Patterns of Pain in Adolescents with Slipped Capital Femoral Epiphysis

Mason Uvodich, BS, Richard Schwend, MD, Ognjen Stevanovic, MD, PharmD, Will Wurster, MD, Julia Leamon, MSN, RN, and Alec Hermanson, MD

Objective To prospectively characterize pain locations in slipped capital femoral epiphysis (SCFE) and evaluate pain locations as predictors of a delay in diagnosis.

Study design This was an institutional review board approved prospective study of 110 children who underwent surgery for SCFE at a tertiary children's hospital between 2009 and 2015. Standardized pain diagrams were completed by 107 children. Pain zones were designated via a composite diagram. Hips without hip pain were categorized as atypical; hips with hip pain were typical.

Results In total, 122 hips were eligible for pain zone analysis. Seventy hips (57.4%) had hip pain. Atypical pain was present in 52 hips (42.6%), which included groin pain in 17 hips (13.9%), thigh/leg pain in 43 (35.2%), knee pain in 32 (26.2%), and posterolateral pain of the hip and leg in 13 (10.7%). A combination of pain zones was present in 48 hips (39.3%). Forty-nine percent of patients had more than 1 visit until diagnosis. The three most common pain locations for typical hips were hip, hip/thigh, and hip/knee pain (77.2% of typical hips). The 3 most common pain locations for atypical hips were isolated thigh, knee, and groin (65.4% of atypical hips). The least common pain presentations had a longer duration of symptoms ($P = .04$) and more healthcare visits before diagnosis ($P = .04$).

Conclusions A combination of pain locations is common in SCFE. Less frequent pain presentations may delay diagnosis. Delays in diagnosis continue despite education efforts. *(J Pediatr 2019;206:184-9).*

Slipped capital femoral epiphysis (SCFE) is seen during the adolescent years, with increased risk in the overweight and obese.[1] There is insufficient awareness of the condition by families and healthcare workers because of its infrequency in the general population, resulting in a delay in diagnosis and treatment.[2] Treatment delays can lead to complications such as worsening deformity, physeal instability, avascular necrosis, impingement, and osteoarthritis.[3-5] Increased duration of symptoms before diagnosis is associated with greater slip angles.[2,6] Slip angle may be associated with an impaired Harris hip score and higher radiographic grades of osteoarthritis later in life.[3] However, there is debate whether slip severity, stability, or acuity contribute to reconstructive procedures later in life.[7,8] Importantly, avascular necrosis is a common indication for hip arthroplasty in those with a history of SCFE.[9] Avascular necrosis is more common in unstable and severe slips and by extension those with a delay in diagnosis. Prompt diagnosis is an important measure to prevent these sequelae.

Pain is the most common symptom of SCFE and is variable. Pain is generally present in the groin, hip, thigh, or knee.[2,10] With progression of the deformity, characterized by anterolateral and superior displacement of the metaphysis relative to the epiphysis, external rotation of hip and an out-toeing gait become apparent.[11] Limited internal rotation with the hip flexed to 90 degrees is characteristic at this stage of deformity. Unless lower extremity pain in an adolescent is considered as a sign of potential SCFE, clinical examination and confirmatory anterior/posterior pelvic and lateral radiographs may not be promptly performed.

Descriptions of pain related to intra-articular hip pathology are described for adult osteoarthritis and other conditions.[12-15] Although several studies have described the pain of SCFE, these are in less detail than for adult osteoarthritis. Pain related to SCFE may be typical, which we define as located over the anterior aspect of the hip joint, or atypical, defined as locations beyond the front of the hip. Atypical pain may confuse the clinical picture, suggesting other conditions that lead to a delay in diagnosis.[16] The purpose of our study was to prospectively identify patterns of pain in adolescents with SCFE. Secondly, we aimed to evaluate pain location as a predictor of a delay in the diagnosis of SCFE. We hypothesized that atypical pain patterns would be associated with a delay in the diagnosis of SCFE. By characterizing the pain of SCFE, we aim to provide a detailed description for the primary care and orthopaedic physician.

