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Long-term follow up of 44 cats undergoing total hip replacement: Cases from a feline hip registry (2010-2020)

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Abstract

Objective: To report indications, complications, and long-term outcomes following feline total hip replacement (THR) using a client-based clinical metrology questionnaire, the Feline Musculoskeletal Pain Index (FMPI), and owner satisfaction.

Study design: Multi-institutional retrospective cohort study.

Animals: Cats ($n = 44$) that underwent THR ($n = 56$).

Methods: Feline THRs submitted to a registry over a 10-year period were reviewed. The FMPI and owner satisfaction surveys were used to assess outcome.

Results: Forty-four cats met the inclusion criteria. Median age was 2 years (range: 0.9-11), and median bodyweight 5 kg (range: 3.3-7.6). British Shorthair and Domestic Shorthair were the most frequent breeds. Most cats were neutered males (33/44) and slipped capital femoral epiphysis (SCFE) was the most common surgical indication (34/56). All implants were cemented micro

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and nano hip implants. Overall complications (11/56) included 9 major complications. The median duration of follow up was 752 days (range: 102-3089). No association was found between clinical variables and complications. The FMPI score improved from 0.111 (range: 0-1.222) to 2.111 (range: 0.888-3.666) postoperatively ($P < .001$). Owner satisfaction was reported as "very good" in 30/33 cases (90.9%).

Conclusion: A validated client metrology questionnaire showed clinical improvement in cats following THR. The most common indication for THR in cats was SCFE occurring in young male neutered cats. Complication rates were comparable to previous reports.

Clinical significance: Total hip replacement appears to be a successful surgical treatment for feline hip disease with very good owner satisfaction and acceptable complication rates.

1 | INTRODUCTION

The prevalence of radiographic feline hip osteoarthritis (OA) has been reported to be as high as 69%, although the condition remains largely underdiagnosed in the cat population.[1] Feline hip dysplasia as a cause of OA has a reported prevalence in the general cat population between 7-32%, with purebred cats being more commonly affected.[2,3] The Maine Coon is overrepresented, with a reported prevalence of hip dysplasia in 29.4% of cases.[4] Other conditions affecting the hip joint and commonly reported in young castrated male cats are: metaphyseal osteopathy (MO), which has been reported to cause osteolysis of the femoral neck with pathological fractures,[5] and slipped capital femoral epiphysis (SCFE), which has been characterized by capital physeal incongruity or displacement of the femoral epiphysis.[6,7]

The most frequently reported clinical signs of feline OA are lameness, impaired mobility, poor grooming habits, reduced ability to jump, reluctance to squat to defecate, and aggression.[8–10] The diagnosis of feline joint pain in the clinical environment may be challenging and unreliable because the main clinical signs associated with feline OA are behavioral in nature.[11,12] Client-based clinical metrology instruments (CMIs), such as the Feline Musculoskeletal Pain Index (FMPI) have been developed to overcome these limitations.[12,13] These questionnaires were designed to measure the sensory and affective effects of pain based on the client's observation of the animal's behavior in the home environment. They have been used as diagnostic aids in clinical practice and outcome measurements in clinical research.[13–16] The most validated version of the FMPI was used in the current study,[14] and this was converted to the FMPI-short form (FMPI-sf) as currently recommended.[17]

Treatment of hip joint pain has been broadly classified into conservative (nonsurgical/medical) and surgical management. Nonsurgical management of feline osteoarthritis involves a combination of environmental modification, dietary modulation, physical therapy, nutraceuticals, and drug therapy.[8,18] When this management is insufficient to provide adequate pain control, or for treatment of other conditions including fractures (acute/chronic), chronic luxations, MO or SCFE, surgical procedures such as femoral head and neck excision (FHNE) and total hip replacement (THR) are indicated.[8,19]

Femoral head and neck excision is a salvage procedure for the treatment of irreparable damage to the hip joint.[20] There are few peer-reviewed published reports regarding the long-term outcomes of cats with FHNE.[5,6,21–25] Reported outcomes following FHNE in cats are variable with satisfactory to good outcomes reported in some studies[5,6,23,25] and inconsistent to poor outcomes reported in other studies.[24,26,27] Schnabl-Feichter and colleagues[22] reported that ground reaction forces of the FHNE operated limb in 17 cats were lower than in other healthy limbs, although these ground reaction force results were in poor agreement with owner questionnaire scores and visual gait analysis (note that the questionnaire utilized in this study has been only validated for assessing acute postoperative pain in cats).[28]

