

# Trends in slipped capital femoral epiphysis: is the rate declining?

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## Abstract

**Purpose** Slipped capital femoral epiphysis (SCFE) is an adolescent hip condition with a high risk of complication. The purpose of this study was to evaluate trends in treatment using a prospectively collected paediatric nationally representative database.

**Methods** A total of 9034 patients undergoing treatment for idiopathic SCFE were selected by querying the Healthcare Cost and Utilization Project's Kids' Inpatient Database for the years 1997, 2000, 2003, 2006, 2009 and 2012. The selected patients were separated based on operative approach and these cohorts were analyzed based on temporal and categorical differences in operative approach, patient demographics and clinical characteristics. Univariate and multivariate analyses were used when appropriate and the Mantel-Haenszel test for trend was used in temporal analysis.

**Results** Overall SCFE procedures have decreased 27.5% ( $p < 0.001$ ). Closed procedures have decreased 28.5% ( $p < 0.001$ ), while open procedures have decreased 44.8% ( $p < 0.001$ ). Bilateral closed procedures have increased 7.2% ( $p < 0.001$ ). The ratio of open to closed procedures decreased in patients aged nine to 12 years and increased in patients aged 13 to 16 years ( $p < 0.001$ ).

**Conclusion** Here we report age stratified trends in treatment for idiopathic SCFE using nationally representative data and show an overall decrease in admissions and procedures over time.

**Level of Evidence** Level III, retrospective comparison study

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## Introduction

Slipped capital femoral epiphysis (SCFE) is the most common adolescent hip condition within the United States, with an incidence of approximately ten cases per 100 000 children. Regional and seasonal variation has been demonstrated based on latitude and other factors.<sup>1</sup> The aetiology of SCFE is unclear but pathogenesis includes either reduced resistance to shear strains along the proximal physis or increased stress along the proximal physis.<sup>2-4</sup> Obesity has been strongly associated with increased incidence, as well as endocrine disorders and systemic disorders.<sup>5-10</sup> A recent study implicates leptin elevation as a mediator of risk for SCFE.<sup>11</sup>

The goal of SCFE treatment is to prevent (and possibly correct) progressive deformity via stabilization of the proximal epiphysis (possibly with physeal arrest).

Complications may include avascular necrosis (AVN), chondrolysis, fixation failure and slip progression and contralateral slip development. *In situ* screw fixation is typically performed for mild and stable SCFE, however, some controversy exists regarding the best treatment for unstable and/or severe slips.<sup>12,13</sup> In the longer term, residual deformity may be associated with osteoarthritis (OA), leading some to recommend open procedures to correct deformity acutely.<sup>14</sup> Ziebarth et al<sup>15</sup> showed that unstable SCFE being treated with the modified Dunn procedure for capital realignment in 40 cases resulted in zero incidence of AVN and low reported incidences of other complications. They reported that this procedure is technically difficult but safe execution may minimize femoroacetabular impingement and ultimately early OA. A 2005 survey of members of the Pediatric Orthopaedic Society of North America found that the majority chose *in situ* fixation with a single screw as choice of treatment for unstable SCFE.<sup>16</sup> More recently, a survey to the members of the European Paediatric Orthopaedic Society still found internal fixation of the femur (ISSF) to be the predominant choice of treatment, however, reduction and osteoplasty was also prevalent.<sup>17</sup>

The purpose of this study was to evaluate trends in treatment rates using a prospectively collected paediatric nationally representative database. We hypothesize temporal trends exist in relative frequencies of treatment approaches using open reduction and closed procedures.

## Materials and methods

Institutional review board approval at our institution was not required for this study. The Healthcare Cost and Utilization Project (HCUP) created the Kids' Inpatient Database (KID), with sponsorship by the Agency for Healthcare Research and Quality. The KID is currently the largest publicly available all-payer inpatient paediatric database containing a nationally representative sample in the United States.<sup>18</sup> This de-identified database contains administrative discharge data from all community ('non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of institutions'), nonrehabilitation hospitals, on paediatric admissions and inpatient stays (younger than 21 years of age) from states participating in HCUP. This data is weighted to create a nationally representative sample of common and rare paediatric conditions. The KID is released every three years with its first release in 1997 and most recently in 2012. The most recent release provided data from 44 participating states with 6.6 million weighted paediatric discharges from 4179 hospitals. HCUP provides data regarding partner participation for each year.<sup>19</sup>