Methods

We prospectively identified 110 adolescents between the ages of 8 and 16 years diagnosed with SCFE and admitted for surgical care at a large tertiary children's

SCFE Slipped capital femoral epiphysis

From the Department of Orthopaedic Surgery, Children's Mercy Hospital, Kansas City, MO

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Table I. Characteristics of patients with slipped capital femoral epiphysis*

Number of patients	108
Sex	
Male	66 patients
Female	42 patients
Average age at diagnosis of SCFE, y	
Overall (range, SD)	12.2 y (9-16, 1.7)
Male	12.8
Female	11.1
Weight percentile for age	
Male patients	88th
Female patients	91st
Weight greater than 95th percentile (% of population)	73 (67.5%)
Weight less than 95th percentile (% of population)	35 (32.5%)
Average age for weight greater than 95th percentile	11.7 y
Average age for weight less than 95th percentile	13.0 y
Race (% of population)	
Caucasian	76 (70.4%)
African American	18 (16.7%)
Hispanic	7 (6.5%)
Asian	0 (0%)
Other	7 (6.5%)
Height	
Male	152.0 cm
Female	160.9 cm

*Includes 1 patient that did not complete the pain diagram.

hospital. Inclusion criteria were any child age 8-16 years diagnosed with stable or unstable SCFE, who received hip surgery, with patient and parent/guardian willing to participate, and the ability to read and write English. Between the years 2009 and 2015, 252 patients were diagnosed with SCFE, with 110 nonconsecutively enrolled in the study. A single research nurse coordinator collected clinical data and pain diagrams and reviewed surgical logs for eligibility. After informed consent was obtained, demographic, social, and health characteristics were obtained (**Table I**). Radiographic data included measurement of slip angle performed by an attending orthopaedic surgeon. The child completed a standard pain diagram **Figure 1** (available at www.jpeds.com). One patient did not complete the pain diagram, and 2 patients were missing diagrams, so a total of 107 pain diagrams were available for analysis.

A composite pain diagram with the 107 patients who participated in pain diagram collection is shown in **Figure 2** (available at www.jpeds.com). Identification of pain locations used in analysis occurred post hoc and 5 possible locations were identified (**Figure 3**). Thirty-eight pain diagrams were collected prior to surgery with the remainder being collected after. Combination pain was defined as more than 1 pain location. During analysis, we designated rare presentations as the least frequent pain presentation types up to 15 cases. Typical pain was defined as presence of anterior hip pain; atypical pain was pain that did not include the anterior hip.

Stable SCFE was defined as being able to ambulate with or without crutches, and unstable SCFE was defined as the inability to bear weight at all.[17] Slip angle severity was measured on the frog lateral radiograph, as the angle between the axis of the femoral shaft and the central axis of the femoral capital epiphysis. An inciting incident was defined as a child or parent recognizing a moment when pain was elicited and whether it was during sport, a fall, or other activity. The number of health practitioner visits before a diagnosis was noted. Subjective delay in diagnosis was defined by the family's opinion on whether there was a delay in diagnosis or not.

Weight percentiles were determined through use of the Weight for Age 2013-2014 Center for Disease Control National Health and Nutrition Survey.[18,19] Despite the prospective study design some data was not obtained and was, therefore, excluded from the analysis. We were unable to obtain height measurements for 12 patients. Seven of the 15 patients with bilateral SCFE had pain in only 1 hip. The 7 hips without pain were classified as atypical.

Statistical Analyses

Data analysis was performed utilizing the IBM SPSS Statistics for Windows v 23.0 (IBM SPSS, Armonk, New Jersey) for

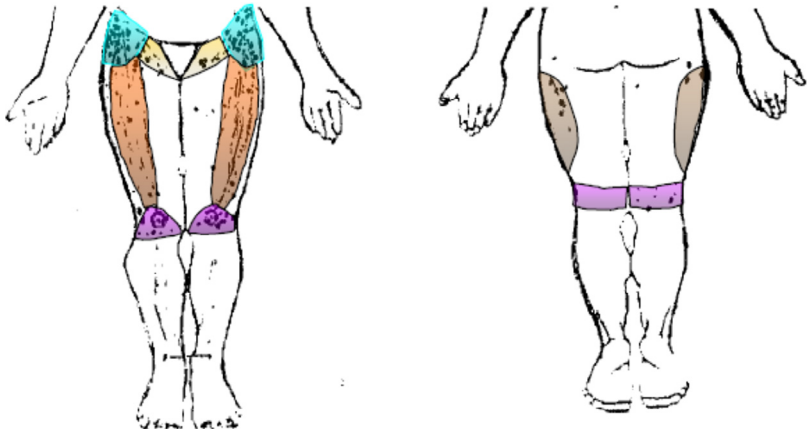

Figure 3. Pain zone designations; hip (*blue*), groin (*yellow*), thigh/leg (*orange*), knee (*purple*), and posterolateral (*gray*) hip. The zones were designated by estimating the apparent boundaries formed from the composite pain diagram. Zones of separate legs were made to be symmetrical when possible.

