We studied the effect of trochanteric osteotomy in 192 total hip replacements in 140 patients with congenital hip disease. There was bony union in 158 hips (82%), fibrous union in 29 (15%) and nonunion in five (3%). The rate of union had a statistically significant relationship with the position of reattachment of the trochanter, which depended greatly on the pre-operative diagnosis. The pre-operative Trendelenburg gait substantially improved in all three disease types (dysplasia, low and high dislocation) and all four categories of reattachment position. A persistent Trendelenburg gait post-operatively was noticed mostly in patients with defective union (fibrous or nonunion). Acetabular and femoral loosening had a statistically significant relationship with defective union and the position of reattachment of the trochanter.

These results suggest that the complications of trochanteric osteotomy in total hip replacement for patients with congenital hip disease are less important than the benefits of this surgical approach.

The lateral transtrochanteric approach for total hip replacement (THR) was introduced by Charnley, who suggested that it would not only facilitate access to the joint but might also restore normal biomechanics by advancing the greater trochanter distally and laterally, thereby creating a more powerful abductor mechanism. However, most surgeons use trochanteric osteotomy selectively, mainly in difficult primary and revision THRs.

We have used the transtrochanteric approach since 1973 in all our patients with congenital hip disease. According to the classification of Hartofilakis et al., there were 34 dysplastic hips, 93 with low dislocation and 65 with high dislocation. The mean age of the patients at operation was 50 years (23 to 77). The mean age of those with dysplasia was 51 years (24 to 68), those with low dislocation 43 years (27 to 77) and those with high dislocation 47 years (23 to 70). A low-friction arthroplasty was used in 143 cases and a hybrid THR with a cementless acetabular component and cemented femoral component in 49. Prior to 1985, a single-plane trochanteric osteotomy using a Gigli saw was performed, and thereafter a broad, thin osteotome was used. For reattachment of the trochanter we applied the two-wires technique of Eftekhar, using a vertical double cross-over and a transverse single wire without a compressing spring. The wires were stainless steel (316L), 1.2 mm in diameter in 54 cases and 1.4 mm in 138 cases. All patients were limited to partial weight-bearing until the trochanter was radiologically healed.

Patients and Methods

Between 1973 and 1996, 219 consecutive THRs in 162 patients with osteoarthritis secondary to congenital hip disease were performed by the same surgeon (GH) using a transtrochanteric approach. A total of 17 patients (22 hips) with follow-up of less than ten years and five (five hips) who developed post-operative infection were excluded, leaving 140 patients (134 women, six men; 192 hips) for evaluation.

According to the classification of Hartofilakis et al., there were 34 dysplastic hips, 93 with low dislocation and 65 with high dislocation. The mean age of the patients at operation was 50 years (23 to 77). The mean age of those with dysplasia was 51 years (24 to 68), those with low dislocation 43 years (27 to 77) and those with high dislocation 47 years (23 to 70). A low-friction arthroplasty was used in 143 cases and a hybrid THR with a cementless acetabular component and cemented femoral component in 49. Prior to 1985, a single-plane trochanteric osteotomy using a Gigli saw was performed, and thereafter a broad, thin osteotome was used. For reattachment of the trochanter we applied the two-wires technique of Eftekhar, using a vertical double cross-over and a transverse single wire without a compressing spring. The wires were stainless steel (316L), 1.2 mm in diameter in 54 cases and 1.4 mm in 138 cases. All patients were limited to partial weight-bearing until the trochanter was radiologically healed.

Patients who retained the original implants had a minimum clinical and radiological follow-up of ten years (10 to 34). Cases that were revised had clinical and radiological follow-up to the time of revision.

The following parameters were investigated: The position of reattachment relative to the original bed of the trochanter. Four categories were recognised: (a) reattachment at the original bed of trochanteric osteotomy (Fig. 1a); (b) distal reattachment in relation to its original
bed, the trochanter having contact with the distal part of the original bed (Fig. 1b); (c) reattachment on the lateral femoral cortex in cases where the femoral neck was resected to the level of the lesser trochanter (Fig. 1c); and (d) reattachment proximal to its original bed (Fig. 1d).

