Subclinical bilateral involvement of the hip in patients with slipped capital femoral epiphysis—a multicentre study

Yusuke Kohno · Yasuharu Nakashima · Toshio Kitano · Tomoyuki Nakamura · Kazuyuki Takamura · Mio Akiyama · Daisuke Hara · Takuaki Yamamoto · Goro Motomura · Masanobu Ohishi · Satoshi Hamai · Iwamoto Yukihide

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Abstract

Purpose This study was conducted to assess the posterior inclination of the contralateral femoral epiphysis in patients with unilateral slipped capital femoral epiphysis (SCFE).

Methods The posterior sloping angle (PSA) was measured using lateral radiographs in 67 patients with a unilateral SCFE and in 41 age-matched normal controls. A symptomatic epiphyseal slip was defined as the development of SCFE.

Results The contralateral PSA in SCFE patients was more widely distributed and significantly larger compared to controls (15.0° vs. 9.0°, $p < 0.0001$). Forty-seven hips (70.1 %) had a PSA of greater than 12.8°, which was +2SD of the control hips. Of the 65 hips excluding the two cases with prophylactic pinning, 11 hips (16.9 %) eventually developed a contralateral SCFE during adolescence and their PSA at the initial visit was significantly larger compared to patients without a contralateral SCFE (18.0° vs. 14.3°, $p < 0.005$) with a cutoff value of 19°.

Conclusions These findings suggested the possibility of bilateral hip involvement in SCFE patients. Hips with greater degrees of PSA ($> 19^\circ$) are likely to become symptomatic.

Keywords Slipped capital femoral epiphysis (SCFE) · Posterior sloping angle (PSA) · Subclinical posterior inclination · Contralateral slip · Bilateral involvement

Introduction

Slipped capital femoral epiphysis (SCFE) is a common hip disorder in adolescence and is a potential cause of hip dysfunction and degenerative hip disease in adulthood [1–5]. SCFE usually occurs in one hip (unilateral SCFE) and some patients develop a contralateral slip (bilateral SCFE) [2, 3, 6, 7]. Bilateral SCFE usually presents in one of two ways—either initially bilaterally or unilaterally followed by bilateral involvement [8]. The prevalence of subsequent contralateral slips detected during adolescence has been reported to range from 7 % to 25 % [9]. However, the prevalence of bilateral hip deformities suggesting bilateral slips detected at long-term follow-up in adulthood is reportedly much greater, ranging from 41 % to 80 % [1, 2, 9–13]. This discrepancy of prevalence between adolescence and adulthood suggests the existence of subclinical changes in the contralateral hip in unilateral SCFE.

The idea of prophylactic pinning came from the fact that a certain number of unilateral SCFE patients developed a symptomatic slip in the contralateral hip. Some risk factors have been reported such as a younger age at the initial SCFE presentation [7, 8], endocrine disorders [14], and renal failure [15]. A larger posterior sloping angle (PSA) in the contralateral hip has also been reported to be a significant risk factor for subsequent slip, and cutoff values for prophylactic pinning ranging from 12° to 14.5° have been identified [16–19]. These studies focused on the difference between

Y. Kohno · Y. Nakashima (✉) · M. Akiyama · D. Hara · T. Yamamoto · G. Motomura · M. Ohishi · S. Hamai · I. Yukihide
Orthopaedic Surgery, Kyushu University, Fukuoka, Japan
e-mail: yasunaka@ortho.med.kyushu-u.ac.jp

T. Kitano
Pediatric Orthopaedic Surgery, Osaka City General Hospital, Osaka, Japan

T. Nakamura · K. Takamura
Orthopaedic Surgery, Fukuoka Children's Hospital, Fukuoka, Japan

the symptomatic and asymptomatic hips; however, little is known regarding subclinical posterior inclination of the capital femoral epiphysis in the contralateral hip in unilateral SCFE patients to our knowledge. Therefore, the purpose of this study was to examine the prevalence and clinical course of contralateral posterior inclination of the capital femoral epiphysis until the epiphyseal closure.

