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Ex vivo comparison of lateral plate repairs of experimental oblique ilial fractures in cats

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Abstract

Objective: To determine the biomechanical behavior of different plate systems used for oblique ilial fracture fixation in cats.

Study design: Ex vivo biomechanical study.

Sample population: Fifty fresh-frozen feline hemipelvises.

Methods: Standardized simple oblique ilial fractures were created and fixed via lateral plating, using different implant systems (10 fractures in each group) The systems were: (1) the Advanced Locking Plate System (ALPS-5); (2) the Advanced Locking Plate System (ALPS-6.5); (3) the Locking Compression Plate 2.0 (LCP); (4) the FIXIN 1.9-2.5 Series (FIXIN), and (5) the Dynamic Compression Plate 2.0 (DCP). Stepwise sinusoidal cyclic loading was applied until failure (10-mm displacement). The groups were compared with regard to construct stiffness and the number of cycles withstood before 1-, 2-, 5-, and 10-mm displacement.

Results: Bending stiffness was lower in ALPS-5 than in other specimens ($P < .05$). The ALPS-6.5 specimens withstood more cycles ($P < .05$) before 2-, 5-, and 10-mm displacement than the ALPS-5 and DCP specimens . The LCP and FIXIN specimens endured more cycles than DCP specimens before displaying 5- and 10-mm displacement ($P < .05$). The ALPS-6.5, FIXIN, and LCP specimens endured higher loads before failure than the DCP specimens ($P < .05$). Screw loosening occurred in all nonlocking specimens, and bone slicing occurred in all locking specimens.

Conclusion: The DCP and ALPS-5 constructs are less resistant to cyclic loading. Failure in nonlocking specimens involved screw loosening. It involved bone slicing in locking specimens.

Clinical significance: Both the plate size and the plate–screw interface are key to lateral plating success in cases of feline ilial fractures. The use of locking plates reduces the risk of the screw loosening in such cases.

Abbreviations: ALPS, Advanced Locking Plate System; DCP, Dynamic Compression Plate; LCP, Locking Compression Plate; PMMA, polymethylmethacrylate.

The results of this study were presented at the ECVS online Annual Congress; July 8-10, 2021.

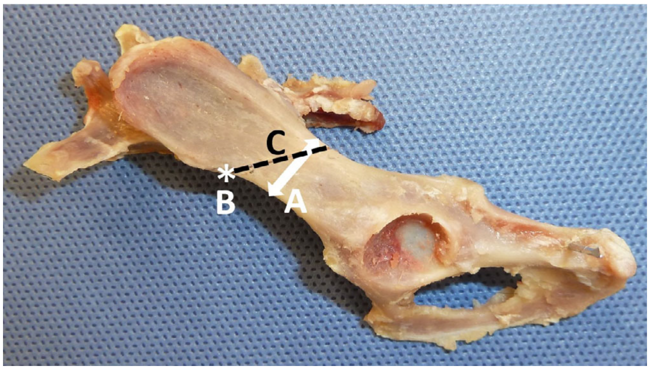

FIGURE 1 Osteotomy planning. (A) Diameter of the ilial bone. (B) Starting point of the standardized osteotomy at the caudo-ventral iliac spine (arrow). (C) Length of the osteotomy (1.5 times distance A). The following steps were used to standardize the osteotomy: the first landmark for creating an oblique ilial osteotomy was directly caudal to the caudo-ventral aspect of the ilial wing, at the transition of the ilial wing to the ilial body. The length of the osteotomy was then calculated using the diameter of the ilium on its dorso-ventral orientation, measured at its narrowest point. This value was multiplied by 1.5. Subsequently the calculated length was transferred to a dorso-caudal point, obtaining the second landmark for the standardized osteotomy. An oblique osteotomy was then created, connecting the landmarks with each other

1 | INTRODUCTION

Pelvic fractures account for approximately one-third of all fractures in cats. Of these, ilial fractures account for up to 50%.[1–3,5] Indications for the surgical fixation of ilial fractures include pelvic canal narrowing, ipsilateral coxofemoral luxation, bilateral fractures, severe pain, and nerve deficits that may be associated with the fracture.[4] Various surgical stabilization techniques have been described in the literature, with lateral plating being the most commonly used technique.[6–14] Clinical and biomechanical studies have demonstrated that screw loosening is a frequent complication in lateral plating that uses nonlocking implants (in up to 100% of the cases).[13,15,16] Screw loosening, in turn, can lead to loss of reduction and consequently to narrowing of the pelvic canal. In a retrospective clinical study, this complication was reduced when locking implants were used for lateral plating.[16]

A recent biomechanical study compared locking and nonlocking implants in a gap model of the feline ilium and demonstrated that initial stiffness and the number of cycles to failure were similar between specimens stabilized with a single lateral locking plating and specimens

