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Comparison of Single versus Double Lateral Plating in Treatment of Feline Ilial Fractures Using Veterinary Cuttable Plates

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Abstract

Objective The aim of this study was to compare the frequency of implant failure and the extent of pelvic canal narrowing associated with the fixation of ilial fractures in cats with a single veterinary cuttable plate (SLP) or double veterinary cuttable plates (DLP) applied to the lateral surface of the ilium.

Study Design Radiographic evaluation of feline ilial fractures plated laterally using SLP or DLP. Pelvic canal narrowing directly postoperatively and at 6 weeks follow-up was objectively measured using the sacral index (SI). Radiographs were evaluated for implant failure and fracture healing.

Results Seventy-seven cats satisfied the inclusion criteria. Twenty-nine fractures were treated with a SLP and 48 with DLP. Implant failure occurred significantly more ($p = 0.001$) in the SLP group (14/29) compared with the DLP group (6/48). Follow-up SI was significantly different between the two groups ($p = 0.048$, SLP median: 1.0 range: 0.83–2.4, DLP median: 0.98; range: 0.76–1.45). Median change in SI was −0.04 (range: −1.4 to 0.05) in the SLP group and 0.0 (range: −0.23 to 0.23) in the DLP group. This difference was significantly different ($p = 0.031$).

Conclusion DLP leads to significantly less implant failure and significantly less pelvic canal narrowing compared with SLP. This difference in pelvic canal narrowing was small and the clinical relevance remains unclear.

Keywords
- feline
- veterinary cuttable plate
- implant
- double plating
- ilial fracture

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Introduction

Fractures of the pelvis are common in cats. Pelvic fractures account for 25 to 32% of all feline fractures.[1,2] Because of the rectangular box-like anatomy, the pelvis most commonly fractures in at least three places. In a study of 556 pelvic fracture cases in dogs and cats, 76% showed 3 or more fracture sites.[3] Two feline studies showed that in ~50% the ilium is involved.[2,4] Indications for surgery include involvement of the weight-bearing axis, severe (>50%) reduction of pelvic canal width, sciatic nerve deficits and severe pain.[5–7] Several ilial fracture fixation methods have been reported, such as intramedullary pinning, pin and wire combination, screw and wire combination, plate and pin combination and lateral as well as dorsal plating.[6–9] Lateral plating is the most

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frequently reported method. However, it is associated with a high incidence (50–62%) of screw loosening when non-locking plates are used, resulting in an increased risk of pelvic canal narrowing.[10,11] Decreased pelvic canal width can lead to obstipation that may progress to megacolon.[10,12] The recommended number of screws placed cranial and caudal to the fracture site is 3.[7] In situations where this cannot be achieved with one laterally applied plate, alternatives like placing two lateral plates (1 dorsal and 1 ventral), extending the plate over the acetabulum, applying the plate dorsal to the ilium or combining lateral and dorsal plating can be considered.[11,13,14]

The objective of this study was to assess the frequency of implant failure and the extent of pelvic canal narrowing associated with the fixation of ilial fractures in cats with a single lateral veterinary cuttable plate (SLP) or double lateral veterinary cuttable plates (DLP) on the lateral surface of the ilium.

We hypothesized that the use of DLP would lead to less implant failure and, consequently to a decrease in postoperative pelvic canal narrowing.

Materials and Methods

Inclusion and Exclusion Criteria

Cats were included in the study if they had ilial fractures that were repaired with open reduction and internal fixation using a single or double 1.5/2.0 veterinary cuttable plate (Synthes GmbH, Oberdorf, Switzerland) between 1996 and 2010. Complete medical and surgical records were required, as well as orthogonal radiographs taken preoperatively, immediate postoperatively and 6 weeks postoperatively. Cases with bilateral ilial fractures, incomplete records or radiographs that did not allow adequate measurements were excluded.