Patients and methods

Patients

This multicentre retrospective study was approved by our institutional review board. From 1992 to 2010, 91 unilateral SCFE patients were treated at Kyushu University Hospital, Osaka City General Hospital, and Fukuoka Children's Hospital. Twenty-one patients were excluded from this study because serial radiographs of the contralateral hips were not available. One patient with radiation-induced SCFE was also excluded due to the iatrogenic a etiology. Two patients with endocrine disorder were also excluded because their contralateral hips might have different courses from regular unilateral SCFE. The remaining 67 patients were included in this study. There were 45 boys and 22 girls with an average age of 11.3 years (range, 7.6–13.8 years). The average follow-up periods were three years (range, five months to seven years and nine months). All the patients were followed up until the epiphyseal closure. Clinical data were collected from the medical records including age at onset, sex, height, weight, body mass index (BMI), physeal stability [20], and past medical history. There were 49 stable cases and 18 unstable cases. The surgical procedure for the initial slip included in situ pinning in 51 cases, manual and gentle reduction and pinning in 12 cases, and proximal femoral osteotomy in five cases. Our treatment guideline for stable SCFE was as follows: in situ pinning for the case with PSA less than 40° and a corrective femoral osteotomy for the case with PSA 40° or more. As for the contralateral hip, careful observation was indicated regardless of PSA when the patient was asymptomatic.

A slip was defined when the patient had hip pain along with the posterior inclination of the femoral epiphysis in this study. When the patient showed the posterior inclination of epiphysis but was not symptomatic, he or she was not diagnosed to have a slip.

The age-matched normal control group included 41 hips in 41 cases presenting with inguinal pain where pathology was not found on exam. Their contralateral hips were used as control in this study. There were 28 boys and 13 girls with an average age of 10.9 years (range, 7.1–15.9 years), and there was no significant difference between the SCFE group and the control group regarding age and sex.

Radiographic measurement

The posterior sloping angle (PSA) was measured as described by Barrios et al. [16] on standard radiographs taken in the classic Lauenstein lateral view. The PSA is defined as the intersection of the neck–diaphyseal axis and a line perpendicular to the plane of the epiphysis (Fig. 1), and we defined the mean PSA of the control group +2SD as the upper limit of normal PSA in this study. We evaluated radiographs taken at the initial visit and at follow-up appointments. All measurements were performed by one observer (Y.K.) and were repeated in a blinded manner during the course of two sessions at least one month apart. Two observers (Y.K. and D.H.) independently made measurements of 30 randomly selected hips. The intraobserver and interobserver reliabilities were evaluated using the intraclass correlation coefficient. All radiographic assessments were performed two times on different occasions by two observers (Y.K. and D.H.) and intraobserver and interobserver reliabilities were evaluated with the use of kappa statistics. Intraobserver reliability of the measurements was 0.89. Interobserver reliability of the measurements was 0.82.

Statistical analysis

A statistical analysis was performed using JMP 9.0.2 (SAS Institute Inc., Cary, NC, USA). The Mann–Whitney *U* test was used to compare the demographic data and radiographic parameters between each group. The chi-square test was used to compare categorical data between each group. The Levene test was used to assess the equality of variances between the SCFE and control groups. A multivariate analysis using a logistic regression model was performed to evaluate the factors associated with a contralateral slip. For all statistical analyses, *p* values less than 0.05 were considered significant. A receiver operator coefficient (ROC) curve was created to predict the PSA value when prophylactic pinning should be considered.

Fig. 1 Radiographic measurement of the posterior sloping angle (PSA). The PSA is measured as the intersection of the neck–diaphyseal axis and a line perpendicular to the plane of the epiphysis

The number needed to treat (NNT) was calculated for this threshold PSA.

Results

Contralateral hip follow-up

Of the 67 unilateral SCFE patients, two patients underwent prophylactic pinning of the contralateral hip. These two cases were excluded from the statistics analysing the PSA value for a subsequent contralateral slip. Of the remaining 65 patients, 11 patients (16.9 %) developed a contralateral slip. These patients were defined as the SLIP(+) group. There were nine boys and two girls with an average age of 11.1 years at the initial visit (range, 9.0–13.0 years). Fifty-four patients (83.1 %) did not have a contralateral slip. These patients were defined as the SLIP(−) group. There were 34 boys and 20 girls with an average age of 11.1 years at the initial visit (range, 7.6–13.8 years). In the SLIP(+) group, the mean initial PSA of the contralateral hips was 18.0°, and it increased to 26.2° (range, 16–44°) at the contralateral slip onset. The mean time to the onset of a contralateral slip was 11.6 months (range, 2–31 months). On the other hand, in the SLIP(−) group, the mean initial PSA of the contralateral hips was 14.3°, and it increased to 16.6° (range, 9–26°) at the time of epiphyseal closure.