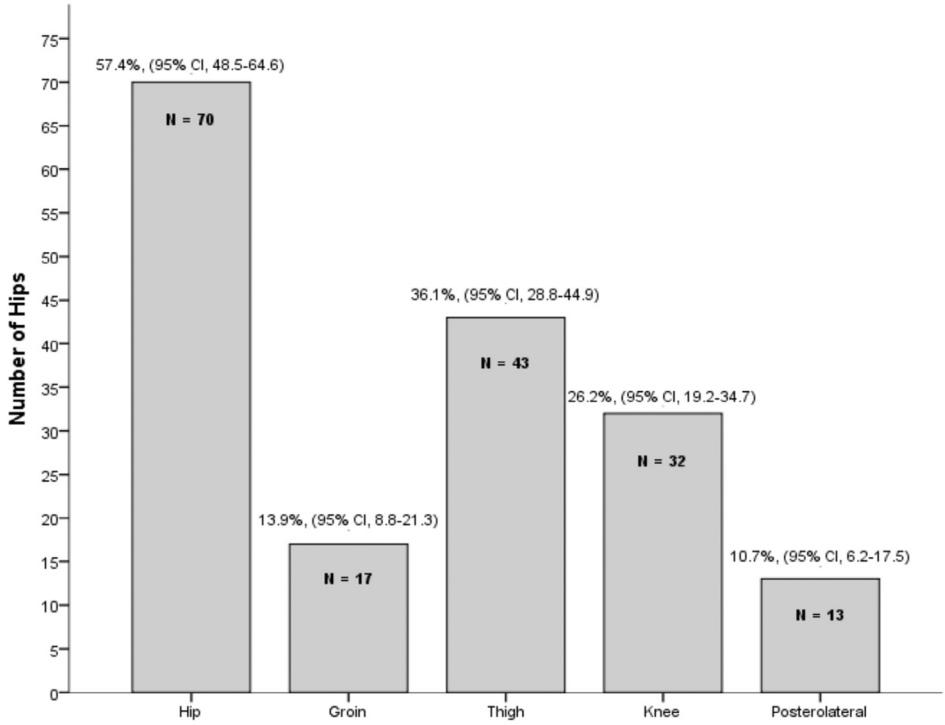

Figure 4. Pain zone frequency for 107 patients (122 hips). N = number of times a pain zone was designated as present in a patient with SCFE. Percent of total hips with respect to the designated pain zone is provided above each bar with their respective CIs.

all data analysis; 95% CIs were obtained for all continuous data and proportions. Frequency and descriptive statistics were obtained for all variables. Patients with bilateral SCFE had their pain zones added if the affected limbs had discrepant pain from one another for determining delays. This resulted in 1 patient changing from hip/thigh to hip/thigh/knee, all other hips were unaffected. For determining differences in the median between non-normally distributed continuous data and 2 groups with certain types of pain, we used Mann-Whitney U tests. Kruskal-Wallis tests were run for ≥3 groups. Spearman rho and Pearson correlations were used for non-normally distributed and normally distributed data, respectively. We used an alpha value of .05. *P* values below .05 were considered statistically significant.

Results

The mean age of our population was 12.2 years, 61% were male, and the mean weight percentile for age was 89.3. A demographic summary and SCFE related data is seen in **Table I**.

Pain diagram data was obtained for 107 patients (122 hips) (**Figure 4**). Sixty-seven patients had 1 pain zone designated, most commonly the hip, thigh, and knee. Combination pain was present in 48 of the 122 hips (39.3%, 95% CI 31.1%-48.2%). There were 14 combinations, 9 had hip pain.

The most frequent type of combination pain was pain in the hip and thigh (n = 10); 36 of the 46 hips with combination pain had pain present in the hip. The 2 most common non-hip combinations were groin/thigh (n = 4) and thigh/knee (n = 3). There were 2 patients with pain located below the knees, 1 with pain in the shin, and 1 with pain in the ankles; these areas were excluded from combination analysis. **Figure 5** illustrates some of the most common pain patterns.