The KID for years 1997 to 2012 was obtained. Using International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) codes,<sup>20</sup> the database was queried to identify patients undergoing treatment for SCFE. We identified admissions between nine and 16 years of age, as it was assumed patients outside of this group were presenting with uncommon pathogenesis due to endocrinopathies or systemic disorders.<sup>21,22</sup> Using the ICD-9-CM diagnosis of 732.2 (nontraumatic slipped upper femoral epiphysis (SCFE)) we identified all patients with SCFE as the primary diagnosis. A secondary or tertiary ICD-9-CM code for SCFE was not considered to be of idiopathic aetiology. Patients were identified as being treated for SCFE with a closed approach if they had ICD-9-CM procedural code 79.45 (closed reduction of separated epiphysis, femur) (CR) or 78.55 (ISSF). Patients were identified as being treated for SCFE with an open approach if they had ICD-9-CM procedural code 79.55 (open reduction of separated epiphysis, femur) (OR) or 79.35 (open reduction with internal fixation, femur) (ORIF). We excluded patients who had simultaneous procedural and diagnosis codes for fractures (procedural 78.55 or 79.35 and diagnoses 820.01 (closed fracture of epiphysis of neck of femur) or 820.11 (open fracture of epiphysis of neck of femur) or 820.00 (closed fracture of intracapsular section of neck of femur)). Likewise, we excluded patients with a diagnosis believed to be strongly associated with atypical SCFE (e.g. hypothyroidism). To avoid capturing late sequelae leading to admission, we excluded patients with a diagnosis of AVN or patients with a procedure code for removal of implanted device from femur (ICD-9-CM 78.65). The KID

does not track unique patients over time and consequently does not provide any information on readmission. We also excluded patients who had three SCFE procedure codes on discharge, as these were felt likely to be related to complications or unusual cases and not representative of typical idiopathic SCFE. Finally, we excluded patients with both open and closed procedure codes on the same visit. Patient demographics and clinical characteristics obtained included age in years, gender, race and length of stay (LOS).

## Statistical analysis

The staged survey design of the KID required analysis methods allowing for the complex survey sampling design to be incorporated into the computations. All statistical analyses considered the complex survey sampling design utilized by the KID. Each stratum within the database is assigned a value for a particular hospital and physical location in the United States. Part of the process in creating the KID weights for discharge includes dividing the American Hospital Association universe discharge values by the discharge values within said KID stratum. These weighted discharge numbers are used for analysis.

Temporal trend analysis was done with the Mantel-Haenszel test for trend across years categorized by the defined procedural approaches. Univariate and multivariate models were used with linear regression or binary logistic regression. Testing for linearity of continuous variables was done using the Box-Tidwell procedure, where the independent variables are determined to be linearly related to the logit of the dependent variable. With comparison of multiple independent variables, a high risk of type I error was present during statistical analysis and Bonferroni correction was used as a conservative correction measure. Univariate analysis variables used in a multivariate analysis were obtained if  $p \leq 0.20$  in the univariate analysis and the outcome was considered statistically significant with  $p \leq 0.05$ . All  $p$ -values reported are two sided. Univariate analysis for group membership based on procedure type and association with patient demographics, LOS and days until primary procedure were evaluated using univariate logistic regression, the chi-squared test or Fisher's exact test when appropriate. The statistical analyses were performed using IBM SPSS Statistics, version 23.0 (SPSS Inc., Chicago, Illinois) and SAS version 9.4 (SAS Institute, Cary, North Carolina) when appropriate. The HCUP data user agreement for the KID prohibits posting patient discharges for less than or equal to ten cases and ' $\leq 10$ ' is used in lieu for descriptive purposes. Otherwise, '0' is used when there were no recorded occurrences.