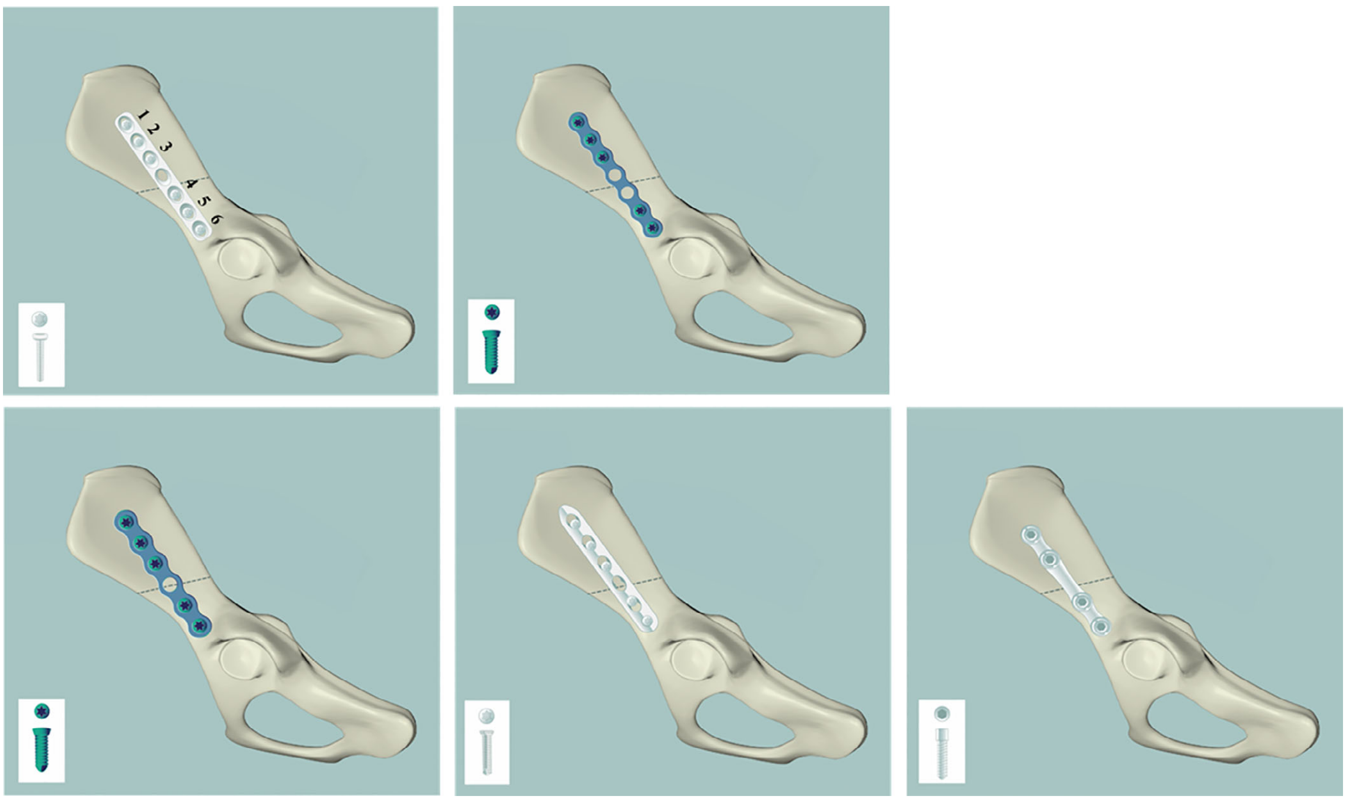

FIGURE 2 The five different groups used in this study, categorized into locking (ALPS-5, ALPS-6.5, LCP, FIXIN) and nonlocking (DCP) specimens. Top, from left to right: DCP, Dynamic Compression Plate 2.0; ALPS-5, Advanced Locking Plate System 5. Bottom, from left to right: ALPS-6.5, Advanced Locking Plate System 6.5; LCP, Locking Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series. Cortical screws placed in the DCP group are numbered 1 to 6 (cranial to caudal)

stabilized with orthogonally applied nonlocking implants.[13] It also showed that locking implants withstood more cycles before 5- and 10-mm displacement than single nonlocking implant groups.[13] Furthermore, screw loosening occurred only in specimens fixed with nonlocking systems.[13] Although those results are relevant, they cannot be translated directly to clinical decision making, because that ex vivo study used a gap model, whereas the most common fracture of the feline ilium is an oblique fracture without a gap.[5] Mechanical behavior in anatomically reducible (transverse/oblique) and nonreducible (comminuted) fractures differs significantly.

Thus, to evaluate if locking implants are also associated with a lower occurrence of screw loosening in a reducible fracture model in a biomechanical context, we used an ex vivo fracture model that simulated oblique reducible fractures in cat ilium specimens. We investigated the biomechanical performance of four commonly used locking plate systems and a standard, nonlocking DCP implant in this most common fracture type of the feline ilium. We hypothesized that there would be no differences in bending stiffness among systems, and that locking plate constructs would withstand more cycles before a given displacement than the standard, nonlocking DCP constructs.

2 | MATERIALS AND METHODS

2.1 | Specimen procurement and preparation

Anatomic specimens were collected according to our institution's regulations. Fifty feline hemipelvises were collected from 25 adult male and female cats, which were euthanized for reasons unrelated to the study. The specimens were donated by the cats' owners for research and teaching purposes, with written approval. Prior to preparing the cadavers for the study, medical records were checked to ensure exclusion of cats with diseases that could potentially influence bone quality (endocrinopathies, prolonged steroid administration, and renal diseases). The mean age of the cats was 5 years (SD ±2.7 years) and the mean weight was 5.0 kg (±0.85 kg).

