of the regional lymph nodes.
270 Alternative treatment options were offered to dogs' owners, and included: marginal excision and
271 primary closure followed by radiation therapy and/or systemic chemotherapy depending on tumour
272 grade and regional lymph nodes status; and a two-step procedure that involved tumour excision and
273 histological examination of surgical margins followed by a second reconstructive surgery.
274 However, all owners opted for the one-stage procedure, primarily for financial reasons, and
275 accepted the potential risk of incomplete tumour excision.
276 This report describes a novel one-stage surgical procedure for preputial reconstruction in dogs,
277 consisting of a full-thickness oral mucosal/submucosal graft combined with a caudal superficial
278 epigastric axial pattern flap. Although the reconstructive technique here reported was performed as
279 a single stage procedure, 50% of the dogs developed short-term complications, which required
280 further surgery. The high complication rate encountered in this case series raises the question
281 whether a single stage reconstruction of the prepuce may actually be superior to previously reported

techniques. Further studies are needed to assess results of preputial reconstruction with caudal superficial axial pattern flaps alone, without mucosal grafts. However, our clinical experience with this small series of dogs suggests that lack of mucosal lining may result in a more pronounced scar contraction and consequent paraphimosis. To prevent this complication, it may be advisable to create a larger preputial orifice (30-40% more than a normal preputial opening), in order to prevent stenosis due to tissue contraction during healing process. Despite the low number of dogs included in the present study, functional results and feasibility of the procedure reported suggest that combination of caudal superficial epigastric axial pattern flap and mucosal graft may be a valid alternative for preputial reconstruction in dogs following tumour excision or extensive traumatic preputial damage. Long-term outcome in all dogs that we treated encourages clinical use of this single stage reconstructive technique, when indicated.

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