Radiographic Assessment

Radiographs were assessed by a single observer. Preoperative radiographs were assessed for fracture location and type according to the classification system of Messmer and Montavon (►**Supplementary Table S1**, available in the online version)[3] Correct and similar positioning of radiographs used for measurements immediately postoperatively and 6 weeks postoperatively was visually assessed based on the position of the spine, ilial wings and, if possible, the size of the obturator foramina. Immediate postoperative radiographs were assessed for apparatus, apposition, plate length (defined by the number of plate holes) and number of screws inserted cranial and caudal to the fracture site. Fracture reduction was scored on these radiographs as anatomic, near anatomic, good, fair or poor. Six weeks postoperative radiographs were additionally assessed for implant failure and fracture healing. Implant failure was recorded when one or more screws had visually lost screw length engaged in bone (screw purchase) or when plate failure occurred. Loss of screw length was evaluated on radiographs that were similar in position to the immediate postoperative radiographs. To objectively measure any progression of pelvic canal narrowing, the sacral index (SI) was used as described by Hamilton and colleagues and Schmierer and colleagues[10,11] The SI measurements were assessed on ventrodorsal radiographs of the pelvis taken immediately postoperatively and 6 weeks postoperatively (►**Fig. 1**).

Implants

Implants used were 1.5/2.0 stainless steel veterinary cuttable plates in combination with 1.5 mm or 2.0 mm diameter stainless steel cortex screws of variable length. All plates were applied dorsally or ventrally to the lateral ilial body (►**Fig. 2**). If double plates were used, the first plate was applied laterally and the second plate applied dorsal or ventral to the first plate (►**Fig. 3**). If contralateral sacroiliac luxation was present, this was always repaired by placing a 1.5 and/or a 2.0mm cortical screw in the wing of the ilium and body of the sacrum by a dorsolateral approach. In cases with two screws placed in the sacrum, one screw was placed in the cranial part of the sacrum and the second screw was placed caudally to the first screw.

Other Injuries

Concomitant injuries were classified as orthopaedic, or related to other body systems, and frequency was compared between groups.

Statistics

All statistical analyses were performed with SPSS Software (SPSS 24.0 Command Syntax Reference 2016, SPSS Inc. Chicago, Illinois, United States). Normality was assessed with Kolmogorov–Smirnov tests and parametric or non-parametric tests were used accordingly. Students *t*-tests or Mann–Whitney U tests were used for comparison of continuous data; Pearson chi-squared tests were used for comparison of categorized data and Wilcoxon signed-rank tests were used for paired observations. A p-value < 0.05 was considered significant.

Results

Seventy-seven cats satisfied the inclusion criteria. The cats ranged in age from 0 to 14 years with a median of 2.1 years. Thirty-four cats were male (32 neutered, 2 intact) and 43 females (16 neutered, 27 intact). The median weight was 3.6 kg (range: 1.6–7.1 kg). There was no significant difference in distribution of gender, age or weight between the two groups. Twenty-nine fractures were treated with a SLP and 48 with DLP.

Fracture Configuration

Ilial fracture configuration is shown in ►**Table 1**. A total of 10 combinations of fractures occurred in the 77 cats. Two combinations accounted for 42/77 of all cases. The most common combination was a simple fracture of the ilial body, without fracture of the ischial body and with contralateral sacroiliac joint luxation (63-B1.1, 25/77 cases) The second most common combination was a multifragmentary fracture of the ilial body, without fracture of the ischial body but with contralateral sacroiliac joint luxation (63-B2.1, 17/77 cases). Distribution of unilateral or bilateral involvement, simple or multifragmentary