Union. The trochanter was considered to be radiologically healed based on trabecular continuity between the trochanteric fragment and the femur. Fibrous union was defined as a persistent radiolucent gap < 15 mm, and nonunion in gaps larger than that.8

The presence of heterotopic ossification. This was assessed according to Brooker’s classification.9 Only type IV was considered to be significant because the functional results of THR are not affected unless ankylosis occurs.

We also investigated breakage of the wires and migration of wire fragments, and early and late clinical consequences that may be linked to the trochanteric osteotomy, such as dislocation, nerve palsy, bursitis, persistent Trendelenburg gait, aseptic loosening of the components in relation to the position of the reattached trochanter and rate of union of the trochanteric osteotomy.

Statistical analysis. The chi-squared test was used to evaluate the associations between two categorical variables. Statistical significance was set at $p < 0.05$.

Results

Position of reattachment. The trochanter was reattached on its original bed in 72 hips (38%), 23 of which were dysplastic, 38 with low dislocation and 11 with high dislocation. There was distal reattachment of the trochanter in 33 hips (17%), of which five were dysplastic, 18 with low dislocation and ten with high dislocation. In 25 hips (13%), two with low and 23 with high dislocation, the trochanter was reattached on the lateral cortex of the femur. Proximal reattachment was undertaken in 62 hips (32%); six dysplastic, 35 with low and 21 with high dislocation. Optimal reattachment (original bed or distal) was obtained in 82% (28 of 34) of the dysplastic hips, 60% (56 of 93) of the hips with low dislocation and 32% (21 of 65) of those with high dislocation ($p < 0.001$).

Rate of union. Bony union was obtained in 158 hips (82%) fibrous union in 29 (15%) and nonunion in five (3%), of which two had a low and three a high dislocation. No patient with a fibrous union or nonunion needed further surgery for this problem. Early union during the first three months occurred in 103 hips (54%) and delayed union in 55 (29%). In the latter case the trochanter united between three and six months in 31 hips, between six and 12 months in 19 hips, and later than 12 months in five hips. The rate of union had a statistically significant relationship to the position of reattachment, with the lowest values being with proximal reattachment ($p < 0.001$).

Breakage and migration of the wires. Breakage of the wires occurred in 133 hips (69%): in 57 only the vertical wire was broken, in 22 only the transverse, and in 54 both wires were broken. They were broken in all but one of the five hips with nonunion, in all but one of the 29 hips with fibrous union, and in 101 of the 158 hips with united trochanters. Of the 101 hips with a united trochanter, the wires broke in 88 (87%) after union but in only 13 before union.

There was a statistically significant relationship between breakage of the wires and defective union ($p = 0.002$), but no relationship between breakage and the position of reattachment ($p = 0.086$).

Migration of wire fragments was seen in 37 hips. Most fragments migrated proximally or distally. In five cases migration was medially to the shaft of the femur and in four the wires were found near the acetabulum. Breakage of the wires had no significant adverse effect on pain and function.

Heterotopic ossification. Brooker type IV ossification was noticed in only three hips, resulting in complete ankylosis in
one hip and gross limitation of movement (flexion < 20°) in the other two.

**Dislocation.** Six hips (3%), five with high dislocation and one with low dislocation, dislocated between three and seven weeks post-operatively. In these cases the trochanter was reattached proximally in three hips, on the femoral cortex in two and *in situ* in one. Two of the dislocated hips were reduced under general anaesthesia, two required open reduction, and in two the acetabular component was revised. In all six hips dislocation occurred before union of the trochanter, but this was achieved after reduction of the dislocation. Five of the dislocated hips had a hybrid THR.