Ventro-dorsal and lateral-oblique pelvic radiographs were taken after euthanasia to select specimens of similar size and to detect obvious bone pathology. Only specimens with an ilioacetabular length (defined as the distance from the cranial border of the acetabulum to the cranial border of the ilial wing) of 4.8 ± 0.48 cm were included to limit size variability.[13] After radiographic screening, the pelvis, sacrum, and seventh lumbar vertebra (L7) were dissected. All soft tissue was removed, leaving the sacro-iliac joint intact. The pelvises were stored in saline-soaked gauze at −20°C. Prior to instrumentation, the pelvises were thawed at room temperature for 24 h.[11,13]

To ensure consistent orientation during potting and testing, a 1-mm Kirschner wire was placed transversely across the ischial tubercles in the intact pelvis, with the wire representing the horizontal plane. This wire was used during potting and biomechanical testing for orientation of the hemipelvis, which were placed at a physiological 20° angle of external rotation.[11,13] The hemipelvises were obtained by first cutting the pin on the midline. Then, the pelvis was cut through the pelvic symphysis using an oscillating saw (DePuy Synthes, Oberdorf, Switzerland). The sacrum and L7 were also cut on the midline.[13] A standardized oblique ilial osteotomy (Figure 1) was made through the lateral, dorsal, and ventral cortex with a 0.3-mm blade (DePuy Synthes). The remaining cortex was osteotomized after plate application.

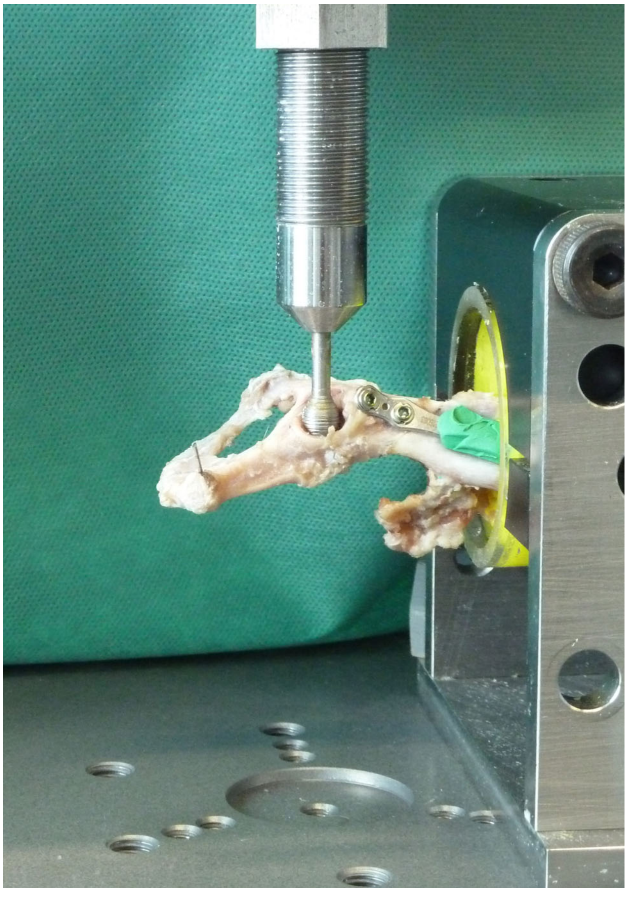

FIGURE 3 Cantilever bending test setup. The specimen is embedded in a polymethylmethacrylate cylinder. The acetabulum faces upward and is ventrally loaded using a custom rod, which is attached to a servohydraulic test system

TABLE 1 Bending stiffness and displacement cycles in different groups

Variables	Displacement	DCP	ALPS-5	ALPS-6.5	LCP	FIXIN	*P*-values
		a	**b**	**c**	**d**	**e**	
Bending stiffness, Nm		61.1 ± 4.5	48.2 ± 9.0	59.5 ± 5.3	60.3 ± 3.9	61.7 ± 6.7	a versus b: .001*
							a versus c: .69
							a versus d: .85
							a versus e: .85
							b versus c: .001*
							b versus d: .001*
							b versus e: .001*
							c versus d: .85
							c versus e: .55
							d versus e: .69
Cycles to certain displacement	1 mm	1494 ± 750.4	1336 ± 573	3029 ± 1896	2157 ± 603.7	2903 ± 1564.5	a versus b: .85
							a versus c: .08
							a versus d: .48
							a versus e: .11
							b versus c: .06
							b versus d: .38
							b versus e: .08
							c versus d: .35
							c versus e: .86
							d versus e: .44
	2 mm	2402 ± 883	2764 ± 1309.1	5188 ± 2487.2	3664 ± 1085.3	4500 ± 1801.6	a versus b: .69
							a versus c: .001*
							a versus d: .13
							a versus e: .01*
							b versus c: .003*
							b versus d: .31
							b versus e: .04*
							c versus d: .07
							c versus e: .44
							d versus e: .35
	5 mm	3832 ± 1455	4549 ± 743	7596 ± 2454.3	6221 ± 1950.3	6618 ± 1983.9	a versus b: .48
							a versus c: .001*
							a versus d: .01*
							a versus e: .003*
							b versus c: .001*
							b versus d: .07
							b versus e: .03*
							c versus d: .13
							c versus e: .32
							d versus e: .69

TABLE 1 (Continued)

Variables	Displacement	DCP	ALPS-5	ALPS-6.5	LCP	FIXIN	*P*-values
		a	b	c	d	e	
	10 mm	4443 ± 1855.8	4993 ± 524.6	8689 ± 2707.2	7256 ± 2252.2	7069 ± 2138.9	a versus b: .67
							a versus c: .001*
							a versus d: .01*
							a versus e: .02*
							b versus c: .001*
							b versus d: .04*
							b versus e: .06
							c versus d: .19
							c versus e: .13
							d versus e: .85

Abbreviations: ALPS-5, Advanced Locking Plate System 5; ALPS-6.5, Advanced Locking Plate System 6.5; DCP, Dynamic Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series; LCP, Locking Compression Plate 2.0.

