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PAPER

Primary stabilisation for tail avulsion in 15 cats

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Objectives: To evaluate the effects of a primary tail stabilisation technique in relieving pain and supporting nerve recovery in cats that have lost voluntary motor function and pain sensation in the tail without caudal nerve transection.

Materials and Methods: Retrospective review of medical records and preoperative diagnostic tests, including clinical examination results and tail radiographs of cats suffering from tail avulsion with loss of pain perception in the tail between 2009 and 2015. Cats with open tail fracture, tail wounds that necessitated an amputation or caudal nerve root transection were excluded. Tail reconstruction was performed, after surgical exploration, with two nylon sutures.

Results: Fifteen cats were included, all of which had lost voluntary motor function in the tail and 8 of 15 were urinary incontinent. After surgery, 11 cats recovered voluntary tail function and pain sensation within 14 to 90 days (mean 39 days). Five of the eight previously incontinent cats recovered urinary continence within a month of surgery.

Clinical Significance: The reported method of primary tail stabilisation is associated with recovery of lost function in the majority of cats presenting with tail avulsions, loss of pain sensation in the tail but without caudal nerve root transection. A comparison study is required to determine whether these results are superior to conservative management.

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INTRODUCTION

Tail avulsion is defined as the detachment or tearing of a caudal vertebra from the adjacent caudal vertebra or the sacrum while the continuity of the skin and surrounding tissue is preserved (Bernasconi *et al.* 2001, Tatton *et al.* 2009).

Avulsion of the tail can be a serious condition that results in shearing or avulsion injuries of the caudal nerves. Consequently, loss of tail voluntary motor function and pain sensation can occur in association with urinary and faecal incontinence if the sacral nerve roots are concurrently affected. During tail avulsion, the sacral nerve roots, which control urinary and faecal continence may also be subject to caudally directed traction. Incontinence has been associated with a poorer outcome and is a frequent cause of euthanasia of affected animals (Smeak & Omlstead 1985, Bernasconi *et al.* 2001, Tatton *et al.* 2009, Lamb 2010, Weh & Kraus 2012).

The challenges in these cases arise from the difficulties in clinically assessing the severity of caudal and sacral nerve injuries. Local oedema, neurapraxia and axonotmesis have a good prognosis but cannot be clinically differentiated from neurotmesis, which is associated with a poor prognosis (Allodi *et al.* 2012, Rajasekaran *et al.* 2015).

In a study by Tatton *et al.* (2009), investigating cats with sacrocaudal injury, all 11 cats that had intact tail base sensation regained control of urination within 3 days. In contrast, 4 of the 10 cats without tail base pain sensation that were treated medically did not recover control of urination by day 30 (Tatton *et al.* 2009, Lamb 2010). Medical management might be unconducive to nerve repair if there is incomplete reduction of the fracture-luxation and failure to restore the integrity of the vertebral canal. Moreover, persistent motion at the fracture site might be a source of ongoing stretching, which could result in delayed healing of the nerve roots and chronic pain (Bernasconi *et al.* 2001, Bali *et al.* 2009, Eminaga *et al.* 2011). However, medical management or tail amputation are still the main treatments for sacrocaudal luxation and associated injuries because of the lack of prognostic information regarding tail voluntary motor function and urinary continence recovery following primary surgical stabilisation (Smeak & Omlstead 1985, Bernasconi *et al.* 2001, Tatton *et al.* 2009, Lamb 2010). Moreover, although tail amputation is rarely a source of surgical complications, it can result in dysaesthesia, pain complications, mutilation and aesthetic concerns for the owners (Walker *et al.* 1998, Bernasconi *et al.* 2001).

Considering the outcomes of the two main therapeutic options listed above, the objective of this study was to evaluate the outcome after application of a primary tail stabilisation in cats that have lost voluntary motor function and pain sensation in the tail.

MATERIALS AND METHODS

Data collection

Medical records of cats suffering from tail base avulsion (avulsion between S1 and Co2) with loss of pain perception and voluntary movement of the tail and that had undergone surgical reduction between 2009 and 2015 were retrospectively analysed. All cats with an open tail fracture, tail wounds that necessitated an amputation or caudal nerve root transection (as observed during surgical exploration) were excluded. Cats presenting with associated orthopaedic lesions were not excluded, other than cats with additional vertebral column injuries.

Neurological exams

Neurological exams were performed preoperatively, at 48 hours postoperatively, and at three or more months postoperatively for each cat.