**Leg lengthening.** In the 65 cases of high dislocation there was a mean leg lengthening of 3.5 cm (1 to 6).

**Nerve palsy.** Post-operative nerve palsy was noticed in five patients (3%), three with high dislocation and two with low dislocation. There were three cases of femoral nerve palsy, one peroneal nerve palsy and one with palsy of both nerves. Two of the femoral nerve palsies resolved completely within six months, while only partial recovery was observed in two. One peroneal nerve palsy resolved completely and one partially. In the three patients with high dislocation and post-operative nerve palsy, the limb length was increased by 3.0 cm, 3.5 cm and 4.0 cm, respectively.

**Bursitis.** There were 26 patients (14%) with symptomatic trochanteric bursitis; 19 were treated with non-steroidal anti-inflammatory drugs and six with local injection of steroids. In one patient with persistent pain the wires were removed. All patients remained pain-free after treatment.

**Trendelenburg sign.** This was positive immediately pre-operatively in five of the 34 dysplastic hips, 37 of the 93 hips with low dislocation, and all 65 hips with high dislocation. At the latest follow-up the sign became negative in four of the five hips with dysplasia, 24 of the 27 with low dislocation and 40 of the 65 with high dislocation. The improvement of the Trendelenburg gait was statistically significant in all three types of the disease (Table I) and in all four categories of reattachment of the trochanter (Table II). A persistent Trendelenburg gait was noticed post-operatively more often in patients with defective union (*p* = 0.006, Table III).

**Aseptic loosening.** A total of 71 THRs (37%; 55 Charnley low-friction arthroplasties and 16 hybrids) were revised for aseptic loosening: 42 (33 of the Charnley type and nine

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**Table I.** Improvement of Trendelenburg sign in relation to diagnosis

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>Improvement (%)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysplasia (34)</td>
<td>5</td>
<td>1</td>
<td>4 (80)</td>
<td>0.015</td>
</tr>
<tr>
<td>Low dislocation (93)</td>
<td>37</td>
<td>13</td>
<td>24 (65)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>High dislocation (65)</td>
<td>65</td>
<td>25</td>
<td>40 (62)</td>
<td>N/A†</td>
</tr>
</tbody>
</table>

* *p* = 0.695 for comparison between the rates of improvement
† the *p*-value cannot be estimated because all patients pre-operatively had a positive Trendelenburg sign

**Table II.** Improvement of Trendelenburg sign in relation to position of reattachment of the trochanter

<table>
<thead>
<tr>
<th>Trochanteric position of reattachment (number of hips)</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>Improvement (%)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original bed (72)</td>
<td>29</td>
<td>11</td>
<td>18 (62)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Distal (33)</td>
<td>13</td>
<td>5</td>
<td>8 (62)</td>
<td>0.003</td>
</tr>
<tr>
<td>Femoral cortex (25)</td>
<td>25</td>
<td>7</td>
<td>18 (72)</td>
<td>N/A†</td>
</tr>
<tr>
<td>Proximal (62)</td>
<td>40</td>
<td>16</td>
<td>24 (60)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* *p* = 0.792 for comparison between the rates of improvement
† the *p*-value cannot be estimated because all patients pre-operatively had a positive Trendelenburg sign

**Table III.** Improvement of Trendelenburg sign in relation to trochanteric union

<table>
<thead>
<tr>
<th>Union of the trochanter (number of hips)</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>Improvement (%)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union (158)</td>
<td>81</td>
<td>25</td>
<td>56 (69)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Fibrous union (29)</td>
<td>21</td>
<td>9</td>
<td>12 (57)</td>
<td>0.026</td>
</tr>
<tr>
<td>Nonunion (5)</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>N/A†</td>
</tr>
</tbody>
</table>

* *p* = 0.006 for comparison between the rates of improvement
† the *p*-value cannot be estimated because all patients pre-operatively had a positive Trendelenburg sign
hybrids) for both components, 16 (14 of the Charnley type and two hybrid) for the acetabular component only and 13 (eight Charnley type and five hybrids) for the femoral component only. Therefore, 58 acetabular components (30%; 47 cemented and 11 cementless) and 55 cemented femoral components (29%) were revised for aseptic loosening at a mean of 17 years (5 to 28) and 16 years (5 to 28), respectively, from the index operation. A further seven hybrid hips had exchange of the polyethylene liner because of excessive wear.