Total hip replacement is currently considered the gold standard treatment for management of debilitating conditions of the hip joint in dogs, with success rates of approximately 95% and complications reported in 7-22% of cases.[29,30] Feline THR has only been described previously in case reports and small cases series,[24,26,27,31–34] with a total of 25 feline THR procedures reported across studies. Subjectively excellent outcomes have been reported, with major complications requiring surgical revision described in only 3 cats.[27,31,33]

To the authors' knowledge, no study to date has reported a large cohort of cats following THR from multiple centers using a validated client-based CMI and owner satisfaction. The objective of this study was to describe signalment, surgical techniques, implants, complications and owner perceived outcome in a cohort of 44 cats from a multiuser registry.

2 | MATERIALS AND METHODS

2.1 | Case selection

This was a multiuser study that included cats that had a THR from a practice registered with the British Veterinary Orthopedic Association – University of Liverpool (BVOA-UoL) Feline Hip Registry (FHR). Inclusion criteria included a fully completed consent form by the cat's owners and all data variables being submitted by participating surgeons on a secure database (Microsoft SharePoint, Microsoft, Redmond, Washington) website from June 2010-2020. The local university research ethics review committee granted ethical approval for the study (VREC855).

2.2 | Data collected: signalment, indications, surgery, and complications

Recorded information included cat signalment (breed, date of birth, sex, and reproductive status) and bodyweight. Details of the surgical procedure included the date of surgery, indication for THR, if this was the first or second THR, hip joint side operated on, THR method, implant sizes and cementing technique. Another form was submitted by the operating veterinary surgeon to the SharePoint site, which detailed complications (date, type, severity and action taken) and if they occurred at the time of surgery or at a later date. Time frames and classification of complications were documented according to the definitions proposed by Cook et al.[35]

2.3 | Outcome assessment following THR

All owners were sent a customized electronic survey (https://www.liverpool.ac.uk/csd/software-support/survey-software/). This survey included questions about complications and owners' satisfaction ratings and also reproduced the 17-question FMPI.[14] All the recorded information was exported to a data-processing spreadsheet (Microsoft Excel 2016, Microsoft) where the data was analyzed. These data included the cats' signalment, hip joint side operated, complications, number of further surgeries, owner's satisfaction, and perceived preoperative and postoperative FMPI scores. The most validated version of the FMPI was used (version 9),[14] with questions 1-17 based on the advice of 1 co-author, and author of the FMPI (BDXL). Further, based on ongoing work by 1 co-author, the items were then scored from "normal/good function = 0" to "not at all/poor function = 4" depending on the cat's willingness to perform the activity, and 9 questions were used in analysis. These 9 items constitute the FMPI-short form (FMPI-sf)[17] which is a refinement of the FMPI based on studies over the last decade.[13–15,36–39] The FMPI-sf is available at: https://cvm.ncsu.edu/research/labs/clinical-sciences/comparative-pain-research/clinical-metrology-instruments/ and as supplementary material.

2.4 | Data and statistical analysis

Data (age, bodyweight, time between surgeries/complications and FMPI-sf scores) was non-normally distributed, so descriptive statistics including median, range and interquartile range (IQR) were calculated. The preoperative and postoperative FMPI-sf scores per cat were tested for normality using a Shapiro-Wilk test, and a nonparametric test (the Wilcoxon signed-rank test) was used to determine any statistical associations. Preoperative FMPI-sf scores were compared with the postoperative FMPI-sf scores using a Wilcoxon signed-rank test to evaluate any statistical associations. The Shapiro-Wilk and the Wilcoxon signed-rank tests were performed using Prism software (GraphPad Prism 9.0., San Diego, California).

An univariable binary logistic regression with the presence or absence of complication as the outcome was performed to assess for associations of independent variables with complications. Variables assessed included age, weight, sex, indication for THR (fracture, SCFE, hip dysplasia/OA), first or second hip, femoral implant size, femoral head size and acetabular cup size. Each hip was considered an independent unit for the purpose of logistic regression. Significance was set at $P < .05$.

