Article published online: 2024-12-27

Minimally Invasive Placement of Cannulated Headless Compression Screws for Reduction of Sacroiliac Luxation in 14 Cats

Lars de Jong[1,2] Joachim Lucas Jozef Proot[3] Lorenzo Josepha Paul Pillin[3] Luc August Adèle Janssens[2,4]

[1] Southern Counties Veterinary Specialists, Ringwood, Hampshire, United Kingdom
[2] Surgery Department, Evidensia Dierenziekenhuis Hart van Brabant, Waalwijk, Brabant, The Netherlands
[3] Surgery Department, Evidensia Dierenziekenhuis, Barendrecht, Zuid-Holland, The Netherlands
[4] Independent Researcher, Greyton, Western Cape, South Africa

Address for correspondence Lars de Jong, DVM, MSc, MRCVS, Southern Counties Veterinary Specialists, Forest Corner Farm, BH24 3JW, Ringwood, Hampshire, United Kingdom (e-mail: lars.de.jong@evidensia.nl).

Vet Comp Orthop Traumatol 2025;38:194–199.

Abstract

Objective To describe percutaneous fluoroscopy-guided placement of self-drilling, self-tapping, 3.0 mm cannulated headless compression screws (HCS) for surgical reduction of sacroiliac luxation (SIL) in cats, and to document clinical outcome.

Materials and Methods Medical records of cats with SIL, managed by percutaneous fluoroscopy-guided placement of a 3.0 mm HCS, were reviewed. Short-term outcome was assessed by clinical examination and radiographs. Long-term outcome was assessed using an owner questionnaire.

Results A total of 14 cats, with 17 SIL (11 unilateral and 3 bilateral), were included. Mean postoperative sacroiliac joint reduction was 85%, median sacral purchase was 63% for unilateral and 38% for bilateral HCS, and pelvic canal diameter ratio and hemipelvic canal width ratio were satisfactory in all cases. At follow-up, all cats exhibited satisfactory clinical improvement. Radiographic assessment revealed no implant-related complications of the unilateral HCS; however, screw loosening was observed in 3/6 of bilateral HCS. Owner satisfaction was good, with 10/11 of owners being very satisfied and 1/11 being satisfied.

Clinical Significance Percutaneous fluoroscopy-guided placement of a 3.0 mm HCS is a safe and effective method for unilateral surgical reduction of SIL in cats. Further studies are needed to establish the most appropriate procedure to treat bilateral SIL.

Keywords
- sacroiliac luxation
- cats
- cannulated headless compression screw
- minimally invasive
- fluoroscopy-guided

Introduction

Sacroiliac luxation (SIL) is a common injury in cats, accounting for approximately 60% of pelvic injuries.[1] Due to the rigid anatomic structure of the feline pelvis, a unilateral SIL is frequently accompanied by other fractures, most commonly to the contralateral hemipelvis.[2–4] In cats bilateral SIL is reported in 27 to 46% of cases.[1,5–8]

Both surgical and conservative treatment options for SIL have been published. Conservative treatment is considered acceptable in cases where there is minimal instability, pain and displacement, neurological deficits are absent, and there is no substantial decrease in pelvic canal diameter.[6,7] The presence of marked pain, nonambulatory lameness, narrowing of the pelvic canal by 50%, neurological deficits (attributed to the SIL), and failure to ambulate after 3 days of strict

received
October 10, 2023
accepted after revision
October 21, 2024
article published online
December 27, 2024

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

DOI https://doi.org/10.1055/s-0044-1793944.
ISSN 0932-0814.

crate rest are considered indications for surgery in multiple studies.[3,6,9] Additionally, surgical treatment has been advocated for any pelvic fracture that affects the weight-bearing axis, which includes SIL.[2,8] Many authors recommend surgical treatment over conservative treatment for management of SIL, to increase patient comfort and minimize pain, to accelerate recovery, to maintain a physiological pelvic canal diameter, and to facilitate earlier relief from neurological deficits.[3,4,7,9]

