Surgical reduction and stabilization for repair of femoral capital physeal fractures in cats: 13 cases (1998–2002)

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Objective—To evaluate anatomic reduction and surgical stabilization of femoral capital physeal fractures in cats.

Design—Retrospective study.

Animals—13 cats.

Procedure—Medical records of cats with unilateral or bilateral femoral capital physeal fractures evaluated from 1998 to 2002 were reviewed. Age and weight of cats at the time of surgery; breed; sex; concurrent injuries; severity of lameness before and 1, 2, 4, 6, and 8 weeks after surgery; the amount of fracture reduction achieved and number of Kirschner wires (K-wires) used; degree of degenerative joint disease of the hip joint and lysis of the femoral neck and head observed after surgery; whether K-wires were removed after surgery; and complications after surgery were evaluated.

Results—Thirteen cats with 16 capital physeal fractures were identified. There was significant improvement in the severity of clinical lameness in all cats from weeks 1 through 4 after surgery. There was no correlation between the scores of the individuals who evaluated radiographs for fracture reduction and placement of K-wires.

Conclusions and Clinical Relevance—Results suggested that surgical stabilization and repair of femoral capital physeal fractures facilitate a short recovery period and a good prognosis for return to normal function in cats. (*J Am Vet Med Assoc* 2004;224:1478–1482)

Femoral capital physeal fractures are common injuries in cats. Treatment of these fractures may include rest and medical management, femoral head excision, and surgical reduction and stabilization with multiple pins.[1] Femoral head and neck fractures have been classified as capital, physeal, subcapital, or transcervical.[1] In addition, physeal fractures may be classified according to the Salter-Harris classification.[2] The femoral capital physis is expected to close between 30 and 40 weeks of age in cats.[3] Physeal dysplasia of the capital femoral epiphysis in cats has been described and is reported to be most common in obese, neutered males.[4,5]

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Results of 1 study[6] indicate that cats with femoral capital physeal fractures treated with rest and medical management may develop a malunion or a nonunion causing persistent lameness. Ostectomy of the femoral head and neck is often recommended and is a common procedure that usually leads to a functional result.[7] Results of previous reports,[1,8] although limited, support internal fixation for treatment of femoral capital physeal fractures. Reconstruction of the fracture site is optimal for maintenance of the hip joint and a return to normal anatomic configuration, which is believed to result in the fastest recovery and best function postoperatively.[8-10] To the author's knowledge, the incidence of vascular necrosis of the femoral head and neck has not been documented in cats.

The purpose of the study reported here was to evaluate anatomic reduction and surgical stabilization of femoral capital physeal fractures in cats. Factors that may affect outcome, including nonunion, migration of **Kirschner wires (K-wires)**, persistent lameness, avascular necrosis of the femoral head and neck, and infection of the surgery site, were also evaluated.

Criteria for Selection of Cases

Medical records and radiographs of all cats with unilateral or bilateral femoral capital physeal fractures evaluated at the All-Care Animal Referral Center from 1998 to 2002 were included in the study.

Procedures

Data obtained from medical records included age, sex, breed, and weight. Concurrent injuries; the number, size, and placement of K-wires used during surgery; and whether the K-wires were removed subsequent to fracture healing were also recorded.

The severity of clinical lameness was graded according to a system that was developed and used for each cat during examinations performed before and at 1, 2, 4, 6, and 8 weeks after surgery. Severity of lameness was graded as no lameness observed (grade 1), mild lameness observed at a walk (grade 2), moderate lameness observed at a walk (grade 3), toe-touching lameness (grade 4), or non–weight-bearing lameness (grade 5). Examination included evaluation of the surgery site for infection, whether signs of pain were elicited during examination of range of motion of the hip joint, severity of lameness, and radiographic evaluation.

Butorphanol[a] (0.2 mg/kg [0.09 mg/lb], IV) and glycopyrrolate[b] (0.01 mg/kg [0.045 mg/lb], IV) were administered to cats before surgery. Anesthesia was induced with a mixture of ketamine[c] (5 mg/kg [2.3 mg/lb]) and diazepam[d] (0.25 mg/kg [0.114 mg/lb])

administered IV and maintained with isoflurane. Cephazolin sodium[e] (22 mg/kg [10 mg/lb], IV) was administered before surgery. Hair on the affected limb was clipped from the dorsal midline to the tarsal joint, and the clipped area was aseptically prepared for surgery by use of alternating chlorhexidine and generic isopropyl alcohol scrubs. Cats were positioned in lateral recumbency with the affected limb suspended by use of a porous tape sling. Sterile bandage material was used to cover the limb from the tarsal joint to the digits. The surgery site was draped with multiple layers of sterile drapes.