**Table 1** Demographics and clinical characteristics for patients being treated by procedure type

Parameter	1997	2000	2003	2006	2009	2012	p-value
Total procedures	2189	1755	1806	1580	1524	1586	< 0.001
Race							
White (%)	648 (29.6)	536 (30.6)	382 (21.2)	401 (25.4)	404 (26.5)	451 (28.4)	0.055
Hispanic (%)	263 (12.0)	268 (15.3)	213 (11.8)	163 (10.3)	199 (13.1)	228 (14.4)	0.504
Black (%)	540 (24.7)	515 (29.3)	442 (24.5)	367 (23.3)	326 (21.4)	397 (25.0)	0.011
Native American (%)	15 (0.7)	≤ 10	≤ 10	≤ 10	≤ 10	18 (1.1)	0.117
Asian or Pacific Islander (%)	13 (0.6)	43 (2.5)	27 (1.5)	16 (1.0)	15 (1.0)	48 (3.0)	< 0.001
Other	47 (2.2)	60 (3.4)	52 (2.9)	61 (3.9)	69 (4.5)	88 (5.6)	< 0.001
<b>Closed procedures (%)</b>	1901 (86.8)	1605 (91.5)	1647 (91.3)	1462 (92.9)	1340 (89.2)	1360 (87.9)	< 0.001
Bilateral (%)	346 (18.2)	242 (15.1)	335.82 (20.4)	283 (19.3)	347 (25.9)	371 (27.3)	< 0.001
Age (yrs)	12.1 sd 1.6	12.0 sd 1.6	12.1 sd 1.6	12.0 sd 1.5	11.9 sd 1.5	11.9 sd 1.5	< 0.001
Total LOS (days) (range)	2.0 sd 1.5 (0 to 10)	1.8 sd 1.3 (0 to 11)	1.8 sd 1.1 (0 to 8)	1.8 sd 1.1 (0 to 8)	1.7 sd 1.0 (0 to 7)	1.7 sd 1.3 (0 to 21)	< 0.001
Sex							
Female (%)	625 (32.9)	577 (35.9)	495 (30.0)	451 (30.9)	386 (28.8)	485 (35.7)	0.244
Male (%)	1103 (58.0)	907 (56.5)	895 (54.3)	816 (55.8)	720 (53.8)	689 (50.7)	
<b>Open procedures (%)</b>	288 (13.2)	147 (8.5)	156 (8.7)	108 (7.1)	147 (10.8)	159 (12.1)	0.030
Bilateral (%)	27 (9.5)	≤ 10	23 (14.6)	14 (13.3)	18 (12.3)	15 (9.3)	0.915
Age (yrs)	12.3 sd 1.7	12.1 sd 1.7	12.0 sd 1.7	12.2 sd 2.0	12.4 sd 1.7	12.7 sd 1.6	< 0.001
Total LOS (days) (range)	2.3 sd 1.6 (0 to 11)	2.5 sd 1.7 (0 to 9)	2.3 sd 2.0 (0 to 13)	2.4 sd 1.6 (0 to 9)	2.6 sd 1.4 (0 to 7)	3.0 sd 1.7 (0 to 8)	< 0.001
Sex							
Female (%)	90 (31.3)	61 (41.6)	54 (34.7)	26 (24.2)	57 (39.1)	56 (35.5)	0.422
Male (%)	184 (64.0)	83 (56.3)	81 (52.0)	69 (63.9)	76 (52.0)	95 (59.8)	

Integers reported as nationally representative count. Age reported as mean years and sd. LOS reported as mean days and sd followed by range (minimum to maximum). Percentages for bolded items are for totals within year, all other percentages are within procedure class. P-values reported using the Mantel-Haenszel test of trend for procedure categories, Pearson chi-squared or regression where appropriate.

