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# Comparison of usefulness of different diagnostic procedures in slipped capital femoral epiphysis in cats

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Summary

**The aim of the study was to compare the usefulness of different diagnostic procedures – radiology, computed tomography and histopathology – in slipped femoral epiphysis in cats (SCFE). Case histories of 7 cats and radiographic, computed tomography and histopathological findings for these animals were reviewed and compared with previously published cases of slipped capital femoral epiphysis. Three cats underwent computed tomography examination. Contrary to the literature data, the British Shorthair breed was overrepresented in the examined group (57.1%). In five cats, slipped capital femoral epiphysis developed unilaterally, but in one of these cats SCFE had also been diagnosed in the contralateral hip joint 6 months after initial treatment. Patients with SCFE were surgically treated by femoral head and neck amputation. The study suggests that the results of X-ray and computed tomography examinations are comparable. An early diagnosis, with very subtle changes of SCFE detected successfully by computed tomography, could lead to conservative or early surgical treatment. Histopathological findings are helpful in SCFE and confirm the correct diagnosis. Furthermore, the results do not support the theory that slipped capital femoral epiphysis develops mainly in overweight and neutered cats.**

**Keywords: hip joint, slipped capital femoral epiphysis, physeal dysplasia, cat, computed tomography**

Slipped capital femoral epiphysis (SCFE) has been described in human medicine as a condition of predominantly teenage males, with obesity being a contributing factor (11, 22). The disease develops mainly bilaterally and is of an atraumatic origin (14). Slipped capital femoral epiphysis has also been described in mainly young (4.5-24 months), neutered male cats (16, 18, 21). Some studies have shown that SCFE occurs predominantly in Siamese cats, but until now a breed predisposition has not been confirmed (18). Untreated, SCFE leads to hypertrophic pseudoarthrosis or degenerative joint disease in humans (1, 13, 18, 22). Clinical signs are non-specific. The main symptom is lameness, which can develop acutely or be of chronic duration, without a history of previous trauma. Muscle atrophy, crepitation and painful reaction to palpation with a limited range of hip joint motion can be detected. SCFE develops mostly bilaterally, but it may have different severity and affect one or both sides independently (2, 6, 9, 18, 27). Patients do not show any other abnormalities in addition to those mentioned above (11, 13, 18). Predisposing factors for SCFE are sex, obesity, castration, and delayed physeal closure as a secondary effect of gonadectomy (13, 25).

The aim of the study was to compare the usefulness of different diagnostic procedures – radiology, computed tomography, and histopathology – in slipped capital femoral epiphysis in cats.

## Material and methods

Seven cats with signs of hind limb lameness of different severity were referred to and diagnosed in the Clinic for Small Animal Diseases of the Faculty of Veterinary Medicine, Warsaw University of Life Sciences SGGW. Their lameness was unrelated to trauma, and clinical signs developed gradually. All cats were of different ages, between 7 and 25 months, male, neutered except one. Four of them

**Tab. 1. Breed, sex, age, age at neutering, body weight, and bilaterality of seven cats with slipped capital femoral epiphysis (SCFE)**

| Cat number | Breed | Sex | Age (months) | Age at neutering (months) | Body weight (kg) | Bilateral |
|---|---|---|---|---|---|---|
| 1 | British Shorthair | MN | 20 | 12 | 6.4 | Yes |
| 2 | British Shorthair | MN | 25 | 9 | 6.0 | Yes |
| 3 | Maine Coon | MN | 21 | 11 | 6.5 | No |
| 4 | Maine Coon | M | 7 | – | 5.0 | No* |
| 5 | British Shorthair | MN | 19 | 8 | 6.2 | No |
| 6 | Domestic Shorthair | MN | 16 | 7 | 5.9 | No |
| 7 | British Shorthair | MN | 14 | 10 | 5.2 | No |

