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ORIGINAL STUDY

Contralateral slip prediction in Slipped Capital Femoral Epiphysis : is bone age the answer ?

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Prophylactic pinning of an asymptomatic hip in Slipped Capital Femoral Epiphysis (SCFE) is controversial. Bone age has been used as a predictor of future contralateral slip risk and also in the decision making for prophylactic intervention. The efficacy of bone age at predicting a contralateral slip was tested in this study.

Eighteen Caucasian children prospectively had bone age assessment using wrist and hand radiographs when presenting with a unilateral SCFE. After *in situ* fixation of the affected side prospective monitoring was performed at regular intervals in the outpatient department. Surgical intervention was undertaken if the contralateral hip was symptomatic.

Three children (2 boys and 1 girl) went on to develop a contralateral slip at a mean of 20 months from initial presentation. Six children were deemed at risk of contralateral slip due to a bone age of $\geq$ 12.5 years for boys and $\geq$ 10.5 years for girls. Only one from this group developed a contralateral slip. The relative risk of proceeding to a contralateral slip when the bone age is below the designated values was 1 (95% confidence interval of 0.1118 to 8.95). The sensitivity and specificity were 33% and 66% respectively. The positive predictive value was 15% and the diagnostic efficiency was 61%.

Although this is a small study, it would appear that delayed bone age by itself is not a good predictor of future contralateral slip. Routine prophylactic pinning is not justified based on bone age alone, with the risks of surgical fixation it carries. A prospective long term longitudinal study is required.

Keywords : slipped femoral capital epiphysis ; contralateral slip ; risk ; bone age.

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is a common disorder of unknown aetiology, affecting the adolescent hip. The reported prevalence of bilaterality varies from 18 to 50% (*5, 9, 10, 16*). Prophylactic pinning of the asymptomatic contralateral side at initial presentation with unilateral SCFE is controversial because it is not without complication (*2, 3, 13*). Children with SCFE have a delayed skeletal maturity (*7, 12*). The bone age has been used as a predictor of future contralateral slip

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using various methods for assessing the bone age (*14, 16, 17*). Segal *et al* (*16*) suggested that prophylactic fixation should be considered at a bone age of $\geq$ 12.5 years in boys and $\geq$ 10.5 years in girls. Rostoucher *et al* (*15*) proposed prophylactic fixation at a bone age of $\geq$ 13 years in boys and $\geq$ 12 years in girls. Marcus and Leo (*11*) reported that a bone age in boys of < 13 years represents a high risk for a contralateral slip. Stasikelis *et al* (*17*) showed that a bone age in boys of $\geq$ 11 years at the time of a unilateral slip was predictive of a contralateral slip. The present study was designed to prospectively follow-up a cohort of children with unilateral SCFE who had bone age assessment at presentation. The efficacy of bone age to predict future contralateral slip was tested.

MATERIALS AND METHODS

Between 2000 and 2004 twenty-two children presented with SCFE. Children with metabolic and endocrine disorders, bilateral presentation, of non-caucasian descent and those lost to follow-up were excluded from this study. The study included 18 caucasian children (11 boys and 7 girls) with a primary diagnosis of unilateral SCFE of idiopathic origin who had a bone age estimation at initial presentation. All children attended a specialist children's hospital and all were under the care of one paediatric orthopaedic surgeon. All patients underwent percutaneous single screw fixation of their symptomatic hip. Patients and parents were informed about the chance of contralateral slip and relative risks of prophylactic fixation, and advised to attend hospital immediately on development of symptoms in the contralateral hip. Surgical intervention on the contralateral hip was performed if symptomatic. They were followed prospectively at regular intervals (3 months) until skeletal maturity.

Bone age was estimated by experienced paediatric radiologists at a large tertiary referral hospital, with hand and wrist radiographs using the Greulich and Pyle method (*4*). The slip angle was graded according to Southwick into mild (< 30°), moderate (30° to 50°) and severe (> 50°). Stability of the slip was assessed using the weight bearing status and chronicity classified according to the duration of symptoms into acute (< 3 weeks), chronic (> 3 weeks) and acute on chronic (acute symptoms developing in chronic cases) (*10*). Postoperatively patients were mobilised partial weight bearing with crutches initially and gradually advanced to full weight bearing as tolerated.