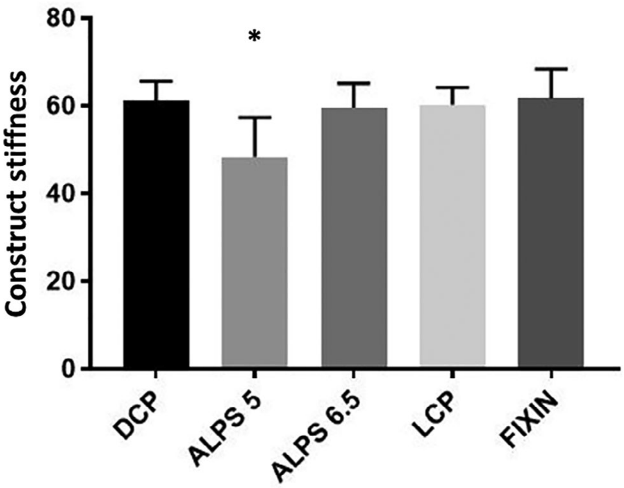

FIGURE 4 Bar graph of the construct stiffness of each construct type. ALPS-5, Advanced Locking Plate System 5; ALPS-6.5, Advanced Locking Plate System 6.5; DCP, Dynamic Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series; LCP, Locking Compression Plate 2.0. * $P < .05$

2.2 | Testing groups

Each hemipelvis was randomly assigned to one of five fixation groups using the RAND function in Excel version 15.31 (Microsoft, Redmond, Washington). The groups were: (1) a 7-hole Advanced Locking Plate System 5 (ALPS-5, Kyon AG, Zurich, Switzerland); (2) a 6-hole ALPS-6.5 (ALPS 6, Kyon AG); (3) a 6-hole Locking Compression Plate 2.0 (LCP, DePuy Synthes, Oberdorf, Switzerland); (4) a 4-hole FIXIN 1.9-2.5 Series (FIXIN, Intrauma, Rivoli, Italy); (5) a 7-hole Dynamic Compression Plate 2.0 (DCP, DePuy Synthes). All implants were applied following Arbeitsgemeinschaft für Osteosynthesefragen (AO) principles and the manufacturer's guidelines, by an experienced board-certified surgeon (DECVS). Implants were placed to ensure that one screw engaged 50% of the sacral body through the plate. To achieve precise placement of the sacral body screw, an aiming device (Veterinary Instruments, Sheffield, UK) was applied to insert the first screw into the center of each sacral body. Screw positions from the DCP group were numbered from cranial to caudal for precise analysis (Figure 2). Cortical screws from the DCP group were tightened by hand, and locking screws were tightened using a torque limiter (0.4 N m, Synthes LCP-2.0 recommendation). The 0.4 N m torque limiter was also applied for ALPS specimens. FIXIN screws were tightened until the conical screw head locked adequately into the bushing device (Figure 2).

After plating, the cranial part of the specimen (ilial wing, sacrum, and L7) was potted in polymethylmethacrylate (PMMA). To reinforce the specimen-PMMA interface, additional K-wires were anchored into the cranial area of the specimen prior to potting. To avoid PMMA interference with the implant, modeling clay was applied around the implants before potting and was removed after, confirming a free margin of ≥3 mm PMMA around the implant.

To standardize the potting process, the long axis of the ilium was placed in a holding device and introduced into the potting cylinder, precisely perpendicular to the underlying table.[13]

2.3 | Biomechanical testing

Prior to testing, each specimen was firmly attached to a servo-hydraulic mechanical testing machine (Instron E3000, Norwood, Massachusetts) with the ilial long axis