Table II (available at www.jpeds.com) provides details regarding the characteristics of the slipped epiphyses studied. Seven patients with bilateral SCFE had pain only unilaterally. Five of 7 patients with absent pain in 1 hip with bilateral SCFE had pain present only in the hip with the greater slip angle. There was an inciting incident in 81 patients (75%). Pain severity was not related to pain location or slip stability.

Delays in diagnosis were separated based on subjective delay, duration of symptoms (in weeks), days from initial visit until surgery, and number of visits until a diagnosis was made. Fifty-five patients (50.9%) reported a subjective delay in diagnosis. The median duration of symptoms was 4 weeks (IQR 3-18). Duration of pain symptoms greater than 4 weeks was considered a delay in diagnosis for analysis. The median time from initial visit to surgery was 5 days (IQR 1-28.5). 49% of SCFE patients were undiagnosed following their first visit, 22% remained following their second visit, and 99% of patients were diagnosed by the sixth visit. Thirty-one of the patients presented to pediatrics (28.7%), 17 presented to orthopaedic surgery (15.7%), 34 presented to emergency department (31.5%), 1 presented to sports medicine (.9%), 7 presented to

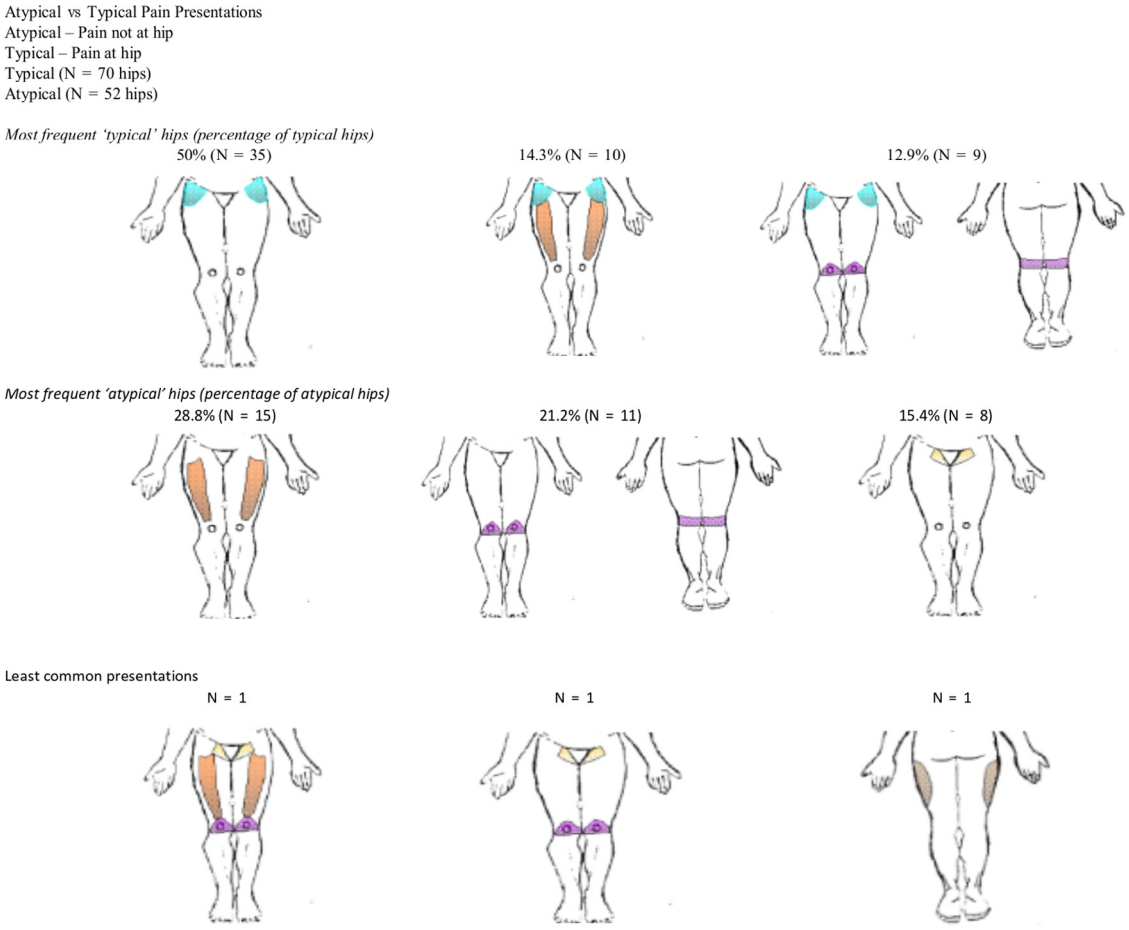

Figure 5. These images are divided into atypical and typical pain patterns. N = number of patients with the indicated combination. The most common pain pattern was solitary hip pain (n = 35), followed by hip and thigh pain combined (n = 10) and hip and knee pain (n = 9). The most common atypical pain was pain in the thigh alone (n = 15), followed by isolated knee (n = 11), and then isolated groin pain (n = 8). The least common atypical pain presentations were groin and knee (n = 1), groin thigh and knee (n = 1), and posterolateral pain in isolation (n = 1).

a chiropractor (6.5%), and 18 to their primary care provider (16.7%). There were no objective differences in delay identified between providers.

Pain and Related Associations

Hips with knee pain had a greater mean slip angle than those without (mean difference of 11 degrees (95% CI 3.2-18.8; $P = .018$). Those with combination pain had greater mean slip angles than those with an isolated pain location (mean difference of 10 degrees (95% CI 2.5-16.5; $P = .003$, respectively).

Patients with knee pain were more likely to have a subjective delay in diagnosis ($P = .019$). The presence of combination pain was not associated with a delay.

Hip pain was negatively correlated with groin pain (r = -.275 $P = .002$). Groin pain occurred more in the absence of hip pain than in the presence ($P = .003$). Rare pain presentations had a greater median duration of symptoms (13.5 weeks, IQR 20, range 3-96, $P = .039$) and visits until diagnosis (2 visits, IQR 1, range 1-10, $P = .036$). Rare pain patterns are seen in **Table III** (available at www.jpeds.com). Atypical and typical pain had no significant differences in measures of delay.