3 | RESULTS

3.1 | Signalment

Forty-four cats met the inclusion criteria having had a THR that was included on the BVOA-UoL FHR between 2010 and 2020. The median age of cats at the time of surgery was 2 years old (range: 0.9-11), with over 60% of cats being less than or equal to 2 years old. Median bodyweight was 5 kg (range: 3.3-7.6). There were 33 neutered males, 11 neutered females, and 1 intact female, with neutered males accounting for 75% of cases. Breed distribution showed the British Shorthair (BSH) (n = 15) to be the most frequently represented breed followed by the Domestic Shorthair (DSH) (n = 13), Maine Coon (n = 9) and Bengal (n = 2). One cat from each of the following were present: Ragamuffin, Ragdoll, Burmese, British Blue, and a Norwegian Forest Cat.

3.2 | Indications, surgical procedure, and implants

Thirty-two cats (32/44) underwent unilateral THR and 12 cats (12/44) staged bilateral THR, accounting for a total of 56 THR procedures. Median time between surgeries for cats undergoing bilateral procedures was 72.5 days (IQR = 50.75-112.25 days). The most common indication for THR was SCFE (n = 34). Other reported indications included fresh and chronic femoral head/neck fractures (11), osteoarthritis/hip dysplasia (8), revision of failed FHNE from previous SCFE (2) and recurrent hip luxation (1).

Cemented hip implants (CFX micro and nano, BioMedtrix, Whippany, New Jersey) were used in all 56 procedures. Modular implants were used in $n = 50$ hips and monoblock implants applied to $n = 6$ of the remaining total hip replacements. Cemented hip implant femoral implant sizes were #1 + 0 mm ($n = 2$), #1 + 2 mm (2), #2 (4), #3 (46), #3 + 0 mm (1) and #3 + 2 mm (1). Modular femoral head sizes ranged from 8 mm + 0 (26), 8 mm +2 (23) and 8 mm +5 (1). The rest of the cases (6) had 6 mm monoblock femoral heads implanted. The acetabular cup sizes used were 10 mm (6), 12 mm (49) and 14 mm (1). Thirteen cases had cement mixed under vacuum; the remaining 43 cases had cement placed following hand mixing techniques.

3.3 | Complications

No intraoperative complications were reported. The overall incidence of postoperative complications was 19.6% (11/56): 9 complications were major (16.1%) and 2 minor (3.57%) (Figure 1). Median time to major complication was 34 days (IQR = 15.5-116). Seven complications occurred in the perioperative period (<3 months), 2 complications occurred in the short-term period (>3-6 months), and 2 in the long-term period (> 12 months).[35]

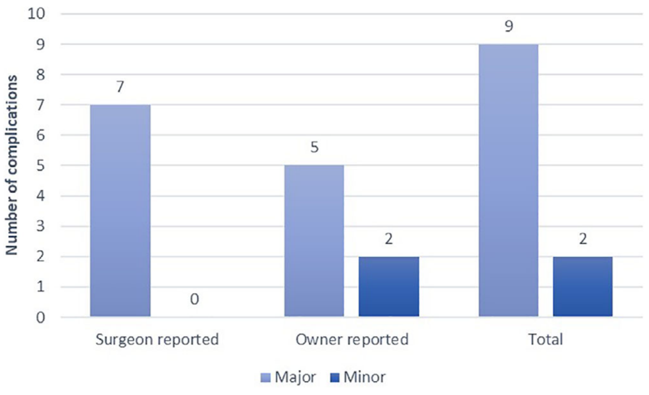

FIGURE 1 Number of postoperative complications reported by the owner ($n = 7$), veterinary surgeon ($n = 7$) and total complications reported ($n = 11$) after 56 feline total hip replacements

3.3.1 | Surgeon reported

All surgeon-reported postoperative complications (7/56) were considered major according to Cook et al.[35] These included luxation (n = 5), femoral fracture (1) and implant failure (1) (Table S1). Only 3 complications were reported by both surgeon and owner, which included implant failure (1) and luxation (2) (Figure 1).

3.3.2 | Owner reported

Previously unreported complications/observations made by the cat owners included 2 major complications, 2 minor complications, and 2 observations. These included luxation (1), medial patella luxation (1) as major complications and minor wound dehiscence (1) and ongoing lameness (1) as minor complications. Twenty-four hours of postoperative lethargy (1) and unwillingness to jump (1) were considered observations, as the former was noticed in a cat with ongoing contralateral hip osteoarthritis (Figure 1).

