METATARSUS PRIMUS VARUS

A STATISTICAL STUDY

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A survey of 6000 schoolchildren discovered 36 cases of unilateral and 60 cases of bilateral hallux valgus, defined as a metatarsophalangeal angle of more than 14.5°, measured on standing radiographs. Metatarsus primus varus was found not only in the early stages of hallux valgus but in the unaffected feet of children with unilateral hallux valgus.

Adduction of the first metatarsal is not due to differential growth of the cortices of the first metatarsal nor is it a consequence of malalignment of the metatarsocuneiform joint. The intermetatarsal angle did not correlate with the angle of metatarsus adductus nor with the intercuneiform angle.

The angle between the first and second metatarsals has long been considered an important factor in the development of hallux valgus. Truslow (1925) believed that the increased intermetatarsal angle which he labelled metatarsus primus varus was congenital, and that it inevitably resulted in hallux valgus.

In their statistical survey of normal and hallux valgus feet, Hardy and Clapham (1951) found that the most consistent correlation in all their data was the association between the severity of hallux valgus and the magnitude of the intermetatarsal angle (r = 0.71). Lundberg and Sulja (1972) found a similar correlation but were cautious about interpreting the relationship in aetiological terms. Piggot (1960), however, contradicted the widely held belief that metatarsus primus varus was the underlying cause of hallux valgus, noting that some cases of hallux valgus had normal intermetatarsal angles.

Hawkins, Mitchell and Hedrick (1945) suggested that bunion operations failed because of inadequate correction of the intermetatarsal angle, while Antrobus (1984), who performed Keller's arthroplasty on both adolescent and adult bunions, noticed that postoperatively the increased intermetatarsal angle returned to normal, and concluded that the metatarsal deviation was secondary to the hallux valgus. The secondary role of the intermetatarsal angle was also supported by the biomechanical studies of Snijders, Snijders and Philippens (1986) who thought that in hallux valgus the proximal phalanx acted like a wedge, pushing the first metatarsal into varus. The results of a number of studies on these angles are given in Table I.

Our study was aimed at determining the aetiological importance of the intermetatarsal (IM) angle by comparing the angle in the affected foot of children with unilateral hallux valgus with the angle in the unaffected feet. Since hallux valgus usually becomes a bilateral deformity we presume that the unaffected feet, in such children, are at risk and that both feet should have increased intermetatarsal angles if abnormality of that angle is the primary defect. We have also examined the radiographs of children with hallux valgus to try to discover the cause of the increased intermetatarsal angle.

PATIENTS AND METHOD

A total of 6000 ten-year-old schoolchildren were screened by the Kettering Chiropody Department. Of these, 310 were thought to have hallux valgus and their metatarsophalangeal (MTP) angles were measured with a goniometer. Just under half (150) these children demonstrated the two criteria necessary for radiographic examination, namely, hallux valgus angle in excess of 15° and a visible bunion.

The radiographic criterion of hallux valgus was an
MTP angle of more than 14.5° measured on a dorsoplantar radiograph taken with the child standing comfortably on both feet. The X-ray beam, directed at 15° from the vertical, was aimed at the navicular. The focus to film distance was 100 cm. A foot was classified as normal if the MTP angle was 14.5° or less.

Of the 150 children having radiographs, 96 (1.6% of the number screened) were found to have hallux valgus of one or both feet; 36 had unilateral hallux valgus and 60 bilateral. Most of the children were female (86%). None of the boys had bilateral hallux valgus, but 36% of the unilateral cases were male. Only the left foot was involved in 17 children (11 male); and only the right foot in 19 (two male).

The mean MTP angle was calculated for left and for right feet and the statistical significance of the difference was estimated using a one-tailed t-test.

The IM angle was measured between lines bisecting the shafts of the first and second metatarsals and the mean angles for right and left feet were calculated. A

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**Table 1. Mean values for hallux valgus and intermetatarsal angles**