An inciting incident was more associated with an unstable SCFE than not ($P = .002$). Those with an unstable slip were more likely to have hip pain than not compared with those with stable ($P = .046$). Also, those with an unstable slip were more likely to have knee pain than those with a stable ($P = .033$). Pain in the groin, leg/thigh, and posterolateral hip was not different between the 2 types of slips.

Discussion

Pain diagram collection was successful in identifying areas where SCFE pain localized. As expected, hip pain was the most common location among affected hips. Groin pain was relatively uncommon and was frequently accompanied by pain location other than the hip. Hip and groin pain as delineated in the diagrams may be difficult to differentiate clinically and may represent a single "zone" with respect to SCFE pain.

Posterolateral thigh pain was almost always seen (7 of 8 times) with hip pain. Patients with knee and combination pain had greater slip angles. This may suggest that the larger slips cause greater irritation of nearby nerves, resulting in more locations of pain and more distal pain.

Our data indicate knee pain was not a significant predictor of a delay in diagnosis. However, knee pain has been a predictor of delay in diagnosis by various other studies.[2,4,6] We found that the least common 15 presentations were associated with more visits until diagnosis and a longer duration of symptoms. The rare pain patients had a higher frequency of pain in areas other than the hip, though these were frequently in combination with hip pain, which may confuse the clinical picture.

Superimposition of our pain diagrams to form 1 composite diagram produced identifiable patterns (**Figure 2** and **Figure 3**). The hip and groin were affected followed by the anterior surface of the thigh down to the knee where pain occurred lateral, medial, and infrapatellar. These sites of pain are described in previous literature.[2,20] In our study, medial thigh pain was rare and was present in only 1 patient. Pain lower than the knee was uncommon.

Our patients were similar demographically to those seen in the literature.[1,21] The average weight percentile for male patients was the 88th and for female patients was the 91st. Manoff et al previously described this association. Schur et al found no change in the average time from symptom onset to diagnosis of SCFE in 2-year intervals from 2003 to 2013. Our average duration of symptoms was 15.1 weeks, similar to their average.[22] Although the symptoms of SCFE are well known, delays in diagnosis are still too common.

Studies have noted areas of pain to be in the hip, groin, thigh/leg, and knee in SCFE patients.[2,6,10,11,17,21] Studies investigating other types of intraarticular hip pathology note a higher prevalence of groin pain than seen in SCFE.[12,14,15] This suggests that SCFE may be a unique disorder in contrast to other intra-articular pathology. Delays in diagnosis as defined by a greater duration of symptoms were found in those with knee or distal thigh pain,[6,16] although we did not find this.

