FEMORAL ANTEVERSION

A CLINICAL ASSESSMENT OF IDIOPATHIC INTOEING GAIT IN CHILDREN

RICHARD H. GELBERMAN, MARK S. COHEN, SHEKHAR S. DESAI, PAUL P. GRIFFIN, PETER B. SALAMON, TIMOTHY M. O'BRIEN

From the Children's Hospital Medical Center, Boston

Hip rotation in extension and flexion was studied in 23 patients with idiopathic intoeing gait. In extension all the hips had markedly increased medial rotation and limited lateral rotation, fulfilling the criteria of excessive femoral anteversion. In flexion, however, rotation varied widely; in one group of patients medial rotation remained greater than lateral, but in the second group lateral rotation was equal to or greater than medial.

CT scans showed that the hips in the first group were significantly more antverted than those in the second. Clearly measurement of hip rotation in extension alone does not provide a dependable indication of femoral anteversion in children with intoeing gait; rotation in flexion also needs to be measured.

There is at present no consensus on the criteria for clinical diagnosis of excessive femoral anteversion in otherwise normal patients with intoeing gait. Several authors believe that markedly increased medial rotation of the hip in extension, with corresponding limitation of lateral rotation, is presumptive evidence of excessive anteversion (Fabry, MacEwen and Shands 1973; MacEwen 1976; Kumar and MacEwen 1982; Kling and Hensinger 1983). Other authors ascribe numerical guidelines of hip rotation in extension for diagnosis (Reynolds and Herzer 1959; Alvik 1962; Swanson, Greene and Allis 1963; Pitkow 1975; Staheli 1977). However, most authors agree that these criteria are arbitrary, and it has been shown that hip rotation in extension alone is not a reliable determinant of femoral anteversion (Staheli, Duncan and Schaefer 1968; LaGasse and Staheli 1972; Cyvin 1977; Reikerås and Bjerkreim 1982).

The purpose of this study was to investigate the correlation of femoral neck anteversion with hip rotation in extension and in flexion in children presenting with intoeing gait.

MATERIALS AND METHODS

Twenty-three children who presented primarily with intoeing at the Children's Hospital Medical Center between January and October 1985 were studied. There were 15 girls and eight boys ranging in age from 3 to 10 years. All patients were examined and their torsional profiles fulfilled the clinical criteria of Staheli (1977, 1980) for excessive idiopathic anteversion of the femoral neck. All measurements of hip rotation were recorded by one of us (RHG) to eliminate inter-observer variation (Luchini and Stevens 1983).

Rotation. Hip rotation in extension was measured with the child lying prone and with the knees flexed to 90° so that the lower leg indicated the angle of rotation; the angle between the tibia and the vertical was measured. Care was taken to hold the pelvis firmly onto the table while the lower leg was passively moved through an arc both medially and laterally. Hip rotation in flexion was measured with the child lying supine and with both the hip and knee held in 90° of flexion. Each leg was examined separately and the measurements recorded with a goniometer.

All hips had markedly increased medial rotation and limited lateral rotation in extension, but rotation in flexion varied greatly. The patients were therefore divided into two groups based on the range of rotation in flexion: Group I comprised 15 patients (30 hips) in whom medial rotation in flexion was consistently greater than lateral rotation; Group II comprised eight patients.
(16 hips) in whom lateral rotation of the flexed hip equalled or exceeded medial rotation.

Twenty normal children aged 3 to 10 years, with normal gait, served as controls and formed Group III. These children presented to the orthopaedic clinics for musculoskeletal conditions not related to the lower limbs. Rotation of the hip in flexion and extension was measured.