Comparison of PSA between the contralateral hips in SCFE patients and the control hips

The PSA of the contralateral hips in SCFE patients and the control hips were 15.0°±3.8° and 9.0°±1.9°, respectively,

showing a significantly larger PSA in SCFE patients ($p<0.0001$) (Fig. 2). When the deviation of value was compared between these groups, the PSA of the contralateral hips in SCFE patients was significantly more widely distributed (range, 7–22° vs. 6–12°, $p<0.0001$) compared to control hips. When the normal range of the PSA was defined as the mean value ± 2SD, 12.8° was the upper limit of the normal PSA in this study. Of the 67 hips in unilateral SCFE patients, 47 hips (70.1 %) had a PSA greater than 12.8°.

Comparison of the PSA between the SLIP(+) and SLIP(−) groups

The PSA of the contralateral hips in the SLIP(+) and SLIP(−) groups were 18.0°±3.6° and 14.3°±3.6°, respectively, showing a significantly greater PSA in the contralateral hips in the SLIP(+) group ($p<0.005$) (Fig. 3, Table 1). Other factors including age, sex, BMI, stability in the initial hip, and PSA in the initial hip did not influence a contralateral slip (Table 1). A multivariate analysis also showed that the value of contralateral PSA was the only significant risk factor for a subsequent slip ($p=0.0040$, Table 2) with an odds ratio (OR) of 1.69 per degree (95 % CI, 1.25–2.59). A ROC curve demonstrated that a PSA of 19°, which maximised sensitivity (true positives) while minimising 1 – specificity (false positives), was an optimal degree for prophylactic pinning (Fig. 4). When the cutoff value was 19°, sensitivity was 0.64 and 1 – specificity was 0.14. The NNT was 2.0, meaning that if a surgeon pinned all hips presenting with a unilateral SCFE with a contralateral PSA larger than 19°, 2.0 hips would need to be pinned to prevent 1 hip from progression to bilateral involvement. The area under

Fig. 2 The comparison of contralateral PSA between the SCFE and control groups. *PSA* posterior sloping angle. The contralateral PSA in unilateral SCFE patients was significantly greater and also widely distributed compared to the control group. Approximately 70 % of SCFE patients had an PSA greater than 12.8°, which was +2 standard deviation compared to control hips

Fig. 3 The comparison of the contralateral PSA between the SLIP(+) and SLIP(−) groups. The contralateral PSA was significantly greater in the SLIP(+) group

the curve was 0.77 meaning moderate discrimination detection of a contralateral slip.

Discussion

We examined the PSA of contralateral hips in unilateral SCFE patients. Our results showed that the contralateral PSA in SCFE patients at the initial visit was significantly larger and more widely distributed than the PSA in control groups. Approximately 70 % of contralateral hips in SCFE patients had more than 12.8° of PSA, which was the upper limit of normal PSA defined in this study, suggesting subclinical bilateral involvement in many SCFE patients. The value of

the initial PSA was a significant factor for a subsequent slip with a cutoff value of 19°.

There were several limitations to this study. First, the normal range of PSA is not clearly defined, thus we regarded the mean PSA of the control group +2SD as the PSA upper limit. Using this criterion, 70 % of unilateral SCFE patients had a PSA greater than the upper limit of normal in contralateral hips. Considering the reported prevalence of bilateral deformities detected in adulthood (40–80 %) [12], it might be compatible that posterior inclination more than this upper limit was regarded as subclinical posterior inclination. Second, we defined a slip as a symptomatic posterior inclination of the capital femoral epiphysis, thus an asymptomatic hip was not assumed as a slip regardless of the PSA. Although this definition is controversial, the hips in the SLIP(−) group had an epiphyseal closure without significant deterioration of PSA. This topic needs further clarification. Third, our study does not include re-examination at long-term follow-up. Therefore it is unclear whether this subclinical posterior inclination resulted in degenerative hip disease or not. Further follow-up and evaluation are needed.