Combination pain is not well described in the literature. Distal thigh/knee pain was used in some studies,[6] and others noted 3 patients with mild distal thigh and knee pain in association with hip discomfort of 106 patients.[2] Combination pain may be an overlooked aspect of pain associated with SCFE. Our findings suggest a large role of combination pain in the typical SCFE patient and that rare combinations may predispose to delays in diagnosis.

Careful characterization of the pain in patients with SCFE enabled a pattern of pain to emerge, that can involve the entire lower extremity. When hip and groin pain are considered separate, the percentage of hips with pain outside the hip approaches 50%. Primary care providers and other healthcare practitioners should consider the diagnosis of SCFE in the adolescent with hip pain but should be suspicious of SCFE with any pain as illustrated in **Figure 5**.

A thorough history, physical examination, and proper radiographs along with radiographic interpretation complement the pain patterns provided in this study. Aspects of the history which can suggest SCFE include an inciting event, recent growth spurt, pain with exercise or stairs, or a predisposing medical history such as obesity or other endocrine disease.[23,24] The physical examination of patients with SCFE should assess range of motion. Patients with SCFE have reduced hip abduction, flexion, and internal rotation. There is often obligate external rotation with hip flexion. Pain may also be elicited with resisted straight leg raise. Patients often demonstrate a limp and an external foot progression angle.[23,25]

Radiographic interpretation is essential to the diagnosis of SCFE. Early radiographic findings include blurring and widening of the physis. There are several signs that can assist with the interpretation of radiographs. Klein's line is a line parallel to the superior edge of the femoral metaphysis, which intersects with a portion of the epiphysis in a normal hip but may not in SCFE. The metaphyseal blanch sign is an increased density of the proximal metaphysis near the epiphysis because of overlapping of bone.[23] Lastly, a recent small study suggests a new S-sign that looks for a discontinuity in a curvilinear line between the inferior metaphysis and the epiphysis of the femur.[26] This study demonstrated a sensitivity and specificity of 96.5% and 85.0%, respectively when the S-sign and Klein's line were used together.

There was no power analysis performed in advance of the study because we did not have pilot data of pain distribution or delay cutoffs. There was selection bias toward consenting more patients with unstable SCFE, probably because of a longer duration of hospital stay and resulting availability. Forty of the 252 total eligible patients during this period had unstable slips (15.9%), and 34 of the 108 (31.5%) of the patients used in analysis had unstable slips ($P = .0016$). This may have altered the frequency of each pain type compared with the general population of patients with SCFE. Subgroup analysis of different pain locations may be limited due to the small numbers in each group. Although this study was prospective, enrollment was non-consecutive. Some of the patients had missing data. Recall bias may be present in patients who completed pain diagrams after surgery and is a significant limitation to the study. Multiple post hoc analyses likely increased the risk of a type I error. Groin and hip pain may be seen as typical pain associated with intra-articular hip pathology. Therefore, analyzing these pain zones as 2 separate pain zones may have yielded meaningfully different statistical findings as compared with if they were analyzed as one zone. The physical examination is a critical piece in the evaluation of suspected SCFE. Our study lacks data on physical examination findings. Endocrine disease is a known risk factor for SCFE. We did not exclude nor collect data regarding comorbid endocrine disease or past radiation exposure in our study. We did not collect copies of radiographs from outside of our hospital nor the timing or interpretation of these. As a tertiary referral center, our patient population may significantly differ from those encountered in a primary care setting. Our catchment area consists of an urban population with frequent rural referrals. These patients are predominantly English speaking. Thirty-eight percent of our patients had Medicaid for insurance, and 7.5%

were uninsured. This may have altered time to diagnosis data via problems with access to healthcare.