A slight variation of the standard craniolateral approach was used to gain access to the affected hip joint. The skin incision was made in a cranioproximal to caudodistal direction to facilitate placement of the K-wires. After identification of the fracture, an appropriate number of 0.035-inch K-wires were placed normograde, starting from distal to the greater trochanter and exiting through the neck of the femur. The site where the K-wires exited the bone was identified before the fracture was reduced. After the fracture was reduced, the K-wires were advanced into the proximal femoral epiphysis. The articular surface of the femur was inspected after placement of K-wires to ensure that no K-wires were placed within the joint. Closure of the joint capsule (when possible), muscles, and subcutaneous tissues was performed by use of 2-0 polydioxanone in a simple interrupted pattern. Closure of the skin was performed by use of skin staples or 3-0 nylon[f] in a simple interrupted pattern.

The need for analgesic drug administration was determined on the basis of serial assessments of physiologic parameters (including changes in heart rate, peripheral circulation, blood pressure, and respiratory rate and pattern) and behavioral characteristics (including vocalization; changes in posture; guarding or protecting the limb; restlessness or reluctance to move; cessation of grooming; and changes in sleeping, eating, or elimination habits). Butorphanol[g] (injectable mixed with syrup[h] at 0.33 mg/mL) was administered at a dosage of 1 mg, PO, every 8 to 12 hours after surgery, as determined by results of the serial assessments previously described. Butorphanol was not administered to all cats in the study, and no other analgesics were administered. Bilateral fractures did not occur simultaneously in 2 of the 3 cats, and in the remaining cat, the surgical repair of each fracture was performed on separate dates.

Lateral and ventrodorsal radiographic views were obtained before and immediately after surgery during general anesthesia. Fractures were classified according to a previously described technique[1] and by the Salter-Harris classification.[2] Radiographs were evaluated by 3 surgeons (2 surgery residents and a diplomate of the American College of Veterinary Surgeons) and a diplomate of the American College of Veterinary Radiology, retrospectively, for placement of the K-wires, fracture reduction, degenerative joint disease, and lysis of the femoral head and neck. The capital physis was monitored radiographically for complications after surgery and healing. A grading system for the quality of fracture reduction that was achieved during surgery was developed. Reduction of the fracture was graded as anatomic reduction (grade 1), good reduction and functional outcome likely (grade 2), malaligned and possibly requires revision (grade 3), or unable to achieve adequate reduction (grade 4). A separate grading system was recorded for placement of K-wires. Placement of K-wires was graded as adequate depth into the proximal femoral epiphysis and divergent K-wires with good spacing (grade 1); adequate depth, slightly divergent K-wires, and adequate spacing (grade 2); adequate depth, parallel to convergent K-wires, and decreased spacing (grade 3); inadequate depth, convergent K-wires, and K-wires not adequately spaced (grade 4); or K-wires possibly in the joint or unsatisfactory placement of K-wires (grade 5).

The femoral neck and head regions were monitored for the development of the classic apple-core lesion also referred to as avascular necrosis. The degree of degenerative joint disease of the hip joint was monitored in each cat during subsequent radiographic evaluations. Lysis of the femoral head and neck and degenerative joint disease were graded as none (grade 1) to severe (grade 5).

Statistical analyses—All data reduction and analyses were accomplished by use of a computer program.[i] The association between fracture reduction, K-wire placement, lysis (weeks 1, 2, and 4), and degenerative joint disease (weeks 1, 2, and 4) scores for each of the 4 individuals that evaluated the radiographs was assessed by use of the Spearman ranked correlation. The agreement between scores generated by each of the 4 individuals for K-wire placement, fracture reduction, lysis, and degenerative joint disease was determined by use of the Kendall W coefficient of concordance, which varies between 0 (no agreement) and 1 (perfect agreement). Fracture reduction, lysis, and degenerative joint disease scores were evaluated by use of the sign test (a nonparametric procedure). For each of these variables, scores obtained before surgery were compared with scores obtained 1, 2, and 4 weeks after surgery. A value of $P < 0.05$ was considered significant.