Aseptic loosening was observed in 13 of the 34 hips (38%) with dysplasia, 35 of the 93 (38%) with low dislocation and 23 of the 65 (35%) with high dislocation (p = 0.940). The incidence of prosthetic loosening in relation to the rate of trochanteric union and position of trochanteric reattachment is presented in Tables IV and V. The position of reattachment was significantly associated with the rate of aseptic loosening of both the acetabular (p = 0.001) and femoral components (p = 0.003). There was also a statistically significant relationship between defective union of the trochanter and aseptic loosening of both the acetabular (p = 0.01) and femoral components (p = 0.021).

**Discussion**

Charnley1,10 initially recommended the transtrochanteric approach for all THRs. He believed that the problems arising from restricted exposure during surgery might lead to complications more serious than those occurring from the osteotomy itself. He insisted that all orthopaedic surgeons should learn this approach, which would be needed in difficult hips and for revision operations. Although the majority of surgeons today prefer to use other approaches in routine primary cases, this method remains safe and effective in certain instances, including congenital hip disease (Fig. 2), revision surgery, stiff hips, protrusio acetabuli and severe osteoporosis. These conditions affect between 20% and 30% of patients referred for arthroplasty surgery.7

Congenital hip disease presents with both bony and soft-tissue abnormalities. The restoration of the correct centre of rotation during THR is essential for hip biomechanics and survival of the prostheses.3 Transtrochanteric osteotomy is helpful for wide exposure of the hip and reconstruction of distorted anatomy of the acetabulum and proximal femur. Moreover, lateral reattachment of the trochanter increases the abductor lever arm and minimises the reaction forces acting on the acetabulum.3,7

We used the transtrochanteric approach in all our cases. In those with high dislocation, trochanteric osteotomy was performed in combination with shortening of the femur by progressive resection of the femoral neck. We argue against preserving the greater trochanter and shortening of the femur by a subtrochanteric, diaphyseal or distal osteotomy,11-17 because in most cases of high dislocation the greater trochanter is more cranial than the centre of rotation of the femoral head, and its resection and advancement is essential.18,19 Also, the creation of an artificial intraoperative fracture of the femur may cause undesirable complications. Comparison of the different techniques of femoral shortening is difficult because in various papers suggesting subtrochanteric or distal osteotomy,11-17 because in most cases of high dislocation the greater trochanter is more cranial than the centre of rotation of the femoral head, and its resection and advancement is essential.18,19 Also, the creation of an artificial intraoperative fracture of the femur may cause undesirable complications. Comparison of the different techniques of femoral shortening is difficult because in various papers suggesting subtrochanteric or distal osteotomy, there are differences in the types of hips, numbers and ages of patients, follow-up periods and parameters under investigation.11-17

The limitation of our study is that it is longitudinal rather than randomised. Nevertheless, although there are several publications referring to the indications and contraindications, technical details and complications of trochanteric osteotomy in THR, to our knowledge there are no specific studies of the importance of trochanteric osteotomy in THR for patients with congenital hip disease.
In patients with the disease, reattachment of the osteotomised trochanter is not always easy. The difficulties relate to shortened abductor muscles, an often small and malpositioned trochanter and a lengthened limb. Charnley initially recommended reattachment of the trochanter distal to its original bed. However, surgeons who continue to use trochanteric osteotomy prefer to reattach it in its original bed or in a slightly distal position. In our series, this was successful in 28 dysplastic hips (82%) but in only 56 hips with low dislocation (60%) and 21 hips (32%) with high dislocation.