Five of the hips with reported major complications suffered a second major complication at a mean time of 38.8 days (range = 9-89). A second surgery was successful in 3 of the revised hips (3/5), with the other 2 hips resulting in explantation (2/5). The femoral head of the cat with implant failure had worn through the acetabular cup, with both implants subsequently being explanted. The medial patella luxation was managed surgically and only 1 hip luxation was managed successfully with closed reduction. All luxations occurred in hips where a neck length + 0 mm was used (modular and monoblock implants) (Figure 2). All the hips that suffered a reluxation were previously treated with an open

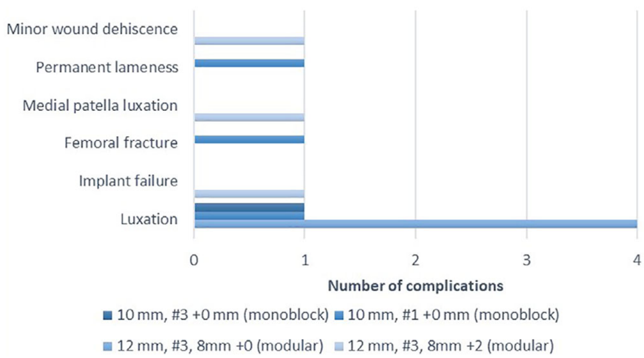

FIGURE 2 Number of postoperative complications with prothesis size combinations used in each case. Implant sizes are shown as acetabular cup followed by femoral stem size for monoblock prosthesis, and added femoral head size for modular prosthesis. One each of minor wound dehiscence, permanent lameness, medial patella luxation, femoral fracture and implant failure, and 5 luxations. THR, total hip replacement

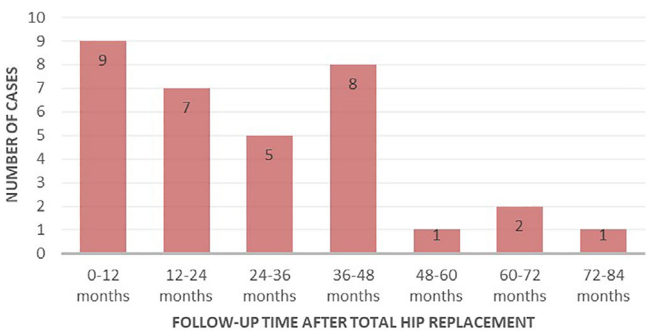

FIGURE 3 Duration of postoperative follow up (months) and number of cases that had a completed online owner questionnaire

reduction with no change of implants. All but 1 of the reluxations that were successfully managed had new larger implants placed (the other hip underwent successful second open reduction with same size implants). No associations with any of the independent variables assessed and reported complications were identified.

3.4 | Outcomes

There was an initial 81% response rate (36/44) to the online survey; however, 3 of these cats were removed from further analysis due to incomplete answers and inability to contact the owners again. The cohort of cats was therefore reduced from 44 to 33 cats at this stage. The median duration of follow up was 752 days (range = 102-3089) (Figure 3).

In 90.9% (30/33) of cases the owner's satisfaction was described as "very good," 1/33 rated their satisfaction as "good" and the remaining 2/33 as "fair." No owners rated