**Anteversion.** All patients in Groups I and II, but not those in Group III, underwent computerised tomography to determine femoral anteversion. These CT studies were carried out with a GE 9800 CT scanner, each taking about 30 minutes. The child’s legs were secured to the table with Velcro straps to prevent any movement occurring between performing the scans of the upper and lower femur. Images were made with a two-second scan time at 120 kVp, mAs varying with patient size. A series of tomographic cross-sectional images from the femoral neck were viewed on the monitor. The tomogram best representing the centre of the femoral head was selected. The axis of the femoral neck was determined by a line connecting three points equidistant between the superior and inferior surfaces of the femoral neck (Weiner et al. 1978). In cases of excessive coxa valga, an attempt was made to obtain an extra CT image through the lower aspect of the femoral neck. These images were then superimposed to lengthen the image of the femoral neck and to determine more accurately the true cervical axis.

Similarly, serial cross-sections were taken through the distal expansion of the lower end of the femur. A line connecting two points along the most posterior aspects of the femoral condyles, as seen on the tomographic projections on the television monitor, was selected for axis measurement. Photographs of the tomographic sections of the neck axis and the distal femoral axis were then superimposed and the angle directly measured (Figs 1 and 2).

Gonadal dosage of radiation was estimated from published data on CT imaging (Carter et al. 1977; McCullough 1980) and from data contained in the National Council on Radiation Protection and Measurements Report (1977). Dosage was determined to be less than 50 millirads for both boys and girls, as compared to 150 millirads sustained by the female gonads during routine anteroposterior radiography of the pelvis. Carcinogenic risk from this procedure can be estimated by evaluating the integral dose, which is the product of the dose and the volume of tissue irradiated. Total integral dose of three slices through the hip was found to be approximately equal to that sustained in anteroposterior radiography of the pelvis (3000 gram-rads).

Statistical analysis was carried out using Student’s t-test. Differences were regarded as significant when \( p \leq 0.05 \). The two-tailed test was used in all cases.

**RESULTS**

Group I comprised nine girls and six boys (30 hips) ranging in age from 3 to 9 years, with a mean age of 5.3 years, who all had greater medial than lateral rotation in both extension and in flexion. Detailed results are given in Table I. In extension, mean medial rotation measured 80° and mean lateral rotation 10°; while in flexion, mean medial rotation was 78° and lateral rotation 45°. The mean CT measurement of femoral anteversion was 49°.

Group II comprised six girls and two boys (16 hips) ranging in ages from 3 to 10 years, with a mean age of 5.5 years (Table II). These patients also had excessive medial rotation with limited lateral rotation with the hip in extension, measuring 71° and 18° respectively (Table III). However, in contrast to Group I all hips showed lateral rotation equal to or greater than medial rotation with the hip in flexion. Detailed results are in Table II. These hips showed a mean medial rotation in flexion of 46° with a mean lateral rotation of 60°. The difference in both medial and lateral rotation in flexion between Group I and Group II hips was highly significant (\( p < 0.001 \)). Mean femoral anteversion was 32° in Group II hips, which was significantly less than the 49° found in Group I hips (\( p < 0.001 \)).
Group III, the control group, comprised eight boys and 12 girls (40 hips) whose ages ranged from 3 to 10 years, with a mean of 5.1 years. They all had approximately equal ranges of medial and lateral rotation, in both extension and flexion. As shown in Table III, mean medial rotation in extension was significantly less than that for both Group I and Group II hips (p < 0.001), while mean lateral rotation was significantly greater (p < 0.001). In flexion, mean medial rotation was still significantly less than in Group I hips (p < 0.001) but not significantly different from that seen in Group II (p > 0.05) while mean lateral rotation in flexion was significantly greater than in Group I (p < 0.001) but was not significantly different from Group II hips (p > 0.05).

**DISCUSSION**

Femoral anteverision is reported to be the most common cause of intoeing gait in children between the ages of 3 and 12 years (Hensinger 1976; Staheli 1977; Kumar and MacEwen 1982; Kling and Hensinger 1983). Various clinical criteria have been based on hip rotation in extension, or increased medial rotation in extension with relatively limited lateral rotation. However, it has been shown that hip rotation in extension does not provide an accurate measure of femoral anteverision (Staheli et al. 1968; LaGasse and Staheli 1972; Cyvin 1977; Reikerås, Bjerkreim and Kolbenstvedt 1982).

