TIBIAL TORSION MEASURED BY ULTRASOUND IN CHILDREN WITH TALIPES EQUINOVARUS

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Previous clinical studies have studied tibiofibular torsion by measuring the angular difference between a proximal (often bicondylar) plane and a distal bimalleolar plane. We measured the angular difference between the proximal and distal posterior tibial planes as defined by ultrasound scans.

We found no significant torsional difference between the right and left tibiae of 87 normal children, nor between their different age groups.

The mean external torsion of 58 legs with congenital talipes equinovarus was 18°; significantly less than the mean 40° in the normal children and 27° in the clinically normal legs of the 22 patients with unilateral congenital talipes equinovarus. We did not confirm the previously reported increase in external torsion with increasing age.

The relative internal tibial torsion we have demonstrated in patients with congenital talipes equinovarus must be differentiated from the posterior displacement of the distal fibula observed by others and which may result from manipulative treatment.

The relative internal tibial torsion we found in the clinically normal legs of children with congenital talipes equinovarus is further evidence that in this condition the pathology is not confined to the clinically affected foot.

An inward deviation of the forefoot in the transverse plane, which produces intoeing, may be brought about by deformity within the foot such as adduction of the metatarsals or an inward curvature of the talus and calcaneus. Alternatively, in the growing child, deforming forces might cause an inward twist at the level of the ankle, in which case the deformity would be accompanied by forward displacement of the distal fibula in the fibular notch. Similar forces, resulting from a baby lying prone with hips and knees flexed, and feet turned in under the buttocks, may produce true internal torsion of the tibia with the positions of the malleoli remaining undisturbed in their relation to each other. In either case, whether the deformity is at the level of the ankle, or in the tibia itself, the axis of the tibiotalar articulation is internally rotated in respect to the axis of the knee.

In congenital talipes equinovarus (CTEV) pathological adduction of the metatarsal and tarsal bones is well recognised (Irani and Sherman 1963; Ritsilä 1969). However, there has been less agreement about the anatomy of the ankle and the tibia. Previous studies have examined the relationship of the proximal bicondylar axis to the bimalleolar axis (Fig. 1). Hutchins et al (1986)
concluded that in CTEV there was a diminution of the normal external torsion seen after birth. However, Wynne-Davies (1964b) and Herold and Marcovich (1976) found no difference, and Swann, Lloyd-Roberts and Catterall (1969) described an increased external rotation of the talus within the mortice, which they attributed to persistent attempts to manipulate the foot into eversion.

The problem of whether the tibia has an abnormal torsion in CTEV can only be solved by measuring the relative alignment of its proximal and distal articular surfaces; this has not proved possible in vivo. However, CT scans and ultrasonography have both been used to produce images of the proximal and distal juxta-articular surfaces of the tibia (Jend et al 1981; Joseph et al 1987). These surfaces are thought to relate closely to the plane of the nearby joint, and can therefore be used to measure tibial torsion. As ultrasonography involves no ionising radiation we used it in this study of tibial torsion in normal children, and in those with CTEV.

**PATIENTS**

All consenting patients with rigid CTEV who attended the orthopaedic clinic at Alder Hey Children’s Hospital from 1987 to 1989 were eligible for inclusion in this study. Those with normal calf and foot size were excluded. All had been treated in infancy by manipulation and strapping, supplemented in some patients by a caliper or orthosis, or by surgical release. Eighty-seven normal children attending the hospital with injuries other than to the tibia or fibula participated in the study as normal controls.

**METHODS**

The child lay prone on a firm table with the leg supported motionless by a seated assistant. The 7.5 MHz probe of a real time ultrasound scanner was maintained in a vertical position for the proximal and distal measurements using
Table I. The mean angular difference between the proximal and distal posterior tibial planes of the legs of 87 normal children

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Mean angle ± SD (degrees)</th>
<th>Number of legs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>40 ± 5.1</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>39 ± 9.2</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>40 ± 8.2</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>41 ± 7.6</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>41 ± 7.7</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>42 ± 7.9</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>41 ± 7.7</td>
<td>18</td>
</tr>
<tr>
<td>11</td>
<td>44 ± 7.9</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>42 ± 6.1</td>
<td>14</td>
</tr>
<tr>
<td>13</td>
<td>38 ± 7.2</td>
<td>14</td>
</tr>
<tr>
<td>14</td>
<td>39 ± 5.7</td>
<td>12</td>
</tr>
<tr>
<td>15</td>
<td>38 ± 7.6</td>
<td>12</td>
</tr>
</tbody>
</table>

Table II. The mean angular difference between the proximal and distal posterior tibial planes of 40 children with CTEV

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of legs</th>
<th>Mean angle ± SD (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>174</td>
<td>40.5 ± 6.7</td>
</tr>
<tr>
<td>CTEV affected leg</td>
<td>58</td>
<td>18.0 ± 10.0</td>
</tr>
<tr>
<td>CTEV normal leg</td>
<td>22</td>
<td>27.6 ± 8.8</td>
</tr>
</tbody>
</table>

An attached spirit level (Fig. 2). This and other details of the technique were as described by Joseph et al (1987). The angular difference between the proximal and distal posterior tibial planes was determined by scans immediately distal to the proximal tibial articular surface and just proximal to the ankle (Fig. 3).

Three paired readings were made on each limb, by each of two investigators. These investigators also separately examined the legs of a group of 10 normal children to provide information on inter-observer error.