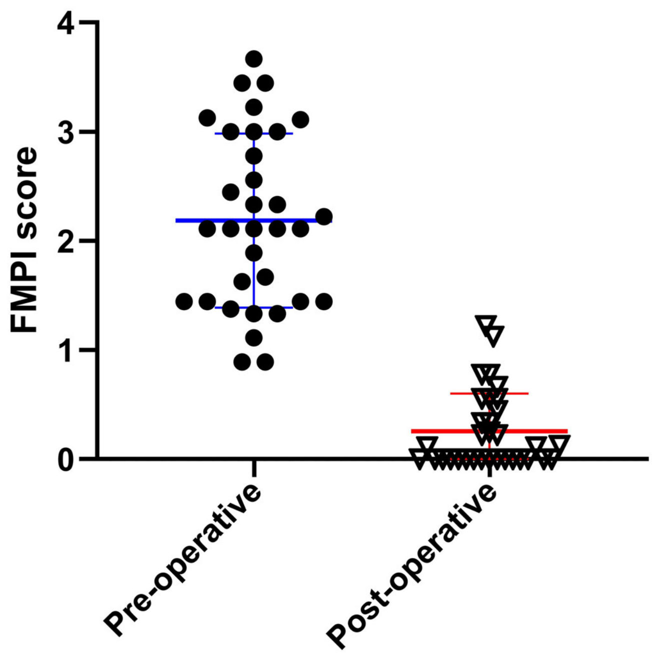

FIGURE 4 Scatter dot plot comparing the preoperative (black circles) and postoperative (inverted triangles) FMPI-short form scores of the 33 cats available for follow up after total hip replacement. The mean (thick lines) and standard deviation (thin lines) are shown for the preoperative (blue) and postoperative (red) scores. Postoperative scores were lower (less musculoskeletal pain) than preoperative scores ($P < .001$). FMPI, feline musculoskeletal pain index

it as "poor" or "very poor." The median postoperative FMPI-sf score was 0.111 (range: 0-1.222), and this was lower than the median preoperative FMPI-sf score, which was 2.111 (range: 0.888-3.666) ($P < .001$) (Figure 4).

4 | DISCUSSION

This is the first study to report indications, surgical procedure, complications, and long-term follow up using a validated client metrology instrument (FMPI-sf) in a large group of cats from a multiuser registry that underwent THR to manage different debilitating conditions of the feline hip joint.

The most represented purebred cats in this study were the BSH and Maine Coon. The median age of the cats was 2 years old, with a median weight of 5 kg and neutered males accounting for approximately 75% of cases. Based on previous literature, this would be expected considering that the most common indication for surgery was SCFE, which is reported in the literature to affect overweight neutered male cats younger than 2 years old.[5–7] A report on femoral neck MO identified the Siamese to be overrepresented for this condition.[5] In the current study, in an attempt to simplify the results, several surgeon-reported indications for surgery such as epiphysiolysis, physeal dysplasia, and capital physeal separation were grouped together into the SCFE category. Some of these cases might have historically been considered cases of femoral neck MO based on presentation and radiographic features.[5] However, this condition in cats has recently been reported to be associated with pyrexia and other clinical signs typically associated with MO in dogs, suggesting that those first reports in the literature might have been classified incorrectly as MO based on their clinical presentation and findings.[40,41] The authors would therefore argue that these 2 disorders (femoral neck MO and SCFE) are different presentations of the same condition based on the shared demographics, presentation, and progression of disease, so the more currently accepted term, SCFE, was used in this report. Our findings are in agreement with previous reports where physeal separation was the most common indication for THR surgery in cats.[24,26,27,31–34]

In this study, 12 cats (27%) underwent bilateral THR, with all cases affected by SCFE. This high percentage of bilateral THR could be explained by the bilateral nature of SCFE and the need to manage these cases with salvage procedures, unlike other hip pathologies that can be managed with open reduction and internal fixation or can be conservatively managed.[8,10,18,42] In the current study, 3 cases underwent THR after a failed fracture repair or open reduction of coxofemoral luxation and 2 cats after unacceptable outcome of FHNE. The new data provided by this study may be useful in advising owners of the potential outcome of THR as a revision strategy after failed management of hip disease with other surgical techniques.

The surgical implants used in the current study were all cemented implants of a single brand (BioMedtrix). All previous case reports have described the use of this same implant type in all feline cases.[24,26,31–34] The most frequently utilized implant sizes were: #3 modular femoral stem, 12 mm acetabular cup and 8 mm +2 femoral head. Interestingly, in the current study all 6 luxations occurred in cases where a + 0 femoral head was implanted. However, 22 other cats had the same implants used with no reported complications. No association was found between using this size of femoral head and the development of luxation. However, low statistical power resulting in a type II error cannot be excluded for this lack of association given the small numbers in each complication group. The 8 mm +0 femoral head implant has been commonly utilized in cases included in other feline THR reports with only 1 luxation reported.[24,26,27,31–34] These findings may suggest that, when planning a feline THR procedure and uncertainty exists, a longer femoral neck (when feasible) should be considered as this might reduce the likelihood of postoperative luxation. A similar finding has been documented in a previous canine THR study where the risk of postoperative ventral luxation was associated with shorter neck extensions;[43] however further research with a larger sample size is necessary in order to make solid recommendations on this subject.

