Spinal fracture and luxation in dogs and cats

A retrospective evaluation of 95 cases

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Summary
The purpose of this retrospective study was to review cases of spinal fractures or luxations (SFL) treated with various modalities in order to describe fracture location, neurological status, treatment, outcome and complications in a patient population at a single centre. The medical records of dogs and cats that had been diagnosed with a SFL between C1 and L7 between January 1995 and June 2005 were reviewed in order to collect pertinent data. Ninety-five cases were included in this study. The severity of spinal cord injury was graded on a scale from 0 to 5. Vehicular trauma was the most common cause of SFL. Spinal fractures were localized between C1-C5 in 10 cases, C6-T2 in one case, T3-L3 in 54 cases, L4-L7 in 36 cases. Thirty patients that were euthanatized without treatment had a median neurological score of 5. Twenty-eight patients, all of which had motor function, were treated conservatively and there was not any change in their median neurological grade at the time of discharge. Thirty-seven patients had surgery, 27 of which were non ambulatory. Thirty-five of 37 were stabilized using pins and/or screws and PMMA or various other techniques. The median neurological grade of surgically treated patients improved by one point between the time of initial diagnosis and discharge. Implant removal was performed in five cases. The patients that were treated with pins and/or screws and PMMA were significantly more improved than conservatively managed patients at the time of discharge, although the surgically treated patients were hospitalized significantly longer than the conservatively managed patients. Our results suggest that dogs that retain pain sensation prior to surgery have a good prognosis for functional recovery. In this study, the dogs that were treated conservatively retained purposeful movement and had a good prognosis for recovery.

Keywords
Spinal, fracture, luxation, dog, cat

Introduction
Spinal fractures, luxations, and fracture-luxations in dogs and cats are common and are often the result of vehicular injury (1, 2–5). Other frequent causes of injury include animal attacks or falling from a height. Reports that describe the distribution of spinal column injuries indicate that they affect the lumbar vertebrae most frequently, followed by sacrococcygeal, thoracic, and cervical vertebrae (1, 3, 5). An increased incidence of fracture-luxation has also been reported at the junction between the mobile and immobile sections of the spine, such as the thoracolumbar and lumbosacral junction due to stress concentration (6). Other studies have described a more even distribution of injury along the spinal column (2, 7). Diagnosis and mechanism of injury have been described in detail elsewhere (2–5, 8–11). The method of treatment selected depends on the signalment of the patient, nature of the injury, neurological status, and individual surgeon preference and experience. Treatment modalities can be broadly classified into conservative and surgical options. Conservative treatment typically involves external immobilization in the form of splints and bandages, cage confinement, exercise restriction, and steroid administration. The objective of surgical treatment is the reduction of the vertebral segments, decompression of the spinal cord and rigid stabilization of the spinal canal. Current surgical options include: pins and polymethylmethacrylate (PMMA), vertebral body plating, vertebral stapling, screws and PMMA, and external skeletal fixation (9–12).

Controversy exists whether surgical or conservative therapy is most appropriate for spinal fracture/luxation. Current indications for surgical intervention are evidence of spinal instability and/or spinal cord compression, deterioration despite appropriate conservative management or unrelenting pain beyond the first 48–72 hours (7, 8, 13). Regardless of these recommendations conservative management has been shown in some studies to have up to 94.4% functional recovery rate (4–6, 8). In light of this, all patients should be given the benefit of conservative management if the owners are willing to undertake physical therapy and nursing care (3, 7).

Previous reports on spinal fracture or luxation cases have focused on a single treatment modality or spinal segment making it difficult to compare treatment modalities amongst one another. The purpose of this retrospective study was to review a large number of cases of canine and feline spinal fractures or luxations treated with various modalities in order to describe fracture location, neurological status, treatment used, outcome and complications in a patient population at a single centre.

Materials and methods
The medical records for all dogs and cats that had been diagnosed with spinal fracture or luxation at the Ontario Veterinary College Veterinary Teaching Hospital of the University of Guelph between January 1995 and June 2005 were reviewed. The data were collected regarding breed, age, sex, weight, history, including type of trauma, duration of clinical signs, progression of clinical signs, neurological assessment (at admission, post-operatively, at discharge and at recheck), radiographic assessment, including location of fracture, luxation or fracture/luxation, and the presence of concurrent injuries. Also, the details of injury management (conservative...
or surgical treatment), type of surgical technique used, intraoperative findings, steroid use, use of splint or bandage, type of splint or bandage, or reason for euthanasia were recorded. Those patients with incomplete medical records, or patients with injuries that only involved the sacral or caudal vertebrae, were excluded from this study. Neurological status was graded using a 5 point scale adapted from Matthiesen (Table 1) (1). Neurological improvement was assessed by calculating the difference between the neurological score at presentation and at discharge.

