Slipped capital femoral epiphysis may be associated with hypothyroidism and other endocrinopathies. Routine screening for such abnormalities is unlikely to be cost-effective since the overall incidence of these disorders, in association with slipped capital femoral epiphysis, is low. The identification of a presenting characteristic which would predict the chance of an associated endocrinopathy would allow only selected children to be screened.

Our aim was to determine if certain characteristics were useful as a screen for patients with an underlying endocrinopathy who presented with slipped capital femoral epiphysis. Between January 1988 and December 1996 we recorded gender, age, height, unilateral or bilateral involvement and an associated diagnosis of endocrinopathy for all patients who were treated for slipped capital femoral epiphysis. Of 166 such patients 13 (7.8%) had an endocrinopathy. Height was the only useful screening characteristic, although bilateral involvement was more likely in those with an endocrinopathy. Most (90.9%) of this latter group were below the tenth percentile for height compared with only 5.4% in those who did not have an endocrinopathy (p < 0.005). The sensitivity and negative predictive value of detecting an underlying endocrinopathy in a patient presenting with a slipped capital femoral epiphysis and short stature (tenth percentile or less) were 90.2% and 98.6%, respectively.

Patients who are on or below the tenth percentile for height at the time of presentation should be screened for a possible endocrine abnormality using measurement of thyroid-stimulating hormone and free thyroxine as a preliminary screening test. These hormones are most likely to be abnormal in the presence of endocrine dysfunction.

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The association of slipped capital femoral epiphysis with juvenile hypothyroidism has been well documented in the literature. The condition has also been associated with other endocrinopathies such as hypopituitarism, deficiency of growth hormone, craniopharyngiomas and hypogonadism. An endocrinopathy is defined as a disorder of an endocrine gland with associated disturbances of hormone levels and secondary physiological effects. Endocrine dysfunction may result from abnormality of the endocrine organ affecting its function either directly or through alteration of its products.

The problem for general orthopaedic surgeons is that endocrinopathy in association with slipped capital femoral epiphysis, is rare but, if unrecognised and untreated, can have serious effects on mental and physical development. The clinical diagnosis of acquired endocrinopathies can be difficult and some authors have advocated routine screening for hypothyroidism or other underlying endocrinopathies in all patients who present with a slipped capital epiphysis. In 1993 the cost of measuring serum thyroxine (T4) and thyroid-stimulating hormone (TSH) in California was reported as $US60 per patient and endocrine testing for all patients is not routinely undertaken beause of the expense. Furthermore, the overall incidence of endocrine disorders in association with slipped capital femoral epiphysis is low and few patients would be identified. A simple screening test for endocrinopathies would therefore be helpful to orthopaedic surgeons.

Patients and Methods

We identified all patients with slipped capital femoral epiphysis treated at our institution between January 1988 and December 1996. We obtained the patients’ details from the medical records and also recorded the time from the diagnosis of endocrinopathy to presentation of the slipped
capital femoral epiphysis, as well as the time of initiation of treatment. In our study 11 out of 13 patients with endocrine abnormalities had a TSH recorded and 12 out of 153 non-endocrine patients had a TSH blood test undertaken at some point in their follow-up. All patients were followed up for at least 24 months. We would expect all undiagnosed endocrinopathies to have presented with symptoms other than slipped capital femoral epiphysis during this period.

One patient was treated by open reduction using an anterior approach followed by pin fixation. The remainder were treated by closed percutaneous internal fixation.

Details of gender, age and whether the slip was unilateral or bilateral were available for all patients. Measurements of height were available for 75 patients without and 11 patients with an endocrinopathy. The height at presentation was plotted against chronological age and a height percentile was obtained using the standardised growth charts of Tanner, Whitehouse and Takaishi. In order to analyse the data, four-cell tables were created, which determined the sensitivity and negative predictive value of detecting an underlying endocrinopathy when presenting with a slipped capital femoral epiphysis and young age (less than ten years), gender, bilaterality, and short stature (tenth percentile or less). Sensitivity is the ability of an index to detect a target disorder when present, while specificity is the ability to identify correctly the absence of a target disorder in patients without the disease. A negative predictive value represents the proportion of patients with a negative test which do not have the target disorder (posterior probability of no disease following a negative result). A positive predictive value represents the proportion of patients with a positive test who manifest the target disorder. Likelihood ratios express how many times a test result is to be found in diseased, compared with non-diseased, subjects.

Results

Of 166 patients with a slipped capital femoral epiphysis, 13 had an endocrine abnormality: hypothyroidism (6), craniopharyngioma (3), suprasellar germinoma (1), hypogonadotropic hypogonadism in a patient with thalassaemia (1), renal osteodystrophy with associated hyperparathyroidism (1) and one case in which the diagnosis was not specified but the patient was on testosterone therapy for short stature at the time of presentation.