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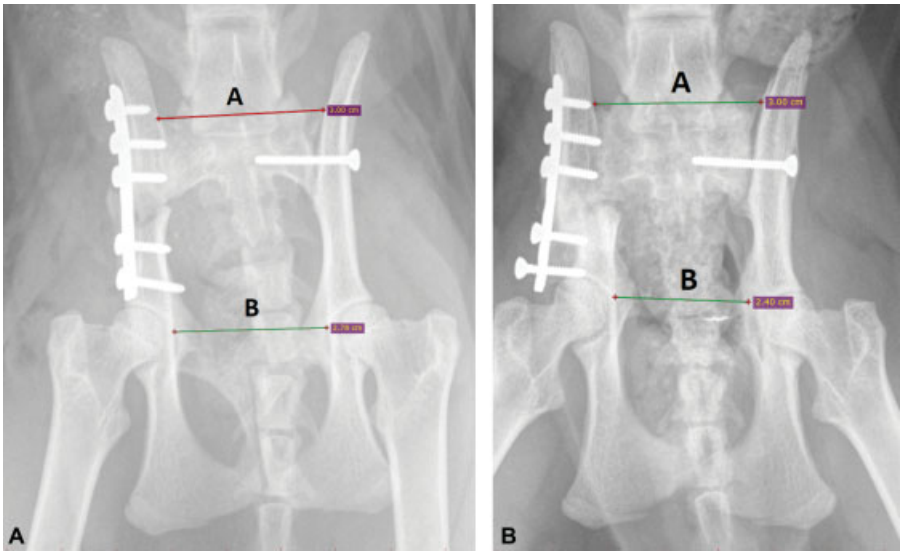

Fig. 1 Ventrodorsal radiographs of a cat treated with a single lateral veterinary cuttable plate, immediate postoperative (**A**) and at follow-up (**B**) showing sacral index measurements as the ratio of the width of the cranial border of the sacrum (**A**) to the width between the medial cortices of the acetabular bones (**B**). This cat suffered two loose screws caudal to the fracture site and pelvic canal narrowing (change in sacral index of 0.11). The sacroiliac luxation at the contralateral side was repaired using one cortical screw.

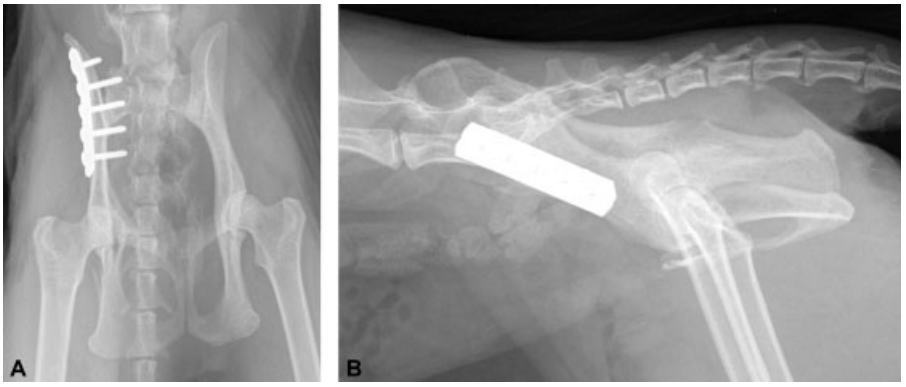

Fig. 2 Immediate postoperative ventrodorsal (**A**) and mediolateral (**B**) radiographic view of a single lateral plate fixation on the ilium of a cat with an ilial, pubic and ischial fracture.

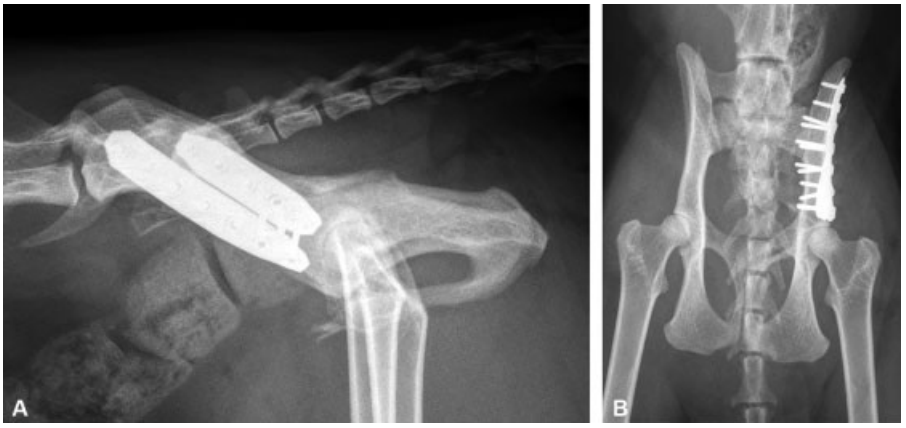

Fig. 3 Immediate postoperative ventrodorsal (**A**) and mediolateral (**B**) radiographic view of a double lateral plate fixation on the ilium of a cat with an ilial and pubic fracture. Note the presence of the transitional vertebra and that the edges of the plate were cut off.