For the purposes of statistical analysis the patients were divided into three treatment groups: conservative, surgical and euthanasia. Medical treatment consisted of one or more of the following modalities: bandage or external splint application, cage confinement and exercise restriction. The surgical techniques consisted of one or more of the following internal stabilization techniques: pins or screws with PMMA, dorsal spinous process plating (Lubra plate®, The Lubra Company, Fort Collins, CO, USA), vertebral body plating, vertebral stapling and vertebral wiring. The treatment groups were not randomized and treatment decisions were made based on clinical assessment, clinician experience and preference as well as owner input and financial means.

### Statistical analysis

All statistical analyses were performed by a statistician using commercial statistical software (SAS/STAT® Software). Logistic regression analysis was used in order to determine if there were significant risk factors (treatment, location of injury, cause, signalment, additional injuries, and complications) for survival. A Wilcoxon Mann-Whitney non-parametric test was used in order to compare neurological status between conservative and surgical cases. When comparing between three or greater populations a Kruskal-Wallis test was used with post hoc non parametric Tukey like adjustments. Comparisons between the treatment groups for the parameters of days in hospital, age and weight were made using a students t-test. A two sided value of p < 0.05 was considered significant in all cases.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Neurological status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No spinal hyperesthesia and no neurological deficits</td>
</tr>
<tr>
<td>1</td>
<td>Hyperesthesia, no neurological deficits</td>
</tr>
<tr>
<td>2</td>
<td>Proprioceptive deficits and/or ataxia</td>
</tr>
<tr>
<td>3</td>
<td>Non-ambulatory with purposeful movement</td>
</tr>
<tr>
<td>4</td>
<td>No purposeful movement with deep pain sensation</td>
</tr>
<tr>
<td>5</td>
<td>Loss of deep pain sensation</td>
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</tbody>
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### Results

Ninety-five cases (11 cats and 84 dogs) met the inclusion criteria for this study. There were 56 (59.9%) males (30 were castrated) and 39 (41.0%) females (21 were spayed). The patients had a median weight of 17.5 kg (range: 1.8 kg to 92 kg) and a median age of two years (range: three months to 15 years). Vehicular trauma was the cause of spinal fracture or luxation in 60 (63.2%) cases. Twenty (21%) spinal fractures or luxations were the result of unknown trauma, 10 were caused by a fall and five were the result of an animal attack.

The spinal fracture or luxation was localized between C1 to C5 in 10 (10.1%) cases, C6 to T2 in 1 (1.0%) case, T3 to L3 in 54 (54.5%) cases and between L4 and L7 in 36 (36.4%) cases. Three patients had multiple spinal fracture luxations with one patient having three affected sites (cervical, thoracic and lumbar) and two patients having two affected sites (thoracic and lumbar and two lumbar). The neurological status in three patients (3.2%) were grade 0, three patients (3.2%) were grade 1, 15 (15.8%) were grade 2, 26 (27.3%) were grade 3, 26 (27.3%) were grade 4 and 22 (23.2%) were grade 5.

Forty-three (45.3%) patients had other injuries, including pulmonary contusions and rib fractures (n=14), long bone or pelvic fractures/ luxations (n=13), abdominal organ injuries (n=5), head trauma (n=3) and skin lacerations (n=2). The overall median neurological score at the time of presentation was 3 (range 0 to 5) and the median neurological score of both the conservatively and surgically treated patients at the time of discharge was 2 (range 0 to 5).

Thirty (31.6%) patients were euthanized without treatment due to poor prognosis for recovery and severity of neurological signs (29, 30.5%), or due to financial constraints (1, 1.1%). The median neurological score at presentation for this group was 5 (range 1 to 5). Of these, 20 (66.7%) were grade 5 and 8 (26.7%) were grade 4. This group of patients had a median age of three years (range: five months to 12 years) and a median weight of 19.2 kg (range: 2.9 kg to 45 kg).