<table>
<thead>
<tr>
<th>Study</th>
<th>Age</th>
<th>Number of feet</th>
<th>Mean hallux valgus (degrees)</th>
<th>Mean IM angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallux valgus feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hawkins et al (1945)</td>
<td>Adults</td>
<td>55</td>
<td>-</td>
<td>13.8</td>
</tr>
<tr>
<td>Hardy and Clapham (1951)</td>
<td>40 (mean)</td>
<td>165</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>Carr and Boyd (1968)</td>
<td>&lt; 18</td>
<td>56</td>
<td>-</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>&gt; 18</td>
<td>24</td>
<td>-</td>
<td>14.2</td>
</tr>
<tr>
<td>Antrobus (1984)</td>
<td>45 (mean)</td>
<td>183</td>
<td>36.9</td>
<td>12.7</td>
</tr>
<tr>
<td>Durman (1957)</td>
<td>41 (mean)</td>
<td>448</td>
<td>-</td>
<td>12.8</td>
</tr>
<tr>
<td>Kilmartin et al (1991)</td>
<td>10</td>
<td>120</td>
<td>19.7 (SD 4.1)</td>
<td>10.56 (SD 2.2)</td>
</tr>
<tr>
<td>Normal feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hawkins et al (1945)</td>
<td>Adults</td>
<td>50</td>
<td>-</td>
<td>5 to 6</td>
</tr>
<tr>
<td>Hardy and Clapham (1951)</td>
<td>22 (mean)</td>
<td>252</td>
<td>15.7</td>
<td>8.8</td>
</tr>
<tr>
<td>Antrobus (1984)</td>
<td>42 (mean)</td>
<td>71</td>
<td>18.7</td>
<td>9</td>
</tr>
<tr>
<td>Durman (1957)</td>
<td>30 (mean)</td>
<td>797</td>
<td>-</td>
<td>8.2</td>
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<tr>
<td></td>
<td>6 to 10</td>
<td>74</td>
<td>-</td>
<td>7.2 (SD 4.5)</td>
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<td>At risk normals</td>
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<td></td>
<td></td>
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<tr>
<td>Kilmartin et al (1991)</td>
<td>10</td>
<td>36</td>
<td>11.7 (SD 1.9)</td>
<td>9.1 (SD 1.5)</td>
</tr>
</tbody>
</table>

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Figure 1 – Length of the lateral cortex of the first metatarsal. The long axis of the first metatarsal is bisected (line A). A perpendicular line bisects the tibial sesamoid (line B). The base of the metatarsal is defined (line C). A ruler is placed flush against the cortex and distance B, C measured. Figure 2 – The metatarsus adductus angle measures the position of the lesser tarsus relative to the midfoot. Line D is between the most distal medial point of the first cuneiform and the proximal point of the navicular. Line E links the distal and proximal lateral points of the cuboid. Line F connects the halfway points of lines D and E. The angle between line F and the second metatarsal bissection gives the metatarsus adductus angle. Figure 3 – The cuneiform angle (C) is that between a line drawn flush with the distal articular surface of the first cuneiform and the long axis bisection of the first metatarsal. Long axis bisections of the medial and intermediate cuneiforms (lines K and J) provided the intercuneiform angle (I).
two-tailed $t$-test was used to estimate the significance of the difference in angle between the hallux valgus and the normal feet. A 95% confidence interval was calculated for the mean increase in the IM angle on the hallux valgus side.

A $t$-test was performed to determine whether the IM angle of the unaffected foot, in unilateral hallux valgus, was significantly different from the angle in the 74 normal feet described by Durman (1957). We used similar methods to compare the IM angles of the children with bilateral hallux valgus with the angles of the unaffected and the affected feet of the unilateral group.

The length of the lateral cortex of the first metatarsal (Fig. 1) and the metatarsus adductus angle (M in Fig. 2) were measured on all radiographs. A third angle, the cuneiform angle (C in Fig. 3) measured the obliquity of the metatarsocuneiform joint (Fig. 3) and the intercuneiform angle (I in Fig. 3) measured the divergence of the long axes of the medial and the intermediate cuneiforms, to determine whether splaying of the first cuneiform could account for an increased intermetatarsal angle.

The Pearson correlation test was used to determine the association between the length of the lateral cortex of first metatarsal and the magnitude of the intermetatarsal angle. The correlation between the cuneiform angle, the intercuneiform angle and the intermetatarsal angle was similarly tested as was the association between the metatarsus adductus angle and the intermetatarsal angle and that between the metatarsus adductus angle and the metatarsophalangeal angle.

Finally a $t$-test compared the metatarsus adductus and cuneiform angles in the bilaterally and in the unilaterally affected feet.

RESULTS

Study 1. In the 36 children with unilateral hallux valgus the mean MTP angle in the affected foot was 18.95° (SD 3.2); in the unaffected foot it was 11.3° (SD 2.4). The difference is significant ($p < 0.0005$). The mean IM angle in the affected foot was 10.04° (SD 1.7); in the unaffected foot it was 9.1° (SD 1.5). The IM angle was on average 1.2° greater in the hallux valgus foot. The 95% confidence interval for the mean difference between the affected and the unaffected foot was 0.3° to 2°. The two-tailed $t$-test indicated that the observed difference was significant ($p < 0.01$).