Both open and minimally invasive surgical techniques have been described for surgical repair of SIL in cats, including lag-screw placement,[5,9] placement of a transiliosacral screw or pin,[3,6,7] transilial pin, screw, or bolt,[3] and bilateral twisted string-of-pearls plates.[10] The most commonly used surgical technique is screw fixation in lag fashion.[2–5,9] Since the feline sacrum has a small corridor for safe placement of a lag screw,[11,12] appropriate screw placement can be challenging. Screws are considered to be placed appropriately when they are in the sacral body and have a sacral purchase of at least 60% of the sacral width.[4,5,9] The importance of anatomical sacroiliac (SI) reduction is less clear, with Shales et al finding no significant difference in the incidence of implant loosening between those SIL cases that were 100% reduced compared with those that were reduced less.[5] Other authors reported SI reduction of <90% as a potential risk factor for implant loosening; however, none of these papers revealed a significant correlation.[13–15]

Intraoperative radiology has been shown to significantly improve the correct placement of lag screws in both dogs and cats.[9,15] In dogs, closed reduction of SIL by fluoroscopy-guided percutaneous lag screw placement has been shown to be an effective technique for surgical management of SIL.[13–16] In one cadaveric study that compared open reduction with minimally invasive reduction in dogs, screw placement was more accurate and more consistent with minimally invasive reduction.[16] Minimally invasive reduction and percutaneous screw placement have been described to be accurate in cats as well.[15,17,18] The use of fluoroscopic guidance used for minimally invasive reduction has been shown to expose the surgical team to a minimal amount of radiation.[19]

Self-drilling, self-tapping, cannulated headless compression screws (HCS) are available for use in small bones in distal extremities in humans.[20] A cadaveric study in cats has been identified, in which regular cannulated screws were used to repair SIL. This study showed that fluoroscopy-assisted percutaneous placement of a 2.4 mm partially threaded, cannulated screw is technically feasible and is a fast method to reduce a unilateral SIL in cats.[21] Another cadaveric study showed that placement of two 2.3 mm HCS was feasible in small dogs and provided better rotational stability than a single 3.5 mm cortical screw.[22] More recently, Jourdain et al reported good functional outcome after the repair of 17 SIL in 11 cats with 2.4 mm cannulated HCS.[23]

The choice to use a 3.0 mm HCS rather than a 2.4 mm HCS for this percutaneous SIL technique was based on a previous study that revealed 2.7 mm cortical screws to have lower probability of screw loosening when compared with other sizes of cortical screws.[5] The core diameter of the 3.0 mm HCS closely resembles the core diameter of a 2.7 mm cortical screw and was therefore considered the most appropriate choice.[20] Previous studies have reported the feline sacral height to be between 4.5 and 9 mm,[5,12] therefore placement of a 3.0 mm HCS in the feline sacrum was considered feasible. No studies comparing the biomechanical properties of 3.0 mm HCS and 2.7 mm cortical screws could be identified by this author.

The purpose of this study was to investigate percutaneous fluoroscopy-guided placement of 3.0 mm HCS for surgical reduction of SIL in cats.

Materials and Methods

Clinical records of cats admitted to Evidensia Dierenziekenhuis Barendrecht or Evidensia Dierenziekenhuis "Hart van Brabant" with SIL (September 2016–April 2019) were reviewed retrospectively. Cats were included if they had unilateral or bilateral SIL, that was repaired with at least one cannulated, self-drilling, self-tapping HCS (DePuy Synthes, Raynham, Massachusetts, United States). Cats were excluded if no follow-up records could be identified. Signalment, concurrent injuries, perioperative radiographic findings, type of surgical procedure, complications, and short- and long-term follow-up were recorded. All procedures were performed by an experienced but non-board-certified orthopaedic surgeon (L.P.) or a Diplomate of the European College of Veterinary Surgeons (L.J.).