Explanations: the cat marked with the asterisk developed SCFE in the contralateral hip joint after the first surgery. MN – male neutered; M – intact male; No* – six months after the first surgery, the second joint was affected

were British Shorthairs, two were Maine Coons, and one was a Domestic Shorthair (Tab. 1). The cats were well kept. A complete history was collected, and orthopedic examination was performed. Clinical examination suggested that the cats suffered from slipped capital femoral epiphysis. Before each planned diagnostic imaging procedure and surgical treatment of SCFE, a complete blood count and serum biochemical analysis were performed, and the cats were tested for FeLV and FIV. Radiologic examinations of sedated cats were performed with an X-ray GE Prestige II, 56 kV, 12 mA. All hip joints were evaluated in a classical ventrodorsal pelvic view. Hips joints of 3 deeply sedated cats were also evaluated by computed tomography (CT). The study was performed with a computer tomograph HiSpeed CT/e Plus (GE) with settings of 120 kV, 350 mA, 1 s tube rotation, a pitch of 1.2, and 5 mm slice collimation. The patients were positioned in sternal recumbency, and multiple binders were used to obtain a perpendicular position of the pelvis relative to the X-ray beam of the gantry.

All cats underwent surgical treatment involving the excision of the femoral head and neck from a typical craniodorsal approach. The patients were anaesthetized with volatile isoflurane anesthetics according to a standard protocol. Samples of tissues obtained after surgical excision of the femoral head and neck were examined histopathologically.

## Results and discussion

The main clinical sign was lameness, which developed acutely or was of chronic duration, without a history of previous trauma. Clinical signs of lameness in each animal developed gradually. Muscle atrophy, crepitation, and painful reaction to palpation with a limited range of hip joint motion were detected. The duration of the clinical signs differed for different animals.

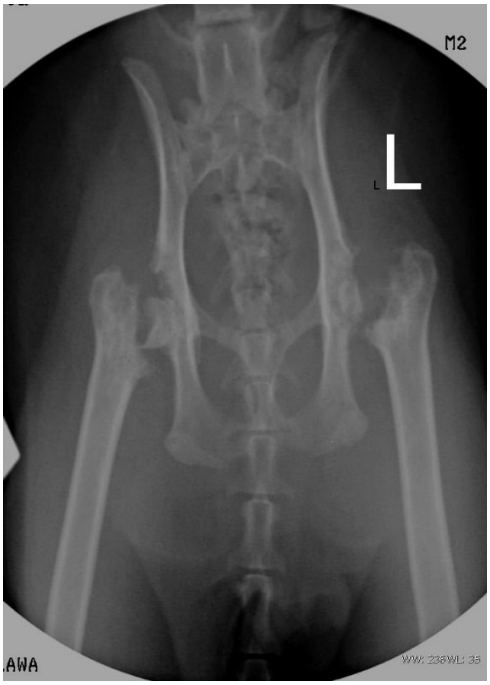


**Fig. 1. A ventrodorsal radiograph of the pelvis of a twenty-month-old male neutered British Shorthair with bilateral lesions. There are areas of radiolucency within the proximal femoral metaphyses, consistent with bone necrosis and bone loss. There is sclerosis of the left femoral head. The changes are very advanced on both sides**


**Fig. 2. A seven-month-old male Maine Coon. A ventrodorsal radiograph of the pelvis with a slight abduction of the pelvic limbs. The left femoral neck is rounded and radiolucent. A fracture is present through the left proximal femoral physis, and there is cranial displacement. The left distal femoral and proximal tibial physes remain open**

Two British Shorthair cats had a bilateral problem, and in one Maine Coon the problem had been diagnosed also in the contralateral hip joint 6 months after initial treatment. The mean age at the time of surgery was 17.8 months (7-25 months), the mean age at neutering was 8.1 months (7-12 months, n = 6, one cat was intact), the mean body weight was 5.8 kg (5-6.5 kg). The differences between the cats' body weights were not significant. The British Shorthair breed was overrepresented in the group (57.1%). In five cats (71.4%), slipped capital femoral epiphysis developed unilaterally, but in one cat SCFE had been diagnosed also in the contralateral hip joint 6 months after initial treatment (Tab. 1).