Results

Thirteen cats with 16 fractures were included in the study. Ages of cats ranged from 3 to 40 months (mean, 19.2 months; median, 18 months). Only 2 cats were < 12 months of age (3 and 6 months). The remaining 11 cats were ≥ 12 months old. Ten cats were male (2 were sexually intact), and 3 were spayed females. Weight of cats ranged from 1.8 to 6.6 kg (4.0 to 14.5 lb; mean, 4.8 kg [10.56 lb]; median, 5.0 kg [11.0 lb]). Breeds represented were predominately domestic short-, medium-, and longhair cats (n = 11); Siamese (1); and Abyssinian (1). All 16 fractures were classified as femoral capital physeal fractures **(Fig 1)**. Thirteen of the fractures were classified as Salter-Harris type I, and 3 fractures were classified as Salter-Harris type II. Three cats had bilateral femoral capital physeal fractures. Two of those cats sustained the second fracture through a separate injury 6 weeks and 3 months after surgical repair of the initial capital physeal fracture. The third cat had bilateral capital physeal frac-

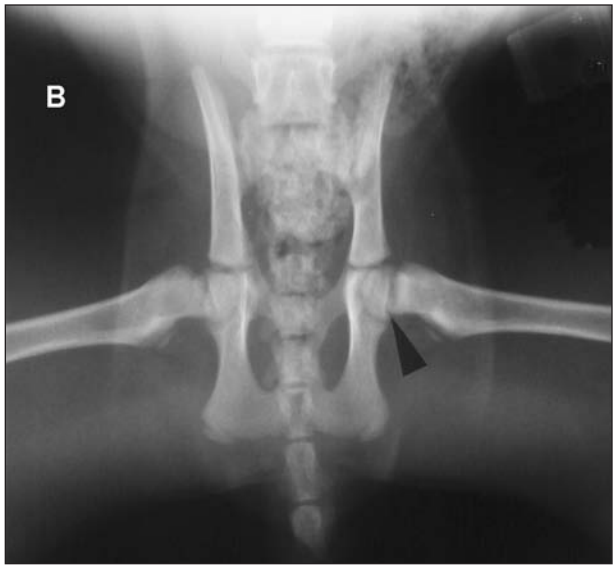

Figure 1—Ventrodorsal (A) and frogleg (B) radiographic views of the pelvis of a cat. Notice the left capital physeal fracture (arrowhead).

tures at the initial evaluation. Five cats were housed indoors, and all 3 cats with bilateral fractures were housed indoors. Of the 10 cats with unilateral fractures, 6 had additional injuries, including fractures of the caudal vertebrae (n = 1), ischium (2), pubis (1), and contralateral acetabulum (1). Treatment of the additional fractures included conservative treatment, amputation of the tail, and internal fixation.

Twelve of 16 fractures were repaired with three 0.035-inch K-wires (**Fig 2**). Of the remaining 4 fractures, 3 were repaired with 2 K-wires and 1 was

Figure 2—Same ventrodorsal radiographic view of the cat in Figure 1A. Notice the capital physeal fracture has been repaired with three 0.035-inch Kirschner wires (K-wires).

repaired with 4 K-wires. Kirschner wires were removed in 9 of 16 fractures and in only 1 cat because of inadequate placement. One cat with bilateral fractures had K-wires in both limbs removed simultaneously 1.5 years after surgery because of unilateral lameness, which resolved after the K-wires were removed. Kirschner wires were removed in another cat that was < 5 months old to prevent premature growth plate closure. In 5 cats, the K-wires were removed because of standard operating procedure. In all cats in which the K-wires were left in place, lameness attributable to the implant was not observed.

Before surgery, the severity of clinical lameness ranged from grade 3 to 5 (mean, 4.1; median, 4). Continuous improvement in the severity of clinical lameness as determined by results of clinical evaluation, including passive range of motion and signs of pain, was observed in all cats during the first 4 weeks after surgery. All cats were evaluated 1 and 2 weeks after surgery, and 10 of 14 were evaluated 4 weeks after surgery. The severity of clinical lameness ranged from grade 1 to 4 (mean, 2.6; median, 2) in week 1, from grade 1 to 3 (mean, 2; median, 2) in week 2, and from grade 1 to 2 (mean, 1.2; median, 1) in week 4. Lameness was not observed in 10 of 14 cats (14 fractures) evaluated > 4 weeks after surgery. There was significant ($P < 0.05$) improvement in the severity of lameness at 1, 2, and 4 weeks after surgery, compared with that before surgery. Also, there was significant improvement in the severity of lameness between weeks 1 and 2 ($P < 0.05$) and between weeks 2 and 4 ($P < 0.05$). Eight of 13 cats were not examined 6

and 8 weeks after surgery, making further statistical analyses not possible. Lameness was not observed (grade 1) in cats that were evaluated 8 weeks after surgery.

In 12 of 16 fractures, placement of K-wires was determined to be unsuitable for stability (grade > 2; **Fig 3**), although in 15 of 16 fractures, reduction of the fracture was graded as 1 or 2. In 1 cat, placement of K-wires and anatomic reduction had improved 1 week after surgery when a second surgery was performed because of migration of the K-wires. This cat continued to be evaluated as previously described after this second procedure. Mild to moderate periosteal bone formation was observed on the medial aspect of the neck of the femur between the lesser trochanter and femoral head in all fractures that were evaluated (n = 8/16) 8 weeks after surgery. There was no significant correlation between the scores of the 4 individuals that evaluated the radiographs for K-wire placement and fracture reduction. The coefficients of concordance for K-wire placement, fracture reduction, and lysis were 0.613, 0.628, and 0.406, respectively. There was no substantial lysis (grade > 3) of the femoral neck and head or degenerative joint disease of the hip joint observed during the healing process. There were no signs of infection observed at the surgical site or involving the K-wires in any of the 13 cats in the study.