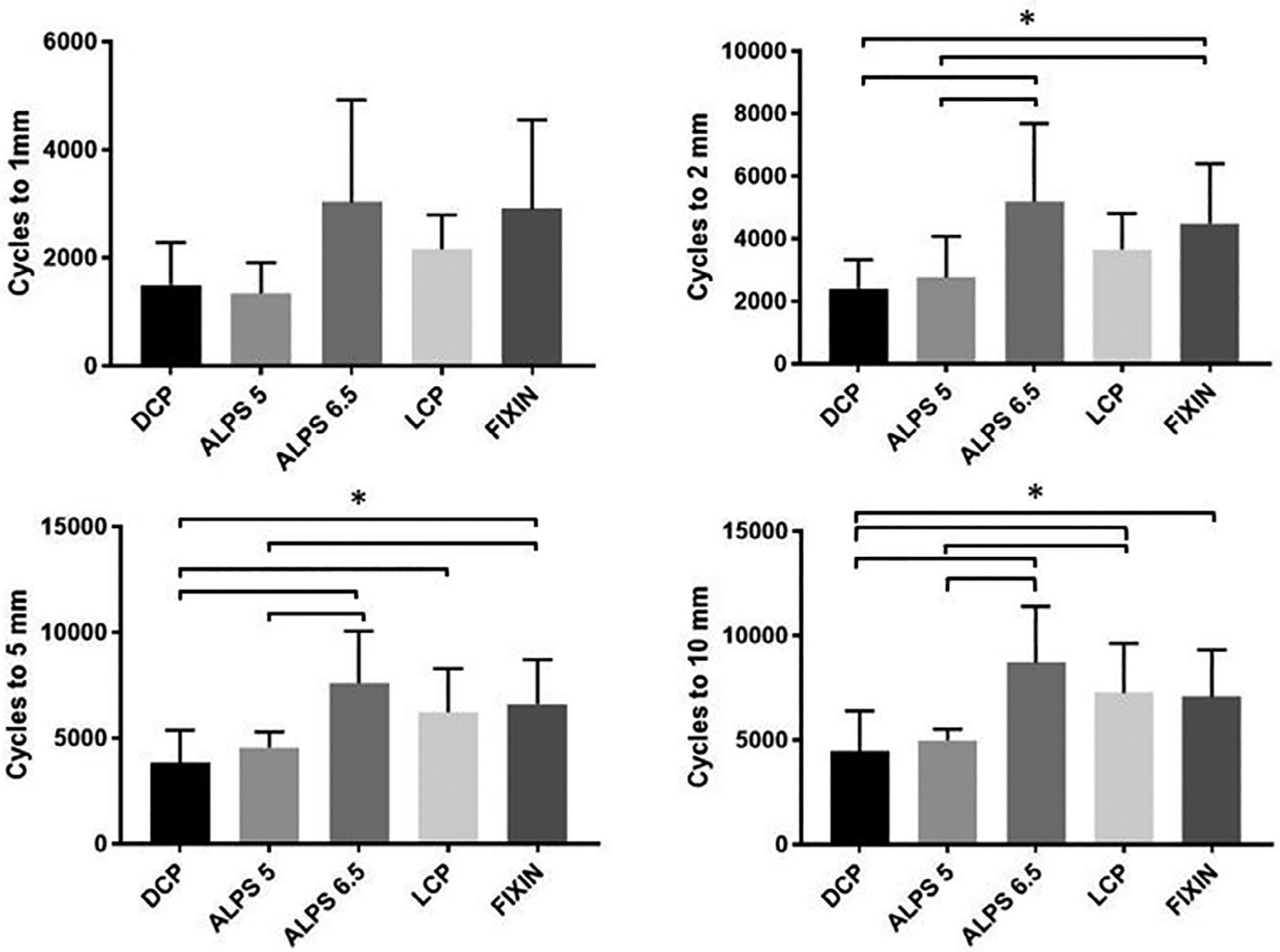

FIGURE 5 Bar graphs of the number of cycles to 1-, 2-, 5-, and 10-mm displacement. ALPS-5, Advanced Locking Plate System 5; ALPS-6.5, Advanced Locking Plate System 6.5; DCP, Dynamic Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series; LCP, Locking Compression Plate 2.0. * $P < .05$

oriented horizontally to the ground (Figure 3). This position was selected to subject the specimens to cantilever bending, as described in previous publications.[11,13]

The specimens were loaded using a custom-made 9.5-mm-diameter sphere connected to a bolt, simulating the cat's femur. The bolt was attached to a load cell compressing the upward-rotated acetabulum from the top downward. The mechanical testing machine was equipped with a 5-kN load cell (Instron ± kN Dynacell™ Dynamic Testing Software, Norwood, Massachusetts).

The specimens were subjected to sinusoidal cyclic loading in a stepwise fashion with a frequency of 2 Hz. Each step consisted of 500 cycles, starting with a baseline preload of 10 N and an initial peak load of 20 N, which increased by 10 N with each step.[17,18] The selection of physiological load values was based on previously published data.[13,17,18] An implant system was considered to have failed, and the test was stopped, when there was a 10-mm axial displacement of the machine transducer. A load–displacement curve was created by plotting the applied load against the measured displacement. The stiffness value was calculated as the slope of the linear portion of the load–displacement curve and was reported in units of N/mm. During cyclic testing, all specimens were sprayed with saline to keep them moist.

2.4 | Data analysis and statistics

The outcomes of this study were the constructs' bending stiffness (N/mm), the number of cycles before a specific transducer displacement (1-, 2-, 5-, and 10-mm), and the mode of construct failure.

Construct bending stiffness was calculated from the ascending linear slope of the load/displacement curve when transducer loads oscillated between 10 and 20 N. The average of three consecutive cycles was recorded. When the stop criterion was reached (10-mm transducer displacement), specimens were examined thoroughly for screw loosening or additional failure modes. Screw loosening was evaluated after removing PMMA, using a 0.4-Nm torque limiter for locking constructs. In the DCP group, screw loosening was determined by "two-finger tightening" in terms of AO principles for 2.0-mm cortical screws.