In unilateral SCFE patients, the prevalence of a subsequent contralateral slip detected during adolescence has reportedly ranged from 7 % to 25 % [9]. In accordance, the rate of later slip development was 16.9 % in our study. However, a contralateral hip deformity possibly due to a slip (or posterior inclination of epiphysis) detected at long-term follow-up has been reported to be more prevalent. Hägglund et al. reported 61 % (159/260) had bilateral involvement after a mean of 33 years [1]. Jerre et al. also reported that the incidence of bilateral slipping was 63 % with use of the standard lateral view of Billing at an average 32 years follow-up time [2, 21]. Their criterion for a slip was based on radiographic findings:

Table 1 Univariate analysis of the factors contributing to a contralateral slip

Factor	SLIP(+) group	SLIP(−) group	<i>p</i> value
Number of hips	11	54	
Age (year)	11.3±1.1	11.1±1.7	0.9492
Sex (male:female)	9:2	34:20	0.2284
BMI (kg/m ²)	24.9±4.5	23.7±3.8	0.2262
Stability of the initial slip (stable:unstable)	9:2	40:14	0.4202
PSA of the initial slip (°)	37.6±18.1	39.9±16.5	0.7019
PSA of the contralateral hip (°)	18.0±3.6	14.3±3.6	0.0049*

*Statistically significant *p* value <0.05

BMI body mass index, PSA posterior sloping angle

Qualitative data were compared with the chi-square test and quantitative data with the Mann–Whitney *U* test

Table 2 Multivariate analysis of the factors contributing to a contralateral slip

Factor	Odds ratio	95 % CI	<i>p</i> value
Age (year)	1.36	0.64–3.40	0.4591
Sex (male:female)	5.31	0.63–81.9	0.1647
BMI (kg/m ²)	1.20	0.95–1.62	0.1534
Stability of the initial slip (stable:unstable)	0.54	0.03–9.28	0.6533
PSA of the initial slip (°)	0.96	0.87–1.03	0.3106
PSA of the contralateral hip (°)	1.76	1.27–2.77	0.0039*

*Statistically significant
p value <0.05

CI confidence interval, *BMI* body mass index, *PSA* posterior sloping angle

femoral heads with decreased anteversion, more than three standard deviations below its predicted position [22]. Additionally the risk of a contralateral slip in unilateral SCFE patients has been reported to be much higher than that of an initial slip [23]. These findings suggested the presence of subclinical changes in the contralateral hip from the initial visit. Our results showed a significant difference in the contralateral PSA between the SCFE and control groups, and 70 % of contralateral hips in the SCFE group had increased posterior inclination compared to the mean PSA + 2SD in the control group. These morphological changes might contribute to future impingement and degenerative joint disease [24–26].

Hurley et al. reported that some SCFE patients have bilateral slips that occur sequentially rather than concurrently [27], thus it is beneficial to determine factors contributing to a contralateral

slip. Barrios et al. reported that the contralateral PSA was an important predictor for a subsequent slip [16]. Park et al. and Phillips et al. performed a further assessment of PSA [18, 19]. The former reported that the cutoff value for prophylactic pinning was a PSA of 13° in girls and the latter reported that it was a PSA of 14°. A younger age at the initial SCFE presentation [7, 8], endocrine disorders [14], and renal failure [15] also have been reported to be risk factors for bilateral SCFE. In our study, a contralateral PSA was the only significant risk factor for a contralateral slip (Tables 1 and 2) and a PSA of 19° was the threshold value for a contralateral slip (Fig. 4). Although 19° is higher than angles previously reported, this value is accompanied with higher specificity. Therefore, prophylactic pinning is worth performing for unilateral SCFE patients who have more than 19° of PSA with high possibility of a contralateral slip.

Fig. 4 Receiver operating characteristic (ROC) curve. The ROC curve demonstrates that the PSA of 19°, which maximises sensitivity (true positives) while minimising 1 – specificity (false positives), was the threshold value for future development of a contralateral slip

In conclusion, we found that approximately 70 % of contralateral hips in unilateral SCFE patients had subclinical posterior inclination of the capital femoral epiphysis, indicating the possibility of bilateral involvement. The contralateral PSA was a reliable predictor of a contralateral slip and a PSA of 19° was the cutoff value for developing SCFE.

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