Anesthesia and Perioperative Care

Patients were premedicated with methadone (0.1 mg/kg IV, Comfortan 10 mg/mL, Eurovet, Bladel, the Netherlands), midazolam (0.25 mg/kg IV, Midazolam 5 mg/mL, Actavis Group PTC, Hafnarfirdi, Iceland), and dexmedetomidine (5 µg/kg IV, Sedadex 0.5 mg/mL, AST Farma, Oudewater, the Netherlands). Anesthesia was induced with intravenous propofol (Propovet 10 mg/mL, Zoetis B.V., Capelle a/d IJssel, the Netherlands) or alfaxalone (Alfaxan 10 mg/mL, Zoetis B. V., Capelle a/d IJssel, the Netherlands) to effect, to allow for endotracheal intubation. Anesthesia was maintained using isoflurane (IsoFlo 100%, Zoetis B.V., Capelle a/d IJssel, the Netherlands) carried in 100% oxygen. Intermittent positive pressure ventilation was used if indicated, based on the patient's clinical condition. At the time of induction, meloxicam (0.2 mg/kg IV, Metacam 2 mg/mL, Boehringer Ingelheim, Ingelheim/Rhein, Germany) was administered intravenously. Perioperative cefazolin (20 mg/kg, Cefazolin Sandoz 1 g, Sandoz, Almere, the Netherlands) was administered intravenously at the time of induction and repeated every 90 minutes if the surgery had not been completed at this point. Postoperative analgesia was achieved using methadone (0.2 mg/kg IV, Comfortan 10 mg/mL, Eurovet, Bladel, the Netherlands) at 4-hour intervals, until discharge.

Radiographic Evaluation

Orthogonal radiographs of the pelvis were obtained under general anesthesia prior to surgery. Sacral width was measured using dicomPACS DX-R software (OR Technology, Oehm und Rehbein GmbH, Rostock, Germany), to determine the optimal screw length. The correct depth was predetermined to be at least 60% of the width of the sacrum in unilateral cases, or as close to 50% of the sacral width as possible in bilateral cases.

Sacroiliac joint joint displacement, pelvic canal diameter ratio (PCDR) and hemipelvic canal width ratio (HCWR) were measured on preoperative radiographs. SI joint reduction, screw purchase within the sacrum, PCDR, and HCWR were measured as previously described on the immediate postoperative radiographs and the follow-up radiographs.[13,14,18] All measurements were performed by the same author (L.d. J.) using vPOP pro software (VetSOS Education Ltd, Shrewsbury, United Kingdom). Screw positioning was considered optimal if the screw purchase within the sacral body was at least 60% and the screw did not exit the sacrum (►**Fig. 1**). A PCDR of $\geq$1.1 indicated satisfactory restoration of the pelvic canal diameter and HCWR of one indicated symmetry of the pelvic canal.[13,14,18]

Surgical Procedure

The sequence of surgical repair was the same in all cases. If concurrent orthopaedic injuries were repaired during the same procedure, the SIL was repaired first. Concurrent fractures of the ilium were repaired with a locking compression plate (DePuy Synthes, Raynham, Massachusetts, United States), fractures of the acetabulum and fractures of the femoral head were treated with femoral head and neck ostectomy (FHNO). Fractures of the pubis, ischium, or the symphysis were not repaired.

Patients were positioned in lateral recumbency on a radiolucent surgical table, with the affected side uppermost. Positioning was aided by the use of sandbags. A fluoroscopic image was obtained to assess positioning. Positioning was considered correct if the L7 transverse processes were superimposed and the L7–S1 endplates were parallel.[13–16,19] Any adjustment in positioning was assessed with repeated fluoroscopy, until positioning was considered satisfactory.