The collected data were analyzed using R statistical software 2016 (R Foundation for Statistical Computing, Vienna, Austria). Model selection was applied according to Akaike information criterion.[13]

Statistical data for construct stiffness and the number of cycles to displacement (1-, 2-, 5-, 10-mm) were calculated by applying linear mixed models comprising fixed and random factors. The random effects included in the models were "cat pelvis" (specimens 1-50 from 25 cats) and "side" (left or right). Factors for the fixed effects included the "testing group" (ALPS-5, ALPS-6.5, LCP, DCP, FIXIN) and "parameter" (construct bending stiffness, number of cycles to a specific transducer displacement of 1, 2, 5, or 10 mm, and load to failure). Probability–probability (P–P) and quantile–quantile (Q–Q) plots were used to test the normality of the data distribution. A post-hoc *t*-test was used to calculate *P* levels. The Benjamini and Hochberg false discovery rate procedure was applied to correct for multiple testing.

3 | RESULTS

All other groups showed superior stiffness compared to the ALPS-5 group ($P < .05$) (Table 1, Figure 4). There were no differences in construct stiffness among the other groups. No differences among the groups were noted in cycles or applied load for 1-mm displacement. The ALPS-5 specimens showed no differences in cycles before 1-, 2-, 5- and 10-mm displacement occurred compared with the DCP specimens (Table 1, Figure 5). There were no significant differences in the number of cycles before 1-, 2-, 5-, or 10-mm displacement or in applied load among the ALPS-6.5, LCP, and FIXIN specimens (Table 1). The ALPS-6.5 group withstood more cycles before 2-, 5-, and 10-mm displacement than the ALPS-5 and DCP groups (both $P < .05$; Table 1, Figure 5). The LCP specimens withstood more cycles and greater load than DCP specimens before 5-mm displacement ($P = .01$), and more than the DCP and ALPS-5 groups before 10-mm displacement (both $P < .05$; Table 1, Figure 5). FIXIN constructs withstood more cycles and load than DCP specimens to 2-, 5-, and 10-mm displacement (all $P < .05$), and more than ALPS-5 specimens to 2- and 5-mm displacement (both $P < .05$; Table 1, Figure 5).

The length of screws for screw position 1 was 8 mm. Screws placed within the caudal fragment varied in length (screw positions 4/5 = 12 mm; screw position six = 14 mm). Screws involving the sacral body (positions two/three) varied between 22 and 24 mm in length.

Screw loosening was observed in all 10 specimens of the DCP group. The sacral body was involved by screw position 2 (n = 4/10) and by screw position 3 (n = 6/10). Nine of 10 screws placed within the sacrum remained

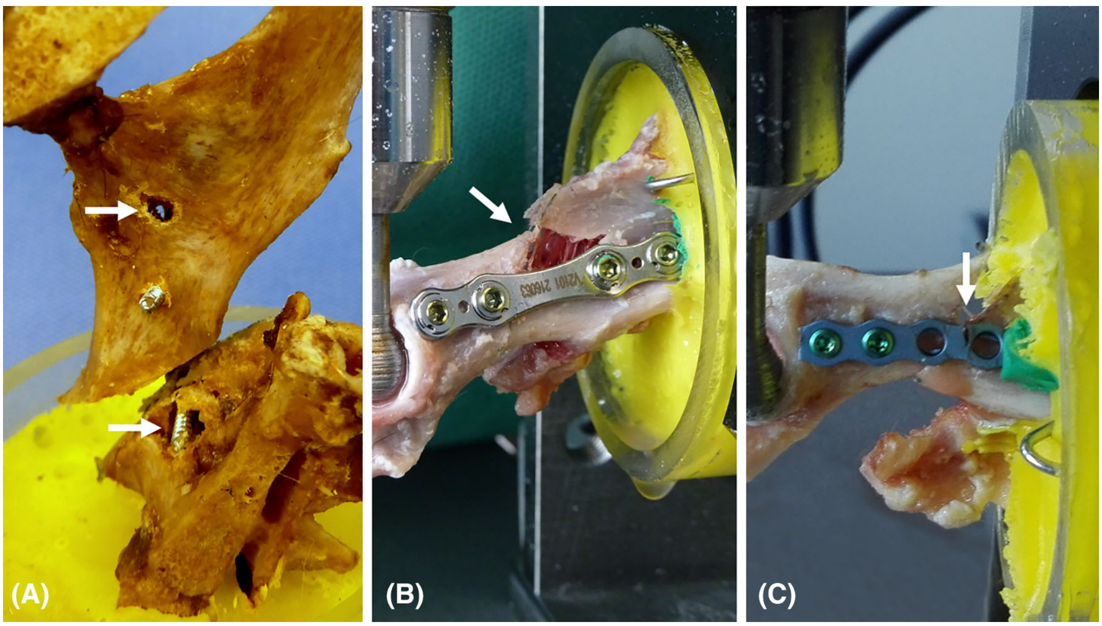

FIGURE 6 Modes of failure. (A) LCP specimen with bone slicing (arrow). (B) FIXIN specimen failed by bone fracture (arrow), which led to 10-mm displacement of the transducer. (C) ALPS-5 specimen failed by implant fracture (arrow). ALPS-5, Advanced Locking Plate System 5; ALPS-6.5, Advanced Locking Plate System 6.5; DCP, Dynamic Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series; LCP, Locking Compression Plate 2.0