RESULTS

Eighty-three percent (15 hips) were defined as stable slips and 83% as chronic or acute on chronic. The degree of slip was mild in 61% (11 hips), moderate in 28% (5 hips) and severe in 11% (2 hips). The demographic data of the children in this study is shown in table I. Two boys and one girl went on to develop a contralateral slip at a mean interval of 20 months from initial slip. All of the contralateral slips were associated with trauma (one child had a skiing injury, one fell while playing football and the third one experienced a fall in the bathroom).

There was no statistically significant difference between the mean bone age and chronological age for boys and girls sustaining unilateral or bilateral SCFE respectively. The range for the chronological age was 39 months in both sexes. There was a narrower range in the bone age, namely 36 months for girls and 24 months for boys. The mean chronological age and bone age for both sexes is shown in table II. Comparing the variance of the chronological and bone ages using the F test, there was no significant difference between the age ranges (variance ratio 2.15 and $p = 0.21$ for boys and variance ratio 1.27 and $p = 0.78$ for girls).

Five boys and one girl presented with bone age below 12.5 years and 10.5 years respectively and were at risk of a contralateral slip. Only one boy in this at risk group developed a contralateral slip. Seven boys and 4 girls had delayed bone age compared to their chronological age (range : 4 to 21 months for boys and 1 to 10 months for girls). None of these children developed a contralateral slip. Of the 3 children who had a contralateral slip, one boy and the girl had an advanced bone age of 7 months and 2 months respectively and the other boy had a delayed bone age of 2 months.

The relative risk for predicting a contralateral slip at initial presentation when the bone age is less than a designated value (12.5 years for boys and 10.5 years for girls) was 1 (95% confidence interval of 0.1118 to 8.95) (table III). The sensitivity

Table I. — Demographic data of all children included in the study

Sex	Laterality	Chronological Age (Years)	Bone Age (Years)	Bone Age & Chronological Age Difference In Months	Chronicity	Stability
M	UNILATERAL	11	11.6	Advanced 6	C	STABLE
M	UNILATERAL	11.5	11	Delayed 5	A	UNSTABLE
M	UNILATERAL	12.9	12	Delayed 9	AOC	UNSTABLE
M	UNILATERAL	13	13	Same	AOC	STABLE
M	UNILATERAL	13.4	13	Delayed 4	AOC	STABLE
M	UNILATERAL	13.11	12.8	Delayed 15	A	STABLE
M	UNILATERAL	13.11	12.8	Delayed 15	C	STABLE
M	UNILATERAL	14	13	Delayed 12	AOC	STABLE
M	UNILATERAL	14.3	12.6	Delayed 21	AOC	STABLE
M	BILATERAL	12.5	13	Advanced 7	AOC	STABLE
M	BILATERAL	12.8	12.6	Delayed 2	AOC	STABLE
F	UNILATERAL	10.3	10	Delayed 3	AOC	STABLE
F	UNILATERAL	10.11	12	Advanced 13	AOC	STABLE
F	UNILATERAL	11.1	11	Delayed 1	AOC	STABLE
F	UNILATERAL	11.10	11	Delayed 10	AOC	STABLE
F	UNILATERAL	12.1	12	Delayed 1	AOC	STABLE
F	UNILATERAL	13	13	Same	C	STABLE
F	BILATERAL	10.10	11	Advanced 2	A	STABLE

A = acute ; C = chronic ; AOC = acute on chronic.