A small approach to the ischial tuberosity was made, to allow the placement of a long Kern bone holding forceps directly on the bone. Alternatively, pointed bone reduction forceps were used to grasp the ischial tuberosity percutaneously. The bone holding forceps was used to manipulate the SI joint into reduction. If this method was not possible due to concurrent ischial fractures on the ipsilateral side, the SI joint was reduced by pulling the femur caudolaterally with pointed bone reduction forceps placed on the greater trochanter. Pointed bone reduction forceps were placed on the dorsal spinous process of the fourth or fifth lumbar vertebra to stabilize the spine during SI reduction. Very short exposures of intraoperative fluoroscopy were used to assess the reduction, continuous exposure was avoided. Reduction was maintained by manual traction on the instruments, with the aid of a piece of string attached to the instruments or with long instruments to increase distance between the hands of the surgeon and surgical assistant from the fluoroscope. When reduction was considered satisfactory, the center of the sacrum was marked by placing a hypodermic needle with long needle holders under fluoroscopic guidance. A 1 cm stab incision was made over the sacrum, at the location of the needle. A 1.1 mm drill guide (DePuy Synthes, Raynham, Massachusetts, United States) was inserted and repositioned until it appeared as a perfect circle over the center of the sacral body on a fluoroscopic image. A 1.1 mm threaded Kirschner wire (DePuy Synthes, Raynham, Massachusetts, United States) was inserted through the drill guide, and drilled through the ilium and into the sacral body. Correct positioning of the Kirschner wire was confirmed with fluoroscopy, and the depth of the Kirschner wire was confirmed with a direct measuring device for HCS 2.4/3.0 mm (DePuy Synthes, Raynham, Massachusetts, United States). A 3.0 mm cannulated, self-drilling, self-tapping HCS (DePuy Synthes, Raynham, Massachusetts, United States) of predetermined length was placed over the Kirschner wire. A compression sleeve (DePuy Synthes, Raynham, Massachusetts, United States) was used to compress the SI joint. After compression was achieved, a cannulated star

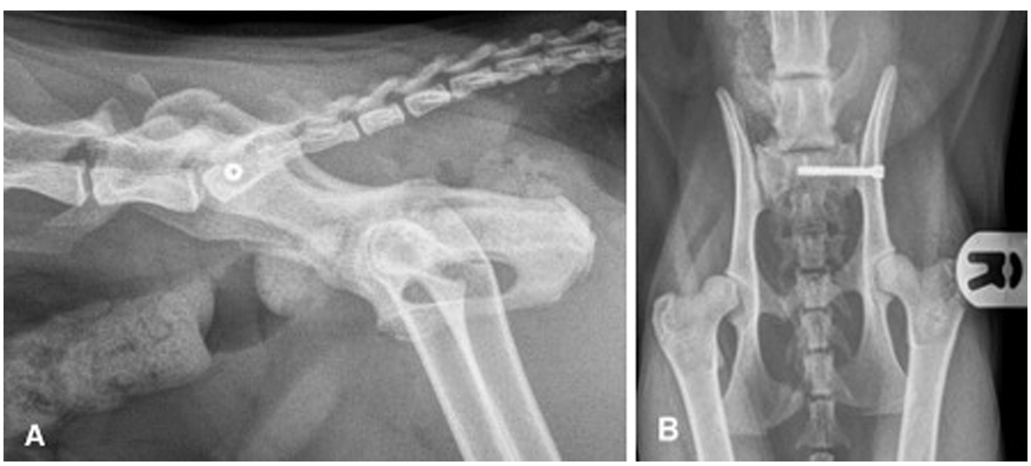

Fig. 1 Lateral (**A**) and ventrodorsal (**B**) postoperative radiographs of the pelvis, illustrating HCS placement with sacral purchase of 61% and SI joint reduction of 83%. Note that the L7 lateral spinous processes on the lateral view are not perfectly superimposed. HCS, headless compression screw.

drive screwdriver (DePuy Synthes, Raynham, Massachusetts, United States) was used to countersink the screw into the ilium. The screwdriver, compression sleeve, and the Kirschner wire were then removed. The subcutis and skin were closed using an absorbable monofilament suture. In cases with bilateral SIL, the entire procedure was repeated on the contralateral side. In the latter cases, the aim was to achieve a sacral purchase close to 50%.