We conclude that in cases of unilateral hallux valgus the IM angle is slightly (but significantly) greater in the affected foot.

Study 2. In the 60 children with bilateral hallux valgus (120 feet) the mean intermetatarsal angle was 10.56° (SD 2.2). This angle does not significantly differ ($p > 0.05$) from the IM angle of the affected feet in the unilateral group; it is, however, significantly greater ($p < 0.01$) than the IM angle in unaffected feet in the unilateral group.

Study 3. In the normal population of six to ten-year-old children studied by Durman (1957) the mean IM angle was 7.2° (SD 4.47). This value is very significantly smaller ($p < 0.001$) than the mean IM angle (9.1°) for the unaffected feet in our unilateral group. The 95% confidence interval for the difference between the mean IM angles of the two samples is 0.9° to 3.5°.

Study 4. Little or no association was found between the length of the lateral cortex and the magnitude of the IM angle. Using the bilateral cases the Pearson correlation was found to be $r = -0.035$ ($p > 0.05$).

Study 5. In the children with bilateral hallux valgus there was no correlation between the IM angle and the angle of metatarsus adductus (Pearson correlation $r = -0.2$, $p > 0.05$). Nor was there a significant difference between the mean metatarsus adductus angle in the bilateral group and that of the undeformed feet of the unilateral group ($p > 0.05$).

The Pearson correlation between the metatarsus adductus angle and the MTP angle was $r = 0.26$ ($p < 0.01$).

Study 6. In the bilateral group there was no significant association between the IM angle and the cuneiform angle ($r = -0.07$, $p > 0.05$). The alignment of the first metatarsal is clearly not determined by that of the metatarsocuneiform joint. The mean cuneiform angle of the bilaterally affected feet did not differ from that for the unilaterally affected feet ($p > 0.05$).

Nor did the intercuneiform angle correlate with the IM angle ($r = 0.16$). Splaying of the cuneiforms cannot be blamed for high IM angle values.

DISCUSSION

Hallux valgus is usually a bilateral deformity (Hardy and Clapham 1951) and children who present with one foot affected must, on the basis of this general observation, be considered at risk of developing deformity in the other. If an increased intermetatarsal angle is the primary defect of hallux valgus, it would be logical to expect that the IM angle in the at-risk foot would be greater than in the feet of normal children, and the results of our study 3 show that this is so. However, as the hallux valgus develops there appears also to be a secondary increase in the IM angle; this was shown by our study 1.

Follow-up studies of children with unilateral hallux valgus will be needed to confirm that the increased IM angle in the unaffected feet predicts their later development of hallux valgus.

Our findings lead us to consider the cause of the increased IM angle. The fact that the length of the lateral cortex and the IM angle correlated poorly indicates that it is not due to disturbed growth of the first metatarsal. Similarly, adduction of the medial cuneiform away from the intermediate cuneiform cannot be considered a predisposing factor, for the intercuneiform angle correlated poorly with the intermetatarsal angle.
Metatarsus adductus has been considered significant by a number of authors, some of whom have reported a direct association between the angle of metatarsus adductus and the degree of hallux valgus (Root, Orien and Weed 1977; La Reaux and Lee 1987). This theory suggests that adductus of the forefoot puts the first metatarsophalangeal joint at greater risk of a valgus deforming force applied by footwear. Our study overturns this theory since we found a poor and probably irrelevant correlation between metatarsus adductus and hallux valgus. Our finding of a weak association between metatarsus adductus and the intermetatarsal angle suggests that an increased intermetatarsal angle is not a consequence of congenital derangement of the whole forefoot.

Although we have failed to discover the cause of an increased intermetatarsal angle we have shown that deformity of the first metatarsal and displacement of the cuneiform bones are both unlikely contenders. The aetiology is unlikely to be detected by further radiographic measurement of the angular relationships of the foot bones. Future investigations should rather address the role of the soft tissues in the development of hallux valgus.

Conclusions. An increased intermetatarsal angle is present in the early stages of juvenile hallux valgus and in feet at risk of developing that deformity. Follow-up of feet at risk will be needed to determine whether the raised intermetatarsal angle is in fact the primary defect of hallux valgus.

The increased intermetatarsal angle is not the consequence of intercuneiform splaying, metatarsus adductus, disproportionate growth of the first metatarsal, nor of deformity of the medial cuneiform. The seat of the deformity and thus the most appropriate point for its correction has yet to be confirmed.

The authors gratefully acknowledge the Chiropody Department of Kettering Health Authority for screening 6000 children and Dr D. Woods, FRCR, for help with the radiography. This study was supported by an Oxford Region Local Research Grant.

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