Patients without an endocrinopathy and slipped capital femoral epiphysis were younger than those with an endocrinopathy (p < 0.005). The mean age at presentation was 12.6 years (8.3 to 17.5) for those without an endocrinopathy and 13.8 years (9.9 to 16.5) for those with endocrine abnormalities. Only one of the 13 patients with an endocrinopathy presented before the age of ten years, while seven of 153 patients without were seen before the age of ten years. The sensitivity and the positive predictive value of presenting at less than ten years of age were 7.69% and 12.5%, respectively. The specificity of presenting at an age of less than ten years and not having an endocrinopathy was 95.4% and the negative predictive value was 92.4%. The likelihood ratio was that a patient was 1.7 times more likely to be less than ten years of age at the time of presentation with a slipped capital femoral epiphysis in endocrine patients when compared without an endocrine abnormality.

Patients with endocrinopathy and slipped capital femoral epiphysis were more likely to have bilateral involvement (p < 0.005). Nine of the 13 patients (69.2%) with endocrine abnormalities were treated for bilateral slipped capital femoral epiphysis. Four were treated for bilateral disease on admission and five were treated for a subsequent slip within 16 months of presentation. There were 37 patients (24.2%) with bilateral slipped capital femoral epiphyses in the group without an endocrinopathy. Of these, 13 were treated on admission and 24 pinned within 26 months of presentation. Six patients without an endocrinopathy presented with a second slipped capital epiphysis within one month of the first. The sensitivity of detecting an endocrinopathy when the incidence of slipped capital femoral epiphysis was bilateral was 69.2% and the specificity was 75.8%. The positive predictive value was 19.6% and the negative predictive value 96.7%. According to the likelihood ratio the presentation of bilateral disease and an endocrinopathy was 3.1 times more likely than with no endocrinopathy.

As shown in Figure 1, most (94.7%) of the patients with no endocrinopathy were above the tenth percentile for height, while 90.9% of the children with an endocrinopathy were on or below the tenth percentile for height (p < 0.005). Sensitivity was 90.9% (10/11) and the negative predictive value was 98.6% (71/72). The specificity of this test was 94.7% and the positive predictive value was 71.4%. According to the likelihood ratio the presentation of height in the tenth or lowest percentile and an endocrinopathy was 17.4 times more likely than with no endocrinopathy.

Serial measurements of height spanning a period of three years or more were available for eight of the 13 patients with endocrinopathies. All of these patients had recorded heights equal to or less than the tenth percentile using the standardised charts of Tanner et al throughout the period of time when a slipped capital femoral epiphysis would be likely to occur (Figs 2 and 3). Seven of the eight patients were reported as having heights in the tenth percentile or lower from their time of presentation. One patient with a craniopharyngioma, however, presented with a height above the 25th percentile at the time of endocrine diagnosis. Despite treatment for this condition this patient was subsequently noted to drop below the tenth percentile which coincided with the period in which the slipped capital femoral epiphysis occurred.

Seven of ten patients with primary childhood onset or secondary hypothyroidism presented with a slipped capital femoral epiphysis after starting thyroid replacement ther-
Height (cm) at presentation was plotted against chronological age and a height percentile was obtained using the standardised growth charts of Tanner et al.\textsuperscript{10} In the non-endocrine group, 94.6% of the patients were above the tenth percentile for height, while most endocrine-deficient children fell into the tenth or lower percentile for height (90.9%).

Serial measurements of height spanning a period of three years or more for five girls with endocrinopathies were plotted against chronological age using the standardised growth charts of Tanner et al.\textsuperscript{10} All except girl number 5 had recorded heights equal to or less than the tenth percentile throughout the period of time when a slipped capital femoral epiphysis would be likely to occur. Girl 5 presented with a height above the 25th percentile at the time of diagnosis of a craniopharyngioma. Despite treatment for this condition the patient’s height was subsequently noted to decrease below the tenth percentile which coincided with the period in which the slipped capital femoral epiphysis occurred.
apy. In the other three patients, their endocrine abnormality was diagnosed one, five and 21 months after the presentation and treatment of the slipped capital femoral epiphysis.

About half (53.8%) of the patients who had a slipped capital femoral epiphysis and an endocrine abnormality were girls. Only 38.6% in the non-endocrine abnormality group were girls.

Discussion

Although the exact aetiology of slipped capital femoral epiphysis is unknown many authors have described it in association with endocrine abnormalities. Thyroid hormone and growth hormone are the hormones most commonly affected in endocrinopathies. Both are required for the growth and maturation of cartilage in preparation for its subsequent calcification and replacement by mineralised osteoid. Together, they cause proliferation and degeneration of chondrocytes in the growth plate, as well as subsequent calcification and ossification of the matrix. In the hypothyroid child, degeneration of chondrocytes is accelerated and mineralisation of matrix is enhanced, but ossification of the mineralised matrix is inhibited. In normal children without an endocrinopathy, the epiphysis is anchored to the metaphysis by interdigitation of the calcified lattice with the opposing filamentous extensions of osteogenic marrow. In a post-mortem specimen of an untreated cretin, the epiphysio-meta-physeal junction was noted to consist of a lattice of solidly calcified cartilaginous matrix, as opposed to the normal ‘mesh type’ union of bone and cartilage. This type of rigid calcified layer makes the epiphysio-meta-physeal junction more vulnerable to shearing forces about the hip. A deficiency of thyroid hormone may therefore play a significant role in reducing stability of the growth plate and subsequently contribute to the pathogenesis of a slipped capital femoral epiphysis.