Aftercare

Patients that were comfortable the day following surgery were discharged with a 5-day course of meloxicam (0.05 mg/kg PO SID, Metacam 0.5 mg/mL oral suspension, Boehringer Ingelheim, Ingelheim/Rhein, Germany). If nonsurgical wounds were identified, a 10-day course of amoxicillin-clavulanic acid (15 mg/kg PO BID, Synulox 50 mg tablets, Zoetis B.V., Capelle a/d IJssel, the Netherlands) was added. The owners were instructed to restrict the patient to a crate for 6 weeks following surgery. None of the patients required deviation from the standard aftercare protocol due to comorbidities.

Follow-Up

Patients were scheduled for re-examination and radiography 6 to 8 weeks after surgery.

An online questionnaire was used to assess long-term outcome. The questionnaire was sent to the owners of the cats at 21 to 55 months after the surgery. This questionnaire was a literal translation of the questionnaire developed by Zamprogno et al[23] to assess degenerative joint disease–associated pain in cats.

Results

A total of 19 cats were treated with at least one HCS during the study period. Five cats were excluded because of incomplete follow-up records. Breeds were distributed as follows: 11 domestic shorthair cats, 1 Bengal, 1 Birman, and 1 British short hair. All cats were neutered, with 8 male and 6 female. The mean age at the time of surgery was 75 months (range: 23–162 months). Mean weight was 4.2 kg (range: 3.3–5.8 kg).

A total of 17 SIL were treated: 7 left, 4 right, and 3 bilateral. All of the unilateral and 1 of the bilateral cases had concurrent fractures of the pelvis; 7 had fractures of the pubis, 7 of the ischium, 5 of the ilium, 3 of the symphysis, 2 of the acetabulum, and 1 of the femoral head.

The mean preoperative SI joint displacement was 54% (range: 11–95%). The mean PCDR was 1.20 (range: 1.03–1.43) and the mean HCWR was 0.94 (range: 0.40–1.59).

The mean postoperative SI joint reduction was 85% (range: 56–98%). All HCS were placed within the sacral bone. Sacral purchase of at least 60% was achieved in 8/11 of unilateral HCS, with a median purchase of 63% (range: 45–85%). Median sacral purchase in bilateral HCS was 38% (range: 25–53%). The mean postoperative PCDR was 1.38 (range: 1.14–1.63) and the mean HCWR was 1.03 (range: 0.86–1.30).

Three cats showed neurologic deficits: one cat lacked deep pain sensation both pre- and postoperative and had postoperative absent proprioception, one cat exhibited a postoperative plantigrade stance on the side of HCS placement, and one cat showed postoperative hind limb paresis on the side contralateral to HCS placement. Preoperative proprioception was not recorded in these cases. All neurologic deficits resolved within 3 months following surgery.

All 14 cats were presented back for re-examination 6to 8 weeks after surgery. All cats were weight bearing at re-examination. Follow-up radiographs were available for 7/14 cats, a written report describing radiographic findings was available for the remaining 7/14 cats; therefore, follow-up measurements could only be performed on 7/14 cats. All of the unilateral screws (11/11) were in the correct position and no loss of screw purchase was recorded. Of the bilaterally placed HCS, 3/6 showed screw loosening, with bilateral screw loosening in 1 cat and left unilateral screw loosening in another cat. All three cases of screw loosening showed screw pull-out from the sacrum, with concurrent loss of SI joint reduction. Since both cats revealed satisfactory clinical improvement on orthopaedic examination and no decrease of PCDR, both cats were treated conservatively by crate rest. The mean follow-up SI joint reduction was 88% (range: 79–95%), which was the same on immediate postoperative radiographs for these cats. Sacral purchase of at least 60% could be measured in 5/7 of unilateral HCS, with a median purchase of 63% (range: 44–88%), which was the same on immediate postoperative radiographs for these cats. The mean follow-up PCDR was 1.25 (range: 1.05–1.54), which was 1.33 on the immediate postoperative radiographs for these cats. The mean HCWR was 1.06 (range: 0.81–1.31), which was 1.02 on the immediate postoperative radiographs for these cats.