LOS, length of stay

## Results

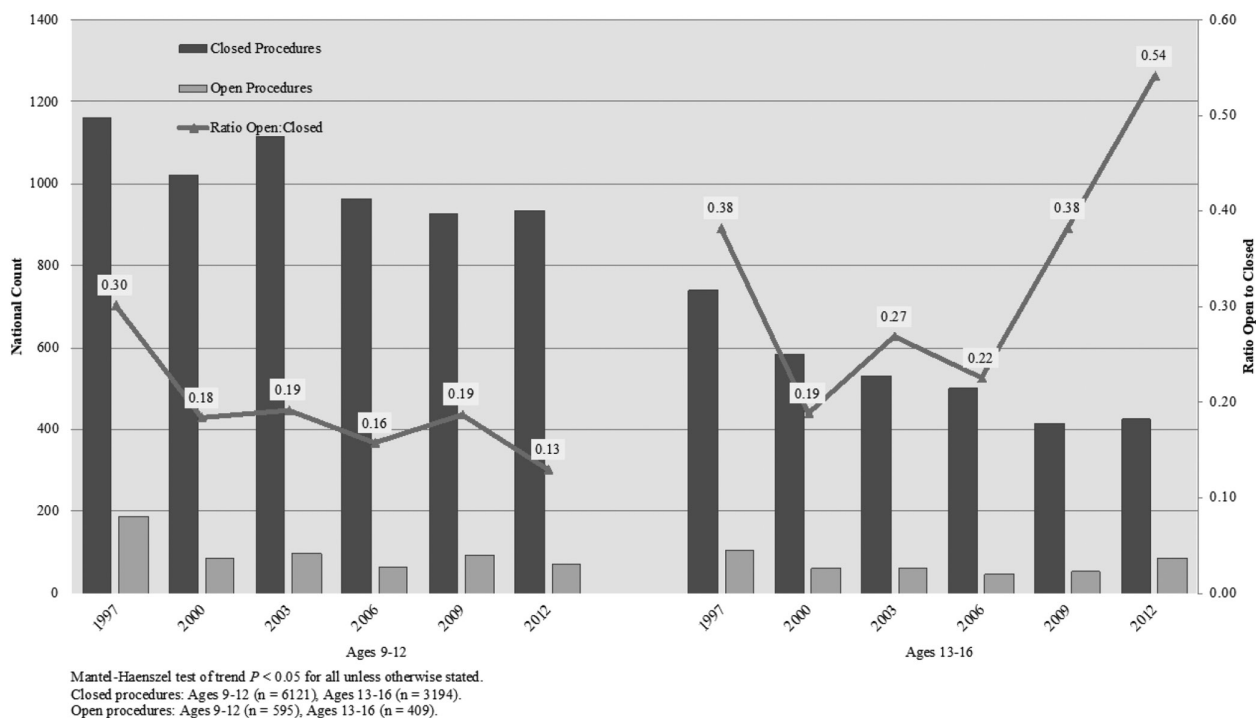
A total of 11 002 patient discharges between the ages of nine and 16 years were identified as having primary discharge diagnosis SCFE (ICD-9-CM 732.2) in the United States for the years 1997, 2000, 2003, 2006, 2009 and 2012. A total of 1698 patient discharges were excluded based on the defined exclusion criteria. Thus 9304 discharges with 10 319 procedures were included in analyses. In all, 9315 (90.26%) closed procedures were identified and 1005 (9.74%) open procedures were identified. ISSF and CR accounted for 7540 (73.06%) and 1775 (17.20%) procedures respectively. ORIF and OR accounted for 103 (1.00%) and 901 (8.73%) procedures respectively. There were a total of 8400 (81.40%) unilateral procedures and 1920 (18.60%) bilateral procedures on discharge. With respect to closed procedures 1825 (19.60%) were bilateral. Of those, 1536 had two ISSF procedures listed and 289 had two CR procedures listed. Of open procedures 94 (9.39%) were bilateral. Of those 91 had bilateral OR. Less than ten discharges had bilateral ORIF.

A substantial decrease in SCFE procedures over time was observed (2189 in 1997 to 1518 in 2012 (-30.63%,  $p < 0.001$ )). Closed procedures decreased -28.46% ( $p < 0.001$ ) and open procedures decreased -44.79% ( $p = 0.03$ ). Bilateral procedures within the closed category had a trend toward increasing (7.23%,  $p < 0.001$ ). These categories are described in more detail in Table 1.

Temporal trends in procedure type according to age group were analyzed with the age groups of nine to 12 years and 13 to 16 years. Both groups saw statistically significant changes over time according to procedure type. There was a gradual decrease in the ratio of open to closed procedures in the nine to 12 years age group, whereas, beginning around 2006 there was an increase in the ratio of open to closed surgery for the 13 to 16 years age group. Yearly changes for the different age groups are shown in Figure 1. The nine to ten years age group had 189 bilateral closed procedures and ≤ 10 bilateral open procedures. The 11 to 12 years age group had bilateral closed and open procedures of 452 and 24 respectively. The 13 to 14 years age group had bilateral closed and open procedures of 275 and 12 respectively. The 15 to 16 years age group had 49 bilateral closed procedures and ≤ 10 bilateral open procedures.

There were small statistically significant changes in LOS over time that were of insufficient magnitude to be clinically meaningful. Table 1 provides a break down for all procedures by year.

The number of days from admission until the principal procedure listed on discharge varied between the three categories. Closed procedures had a range of zero to nine days and 52.3% were done on the same day, 31.8% on the first day and 4.5% on the second day. Open procedures had a range of zero to six days and 61.3% were done on the same day, 21.7% on the first day and 4.5% on the second day.