In hips where the femoral neck was resected at the level of the lesser trochanter (25 hips), the trochanteric fragment had to be reattached to the lateral femoral cortex. Proximal reattachment is undesirable but may be technically unavoidable, as was the case in 21 hips with high dislocation (32%), 35 with low dislocation (38%) and in six with dysplasia (18%). This emphasises the technical difficulties of THR, and, regardless of the three types of congenital hip disease, the reattached trochanter may not always be in the most desirable position. In some stiff hips with high dislocation and others with dysplasia the technical difficulties may exceed those for hips with high dislocation. The position of reattachment of the trochanter is of the utmost importance, as it may affect the rate of union of the trochanteric fragment. In our series the relationship between these parameters was statistically significant.

Trochanteric nonunion has remained a problem, with reported rates of up to 17% in routine arthroplasties. In our series of patients with congenital hip disease, the rates of fibrous union and nonunion were 15% (29 hips) and 3% (five hips), respectively. Nine patients with fibrous union and all five with nonunion had a positive Trendelenburg gait. However, none of the patients with defective union had a dislocation or needed further surgery. It was noted by Eftekhar that those surgeons performing trochanteric osteotomy routinely obtain a better rate of union than those reserving the procedure for cases with difficult anatomical problems.

There were no significant undesirable effects with regard to pain and/or function associated with broken wires in this series. However, there was concern where migration was medial to the shaft or near the acetabulum, because of the possibility of complications such as third body wear or vascular or neurological damage. It is of interest that, of the 101 hips with broken wires and trochanteric union, the wires were broken after union of the trochanter in 88 hips (87%), and in only 13 did the wires break before union. This is not surprising if the time to union of only a few months is compared with breakage years later as a result of continual movements imposed by the surrounding soft tissues.

Although different authors have reported that trochanteric osteotomy increases the risk of heterotopic ossification, Brooker et al stated that unless there was ankylosis (Brooker IV), the functional result is not affected. In our series, Brooker grade IV heterotopic ossification was seen in only three hips (2%).

It is suggested that the surgical approach affects the rate of post-operative dislocation and that the trans-trochanteric approach produces the lowest rate of dislocation. Of the 192 hips in this study, dislocation occurred in six cases (3%), five of which were of the 49 hybrid THRs (10%), but in only one hip (0.7%) of the 143 low-friction arthroplasties. This can be explained by the fact
that in the five cases of dislocation in the hybrid series the acetabular component was inserted in a vertical position with a mean inclination angle of 57° (48° to 80°), in an attempt to obtain cover of the implant with bone. None of the patients with dislocation had either fibrous union or nonunion of the trochanter.

The prevalence of nerve palsy after THR depends on the pre-operative diagnosis, the surgical approach and the experience of the surgeon. The risk is increased, with a reported prevalence of 3% to 15%,\(^8\) in hips with congenital dislocation, because of post-operative limb lengthening. Schmalzried et al.\(^27\) reported no relationship between the operative approach and the prevalence of nerve palsy. In our series, limb lengthening was not related to nerve complications and we believe that the transtrochanteric approach lessens the danger of nerve complications.

Another advantage of trochanteric osteotomy is that it avoids the intraoperative osteotomy necessary when subtrochanteric or distal shortening is used.

In conclusion, the range of complications from trochanteric osteotomy in THR in patients with congenital hip disease are relatively limited (Table VII). However, two of these complications, defective union and proximal reattachment of the trochanter, may compromise the outcome. We suggest that in routine cases of THR trochanteric osteotomy may be optional, but it remains a useful procedure in cases with congenital hip disease, especially those with low and high dislocation. It gives better access to the anatomically abnormal hip joint, improves biomechanics when advancement of the trochanteric fragment is feasible, and facilitates correct alignment of the components. When shortening of the femur is needed, we prefer this to be at the level of the femoral neck, which is a simple technique and avoids the intraoperative osteotomy necessary when subtrochanteric or distal shortening is used.

**Supplementary material**

A table showing the results of the different techniques for femoral shortening is available with the electronic version of this article on our website at www.jbjs.org.uk

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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**