We found an overall complication rate of 11/56 (19.6%), which is similar to previous reports for canine THR (7-22%).[29,30] A marked difference in reported complication rates between surgeons and owners was identified, as previously described by Forster et al.[30] (Figure 1). Postoperative luxation was the most commonly encountered complication, accounting for over half of the reported complications (10.7%, 6/56), occurring at a median time of 26.5 days postoperatively. This is in agreement with the reported incidence of luxation following total hip arthroplasty in dogs (2% to 17%), which has been reported to be highly dependent on surgeon's experience.[44,45] Our study design did not allow for assessment of surgeon's experience; however, THR in cats is a relatively new technique, so it is likely that these surgeries would be within the surgeon's first 50 feline procedures. We also found that a large proportion of THRs that luxated (4/6) suffered a second luxation at a median time of 26.5 days after the first luxation event, which resulted in explantation in 2 hips. The majority of luxations occurred in the short-term postoperative period as previously reported in dogs;[46] however, 2 of the hips in our study luxated in the long-term postoperative period,[35] which may indicate poor healing of the soft tissues or failure to regain muscle mass in the operated limb to support the prosthetic joint after resuming normal activity.[44] Interestingly, all the hips that suffered a reluxation had an open reduction performed with no change of implants, and all but 1 of the hips that did not reluxate had new larger implants (larger acetabular cup and/or longer neck length) placed. Our sample population did not allow for further interpretation of these findings. A larger cohort of cats will be necessary to look at associations between implant revision and rate of reluxation. Complications such as aseptic loosening are usually not noted until several months to years after THR,[47] and it is possible that our study may be underreporting this complication due to the short follow-up period (a minimum of 102 days) in some of the cases included.

The success rate of feline THRs in the current study was confirmed by very good owner satisfaction (∼90%) and improvement of the reported FMPI-sf score before and after THR. This is the first study to use the FMPI to assess outcomes in cats undergoing THR. Previous reports of THR in cats used a combination of follow-up lameness evaluation, orthopedic examination including anatomical measurements and owner interviews several weeks after surgery.[24,26,27,31,33,34] The FMPI has been shown to have an excellent reliability and good repeatability in discriminating between normal cats and cats with OA-related pain,[13] and was further validated in clinical cats affected by OA.[14] The current study used the FMPI-sf, which has been shown recently to have greater responsiveness validity.[17] There is likely to have been some "placebo" effect that influenced the FMPI scores, but the FMPI seems like a logical test to use to assess the outcome of THR in cats as it has been validated as a tool to musculoskeletal pain due to OA. Including a sham surgery group to assess the effects of THR in a blinded, controlled manner would have not been ethical. Ideally, these subjective assessments would have been paired with objective assessments such as accelerometry;[48] however, even objective accelerometry can be subject to placebo by proxy effects.[49]

Another limitation of our study is the possibility of incomplete data submission by the participating surgeons. All surgeons were requested to update their submitted cases with data on any complications that occurred; however, the authors were unable to ensure that all complication data was submitted, which could introduce bias and affect the complication rate. Not all owners of the cats presented in this study replied to the online survey, which introduces further bias and may have resulted in some unreported complications. Increased administrative support for the FHR would allow more frequent dissemination of instructions on how to use the FHR, as well as administration of annual online owners' surveys, which should help to ameliorate this type of limitation in the future. Another limitation of the follow-up assessment is the retrospective use of the FMPI to assess the preoperative and postoperative function of the cats. This test has not been validated for assessing preoperative function when administered post hoc. Kinetic gait analysis using force plates and pressure platforms is the gold standard for assessment of gait abnormalities in dogs and cats,[50,51] however this is not a diagnostic tool that is widely available, and it would not be feasible in this cohort of cats from different institutions across a large geographical area. We failed to identify any associations between variables and specific outcomes in this study, which may be due to the small sample size. This study highlights the importance of contributing cases to projects such as the BVOA-UoL FHR, so that future work can be focused on identifying risk factors for complications and outcome assessment as the number of feline THR procedures increases.

Total hip replacement produced marked clinical improvement in cats suffering from debilitating disorders of the hip joint with a complication rate similar to that previously reported for THR in dogs. The most common indication for THR surgery in cats was SCFE in young male neutered cats. The combination of the validated clinical metrology instrument (FMPI-sf) scores, and reported owner satisfaction were useful in assessing the long-term outcome of cats undergoing THR.

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CONFLICT OF INTEREST

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

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