An aspect of SCFE delay that was problematic to us was identifying a binary time point where a delay had occurred. Perhaps the most intuitive measure of a delay in diagnosis is whether SCFE is diagnosed on the first symptomatic visit or not. We found that 49% of initial visits did not get the correct diagnosis made. Consequently, prospective studies on points in time at which complication rates increase with SCFE may be beneficial in defining a delay. The optimal timing of surgery for unstable SCFE is generally agreed upon to be within 24 hours of presentation.[27,28] However, data on optimal time to surgery in stable SCFE is sparse. Two studies evaluating current management of SCFE show that elective or somewhat delayed fixation is common practice.[29,30] Further analysis may be warranted in looking at pain patterns presented here and measures of a delay. Clinical algorithms may aid in the diagnosis of SCFE and should be the subject of further research. Delays in diagnosis of SCFE can be the result of misdiagnosis but may also develop over a subclinical timeframe. To counteract this, in our opinion, primary care providers should advocate for and raise public awareness of common signs and symptoms of SCFE, with a focus on those at risk. ■

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Reprint requests: Mason Uvodich, BS, Department of Orthopaedic Surgery, Children's Mercy Hospital, 2401 Gillham Rd, Kansas City, MO 64155. E-mail: muvodich2@kumc.edu

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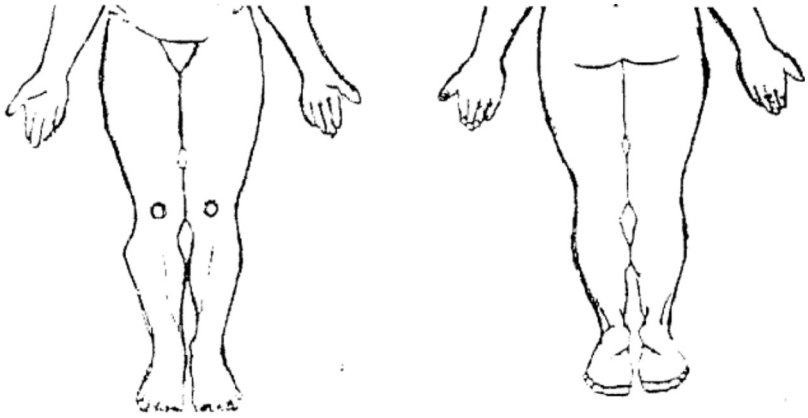

Figure 1. Standard pain diagram. This pain diagram was used for data collection. Pain at a specific location was marked with a dot, whereas shooting or diffuse pain was drawn with a line wherever the patient indicated. Pain severity (*scale not shown*) was assessed on a scale of 0-10 with 10 being the worst pain.

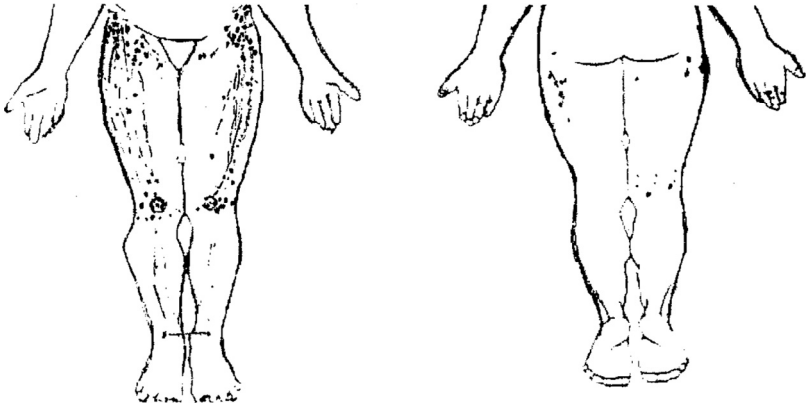

Figure 2. Composite pain diagram. Manual superimposition of individual pain diagram markings onto a single composite diagram was performed for 107 pain diagrams. Dots indicate pain at a specific location, and dashed lines indicate diffuse or radiating pain.

Table II. Characteristics of slipped capital femoral epiphyses

Slip stability (% of population)*	
Stable	74 (68.5%)
Unstable	34 (31.5%)
Average slip angle (degrees)	
Unilateral (range)	45 (9-88)
Bilateral (range)	41 (10-90)
Bilateral involvement (% of population)	15 (13.9%)
Unilateral involvement (% of population)*	93 (86.1%)
Right (% of unilateral)	45 (48.4%)
Left (% of unilateral)	48 (51.6%)

*Includes 1 patient that did not complete the pain diagram.

Table III. Rare pain patterns

Location or combination	Number of hips
Posterolateral	1
Groin/knee	1
Hip/knee/posterolateral	1
Hip/groin/thigh	1
Hip/groin/thigh/knee	1
Hip/groin	2
Hip/thigh/posterolateral	2
Thigh/posterolateral	3
Thigh/knee	3

Pain location or combination designated in the left column with number of times that location or combination was encountered on the right.