fractures, presence or absence of ipsilateral ischial fracture, presence or absence of sacroiliac joint luxation and presence or absence of concomitant pelvic fractures did not differ significantly between the two treatment groups.

Other Orthopaedic Injuries

In the SLP group, 6 cats had other orthopaedic injuries: sacral fracture ($n = 1$), coxofemoral luxation ($n = 2$), tear of the vastus lateralis muscle ($n = 1$), coxofemoral luxation and proximal

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Table 1 Frequency of fracture characteristics for 77 cats with pelvic fractures according to the classification scheme of Messmer and Montavon[3]

Fracture type	No. of cats
62-B1.1	6
62-B1.2	7
62-B1.3	1
62-B2.1	5
62-B2.2	2
62-B3.1	4
63-B1.1	25
63-B1.2	2
63-B2.1	17
63-B3.1	8

intertarsal luxation ($n = 1$), sacral fracture, talar fracture and fibular fracture ($n = 1$). In two of these cats, the orthopaedic injuries were to the contralateral side of the ilial fracture, while in four cases they affected the ipsilateral side. In the DLP group, 9 cats had other orthopaedic injuries: femoral fracture ($n = 5$), coxofemoral luxation ($n = 2$), brachial plexus avulsion ($n = 1$), talar fracture and fibular malleolus fracture ($n = 1$). One of these cats had orthopaedic injuries to the contralateral side to the ilial fracture, while in eight cases they affected the ipsilateral side. The incidence of other orthopaedic injuries was not significantly different between the two groups.

Other Injuries

In the SLP group, four cats had other injuries: ventral abdominal hernia ($n = 1$), pneumothorax ($n = 1$), rib fracture and pneumothorax ($n = 1$) and tail avulsion ($n = 1$). In the DLP group, seven cats had other injuries: bladder rupture ($n = 1$), pneumothorax ($n = 2$), tail avulsion ($n = 3$), pneumothorax and tail avulsion ($n = 1$). The incidence of other injuries was not significantly different between the two groups.

Fracture Reduction

Fracture reduction was classified as anatomic or near-anatomic in 14/29 cases and as good in 10/29 cases in the SLP group versus 35/48 and 10/48 in the DLP group respectively. Only one case was classified as poor reduction in the SLP group and no cases were classified as such in the DLP group.

Plate Length

In single plate fixations, median veterinary cuttable plate size was six holes (range: 4–10). In double plate fixations, the median veterinary cuttable plate size applied to the ventrolateral side of the ilium was five holes (range: 3–7) and to the dorsolateral side six holes (range: 2–8).

Number of Screws Used and Incorporated Cortices

Significantly more screws ($p < 0.001$) were inserted cranial and caudal to the fracture site in the DLP group (cranial: median: 5; range: 3–7) (caudal: median: 4; range: 2–6) compared with the SLP group (cranial: median: 3; range: 2–5) (caudal: median: 3; range: 1–3). The total screw number was significantly higher ($p < 0.001$) for the DLP group (median: 10; range: 5–12) compared with the SLP group (median: 6; range: 3–8).

Significantly more cortices were incorporated cranial and caudal to the fracture site in the DLP group (cranial: median: 10; range: 6–14, caudal: median: 8; range: 4–12) compared with the SLP group (cranial: median: 6; range: 4–10, caudal: median: 6; range: 2–6) ($p < 0.001$). In five cases in the SLP group, less than six cortices were incorporated cranial to the fracture site, whereas in all cases in the DLP group 6 or more cortices were incorporated. For the caudal component, less than six cortices were incorporated in 13 cases in the SLP group versus 1 case in the DLP group.