A total of 11/14 of online questionnaires were filled out between 21 and 55 (mean: 36) months after surgery. None of the cats were in need of analgesia. Two cats had shown signs of obstipation: one cat was treated three times weekly with laxatives because of repeated episodes of obstipation before the administration of oral treatment with laxatives; the other cat was treated with laxatives once in the immediate postoperative period, with subsequent complete resolution of clinical signs. Two cats were reported to have an altered ability to walk, run, use stairs, and jump. In two other cats the ability to jump had changed. The owners of 8/11 judged the quality of life as the same, or almost the same, compared with the quality of life before surgery; 2/11 judged the quality of life as sometimes different, and 1/11 judged the quality of life as regularly different. Owner satisfaction was good; 10/11 owners reported being very satisfied with the results of the surgery and 1/11 owners reported being satisfied.

Discussion

All screws in this study were placed within the sacrum. This is comparable to previous studies with fluoroscopy-assisted percutaneous placement of screws, which reported 92 to 100% of the screws within the sacrum.[14,16,21] It was not considered feasible for the feline sacrum to facilitate overlap of two 3.0 mm HCS within the safe corridor in most patients.[11] Among bilateral HCS, 3/6 revealed screw loosening, with subsequent loss of reduction of SIL repair. Increased risk for screw loosening, with sacral purchase of less than approximately 60% has previously been described in cats.[5] However, even cats with radiographic signs of screw loosening revealed good clinical progression on orthopaedic examination.

The mean postoperative SI reduction in this study was 85%. This is less than the median 94% SI reduction previously described for percutaneous fluoroscopy-guided HCS placement in cats[18] and similar to the mean of 86% SI reduction previously described in cats for open reduction.[5] No loss of SI reduction was seen on the follow-up radiographs, compared with the immediate postoperative radiographs. Although SI joint reduction of >90% has previously been reported as optimal, there is little scientific evidence to support this claim. Accuracy of SI reduction could potentially be improved by placement of a temporary holding pin. This would allow time to reassess reduction, prior to placement of a Kirschner wire in the desired screw position.

The mean PCDR in this study was 1.38, which is more than the median PCDR previously described for percutaneous fluoroscopy-guided 2.4 mm HCS placement in cats.[18] A PCDR of ≥1.1 indicates satisfactory reconstruction of the pelvic canal diameter, which was reached in all cases in this study. A HCWR of 1 indicates symmetrical reduction of the pelvis. The mean HCWR in this study was 1.03. These measurements indicate that this surgical technique achieved satisfactory pelvic canal diameter and near-symmetrical reconstruction of the pelvic canal.

Given the high percentage of implant loosening in cases with bilateral 3.0 mm HCS placement, further studies are warranted to evaluate if other surgical procedures are more appropriate in these patients, or if the addition of a transilial pin, screw, or bolt as described by Yap et al[3] could help reduce the rate of implant loosening. Alternatively, placement of two smaller HCS with sacral purchase of >60% as described by Jourdain et al in cats and Kang et al in small dogs cadavers could be considered.[18]

In this study, reduction of the SIL was maintained manually while a Kirschner wire was placed in the desired screw position, eliminating the need for a separate temporary holding pin. Although this method was feasible and subjectively quick, this method could potentially expose theater staff to more ionizing radiation if reduction is lost during pin placement compared with methods that use a separate holding pin.[13–16,18] Extra-long instruments or a sterile piece of string attached to the instruments was used to move the surgeon's and surgical assistant's hands away from the X-ray beam. All staff wore 0.5 mm lead-equivalent gowns and thyroid collars throughout the procedure. Personal dosimeters were worn on the outside of the lead-equivalent gowns and sent for analysis on a quarterly basis; however, these measurements were not reported. Despite these measures, placement of a separate temporary holding pin could be considered based on surgeon's experience to further minimize exposure to ionizing radiation.