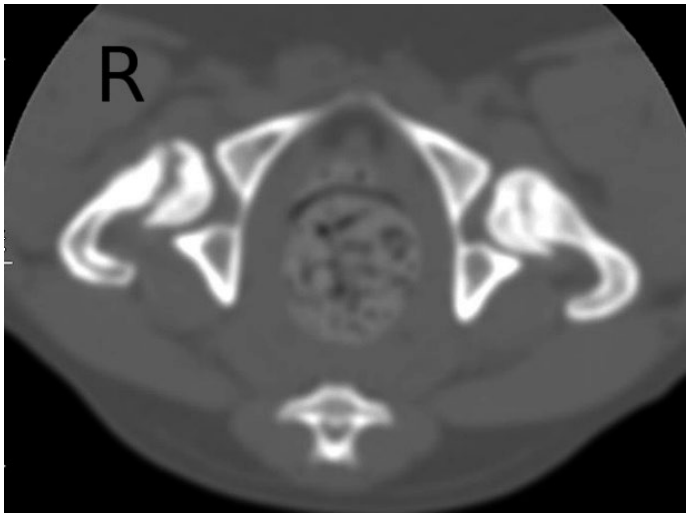


**Fig. 3. A computed tomographic transverse image of the hip joint reveals an area of the right aspect of the femoral neck lysis**

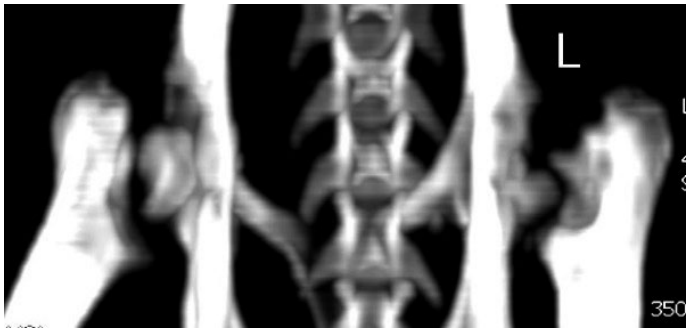


**Fig. 5. A three-dimensional CT reconstruction of the pelvis shows the bone with lytic lesions**

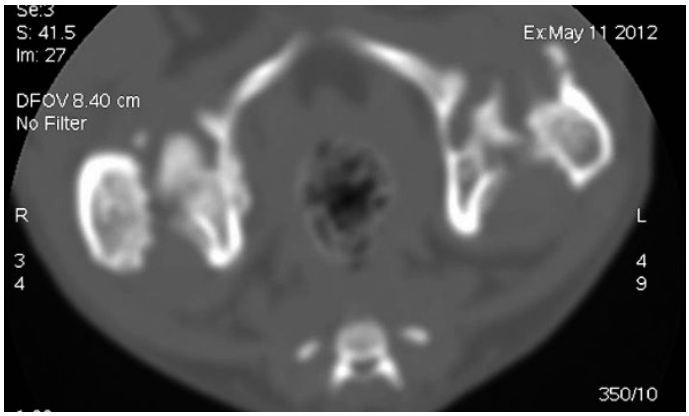


**Fig. 4. A transverse CT image shows complete remodeling and bony fusion of the right and left joints**

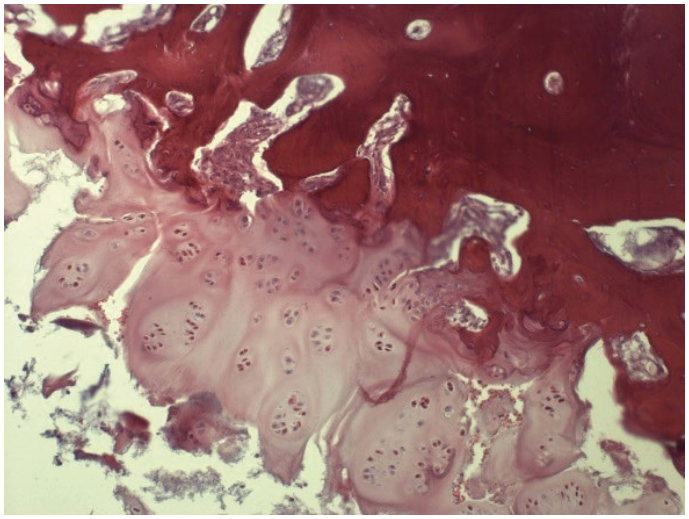

**Fig. 6. Distal margin of a femoral capital epiphysis. Proliferating chondrocytes form small nodules surrounded by extracellular matrix between the subchondral bone of the epiphysis and the cleavage site. H&E, magnification 100 ×**

The pedigree charts of four British Shorthair cats (number 1, 2, 5, 7) (Tab. 1) were analyzed to rule out any genetic relationship. The charts showed no relation of the affected British Shorthair cats to each other. The results of preoperative CBC and serum biochemical analyses for all cats were within normal limits, and tests for FeLV and FIV were negative.