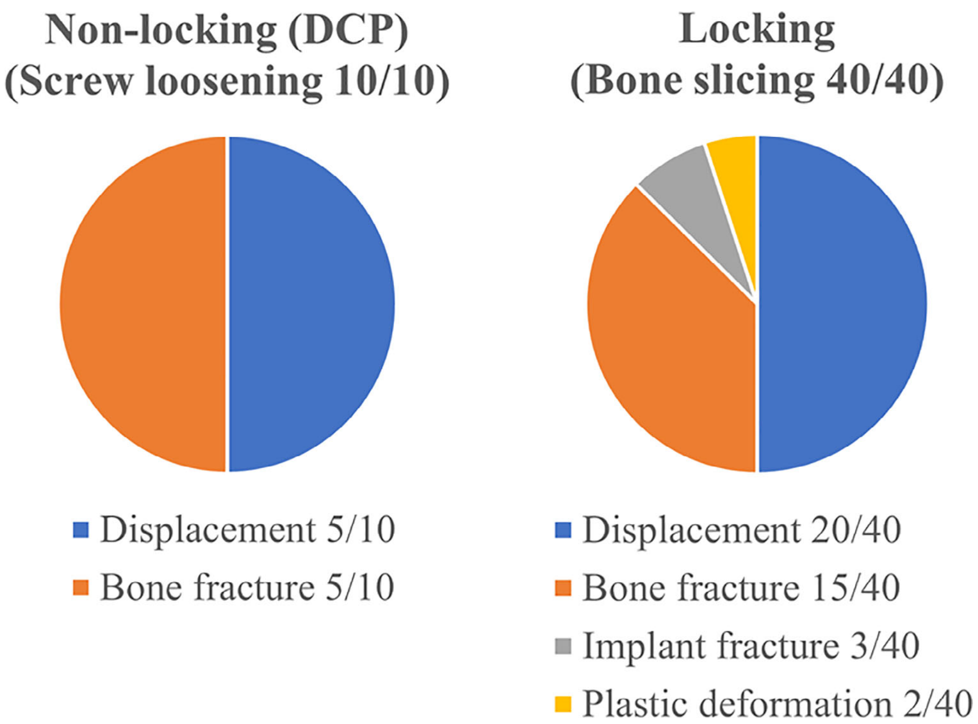

FIGURE 7 Graph showing failure modes between nonlocking (A) and locking (B) constructs. Screw loosening occurred in 100% of DCP constructs. Bone slicing occurred in 100% of locking specimens. Implant fracture (n = 3) and plastic deformation (n = 2) occurred in ALPS-5 specimens. ALPS-5, Advanced Locking Plate System 5; ALPS-6.5, Advanced Locking Plate System 6.5; DCP, Dynamic Compression Plate 2.0; FIXIN, FIXIN 1.9-2.5 Series; LCP, Locking Compression Plate 2.0

tight. Screw loosening in the cranial fragment occurred for screw positions 1 (n = 10/10), 2 (n = 7/10), and 3 (n = 4/10). Screw loosening occurred in some specimens for screw positions 4 (n = 10/10), 5 (n = 6/10), and 6 (n = 3/10).

In contrast, bone slicing (ovoid enlargement of the hole caused by the fixed screws cutting into the bone, Figure 6) occurred in all locking specimens (Figure 7).[13] Catastrophic implant failure occurred in 3 of 10 specimens of the ALPS-5 group between 110 and 130 N. Two ALPS-5 specimens showed plastic deformation, which required the tests to be stopped due to slippage of the transducer from the acetabulum.

4 | DISCUSSION

In our study, all implant group specimens were significantly stiffer than the ALPS-5 specimens, resulting in rejection of our hypothesis that there would be no differences in bending stiffness among systems. For fatigue failure, nonlocking constructs withstood fewer cycles to a predefined displacement than the locking groups, with the exception of ALPS-5, which was not significantly different from the DCP group in terms of displacement. These results partially confirmed our hypothesis that locking plate constructs would withstand more cycles before a given displacement than the standard, nonlocking DCP constructs, as all locking implants, except ALPS-5, withstood more cycles before failure. The worse mechanical performance of ALPS-5 specimens in comparison with the other locking groups may be explained by the small cross-section and area of moment of inertia. The failure mode of the ALPS-5 specimens confirmed that the plate size, rather than the plate–screw interface, played the predominant role in failure. Our results suggest that both the cross-section and the angular stability of the plate are critical for the success of lateral plating of feline ilial fractures.

We found a difference in stiffness between the ALPS-5 specimens and the DCP specimens, but no difference in the number of cycles before failure. When interpreting these results, we should consider that titanium has a lower modulus of elasticity but a higher yield load than stainless-steel implants. The lower modulus of elasticity increases the occurrence of elastic deformation in titanium implants and explains the decreased stiffness of the ALPS-5 constructs in comparison with stainless-steel implants of the same dimensions.[19,20] The fact that the ALPS-6.5 group exhibited greater stiffness than the ALPS-5 can be explained by the bigger cross-sectional area. The ALPS-5 constructs also had two empty screw holes overlying the osteotomy, increasing the implant working length. The decision about the screw placing was made considering the proximity of the screw holes to each other, which did not allow safe screw placement without affecting the osteotomy. Increasing the plate working length has previously been shown to be one of the major criteria in reducing construct stiffness.[21,22]