Twenty-eight (29.5%) patients were treated conservatively with cage confinement and exercise restriction, with or without splinting. The median neurological score at presentation for this treatment group was 2 (range 0 to 4). Of these, 25 (89.3%) patients were grade 1, 2 or 3, with 10 (35.7%) patients being grade 2. One patient required surgical stabilization due to persistent and severe pain and was treated with translilial pinning nine days after initial injury, and one patient had slight neurological worsening from grade 2 to 3 at discharge compared to admission. The patient requiring surgery was placed in the surgical group for the purposes of statistical analysis. The median age of patients in this treatment group was one year (range: four months to 10 years) and the median body weight was 15.0 kg (range: 3.4 kg to 92 kg). The median neurological score at the time of discharge was 2 (range 0 to 3) with a median neurological difference of 0 (range: -1 to 1). The median hospital stay for conservatively managed patients was three days (range: one day to 21 days). Three patients had splints placed as part of their conservative management, two had cervical splints placed for a cervical fracture and one had an entire body splint placed for a lumbar fracture.

Thirty-seven (38.9%) patients were treated surgically. The median neurological score at presentation for these patients was 3 (range: 0 to 5). Of these, 17 (45.6%) did not have any motor function, two of which had no pain sensation. The median age of the patients in this treatment group was three years (range: six months to 15 years) and the...
median body weight was 16.8 kg (range: 1.8 kg to 65 kg). The median neurological score at the time of discharge was 2 (range: 0 to 4) with an improvement in median neurological score of 1 (range: -1 to 2). The median hospital stay for surgically managed patients was six days (range: one day to 20 days). Thirty-five patients (36.8%) underwent surgical spinal stabilization using various techniques that included pins and/or screws and PMMA (13, 37.1%), dorsal spinal process plating using a LUBRA plate, (8, 22.9%), vertebral body plating (6, 17.1%), vertebral stapling (3, 8.6%), vertebral wiring (2, 5.7%), a combination of dorsal spinal process plating and vertebral body plating (2, 5.7%) and translivial pinning (1, 2.9%). The remaining two patients had surgical treatment without stabilization. One patient had multiple fractured lumbar transverse processes removed without stabilization and one patient had a pediculectomy performed and was euthanatized intraoperatively due to spinal cord transection. One patient was euthanatized prior to recovery from anesthesia when malpositioning and failure of the LUBRA plate implants were detected on postoperative radiographs, and two patients died postoperatively; one due to undiagnosed mesenteric avulsion leading to septicemia, and the other due to pulmonary fat embolization. Five patients with cervical lesions had splints placed postoperatively. Two surgically treated patients presented as grade 5, were euthanatized, one at the time of surgery due to the presence of myelomalacia, and the second patient four days postoperatively due to the development of myelomalacia. Implant removal was performed in five cases due to pin migration (n=3), LUBRA plate failure (n=1) and spinal staple migration (n=1). Median interval from surgery to implant removal was 49 days (range: 13 to 61 days). Of the five patients requiring implant removal, all of them had an uncomplicated revision procedure and were ambulatory with varying degrees of ataxia at the time of last recheck examination.

Comparisons made between groups revealed that surgical patients were significantly older than conservatively managed patients (three years versus one year, respectively, p = 0.02), however, the differences in age between the euthanasia groups and other two groups were not significant. Also differences between groups for body weight were not significant. Neurological status at presentation differed significantly between the three groups. Those patients that had been euthanatized had a significantly worse neurological status (median = 5), than either surgically treated (median = 3, p < 0.001) or conservatively managed (median = 2, p < 0.001) patients. Surgically managed patients had a significantly worse neurological status than conservatively managed patients (p = 0.03). Lesion distribution between the three groups was not significantly different.

In order to evaluate the success of treatment, the surgically treated and conservatively treated groups were compared. Neurological status at discharge was not significantly different between the surgically (median = 2) and conservatively (median = 2) managed patients. When comparing the change in neurological score between initial assessment and at the time of discharge from hospital, the surgically treated group (median = 1) was not significantly different from the conservatively managed group (median = 0) (p = 0.09). However, improvement in neurological score of the subgroup of patients that were treated with pins and/or screws and PMMA (improved a median of 1 grade) was significantly better than in conservatively managed patients (p = 0.02). A comparison of complication rate between surgically treated (27%) and conservatively treated patients (7.1%) revealed a trend towards a higher incidence of complications for the surgically treated patients (p = 0.05). A difference in rate of euthanasia was not detected between conservatively and surgically treated patients (p = 0.22). The surgically managed patients were hospitalized for a significantly longer period of time than conservatively managed patients (p = 0.0016).