X-ray examination showed a loss of definition and areas of radiolucency within the femoral neck of the affected limb. Decreased bone density in the metaphysis and incongruence in the hip joint with a decreased bone density of the femoral neck were seen in all cases. On the basis of radiographic imagines, visible changes were diagnosed as slipped capital femoral epiphysis, as well as a sclerosis and fracture of the femoral head. Some differences were visible between radiographs, but these were not significant and they were related only to the degree of displacement of the epiphysis relative to the femoral neck (Fig. 1 and 2).

CT examination revealed broadened physes on the affected side with a slight displacement of the femoral head. Remodeling of the femoral neck could be seen in more advanced cases. Areas with decreased bone density and bone loss were also noticeable (Fig. 3-5).

Histopathologic findings were similar in all cases, with differences only in lesion intensity. Microscopic abnormalities were present at the distal margin of the separated capital epiphysis (cleavage site). Findings consisted of clusters of chondrocytes forming small nodules; cells were embedded in an abundant extracellular matrix. The number of cells in clusters was from five to more than 20, and the chondrocytes were polygonal or round and had scant cytoplasms. Areas of chondrocyte proliferation were intermixed with necrotic cartilage, especially at the cleavage site. The articular cartilage and subchondral bone of the capital epiphysis were normal in all cases. Chondrocytes were visible within the border between the femoral head proliferation of fibrocartilaginous tissue with multifocal nodular proliferations. Between the bone trabeculae and fibrocartilaginous tissue, bone necrosis occurred with focal osteoclastic bone resorption. Histopathological findings were typical of SCFE in cats (Fig. 6) (1, 3, 9, 11, 13, 16, 21).

The pathogenesis of SCFE in cats is not well understood, and there are several unclear and not fully known mechanisms of this disease. Only a few studies on SCFE in cats are available in the literature. Patients do

not show any other abnormalities in addition to lameness (11, 13, 16, 18). All authors report no history of trauma in diagnosed cats, and therefore SCFE is also known as atraumatic fracture of the capital femoral epiphysis (11). Fractures visible in SCFE are classified as type I by the Salter-Harris classification scheme (9, 11). SCFE develops mostly bilaterally in neutered obese cats, but may have different severity and affect one or both sides independently (6, 13, 16, 21, 25, 27). According to different publications, the condition is most often found in European Shorthair, Maine Coon or Siam cats (3, 16, 21).

In previous publications on feline SCFE, obese, neutered males were overrepresented, but the disease affected both intact males and females (2, 18).

One possible cause of SCFE is gonadectomy of young cats, which delays physeal closure and therefore may contribute to the slippage of the capital femoral epiphysis when the animals gain weight (2, 10, 15, 18, 24-26, 28, 29). However, this theory does not explain why SCFE also affects intact males, in which the physeal closure is normal (3, 6, 27). In intact male cats the growth plates of the proximal femur close between the seventh and ninth month of life (1, 19, 21, 23, 26).

Feline physeal dysplasia is a syndrome characterized by capital femoral physis abnormalities that result in a separation of the femoral head from the femoral neck. The condition develops secondarily to pathological changes in articular cartilage in overweight or obese cats that have been neutered at a young age.

Another important factor in the pathogenesis of SCFE are insulin misbalances. Insulin plays an important role in regulating glucose metabolism in chondrocytes, and its higher concentration may promote chondrocyte differentiation (7, 11, 12). Abnormal insulin metabolism alters chondrocyte differentiation. Insulinlike growth factor-1 (IGF-1) may influence the pathogenesis of SCFE. Many other factors that determinate chondrocyte differentiation, such as ion or peptide hormones, may lead to the development of SCFE (11). Histopathological findings indicate physeal dysplasia that results in an open and disorganized growth plate. This change in the growth plate alone is not enough to act on the hip joint. It is unclear whether obesity contributes to the slippage by the increased trauma of additional weight or whether it is another manifestation of an underlying metabolic disorder that results in both physeal dysplasia and obesity (3, 13).