**Fig. 1** Trends in age and slipped capital femoral epiphysis procedure approach type, Kids' Inpatient Database 1997 to 2012.

## Discussion

Surprisingly, we found the overall incidence of SCFE procedures to be decreasing. Open procedures decreased in younger patients while increasing in older patients. To our knowledge this is the first study to examine national trends in treatment for age stratified SCFE patients using the HCUP KID.

The reason for overall decrease in SCFE admissions is not clear, especially given that the rate of childhood obesity continued to increase in the United States over the time-period studied.<sup>23</sup> Patients in this study had an obesity rate of only 13%, much lower than would be expected. This may be due to under-reporting of ICD-9 codes for obesity, which is frequent.<sup>24</sup> Unfortunately, height and weight are not reported in the KID, precluding calculation of body mass index. Since the KID only captures inpatient stays, one possible explanation for fewer admissions is that more procedures are occurring in outpatient settings. It would seem unlikely that SCFE procedures would be routinely performed at outpatient surgery centres, as many exclude paediatric patients. Whatever the cause, another recent investigation in a Canadian province with increasing obesity mirrored the findings of the present study, showing over a ten-year period (2002 to 2011) with

648 total SCFE cases, a statistically significant 34% decrease in the annual incidence of SCFE in 2011 compared with 2002.<sup>25</sup> The counterintuitive finding of decreasing SCFE with increasing obesity in Canada was reproduced in our study. The final year for the KID covered 44 states and it would be extremely unlikely that SCFE patients were travelling to six select states with centres not covered by KID, leading to a falsely decreased number of reported cases. Likewise, ICD-9 coding for SCFE has not changed throughout the time period studied and there were other, rare, procedures done for SCFE, however, these did not change to a relevant degree over time to cause the shift seen in this study. While miscoding is always a concern for large administrative databases such as the KID, the ICD-9 codes did not change over time and the likelihood of SCFE miscoding causing this change is small.

Treatment choices did appear to change over time with a shift towards open procedures for older patients noted beginning between 2006 and 2009. This could have been due to increased application of new surgical approaches or techniques, such as the modified Dunn procedure (published in 2007).<sup>26</sup> Surveys around this time showed some interest in open procedures with the majority still holding reservations.<sup>16,17</sup> The increase in open procedures was followed by an increase in LOS.

Bilateral closed procedures increased over the time period studied. This may be due to increasing rates of contralateral prophylactic fixation or increasing rates of initial presentation with bilateral slip. The database does not differentiate unilateral from bilateral SCFE diagnoses nor prophylactic pinnings, so the cause for increasing bilateral procedures cannot be determined. Generally large databases that allow studying surgical procedures over time are always limited to administrative billing codes or other generic codes and it is difficult to ascertain from any of them whether the SCFE procedures are bilateral at presentation or with prophylactic fixation of one hip.

Several important limitations exist in this study. It is important to understand that the HCUP KID is an inpatient database and nothing is provided in terms of outpatient data or follow-up. It is not clear how often SCFE may be operatively treated in an outpatient setting. This study does not have the ability to capture or extrapolate outpatient setting SCFE treatments on a nationally representative level. Similarly, billing practices drive the definition of inpatients in the HCUP KID and hospitals may not be reporting the patient as an inpatient if the SCFE is treated and the patient is discharged the same day. Another important limitation is to understand that this study only observed temporal trends in treatment approach for SCFE and the rationale for treatment cannot be known. No information is recorded on the severity or stability of the slip or the patients' skeletal maturation. Finally, the age range of nine to 16 years was chosen to represent an idiopathic SCFE population, however, this choice of age range could exclude a possible trend towards patients presenting at a younger age.

## Conclusion

In summary, over the course of 15 years the rates of SCFE admissions overall have decreased and so have the procedures. The proportion of open procedures has increased for patients aged 13 to 16 starting in 2006. Bilateral closed procedures have increased. Further study to determine whether rates of SCFE are truly declining is warranted. Additionally, follow-up of open reduction procedures is needed to determine whether the increased magnitude of surgery will be justified by improved outcomes.

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## COMPLIANCE WITH ETHICAL STANDARDS

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

### OA LICENCE TEXT

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### ETHICAL STATEMENT

**Ethical approval:** Institutional review board approval was not required for this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent:** Formal consent was not required for this type of study.

### ICMJE CONFLICT OF INTEREST STATEMENT

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