Figure 3—Ventrodorsal radiographic view of the pelvis of a cat. Notice the capital physeal fracture of the left femur has been surgically repaired with two 0.035-inch K-wires with less-than-ideal placement due to convergence of the K-wires.

Discussion

Femoral capital physeal fractures are common in cats and must be considered when evaluating cats with acute hind limb lameness, even when the cause of trauma is unknown or considered to be minor. Results of another study[11] indicated that the ventrodorsal frogleg radiographic view is required because of possible tightening of the joint capsule and resultant reduction of the fracture with hip extension that may occur during positioning of the cat for the ventrodorsal view.

Obese neutered male cats may be predisposed to femoral capital physeal fractures because of physeal dysplasia similar to that in overweight, adolescent male children.[5] Multiple risk factors for spontaneous femoral capital physeal fractures in cats > 1 year of age include sex, reproductive status, delayed physeal closure, and abnormally high body weight.[4] Delayed closure of multiple growth plates, including the capital physeal, distal femoral, proximal tibial, distal radial, and proximal radial growth plates, has been detected in cats that had prepuberal gonadectomy.[4,12]

Two of the 13 cats included in the study presented here were sexually intact males. Coincidentally, these were the 2 cats that were < 12 months of age (3 and 6 months). The remaining 9 cats, 6 male and 3 female, were ≥ 12 months old and neutered. Age of cats at gonadectomy was unknown because this procedure was performed by the referring veterinarian; therefore, the association between age at gonadectomy and delayed physeal closure in cats in our study was unknown.

Correlation of the grading systems for fracture reduction and placement of K-wires used in this study was not as high as expected and is a limitation of grading systems and the study. Providing the evaluators with a detailed guideline of the criteria for fracture reduction and placement of K-wires and increasing the number of evaluators may have improved the correlation of the grading systems. Analysis of the data indicated that the most experienced surgeon assigned the highest scores, indicating that this surgeon was more critical of fracture reduction and K-wire placement than the 2 other surgeons or the board-certified radiologist. The scores of the other 2 surgeons were similar, whereas the board-certified radiologist assigned the lowest scores and was less critical of fracture reduction and K-wire placement. This is likely a result of the surgeon's preference for anatomic reduction and correct placement of K-wires in the internal fixation of fractures.

Results of the study reported here indicated that lameness in this group of cats consistently and significantly improved during the 4 weeks after surgery. Analysis revealed that less-than-adequate fracture reduction and placement of K-wires did not affect the outcome. This suggests that ideal surgical technique and placement of K-wires are not necessary for effec-

tive healing of femoral capital physeal fractures in cats. Except for instances in which the K-wire enters the hip joint and must be backed out and removed from the joint, placement of 2 to 4 K-wires that result in reasonable anatomic reduction is likely to result in healing and have a good prognosis. Although the surgeon should always strive for optimal internal fixation, results of this study indicated that rigorous adherence to internal fixation principles and strict anatomic reduction may not be necessary for a satisfactory clinical outcome. The authors have observed that new bone formation tends to develop on the medial aspect of the neck of the femur. This observation is believed to be in agreement with Wolff's law because the bone is being laid down in areas of increased stress.[13]

Results of this study suggest that internal fixation of femoral capital physeal fractures with K-wire placement is the treatment of choice in cats because the recovery period after surgery was short, there was a good prognosis for return to function, and the surgical procedure did not require optimal fixation of the fracture.

[a]Butorphanol, Fort Dodge Laboratories, Fort Dodge, Iowa.
[b]Glycopyrrolate, American Regent Laboratories Inc, Shirley, NY.
[c]Ketamine, Fort Dodge Laboratories, Fort Dodge, Iowa.
[d]Diazepam, Abbott Laboratories, North Chicago, Ill.
[e]Cephazolin sodium, Bristol-Myers Squibb Co, Princeton, NJ.
[f]Ethilon, Johnson & Johnson Co, Somerville, NJ.
[g]Torbugesic, Fort Dodge Animal Health, Fort Dodge, Iowa.
[h]Val Syrup, Fort Dodge Animal Health, Fort Dodge, Iowa.
[i]SPSS, version 10.0, SPSS Inc, Chicago, Ill.

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