The neurological evaluation consisted of evaluating the somatic caudal nerve (tail voluntary motor function observation and pain perception evaluation) and pudendal nerve (perianal and perineal reflexes). Urination was assessed by bladder palpation two to four times per day to evaluate bladder resistance and by observing urinary behaviour both 1 day before the surgery and during the first 48 hours postoperatively. Cats were considered to be urinary continent if normal urinary behaviours were observed (position to urinate above the litter with normal flow) or if urine was found in the litter with an empty or semi-full bladder upon palpation.

During the convalescence period, all urinary incontinent cats were managed with manual bladder expression two to four times a day and a doses of 0·1 mg/kg alfuzosin (Xatral®; Mediwin Ltd, Littlehampton, UK) twice a day and 0·5 mg/kg diazepam (Valium®; Roche, Boulogne-Billancourt, France) twice a day.

Radiographic exams

All cats underwent preoperative and postoperative (immediately after surgery and at follow-up) radiographic assessment of the pelvic, sacral and caudal regions. Different radiographic views were obtained: ventrodorsal, lateral with the tail in a neutral position and lateral with tail traction.

Surgical procedure

The surgical technique described by Bernasconi *et al.* (2001) was performed 1 day after admission. This technique consisted of making a visual inspection of the nerve roots and stabilising the vertebrae if total nerve root transection was not observed. Stabilisation was performed using two lateral sutures, passing each of these through a single-bone tunnel into the base of the dorsal spinous process of S2 (occasionally S3) and then around the transverse processes of the luxated vertebra (most often S3, Co1 or Co2). Only one bone tunnel of 1·1 mm diameter was created using either a K-wire or a drill bit (Fig 1). Using a pointed fragment forceps, the luxated vertebrae were repositioned. Then, a non-absorbable suture line (Polypropylene, Premilene® 2/0; B. Braun France, Ile-de-France, France) mounted on a ½ circle round body needle was passed around one of the transverse processes of the luxated caudal or sacral vertebra and through the drilled hole (Fig 2). A similar procedure was performed on the

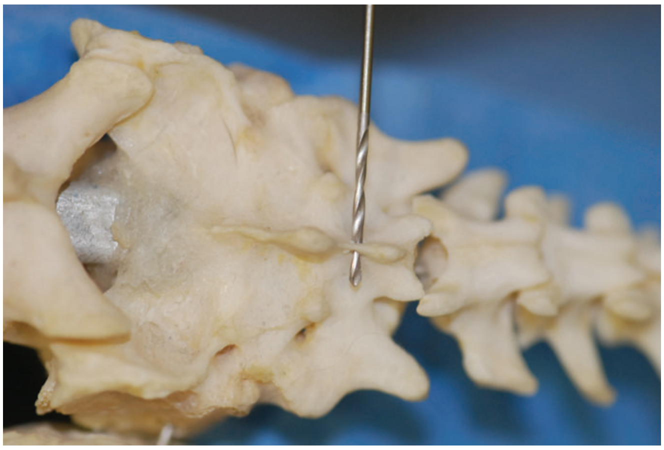

FIG 1. Bone tunnels of 1·1 mm diameter is created using either a pin or a drill bit in the dorsal spinous process of S2 or S3

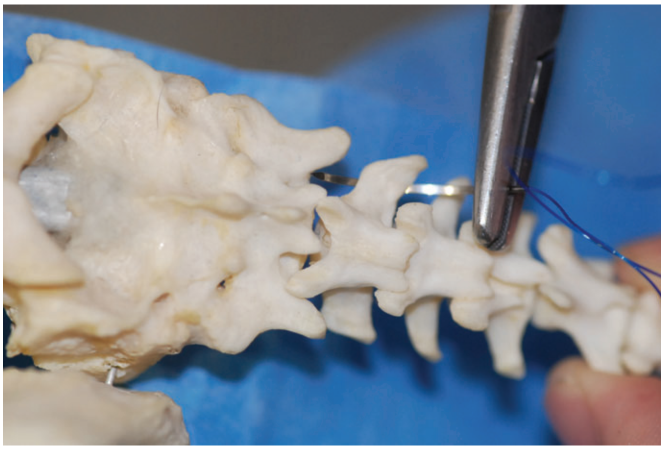

FIG 2. A non-absorbable suture line is passed around one of the transverse processes of the luxated coccygeal or sacral vertebra and through the drilled hole