The natural course of femoral anteverision has been demonstrated by Fabry et al. (1973) in a 20-year follow-up of 1148 hips. Using biplanar radiography, they found that the anteverision for normal children between the ages of three and six years was 27° ± 8°, and between seven and ten years was 22° ± 7°. These values coincide with the findings of plain radiography (Dunlap et al. 1953; Ryder and Crane 1953; Budin and Chandler 1957; Shands and Steel 1958; Crane 1959; Beals 1969; Cyvin 1977) and those on cadaveric femora (Le Damany 1903; Soutter and Bradford 1903; Durham 1915; Kingsley and Olmsted 1948).

Computerised tomography has improved the determination of femoral anteverision (Weiner et al. 1978; Hernandez et al. 1981; Peterson et al. 1981; Bjersand and Eastgate 1982; Reikerås, Bjerkreim and Kolbenstvedt 1983; Widjaja et al. 1985; Gelberman et al. 1986). It correlates well with the measurement of anteverision obtained by conventional biplanar radiography (Reikerås et al. 1982). Slight variations in the location of the sections within the femoral neck do not alter the measurement of femoral anteverision significantly and the mean intra-observer and inter-observer variations are 2° and 3° respectively (Hernandez et al. 1981).
In the clinical determination of femoral anteversion, all authors stress the importance of measuring rotation with the hip held in extension. In flexion, the anterior capsular and soft-tissue structures are relaxed, permitting a greater range of lateral rotation. We found hip rotation as measured in extension to be a poor predictor of femoral anteversion as measured by computerised tomography. Patients with medial rotation in extension greater than 70° had computerised tomographic measurements of anteversion ranging from 23° to 66° (Tables I and II).

The hips in our Group I and II patients all had a mean medial rotation in extension greater than 70° with marked restriction of lateral rotation. However, with the hip held in 90° of flexion we could distinguish between Group I hips in which medial rotation still markedly exceeded lateral rotation and Group II hips in which lateral rotation equalled or exceeded medial rotation, giving a highly significant difference (p < 0.001). Group III hips had approximately equal mean medial and lateral rotation in both flexion and extension, a finding in normal children agreed by many authors.

Computerised tomographic measurements of femoral anteversion gave results in Group I which were significantly greater than in Group II (p < 0.001) and in those reported for normal children of the same age. In contrast, femoral anteversion in Group II hips was comparable to, or only slightly greater than, the mean values reported for normal children, all hips in Group II having anteversion angles within two standard deviations of the mean normal values reported by Fabry et al. (1973).

Our findings suggest that, in addition to femoral anteversion, other factors may influence femoral rotation. McSweeny (1971) studied children with intoeing associated with excessive medial rotation in extension, and reported that one-third of the hips measured by biplanar radiography did not show abnormal anteversion. He suggested that abnormal acetabular rotation accounted for the intoeing gait in these children. Knight (1954) was unable to find radiographic evidence of increased femoral anteversion in many children with intoeing and markedly increased medial rotation in extension. He attributed their gait to shortening of the medial rotators or of the anterior joint capsule. Other factors reported to influence hip rotation in extension include abnormal acetabular shape (Kleiger 1968; LaGasse and Staheli 1972; Engel and Staheli 1974; Reikerás and Bjerkreim 1982), inclination of the pelvis (Kleiger 1968; Engel and Staheli 1974) and asymmetrical placement of the femoral head on the neck (Kleiger 1968).

We did not investigate the acetabulum, but it is conceivable that the excessive medial rotation in the Group II hips with relatively normal femoral anteversion was secondary to tight or contracted anterior soft-tissue structures about the hip. The increase in lateral rotation when the hip is tested in flexion supports this contention.

REFERENCES