Sacral Engagement

There was no significant difference between the two treatment groups in the number of cats in which the sacrum was engaged in the fixation (51/77). When the sacrum was engaged, no significant difference between the two treatment groups was seen in the number of screws that engaged the sacrum.

Fracture Healing

All fractures showed radiographic signs of union at six weeks postoperative except for three cases in the SLP group. These three cases showed radiographic signs of union at 10 weeks (2 cases) and 13 weeks (1 case). Measurement on SI and information about implant failure in these cases was collected from the 10 and 13 weeks postoperative radiographs.

Implant Failure

Implant failure, defined as screw loosening or plate failure, occurred significantly more ($p = 0.001$) in the SLP group (14/29) compared with the DLP group (6/48)). There was a significant difference ($p = 0.001$) in the frequency of screw loosening between SLP (13/29) and DLP groups (6/48). There was no significant difference in frequency of screw loosening between cases with and without sacral engagement. The total number of screws, number of cranial screws and number of caudal screws were significantly higher in the group without screw loosening compared with the group with screw loosening ($p = 0.008$, $p = 0.006$ and $p = 0.02$). In cases with less than six incorporated cortices cranial to the fracture site, screw loosening occurred in 3/5 cats versus 16/72 cats with six or more cortices cranial to the fracture site, $p = 0.06$. In cases with less than six incorporated cortices caudal to the fracture site, screw loosening occurred in 7/14 cats versus 12/63 cats with six or more cortices caudal to the fracture site, $p = 0.02$. Plate failure occurred significantly more ($p = 0.02$) in the SLP group (6/29) compared with the DLP group (2/48).

Pelvic Canal Narrowing

Immediate postoperative SI did not differ between the two groups ($p = 0.8$, SLP median: 1.0; range: 0.83–1.32, DLP median: 1.0; range: 0.79–1.39). Follow-up SI was significantly different between the two groups ($p = 0.048$, SLP median: 1.0; range: 0.83–2.4, DLP median: 0.98; range: 0.76–1.45). Median

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Table 2 Sacral index (SI) and screw loosening for single lateral plating (SLP) and double lateral plating (DLP)

	SLP	DLP	*p*-Value
Postoperative SI	1.0 (0.83–1.32)	1.0 (0.79–1.39)	0.8
Follow-up SI	1.0 (0.83–2.4)	0.98 (0.76–1.45)	0.048
Change in SI	−0.04 (−1.4–0.05)	0.0 (−0.23–0.23)	0.031
Frequency of loose screws	13/29 cats	6/48 cats	0.001

Note: Follow-up SI is at 6 weeks postoperatively, change in SI is immediate postoperatively SI minus 6 weeks follow-up SI.

change in SI was −0.04; range: −1.4 to 0.05) in the SLP group and 0.0 (range: −0.23 to 0.23) in the DLP group. This difference was significantly different ($p = 0.031$) (►**Table 2**).

Discussion

This study shows that DLP leads to significantly less implant failure compared with SLP in cats treated for ilial fractures. Implant failure, defined as screw loosening or plate failure, occurred 3.7 times more in the SLP group. This leads to a significantly higher decrease in pelvic canal width 6 weeks postoperatively in the SLP group.

Screw loosening occurred in 45% of the SLP cases. This is slightly lower than previously reported in single non-locking lateral plating of feline ilial fractures (50–62%), but is still unacceptably high.[10,11,13] It has been suggested that the narrow width of the feline ilium results in insufficient screw purchase and predisposes to screw loosening with lateral plating.[10]

Only 13% of the DLP cases showed one or more loose screws. Significantly more total screws and incorporated cortices were achieved in the DLP group. In caudal ilial fractures, it can be difficult to achieve the recommended number of six cortices in the caudal fragment due to the small distance between the acetabulum and the fracture line.[6] In about half of the SLP cases, the desired number of six cortices could not be achieved caudal to the fracture site. Only one DLP case had less than six cortices incorporated caudal to the fracture site. Screw loosening occurred significantly more in the cats with less than six cortices incorporated caudal to the fracture site (50 vs. 19%). These differences in screw numbers and engaged cortices probably contribute to the difference in screw loosening between SLP and DLP.