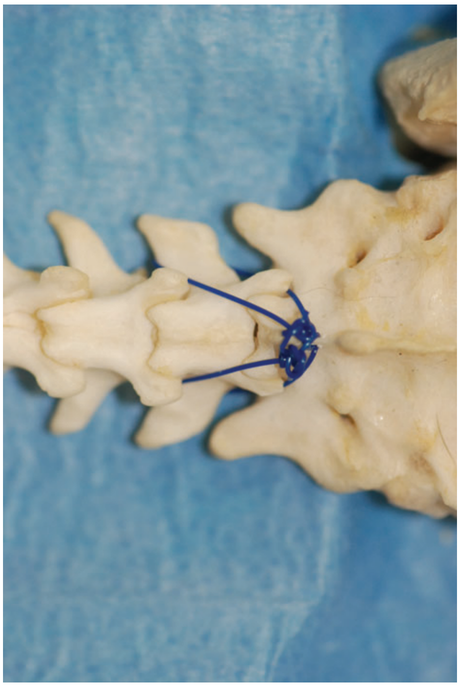

FIG 3. The fixation is performed by progressively tying the knots one at the time

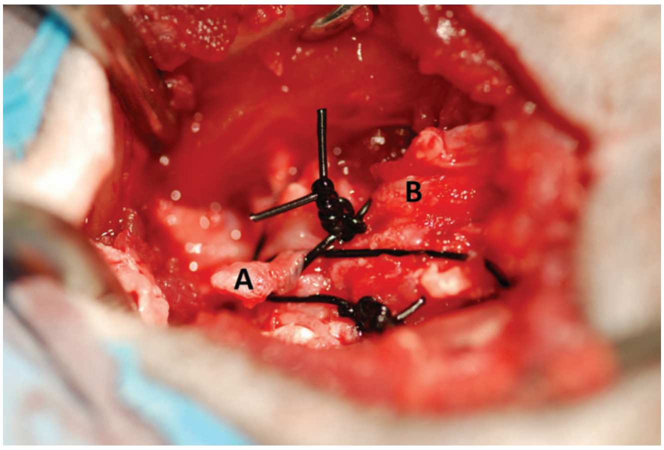

FIG 4. A. Spinal process of S3. B. First caudal vertebra after surgical reduction

contralateral side. Finally, the fixation was performed by progressively tying the knots one at a time while monitoring to ensure that facet reduction was appropriate (Figs 3 and 4). Excessive loop tightness was avoided to prevent dorsal angulation.

Analgesia

Perioperative analgesia was achieved with intravenous morphine (morphine chlorhydrate Cooper®; Sanofi, Paris, France) at 0·1 mg/kg. Postoperative analgesia was also achieved with intravenous morphine (morphine chlorhydrate) at 0·1 mg/kg every four hours for 24 hours and with a dose of 0·05 mg/kg meloxicam (Metacam®; Boehringer Ingelheim France, Reims, France) once per day for 5 days. Preoperatively and everyday until the cats were discharged, pain was assessed subjectively by (1) moving the tail in every direction with the fracture site as a rotation point, (2) palpating the fracture site with pressure and (3) palpating the fracture site without pressure. Pain was then classified in four grades: Absent (if pain was absent upon examinations 1, 2 and 3); Low (if the cat shows pain only in manipulation 1 and no pain in manipulations 2 and 3); Moderate (if pain was observed in manipulations 1 and 2) and severe (if pain was observed in all the three manipulations).

Owner satisfaction

Owners' satisfaction, difficulties in management and the time to nerve function recovery were also assessed by phone call discussion or directly in consultation with owners. The questions varied depending on the owner, but common questions included the following: Are you satisfied with the results of the surgery? Did you observe difficulties or complications during the convalescence period? Did your cat remain incontinent? If yes, how long did it take for the recovery of voluntary urination? Has tail function been recovered? If yes, how long did it take to recover voluntary motor function? If no, have you observed any self-mutilation?

RESULTS

Fifteen cats underwent surgical reduction for tail avulsion from 2009 to 2015 (Table 1). Eleven of the 15 cats were male and four were female. Their average age was 2 years (3 months to 5 years). Avulsion of the tail was consequent to sacrocaudal luxation in 10 of 15 (Fig 5), caudocaudal (Co1-Co2) luxation in 2 of 15 and sacral fracture in 4 of 15; one cat (Case 8) had lesions at both S2-S3 and S3-Co1.

As inclusion criteria all cats had lost voluntary motor function and pain sensation in the tail. Urinary incontinence was identified in eight of 15 cats. Among the eight cats with urinary incontinence, two also had absent perianal and perineal reflexes. In the preoperative phase, all cats that underwent surgery presented with severe pain at the fracture site.

Immediate postoperative radiographic views showed satisfactory vertebral reduction and good alignment of caudal vertebrae in all of the cats (15/15) (Fig 6). Forty-eight hours postoperatively, we observed a reduction in pain at the fracture site in all of the cats; the pain score was "low," and pain was only present upon tail rotation. All cats were discharged at 48 hours postoperatively.