Statistical analysis was by Statmode I and Oxstat on an Amstrad PC 1512.

RESULTS

It proved impossible to measure tibial torsion in children under the age of four years. Our results are based on measurements of children aged four to 15 years, 87 with normal legs and 40 with rigid CTEV.

Observer error. One observer measured the same child’s leg 10 times. He recorded an external torsion of 34.5°, with a standard deviation of 1.8° and with 95% confidence limits ± 1.3°. There was no significant difference in the measurements of 10 normal left tibiae when performed by the two investigators (means: 34.6° and 34.8°; SD, 10.2° and 9.4°; 95% confidence limits, ± 3.8° and ± 3.5° respectively). The correlation between the two investigators was confirmed by one-way analysis of variance.

Normal children. The distal posterior tibial plane was found to be externally rotated in relation to the proximal. Combining readings from right and left legs, the mean external torsion was 40.5° (SD 6.8°). There was no significant difference in the mean angle at different ages (Table I), nor between the mean angle of right legs (41.2°, SD 7.0°) and left legs (39.9°, SD 6.3°).

Children with CTEV. The mean external torsion of the tibia in the affected leg or legs of children with CTEV was 18° (SD 10.0°) (Table II), significantly less than the 40.5° mean angle in control legs (t = 15.9, p < 0.001). The external torsion in the affected tibiae was also less than the 27.6° mean angle of the clinically normal legs (t = 3.9, p < 0.001). However, in these apparently normal legs, the external torsion was significantly reduced as compared to the torsion in tibiae of normal children (t = 8.2, p < 0.001). Thus, the children with talipes equinovarus had a relative internal rotation of both the affected and the unaffected legs as compared to normal children and this internal torsion was more marked in the affected leg.

DISCUSSION

Normal children. It is generally agreed that clinical methods for measuring tibiofibular torsion are subject to a wide range of inter-observer error (Luchini and Stevens 1983). They all use the bimalleolar plane as the distal line of reference; the malleoli are not easily defined, and the fibula is potentially mobile within the fibular notch (Khermosh, Lior and Weissman 1971).

Joseph et al (1987) reported the results of many of the previous studies of tibiofibular torsion. Methods using a torsionometer applied to the malleoli produced mean values in normal children of less than 20° (Wyne-Davies 1964b; Turner and Smillie 1981). These results were confirmed by Hutchins et al (1986) who used computerised tomography (CT).

Measurements of torsion in which the posterior tibial surfaces are defined by CT scans or ultrasound, are more accurate (Butler-Manuel, Guy and Heatley 1990). Jend et al (1981) using computerised tomography, found an outward tibial torsion of 40° ± 9° in normal legs. Joseph et al (1987) first described the method used in the present work, and found an external torsion of 39.9° in normal adults, and 40.5° in normal children. Their 95% probability limit for the accuracy of an individual value was 8.2°. Our measurement of 40.5° external torsion in children from Liverpool coincides with that reported by Joseph et al (1987). With 95% confidence limits of 3.5°
and 3.8° for the two investigators, we believe the method to be accurate and reproducible.

Thus, in the normal child, the bimalleolar plane is externally rotated less than is the posterior surface of the tibia (Fig. 1).

Hutchins et al (1986) found that the bimalleolar plane became more externally rotated during growth, the torsion being only about 10° in the neonate, confirming reports of others who have used the malleoli as the distal reference plane (Ritter, De Rosa and Babcock 1976; Staheli et al 1985). Our failure to demonstrate an increase in the tibial torsion with increasing age in normal children over four years old, may reflect inadequate numbers in each age group or it may be that the observed increase in tibiofibular torsion is due to progressive posterior displacement of the distal fibula in the fibular notch and not to an increase in true tibial torsion.

**Children with talipes equinovarus.** Our results show that external torsion is diminished in both the affected and in the clinically normal legs of patients with CTEV. Thus they have a relative internal tibial torsion, despite treatment involving repeated dorsiflexion and eversion. We believe such manipulation may be responsible for the clinical observation of posterior displacement of the distal fibula (Swann et al 1969). Wynne-Davies (1964a) reported such displacement as seen on lateral radiographs of the feet of patients with CTEV. However, for such views the radiographer places the plate parallel with the forefoot, and any residual foot adduction may lead to an apparent posterior displacement of the fibula (Simmons 1978).

If manipulation leads to fibular displacement it may also be responsible for the late stiffness found in the feet of children with CTEV. We hope in the future to define fibular position at various stages during therapy using ultrasound or CT scans in the transverse plane. External tibial osteotomy is only appropriate in these rare instances of marked internal torsion which are not associated with posterior fibular dislocation.

The demonstration of relative internal torsion in the clinically normal legs of patients with unilateral CTEV provides further evidence that the pathology is not confined to the affected limb. The family studies of Wynne-Davies (1964a) led to the suggestion that both genetic and environmental factors are responsible for the disorder and this appears to be supported by our results.

In the absence of anthropometric data on the length or torsion of upper limb bones, we postulate that a genetic defect causes a mesenchymal disorder of the lower limbs, producing some degree of internal torsion. This may be accentuated in the clinically affected limb by intrauterine position, or if the child sleeps in a prone position with the lateral aspect of a deformed foot resting on the mattress. Alternatively the genetic defect may find greater expression on the affected side.

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**REFERENCES**