In this study, DCP specimens were susceptible to repetitive cyclic loading, as characterized by screw loosening and failure of the constructs. Previous clinical and biomechanical investigations of feline ilial plating also identified screw loosening as the mode of failure of nonlocking implants.[9,13,15,16] In our study, there were already differences between locking systems (other than the ALP-5 systems) and the DCP systems in terms of the number of cycles before 2-, 5- and 10 mm displacement. At these cycle numbers, the loads likely exceeded the frictional forces that 2.0-mm DCP plates may achieve with compression onto the underlying ilial bone. The anatomical characteristics of the ilial bone may promote screw loosening because of the short working length of the screw (the screw length engaging the bone stock). The most cranial screw, and screw number 4, were consistently loose in all DCP specimens. Multiple reasons may explain these findings. First, the screw length for screw position 1 was shorter (8 mm) than for screws placed within the caudal fragment (screw position 4/5 = 12 mm; screw position 6 = 14 mm). Screws involving the sacral body (position 2 or 3) varied between 22 and 24 mm and thus their engagement in the bone stock was almost doubled. The screw working length has significant effects on screw pull-out forces; the short cortical screws in our DCP specimens were therefore more susceptible to loosening.[23] Second, cortical thicknesses vary between the ilial wing (relatively thin cortices) and the ilial mid-/caudal body (increased cortical bone), which increases stress to cortical screws in plate positions requiring short screw working lengths (screw positions 1 and 4). Third, the relatively short lever arm transferred from the servohydraulic transducer along the plate applies high pull-out forces on the screw close to the osteotomy (screw position 4).[24,25]

In this ex vivo biomechanical study, bone slicing was consistently seen in all locking specimens at higher loads. Even single ALPS-5 specimens that failed due to plastic implant deformation at minor loads already showed signs of bone slicing. In human literature, screw cutout, which is another term to describe bone slicing, is reported as a complication of locking plates. This complication occurs most commonly in epiphyseal fractures.[26,27] An increased risk for screw cutout was reported for osteoporotic bones because of the reduced bone density, resulting in insufficient screw–bone integrity. The high incidence of bone slicing in our study may depend on the characteristics of the feline ileum, which might behave similarly to osteoporotic bone in humans, because of the thin cortices.

The results of this study showed higher resistance to cyclic loading for laterally applied locking plate systems in the feline ilium, with the exception of the ALPS-5 system. This may be explained by the functional principle of locking plates/screws. Based on the results of the present investigation, locking implants are an effective strategy for preventing screw pull-out and subsequent construct failure. Locking plates/screws act as a single beam construct that transfers bending forces to compressive stress at the screw–bone interface. This construct requires higher forces in order to cause failure, in contrast with nonlocking constructs, where loosening of a single screw can initiate serial screw loosening.

Thus, taken together, these results indicate that the feline ilium is more resistant to compression loads applied to the screw–bone interface in locking plate systems, with the exception of the ALPS-5 system, than to shearing loads associated with nonlocking constructs, which consistently led to screw pullout and construct failure.

Various limitations should be considered when interpreting the results of this study. First, its ex vivo nature does not allow direct translation to clinical cases. Nevertheless, the chosen cantilever bending test setup is the biomechanical test method of choice, simulating in vivo loading of ilial fractures.[11] Previous investigations in a feline ilium gap fracture model used this setup with comparable results.[13] Furthermore, previous clinical studies found similar biomechanical testing results, namely medial displacement of the caudal ilial fragment and screw loosening, which suggests that this ex vivo model is valid.[15,16] The fracture configuration was selected to simulate one of the most common fracture types in cats.[5] This fracture model provides new information, given that a previous study described the biomechanics of plate constructs in an ilial fracture gap model.[13]

In conclusion, the plate cross-section and plate–screw interface are equally important for the success of lateral plating of fractures in the feline ilium. Our results demonstrated that, compared with nonlocking implants, locking plates offer the advantage of decreasing the risk of screw loosening. However, locking plates may still fail, regardless of angular stability, if they are subjected to loads that exceed the plate strength. Locking plates are therefore indicated for feline ilial fractures, to decrease screw pullout, although the plate must be strong enough to withstand the forces occurring at the fracture site.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this report.

AUTHOR CONTRIBUTIONS

Paulick L, med vet: Design of the study, specimen collection and preparation, biomechanical testing, assistance in surgical interventions, involvement in biomechanical tests and data collection for statistical analysis, data analysis and interpretation, drafting of the manuscript, revision of the manuscript, and approval of the final version of the submitted manuscript. Knell SC, Dr med vet, DECVS: Design of the study, interpretation of statistical data, drafting of the manuscript with intellectual contribution, and approval of the submitted version of the manuscript. Smolders LA, Dr med vet, PhD, DECVS: Preparation and analysis of statistical data, involvement in the interpretation of the biomechanical data, drafting, revision of the manuscript, and approval of the submitted version of the manuscript. Pozzi A, Dr med vet, DECVS, DACVS, DACVSMR, ACVS Founding Fellow, Minimally Invasive Surgery and Joint Replacement: Interpretation of the biomechanical data, critical revision of the manuscript, and approval of the final version of the manuscript. Schmierer PA, Dr med vet, DECVS: Design of the study, performance of all surgical interventions, involvement in data acquisition, interpretation of the biomechanical data, drafting and critical revision of the manuscript, and approval of the final version of the submitted manuscript.

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