Direct clinical follow-up was performed in the referral clinic for nine of 15 cases, and the rest were followed through a phone call with the referring veterinary clinic that performed the follow-up, or with the owners (six of 15), or both. The average time to follow-up was 23 months (2 to 57 months). Only nine cats underwent radiographic assessment 3 months postoperatively. Radiographic views showed persistent vertebral canal continuity in those cats. The time period to tail voluntary motor function and urinary continence recovery was estimated by owners and confirmed by veterinary follow-up. A return of pain sensation in the tail and voluntary motor function was observed in 11 of 15 cases, with an average period of 39 days (from 3 to 90 days) (Table 1). Recovery of urinary continence occurred in five of

Table 1. Description of the clinical cases

Patients	Type of injuries	Time/type of follow-up	Associated problems	Time to tail voluntary motor function recovery (days)	Time to urinary function recovery (days)
1	Fracture S2-S3 with vertebral displacement of S3	three months/clinical	Urinary incontinence, tail paralysis	40	30
2	Luxation S3-Co1	nine months/clinical	Urinary incontinence, Tail paralysis	90	30
3	Avulsion fracture S3-Co1	51 months/clinical	Tail paralysis	21	–
4	Luxation Co1-Co2	five months/clinical	Tail paralysis	14	–
5	Luxation Co1-Co2	36 months/clinical	Tail paralysis	21	–
6	Luxation S3-Co1	26 months/phone call	Urinary incontinence, tail paralysis	No recovery	3
7	Luxation S3-Co1	57 months/phone	Urinary incontinence, tail paralysis	No recovery	No recovery
8	Fracture of the sacrum S2, S3 and luxation S3 Co1	24 months/phone call	Tail paralysis	60	–
9	Luxation S3 Co1	29 months/phone call	Tail paralysis	28	–
10	Luxation S3 Co1 lateral displacement of Co1	30 months/phone call	Urinary incontinence, tail paralysis	No recovery	No recovery
11	Fracture of S2, S3, lateral displacement of S3	25 months/phone call	Urinary incontinence, tail paralysis	No recovery	No recovery
12	Sacral fracture S2-S3,	two months/Clinical	Tail paralysis urinary incontinence	21	21
13	Luxation S3-Co1	24 months/clinical	Tail paralysis	30	–
14	Luxation S3-Co1	eight months/clinical	Tail paralysis urinary incontinence	90	3
15	Luxation S3-Co1	18 months/clinical follow-up	Tail paralysis	3	–

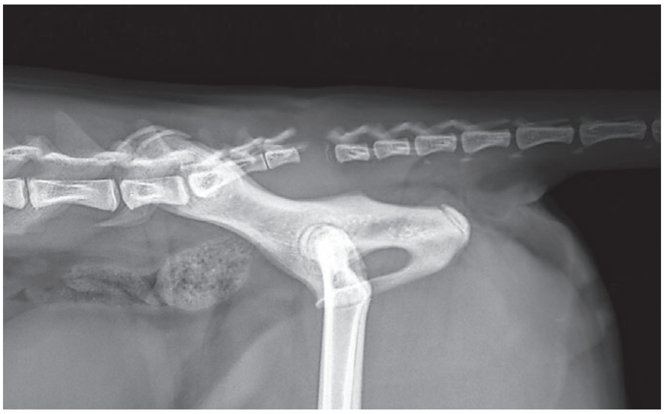

FIG 5. Preoperative X-ray: sacrocaudal luxation

FIG 6. Direct postoperative X-ray: satisfactory vertebral reduction

eight cases within 30 days, including those cases that had lost their perianal and perineal reflexes (Table 1). Among the three cats that did not recover urinary continence, two were euthanased and one was treated medically.

None of the cats that were reassessed exhibited major postoperative complications (*i.e.* those that might necessitate further surgery, such as infection, wound dehiscence, recurrence of the luxation, perineal hernia or tail self-mutilation). Minor complications included some episodic loss of balance during jumping and landing in 14 of 15 cats during the first weeks. Fourteen of 15 owners were satisfied with the results, even in the absence of complete recovery.