No calibration markers were used for radiography. Although the X-ray machine and the dicomPACS DX-R software were digitally calibrated to allow accurate measurements, this calibration does not account for divergence of the X-ray beam and distance between the bone and the sensor. Therefore, the use of calibration markers could have increased accuracy of preoperative measurements.

Owner questionnaires revealed good overall satisfaction with clinical outcome after surgery. Some changes in behavior and postoperative complications were noted by the owners. None of the cats had ongoing need for analgesia, which is comparable to previous studies.[3,7] The two cats that had shown signs of obstipation following surgery both had a satisfactory PCDR and HCWR on both the immediate postoperative radiographs and the follow-up radiographs. The altered ability to walk, run, use stairs, and jump in two cats could be related to implant failure in both cases. The altered ability to jump in another cat could be related to the FHNO that was performed in this case, as no implant-related complications were documented in this case. The cases where quality of life was judged as sometimes different had either shown unilateral implant failure or recurrent obstipation. The case that was judged as regularly different had shown bilateral implant failure. The questionnaire used in this study was validated previously for assessment of pain associated with degenerative joint disease in cats.[23] Although this questionnaire reflects subjective assessment by the owner, it has been suggested to better correlate with force plate analysis than assessment by a veterinary surgeon.[23]

This study had several limitations. Due to the retrospective nature of this study, not all data of interest had been recorded. The number of cases in this study was limited. Procedures and case management were not standardized. However, due to the limited number of surgeons performing the procedures, procedural variation was minimal. To evaluate long-term function, additional orthopaedic examination with objective assessment of limb function would have been preferrable.

Conclusion

This study demonstrated that percutaneous fluoroscopy-guided placement of a 3.0 mm HCS is a safe and effective method for unilateral surgical reduction of SIL in cats. Further studies are needed to establish the most appropriate procedure to treat bilateral SIL.

Authors' Contribution
L.J., J.P., L.P., and L.J. contributed to the conception, study design, acquisition of data, data analysis and interpretation. All authors drafted, revised, and approved the submitted manuscript and are publicly responsible for the relevant content.

Conflict of Interest
None declared.

References

1 Lanz OI. Lumbosacral and pelvic injuries. Vet Clin North Am Small Anim Pract 2002;32(04):949–962, vii–viii

2 Meeson R, Corr S. Management of pelvic trauma: neurological damage, urinary tract disruption and pelvic fractures. J Feline Med Surg 2011;13(05):347–361

3 Yap FW, Dunn AL, Farrell M, Calvo I. Trans-iliac pin/bolt/screw internal fixation for sacroiliac luxation or separation in cats: six cases. J Feline Med Surg 2014;16(04):354–362

4 Tomlinson J. Minimally invasive repair of sacroiliac luxation in small animals. Vet Clin North Am Small Anim Pract 2012;42(05): 1069–1077, viii

5 Shales C, Moores A, Kulendra E, White C, Toscano M, Langley-Hobbs S. Stabilization of sacroiliac luxation in 40 cats using screws inserted in lag fashion. Vet Surg 2010;39(06):696–700

6 Parslow A, Simpson DJ. Bilateral sacroiliac luxation fixation using a single transiliosacral pin: surgical technique and clinical outcomes in eight cats. J Small Anim Pract 2017;58(06):330–336

7 Pratesi A, Grierson JM, Moores AP. Single transsacral screw and nut stabilization of bilateral sacroiliac luxation in 20 cats. Vet Comp Orthop Traumatol 2018;31(01):44–52