A significant difference was not noted for rates of complications between the various surgical techniques or for each technique compared to the overall complication rate of surgically treated patients. Complication rates were not significantly different between fracture location. The surgical site was a predictor for the surgical technique used with cervical lesions being significantly more likely to receive treatment with pins and PMMA (75%) compared to lumbar lesions (8.3%) (p = 0.02). A trend was detected towards thoracic lesions (43%) having a higher incidence of pins and/or screws and PMMA fixation compared to lumbar lesions (p = 0.06).

Lesion localization was a significant predictor of euthanasia with patients with cervical lesions being 0.12 times as likely to be euthanatized (p = 0.04) than patients with lesions in other locations. The presence of additional lesions was compared to complication rate and a significant correlation was not identified (p = 0.49). Lastly, neurological status was compared to lesion localization. Neurological status at presentation was significantly different between patients with cervical lesions (median = 2) and thoracic lesions (median = 4; p = 0.002). A trend was detected when comparing patients with cervical lesions to patients with lumbar (median = 3) and multiple lesions (median = 4), however, neither relationship was significant (p = 0.09 and 0.10 respectively).

Neurological status at discharge was compared between the different locations and significant correlations were not detected. The patients with cervical lesions (median = 0) improved significantly less than the patients with multiple lesions (median = 1, p = 0.04). Patients with lumbar lesions (median = 1) improved significantly less than patients with thoracic lesions (median = 1, p = 0.03). Patients with thoracic lesions (median = 1) improved significantly less than patients with multiple lesions (median = 1, p = 0.03). Although not statistically significant, patients with thoracic lesions tended to improve more than patients with cervical lesions (p = 0.09).

Discussion

The proportion of patients in our study that were euthanatized without treatment (31.6%) was less than in other reports (2, 3, 14, 15). The decision to recommend the euthanasia of patients that are admitted without pain perception is likely to be heavily influenced by the paucity of literature suppor-
ting the successful treatment of patients with such poor neurological status, follow-
ing spinal trauma. A recent study by Olby et al. that evaluated the long-term outcome of patients with traumatic spinal cord injury revealed that regardless of treatment, none of the patients that lost deep pain sensation regained deep pain sensation (15). Two of the patients in that study were considered to have a successful outcome based on the return of ability to ambulate (15). These patients had an abnormal gait, were intermittently fecal and urinary incontinent, and did not regain pain sensation to their limbs but had a voluntary tail wag (15). It was proposed that these patients either demonstrated spinal reflex walking or had surviv-
ing axons crossing the site of injury (15). The presence of a voluntary tail wag sug-
gests there is a descending influence from higher centres lending support to the idea of surviving axons (15). The authors’ conclusion was that a persistent absence of deep pain sensation indicates severe injury but does not confirm complete spinal cord transection and that given time, some of these patients can regain the ability to walk in the face of absent pain sensation (15). In the current study we were unable to assess the neurological recovery potential of pa-
tients with no pain sensation (22, 23.2%) because all of them were eventually eutha-
natized.

The most common cause of spinal injury in the present study population was vehicu-
lar trauma (63.2%), which is similar to pre-
vious reports (1–5). This finding may repres-
tent the significant force needed to cause fracture/luxation of the inherently stable vertebral column. No significant relationships were detected between cause of trau-
ma and severity of injury, location of lesion, presence of multiple lesions, presence of ad-
tional lesions or incidence of compli-
cations.