DISCUSSION

Vertebral repair and alignment limits the continual stretching of, or impingement of bone fragments on, the nerve roots that might follow tail avulsion injury (Bernasconi *et al.* 2001, LeCouteur 2003, Bali *et al.* 2009, Eminaga *et al.* 2010, Rajasekaran *et al.* 2015). Re-establishment of the alignment of the caudal vertebral column may also aid rapid suppression of the associated pain. In this study, 100% of the cats were classified as experiencing "low" degrees of pain 48 hours postoperatively. In contrast, when conservative treatments are applied, up to 50% of cats were reported to continue to experience severe pain several weeks following the injury and thus required analgesic treatment for a minimum period of 1 month (Bernasconi *et al.* 2001, LeCouteur 2003, Bali *et al.* 2009, Eminaga *et al.* 2010, Rajasekaran *et al.* 2015). Vertebral reduction obtained during the immediate postoperative period persisted over time in cats that underwent repeat radiological evaluation, with no complications noted. According to a previous report, an over-reduction with ventral tilting of the caudal vertebrae was observed in 5% of such cases (Bernasconi *et al.* 2001). This is caused by excessive tightening of the suture and may lead to the continuous compression of the nerve fibres (Bernasconi *et al.* 2001). No similar cases were observed in our study.

Seventy-three percent of the cats that underwent primary stabilisation (11 of 15) recovered pain perception and voluntary motor function of the tail. Nerve fibre stretching can be reversible when mild but complete nerve rupture, or neurotmesis, is an irreversible lesion. However, its diagnosis is difficult and subjective. Neurotmesis can be suspected when a vertebral canal displacement of 100% is apparent on radiographs (Weh & Kraus 2012). Therefore, in cases with suspected neurotmesis, surgical exploration is recommended before surgical reduction or amputation is selected (Smeak & Omlstead 1985, Bali *et al.* 2009, Eminage *et al.* 2010, Allodi *et al.* 2012, Rajasekaran *et al.* 2015). In addition, a long convalescence period to allow for recovery of pain perception and voluntary motor function recovery in the tail was observed following both medical treatment and primary stabilisation (Smeak & Omlstead 1985). In our study, this time period varied from 3 to 90 days, but previous studies had shown that it may require up to 150 days (Smeak & Omlstead 1985). Therefore, tail amputation should be discouraged until an assessment of recovery of motor function and pain perception is made at around 90 to 150 days. Amputation should be reserved for cases with neurotmesis diagnosed on exploration, in cases with an absence of tail voluntary motor function recovery after a minimal period of 90 days or if self-mutilation is observed during the convalescence period. However, in this report, no cases of self-mutilation were observed, even in cats with absent tail voluntary motor function recovery.

When medical management is chosen in cats that lost voluntary motor function, 80% had persistent motor deficits (Bernasconi *et al.* 2001). Medical management may involve persistence of vertebral canal discontinuity with significant movements of the luxated or fractured vertebrae. These movements and the traction from the weight of the tail on the nerve roots could contribute to a lack of recovery (Allodi *et al.* 2012). Therefore, a comparison of results between medical treatment and surgical treatment must be interpreted carefully. Medical treatment is proven to be effective when there is still pain perception at the base of the tail, with up to 72% of cats recovering tail motor function with the implementation of medical treatment (Tatton *et al.* 2009, Lamb 2010). Definitive comparison of surgical stabilisation *versus* conservative management of these lesions would require a formal clinical trial and so recommendations without this can only be tentative. Nevertheless, our results and other available data concerning tail voluntary motor function recovery should encourage clinicians to consider primary stabilisation surgery as a first-line treatment pain perception and voluntary motor function have been lost.

Persistence of pain perception at the base of the tail was previously reported to be a good prognostic indicator for the return of urinary continence in less than 30 days (Tatton *et al.* 2009). However, the loss of pain perception at the tail base does not predict a specific outcome with respect to urinary function. In our study, 62·5% of the cats presenting with absent pain perception and urinary incontinence recovered normal urinary continence, which is similar to those obtained with conservative treatment (60%; Tatton *et al.* 2009).

The number of incontinent cats with intact or absent perianal and perineal reflexes in this was low, meaning that no reliable conclusions can be drawn from this population. However, Smeak & Omlstead (1985) reported a 100% recovery rate for urinary continence when the reflexes were present and a 50% recovery rate when the reflexes were absent.

In conclusion, if a cat with tail avulsion is also urinary continent, we recommend surgical exploration in order to assess the nerve lesions. If simple nerve stretching is observed, primary stabilisation could be selected, but if neurotmesis is observed amputation is recommended. Amputation could also be considered during the postoperative period if tail voluntary motor function fails to recover or in cases of self-mutilation. In cases of urinary incontinence, the prognosis for urinary continence recovery is guarded, regardless the type of treatment chosen. For those cases, loss of tail voluntary motor function is considered less important until recovery of urinary continence is observed. Surgical exploration followed by surgical repair or amputation could be recommended in cases of persistent pain with medical treatment.

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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