8 Bird FG, de Vicente F. Conservative management of sacroiliac luxation fracture in cats: medium- to long-term functional outcome. J Feline Med Surg 2020;22(06):575–581

9 Silveira F, Quinn RJ, Adrian AM, Owen MR, Bush MA. Evaluation of the use of intra-operative radiology for open placement of lag screws for the stabilization of sacroiliac luxation in cats. Vet Comp Orthop Traumatol 2017;30(01):69–74

10 Segal U, Bar H, Shani J. Repair of lumbosacral fracture-luxation with bilateral twisted string-of-pearls locking plates. J Small Anim Pract 2018;59(08):501–507

11 Shales CJ, White L, Langley-Hobbs SJ. Sacroiliac luxation in the cat: defining a safe corridor in the dorsoventral plane for screw insertion in lag fashion. Vet Surg 2009;38(03):343–348

12 Burger M, Forterre F, Brunnberg L. Surgical anatomy of the feline sacroiliac joint for lag screw fixation of sacroiliac fracture-luxation. Vet Comp Orthop Traumatol 2004;17(03):146–151

13 Tomlinson JL, Cook JL, Payne JT, Anderson CC, Johnson JC. Closed reduction and lag screw fixation of sacroiliac luxations and fractures. Vet Surg 1999;28(03):188–193

14 Tonks CA, Tomlinson JL, Cook JL. Evaluation of closed reduction and screw fixation in lag fashion of sacroiliac fracture-luxations. Vet Surg 2008;37(07):603–607

15 Rollins A, Balfour R, Szabo D, Chesvick CM. Evaluation of fluoroscopic-guided closed reduction versus open reduction of sacroiliac fracture-luxations stabilized with a lag screw. Vet Comp Orthop Traumatol 2019;32(06):467–474

16 Déjardin LM, Marturello DM, Guiot LP, Guillou RP, DeCamp CE. Comparison of open reduction versus minimally invasive surgical approaches on screw position in canine sacroiliac lag-screw fixation. Vet Comp Orthop Traumatol 2016;29(04): 290–297

17 Wills DJ, Neville-Towle J, Podadera J, Johnson KA. Computed tomographic evaluation of the accuracy of minimally invasive sacroiliac screw fixation in cats. Vet Comp Orthop Traumatol 2022;35(02):119–127

18 Jourdain M, Fernandes D, Védrine B, Gauthier O. Fluoroscopically-assisted closed reduction and percutaneous fixation of sacroiliac luxations in cats using 2.4 mm headless cannulated compression screws: Description, evaluation and clinical outcome. Vet Surg 2024;53(04):603–612

19 Naiman JH, Zellner EM, Petrovsky BL, et al. Radiation exposure associated with percutaneous fluoroscopically guided lag screw fixation for sacroiliac luxation in dogs. Vet Surg 2021;50(05): 1065–1075

20 DePuy Synthes. 2.4 mm and 3.0 mm Headless Compression Screws. Surg Tech 2017

21 Fischer A, Binder E, Reif U, Biel M, Bokemeyer J, Kramer M. Closed reduction and percutaneous fixation of sacroiliac luxations in cats using 2.4 mm cannulated screws - a cadaveric study. Vet Comp Orthop Traumatol 2012;25(01):22–27

22 Kang A, Lee H, Lee A, Roh Y, Sim B, Jeong J. Biomechanical comparison of double 2.3-mm headless cannulated self-compression screws and single 3.5-mm cortical screw in lag fashion in a canine sacroiliac luxation model: a small dog cadaveric study. Vet Comp Orthop Traumatol 2024;37(01):13–22

23 Zamprogno H, Hansen BD, Bondell HD, et al. Item generation and design testing of a questionnaire to assess degenerative joint disease-associated pain in cats. Am J Vet Res 2010;71(12): 1417–1424