In humans, only a few spinal injuries are consid-
ered to be surgical emergencies (16). How-
ever, early spinal cord decompression has been shown to improve neurological re-
covery (17, 18). Experimental evidence supports the concept that spinal cord com-
pression is a potentially reversible form of secondary injury (17). Closed decom-
pression involving traction devices is a com-
monly used treatment modality in human spinal trauma patients but is not technically feasible in canine and feline patients. Spinal decompression in small animals with spinal injuries typically involves surgical reduc-
tion and stabilization. Previous reports sug-
uggest that surgically treated spinal injury in small animals had a greater neurological improvement (3). However, the findings of our study did not provide very strong evi-
dence for this conclusion because at the time of discharge from the hospital, a sig-
nificant difference between the surgical and conservative groups was neither detected in the neurological scores, nor in the change in score during hospitalization. One important factor to consider though is that our sur-
gically treated group had a significantly worse neurological score at the time of pres-
tation than the conservatively managed group. Other contributing factors to our lack of statistical significance was the small group sizes and lack of power. Also, the pa-
tients were seemingly discharged at a com-
parable neurological score regardless of treatment group. This is likely due to the fact that patients are typically considered ready for discharge from our hospital when they retain or have regained purposeful move-
ment, can urinate normally, and are com-
fortable. This is evident by our finding that surgically managed patients were hospital-
ized for longer than conservatively man-
aged patients.

Among the various surgical techniques and implants that were used for stabilization of spinal injuries in our study, the pins and/ or screws and PMMA technique was used most frequently, and was associated with a significantly greater improvement in neuro-
logical status when compared to conser-
vatively managed patients. This finding pro-
vides support for current treatment recom-
mandations regarding surgical treatment of spinal fractures, luxations or fracture/lux-
ations (8, 9, 12, 19). The problems of mi-
gation or failure of implants that required implant removal were related to the use of various implants systems, which suggests that technical errors as well as inherent limi-
tations of certain implants could be con-
tributory factors for failure. Indeed, the inci-
dence of implant related problems may be much greater than reported in our study be-
cause of the limited follow-up of many of our cases. The increased complication rate of surgically managed patients may be in-
fluenced by the increased number of pa-
tients that returned for recheck examina-
tions, or the obvious fact that implant com-
pliation is simply not seen unless implants are used. The majority of surgical compli-
cations were considered severe, with two requiring euthanasia and five requiring a se-
cond surgery for implant removal.

The difference in neurological status be-
tween lesion locations along the spine is likely due to the previously reported larger ratio of spinal canal to spinal cord in the cer-
vical spine relative to the thoracic and lum-
bar spine. Lesion distribution within the cer-
vical spine was consistent with previous re-
ports (4, 20, 21) in which the majority of lesions involved the atlas or axis (7, 70%). Patients with cervical lesions in this study were significantly more likely to be treated with pins and PMMA (75%) when com-
pared to patients with lumbar lesions (8.3%). Current treatment recommen-
dations for cervical spinal injuries are for con-
servative therapy with splint or bandage, unless the patient is deteriorating neurolog-
ically (4, 8), due in part to a high perioper-
ative mortality rate (36–37%) in previous re-
ports (4, 20). In the current study peri-
operative mortality was not seen following cervical stabilization but only four such pro-
cedures were performed. Although the re-
sults should be interpreted with caution due to the small sample size, our study indicates that surgical management of cervical spinal frac-
ture/luxations is a successful treatment option that is associated with a low compli-
cation rate and a good clinical outcome.

The patients with lumbar lesions had sig-
nificantly less improvement than those with thoracic lesions. Lumbar lesions were also associated with a better neurological status at presentation when compared to the pa-
tients with thoracic lesions although this difference was not significant. A possible expla-
nation for this difference is that the cauda equina is more resistant to compres-
sion than the spinal cord. Of note is that the difference in neurological status between the lesion locations represents less than one neurological grade. The mean neurological score at discharge for all lesion locations
was ambulatory with varying degrees of ataxia. It is unlikely that this difference in neurological improvement is clinically significant.

In the present study, both surgically and conservatively treated patients showed significant clinical improvement. Although none of the patients were managed with external skeletal fixation, this treatment modality has been demonstrated to be stronger than an intact spine and pins and PMMA in extension, flexion, and rotation (12) and appears to be a viable treatment option that offers the potential benefit of minimally invasive percutaneous placement (22). Likewise, none of the patients in the current study were treated with locking compression plates (LCP) or veterinary string of pearls plates (VSOP). An increasing number of spinal trauma cases are reportedly being treated with locking fixation technology (23). The development and increasing experience with LCP and the VSOP may change the accepted standards for internal fixation of spinal fracture/luxations in the future, however, further research and case experience is needed.

Conclusion

The treatment of acute spinal trauma causing spinal fracture, luxation or fracture/luxation is an evolving field. The study presented herein supports the current recommendations for surgical intervention utilizing pins and/or wire and PMMA for all locations of injuries.

References


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