Unlike in cats, SCFE in dogs is usually a result of a severe trauma, typically a road traffic injury. Due to the traumatic origin, it is not possible to point out the predilection for SCFE in these animals, although some studies have shown more frequent occurrence of SCFE in large dog breeds. Histopathological findings revealed fracture lines through regularly oriented chondrocytes (3). The latest study on SCFE in dogs reports an atraumatic development of the condition. Moores describes typical changes, which were found in three young dogs between six and fourteen months of age (17). One of the dogs was overweight. The author classified the condition as SCFE on the basis of the chronicity of the disease and the lack of history of trauma. The pathogenesis of SCFE is not known, but osteochondrosis may be a cause, since the widening of the articular cartilage in large, growing dogs can predispose to slippage due to forces acting on the joint. It is possible that SCFE in dogs is not of a traumatic origin and that trauma only leads to acute symptoms of previous subtle lameness overlooked by the owners. Therefore, it is possible that SCFE occurs more frequently than previously thought and that a slipped epiphysis in the coxofemoral joint without a history of trauma should not be classified as a true SCFE.

The occurrence of SCFE in sibling cats from the same litter may support a genetic etiology of this condition (3). SCFE may develop not only in the hip joint, but in other joints as well (18, 29). Newton found changes typical of SCFE at necropsy in the coxofemoral joints (18), proximal humeral epiphysis, and proximal and distal femoral epiphysis of two adult neutered European Shorthair cats. Histopathological findings showed typical changes seen in SCFE, and these changes were not the result of the slippage but had developed earlier. SCFE is therefore a process secondary to physeal dysplasia.

Diagnosis of SCFE is typically based on clinical and radiographic examinations. Special attention should be given to the proximal femoral physis in VD view. Physes may become widened at an early stage of SCFE. The metaphyseal blanch sign, described as a heterogeneous area of increased density in the proximal metaphysis, can appear as one of the first healing signs. A lateral view shows a displacement of the femoral head the soonest. X-rays are the easiest to obtain, and they provide an excellent basis for screening examinations in the case of hip pain and lameness in every patient. In general, the rate of correct radiological diagnosis of SCFE in high.

Computed tomography (CT) can provide additional data for evaluating the extent and severity of the disease. CT is a sensitive method for early detection of the disease. In advanced condition it can evaluate the degree of displacement of the capital femoral epiphysis as well as changes inside the slipped head. Multiplanar reconstruction (MPR) and 3D volume rendering (VR) are useful in evaluating the relation between the femoral head and metaphysis from different views. Although an advanced stage of the disease is easy to identify, subtle changes at an early stage are harder to detect. Only a small widening of the physis may be visible by the time the femoral epiphysis becomes displaced. The metaphyseal blanch sign can also be recognized. The spatial resolution of a CT scan is lower than for radiographs, but the contrast resolution is higher.

The main difference between these two imaging techniques is that CT reconstructions can be viewed

in three planes. CT makes it possible to evaluate tissue slices. Comparing the two methods, radiographs in VD projection seem to be adequate for the evaluation of SCFE chronicity due to the physeal dysplasia of the femoral head. CT is more accurate, but the results of one study suggest concordance between the two methods (8). Nevertheless, subtle changes early in the course of SCFE may be easier to detect with CT, when conservative treatment is still possible (8). Early surgery may also produce good results (4, 5, 13, 20). It is questionable whether CT is indicated in cats with advanced SCFE, since radiographs are often sufficient to make a diagnosis, and the only suitable treatment option is femoral head and neck ostectomy. Histopathological examination, regardless of the severity of the changes is helpful in SCFE diagnosis.

Additionally, the theory that SCFE develops in neutered and overweight cats could not be definitively confirmed. The mean age at the time of surgery was 17.8 months (7-25 months), the mean age at neutering was 8.1 months (7-12 months, n = 6, one cat was intact), and the mean body weight was 5.8 kg (5-6.5 kg). The differences between the cats' body weights were not significant.

Only 2 out of 7 patients had been neutered before physeal closure, and only one patient could be considered slightly overweight (European Shorthair with body weight of 5.9 kg), although many ESH cats weighing between 4 and 5 kg are described as having normal body weight. It is therefore possible that neither neutering nor excess weight, but other factors led to the development of SCFE.

Although CT scan is more accurate and enables 3D reconstruction, X-ray examination is sufficient to diagnose SCFE. Early, subtle changes that are not visible on X-ray, but could be detected in a CT scan, would require screening studies in the population of young cats and breeds prone to the disease, which is practically infeasible. Histopathological changes are typical of SCFE and confirm the diagnosis.

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