Table II. — Table showing the mean values for chronological and bone age in boys and girls

	Mean	Standard Deviation	Minimum	Maximum	Variance	Coefficient of Variation
Bone Age Male : Unilateral slip	12.4	0.72	11	13	0.52	0.058
Chronological Age Male : Unilateral slip	13.1	1.2	11	14.25	1.36	0.087
Bone Age Male : Bilateral slip	12.75	0.36	12.5	13	0.125	0.028
Chronological Age Male : Bilateral slip	12.6	0.18	12.42	12.7	0.031	0.014
Bone Age Female : Unilateral slip	11.5	1.05	10	13	1.1	0.091
Chronological Age Female : Unilateral slip	11.5	0.98	10.25	13	0.95	0.086
Bone Age Female : Bilateral slip	11					
Chronological Age Female : Bilateral slip	10.83					

Table III. — 2X2 Table of children at risk of contralateral slip (having a bone age below 12.5 years in boys and 10.5 years in girls) and the total number of unilateral and contralateral slips in the study

	Contralateral Slip	Unilateral Slip
At risk of contralateral slip	1	5
Not at risk of contralateral slip	2	10

Sensitivity of bone age predicting contralateral slip = proportion of true positives = 1/1 + 2 = 33%

Specificity of bone age predicting contralateral slip = proportion of true negatives = 10/10 + 5 = 66%

Positive predictive value = 1/1 + 6 = 15%

Negative predictive value = 10/10 + 2= 83%

Diagnostic efficiency = 1 + 10/ 1 + 10 + 2 + 5 = 61%.

and specificity were 33% and 66% respectively. There was a positive predictive value of 15% and a negative predictive value of 83%. The overall diagnostic efficiency of bone age at predicting a contralateral slip was 61%.

DISCUSSION

In this cohort of children, a bone age below a designated value (10.5 years for girls and 12.5 for boys) and a delay in the bone age compared to the chronological age did not predict those that would go on to develop a contralateral slip. Using these criteria in this cohort to identify children who need prophylactic pinning of their hip would have resulted in unnecessary operations in 6 children.

Children with SCFE have a delayed skeletal maturity (*7, 12*). SCFE occurs in a narrow time period of bone age, regardless of the child's chronological age (*8, 10, 17, 18*). Loder *et al* (*8*) coined the term 'Narrow Window' of skeletal age and epiphyseal slipping. They also showed that the skeletal age was advanced in younger children and delayed in older children. Our study showed similar findings.

Prophylactic pinning of the contralateral hip at initial presentation is controversial. Segal *et al* (*16*) reported a high incidence of contralateral slip of 69% and suggested prophylactic fixation when the bone age was 12.5 years or less in boys and 10.5 years or less in girls. Hagglund *et al* (*5*) reported a 40-80% risk of contralateral slip and recommended prophylactic fixation in all cases of SCFE. Rostoucher *et al* (*15*) proposed prophylactic fixation in children with a bone age of $\geq$ 13 years in boys and $\geq$ 12 years in girls, in patients who have not reached puberty, in patients who have an SCFE with larger displacement and with an open growth cartilage. In 69 unilateral SCFE, 51 hips had prophylactic fixation with 2% complication rate and 18 hips did not undergo prophylactic pinning ; none in this group of 18 developed a contralateral slip. Loder *et al* (*9*) reported a mean age of 12 years in children who developed a contralateral slip. In contrast, Jerre *et al* (*6*) did not find any association between the index slip and the subsequent slip in terms of age, sex, duration of symptoms, degree and stability of slip. Prophylactic pinning of an asymptomatic hip is not without complication (*2, 3, 13, 15, 18*) and the evidence must be compelling to justify this procedure. The results of meta-analysis on SCFE literature showed that most surgeons support close monitoring of the contralateral hip rather than prophylactic fixation (*1*).

The evidence for the efficacy of bone age to predict a future contralateral slip is confusing and studies may have introduced confounding factors by not stratifying by sex and race and using different methods for bone age assessment. The present study is a prospective assessment of a single race cohort of children followed closely and whose bone age assessment was performed by the same department hence ensuring accuracy of the measurements. Contralateral intervention was indicated only if symptomatic.

Using bone age at initial presentation of a slipped capital femoral epiphysis to predict the likelihood of future contralateral slip in both sexes is not accurate and will lead to possible over treatment. The authors cannot justify contralateral pinning of asymptomatic hips on the strength of evidence of bone age alone and they consider that close monitoring is preferable.

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