Some patients with an endocrinopathy will present with slipped capital femoral epiphysis before recognition of their endocrinopathy. All nine cases in the study by Puri et al developed a slip or had symptoms before the diagnosis of hypothyroidism was made, although two had documented symptoms two and three months before being diagnosed with hypothyroidism. In three of 85 patients in the study by Loder et al the diagnosis of an endocrine problem was not made when they presented with a slipped capital femoral epiphysis. Thus, patients can present with a slip before the diagnosis of an endocrinopathy and a method of prospective selective endocrine testing would be useful.
Some patients with a recognised endocrinopathy will develop a slipped capital femoral epiphysis. Wells et al reported that eight out of nine patients developed a slip while being treated for their endocrine deficiency. In our study, seven patients with a known endocrinopathy (primary or secondary hypothyroidism) were receiving appropriate treatment when they presented with a slipped capital femoral epiphysis. Three of the seven, however, had hip symptoms recorded before the diagnosis of an endocrinopathy was made. Therefore, although the exact role of thyroxine in the pathogenesis remains unclear, even those patients receiving adequate treatment for endocrinopathies deserve close monitoring for the early signs of slipped capital femoral epiphysis.

Several patient characteristics such as age, bilaterality, and height have been suggested to identify those patients with slipped capital femoral epiphysis and an associated endocrinopathy. Previous authors have suggested that only children with hypothyroidism or deficiency of growth hormone present under the age of ten years with slipped capital femoral epiphysis.\(^3,14\) In our study, seven patients with no endocrinopathy presented with a slipped capital femoral epiphysis under the age of ten. Only one of six patients with primary acquired hypothyroidism was seen before the age of ten; all other patients with endocrinopathies presented between the ages of 11 yrs 11 months and 16 years 5 months. The significant overlap in the age distribution of patients, with and without endocrinopathy, was reflected in the poor results for sensitivity and positive predictive value.

Neither age nor bilaterality was a useful screening characteristic.

The prevalence of bilaterality (69.2%) was similar in those with and without an endocrinopathy. Other authors have suggested that the incidence of bilaterality in cases of slipped capital femoral epiphysis with an endocrinopathy is so high that prophylactic pinning of the opposite side should be considered.\(^3,14\) A policy of bilateral pinning of all hips in children with an endocrinopathy would result in approximately 30% of patients receiving a potentially unnecessary procedure. Given all the possible complications associated with surgical treatment it is difficult to justify prophylactic pinning of the contralateral hip in all these patients.\(^5\)

Only 13 patients (8%) presented between 1988 and 1996 with slipped capital femoral epiphysis, and an endocrinopathy. This reinforces the concept that the overall incidence of slipped capital femoral epiphysis associated with such abnormality is probably too low to justify routine screening. The common finding among the patients with endocrine disorders was short stature. The most appropriate screening test is measurement of the levels of TSH and free T4 levels. Hypothyroidism is the most common disorder and children with more complicated forms of endocrinopathy often have disturbances of thyroid function.

Our suggested crucial percentile using the standardised growth charts of Tanner et al\(^10\) is the tenth or lower. The sensitivity of this index in detecting when an endocrinopathy was present was 90.9% with a negative predictive value or the probability of no disease being present of 98.6%. This high negative predictive value suggests that a negative result will miss very few patients and indicates that measurements of height in patients with slipped capital femoral epiphysis would be helpful in deciding whom to screen for endocrine disorders. The graphs of the long-term follow-up of height in those patients emphasise two points. First, children with endocrinopathies are subject to periods of decreased growth and secondly, most such children will have a height below the tenth percentile at the time of the presentation of slipped capital femoral epiphysis.

Our study has two main limitations. First, we did not have measurements of height on all patients. We believe, however, that patients of low stature, with or without endocrinopathy, would be more likely to have had their height recorded. As a result, if we had had such measurements on all patients it would, if anything, have improved the sensitivity and negative predictive values of height as a screening characteristic. Secondly, our study was carried out in a tertiary care institution with presumably a higher rate of endocrinopathy. In centres with a lower prevalence of disease the sensitivity and specificity would remain unchanged. The positive predictive values, however, would drop and the negative predictive value would rise. Thus, the percentage of children who were screened, but found not to have an endocrinopathy, would increase, but the percentage with an endocrinopathy who were missed by selective screening would become even lower than in our study.

We suggest that all patients who present with a slipped capital femoral epiphysis should have their height measured and a growth history taken. Those patients on or below the tenth percentile for height for chronological age should be screened for a possible endocrine abnormality by determining levels of TSH and free T4. These are the studies most likely to be abnormal in the presence of endocrine dysfunction.

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.

References