While double plating appears to reduce screw loosening in this study, it can sometimes be difficult to place two plates on the lateral side of the ilium. Contouring and twisting the ventral plate to better fit the ilium caudal to the fracture can help with accommodating both plates. Another option to increase the number of cortices caudal to the fracture site is the use of T-plates. Troger and Viguier reported 22% screw loosening when feline supracotyloid fractures were repaired using a non-locking T-plate, although no specific information on engaged cortices on either site of the fracture was reported in this study.[15] Alternatively, single plating with locking implants or TPLO plates could be used and may be a technically easier alternative.[11,16–18] Locking implants result in less screw loosening compared with non-locking plates in *ex vivo* biomechanical and clinical studies for feline ilial fracture repair.[11,14,18] The use of TPLO plates was described in a small number of feline patients. No implant-related complications occurred in these studies.[16,17]

To achieve more screw purchase cranial to the fracture site with lateral ilial plating, the sacrum can be engaged with screw placement. The benefit of sacral screw engagement remains unclear. Two studies in dogs evaluated the benefit of engaging the sacrum with triple pelvic osteotomies with conflicting results.[19,20] One *ex vivo* biomechanical feline fracture gap model study showed a benefit of sacral engagement in ilial fracture repair, although this study was not representative of common ilial fracture configurations.[14] However, results of clinical studies into feline ilial facture repair are conflicting.[10,11,13] In the present study, the frequency of sacral engagement did not differ between the two groups. Also, the incidence of screw loosening was not significantly different between cases with and without sacral engagement. This suggests that in the population in this study, there was no benefit of sacral engagement with regard to screw loosening.

Reducing the incidence of screw loosening is an important factor in considering different treatment options, since screw loosening has been associated with pelvic canal narrowing and a possible increased risk for constipation.[12,13] However, other studies show that pelvic canal narrowing can be minimal or clinically irrelevant, even in the presence of loose screws.[11,15] In the present study, immediate postoperative pelvic canal narrowing was similar for both groups and present in more than one-third of the cats. Immediate postoperative pelvic canal narrowing could be a result of poor fracture reduction or contralateral sacroiliac luxation that may not have been reduced anatomically. However, in most cats in this study, fracture reduction was reported to be anatomical to good, and fracture reduction was only scored poor in one cat. At 6 weeks follow-up, a significantly higher change in SI occurred in the SLP group. It is not known if this resulted in a poorer clinical function, since this study did not include clinical functional outcome or long-term follow-up.

There are several limitations to this study including those intrinsic to a retrospective analysis. No long-term follow-up was performed and no information about clinical function was available. It was not possible to blind the radiographic assessor since the implants are clearly visible. To address this possible bias, the objectively measured SI was used. Using a single observer for radiographic assessment could potentially lead to a bias. However, this would be consistent across all cats. No information was recorded about the length of the sacral screw in case of sacroiliac luxation. The recommended screw length of 60% of the width of the sacrum may not have been achieved in all cases (for example in the case presented in ►**Fig. 1**). Less than 60% sacral screw engagement could result in inappropriate stability of the sacroiliac fixation, contributing to subsequent pelvic canal narrowing.[6]

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In conclusion, the use of DLP led to significantly less implant failure and less pelvic canal narrowing compared with the use of a SLP in this population. However, the difference in pelvic canal narrowing is small and the clinical relevance of this remains uncertain and warrants clinical follow-up studies.

Authors' Contributions

All authors contributed to the conception of study, study design, acquisition of data and data analysis and interpretation. They drafted, revised and approved the submitted manuscript and are publically accountable for relevant content.

Conflict of Interest

None declared.

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