A COMPARISON OF THE TRANSTROCHANTERIC, HARDINGE AND LIVERPOOL APPROACHES IN PRIMARY HIP REPLACEMENT

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ABSTRACT

The effects of three lateral approaches to cemented Charnley total hip arthroplasty were studied in two hundred and sixty four hips. The Hardinge approach was used in 82 patients, the transtrochanteric approach in 94 and the Liverpool approach in 88. Mean follow-up was 2.6 years (2-3 years). The over-all clinical results were similar for the three groups.

Roentgenographic follow-up evaluation showed that alignment of the femoral stem was significantly better in the transtrochanteric group. Grade III socket demarcation occurred more frequently in the Liverpool approach. There was no difference in femoral cement distribution in the three approaches, but in the Hardinge approach acetabular cement distribution was poor.

There was no increase in Trendelenburg gait after the Hardinge or Liverpool approach compared with the transtrochanteric approach. Dislocation was a problem in the transtrochanteric approach. Risk factors for dislocation were placing the acetabular cup too retroverted and detachment of the trochanter. A severe form of heterotopic bone formation occurred five times more frequently in the Liverpool approach than in the other two approaches.

INTRODUCTION

Charnley emphasized the importance of removal of the trochanter in total hip arthroplasty. He suggested that this approach provides excellent exposure of the acetabulum and better placement of the prosthesis. He used a single horizontal loop of wire to fix the trochanter. Non-union occurred only when early rehabilitation was introduced. Since then many techniques have been described to fix the trochanter to improve healing [1,4,8,19,48]. Although good results have been achieved in the hands of the originator of the technique, the incidence of non-union is much higher in the hands of other surgeons.

An alternative to the transtrochanteric approach is the direct lateral approach of McFarland and Osborne[30] wherein the trochanter is not violated. Modifications of this approach; namely, the Liverpool [43] and Hardinge[18] approaches, are widely practised in the United Kingdom. A major criticism of these approaches is that they violate the important abductor muscle mass and have potentially permanent sequelae, including postoperative limp and weakness[33]. Horwitz [22] compared the transtrochanteric approach with a modified Hardinge approach and suggested there is no statistical difference in clinical results.

This prospective study was undertaken to determine the short term effect of three commonly used lateral approaches (Hardinge, transtrochanteric and Liverpool) on early clinical, functional results, radiological findings and complications.
MATERIALS AND METHODS

From January 1987 until October 1989, 354 Charnley low-friction arthroplasties were performed by three consultants at the Clatterbridge Hospital, Wirral, U.K.. Of the 354 operations, 264 arthroplasties performed for primary osteo-arthritis were selected for this study: 82 by the Hardinge approach, 88 by the Liverpool approach and 94 by the transtrochanteric approach. To maintain the groups’ compatibility, secondary osteoarthritis, previous hip operations and infected total hips were excluded.

Approaches:

**Transtrochanteric**[48]: In this approach, the trochanter is cut using a Gigli saw to create a biplane osteotomy. The trochanter is fixed using a single horizontal compression wire and a double vertical wire.

**Hardinge**[18]: In this approach the gluteus medius is reflected anteriorly in continuity with a portion of vastus lateralis in a bucket handle fashion. The conjoint tendon with gluteus minimus and the capsule were elevated as a flap.

**Liverpool**[43]: This approach is similar to Hardinge. The only modification is that a sliver of trochanteric bone is taken with the gluteal flap to allow better fixation of the flap to the greater trochanter during closure.

A Charnley hip prosthesis was fixed using methylmethacrylate (Palacos) in every case. All three surgeons were trained at Wrightington Hip centre (U.K) and adopted a similar cementing technique for their patients. The cup was fixed after drilling multiple holes for fixation with cement, thorough irrigation and obtaining a dry field. In the Liverpool approach, the acetabulum was reamed to expose cancellous bone, whereas in the other two approaches subchondral bone was left intact.

The cemented femoral components were inserted by broaching of the intramedullary canal, with removal of all loose cancellous bone, followed by thorough irrigation and drying of the canal. A distal intramedullary plug and vent tubes were used for all patients. The cement was packed manually and femoral components of the same size were used for all of the patients. Postoperatively, all patients were treated with intravenous antibiotics for 24 hours. All patients were placed in an adductor pillow in the operating room. Postoperatively, all patients followed a physical therapy regimen while in bed, including isometric knee extension and hip abduction, beginning on the first postoperative day. Ambulation also was permitted on the second postoperative day. Patients were allowed to weight bear as tolerated with crutches.

All patients were followed up at six weeks, six months and one year after surgery with a mean follow-up of 2.6 years (Range 2–3 years). Clinical outcome was assessed using the Charnley 1-6 point grading system separately for pain, function of walking, and range of movement, in which a score of 6 represented the best possible result (Table 1a). In terms of patient categories defined by Charnley[4], 136 hips were A (unilateral hip disease, no other functional disabilities), 81 were B (bilateral hip disease otherwise no functional disabilities), and 47 were C (hip disease with systemic disease or other functional disabilities). Results were grouped (Table 1b) into excellent, good, fair and poor using the criteria of Wejkn[46]. In addition further assessment was carried out with regard to gait status, power of abduction and the Trendelenburg test (Table 1C). Clinical records were evaluated for complications such as wound infection, hematoma, dislocation, deep vein thrombosis, neurologic and vascular problems and heterotopic bone formation.
A detailed radiological evaluation was performed in each patient. Anteroposterior and true lateral roentgenographs of the hip were obtained in all 264 patients (Fig 1 & 2). A standardized true lateral view was obtained by positioning the patient flat on the table with the limb held in neutral rotation. The film was placed parallel to the neck (i.e., about 45 degrees to the leg) above the greater trochanter.

The radiographs were carefully reviewed to determine the position of prosthetic components (Table 2), the cement distribution (Table 3), the presence of radiolucent lines, trochanteric complications and the formation of heterotopic bone. Six variables were measured to determine prosthetic position and all radiological measurements were performed by the author.

**Acetabular angle**: Measured on the AP view of the pelvis by drawing a line through the medial and lateral margins of the equatorial marker wire of the acetabular component and a horizontal line through the most inferior aspect of the ischial tuberosities (Acceptable 30-50°)

**Version of the Cup**: (Woo[47]): These measurements were not considered as absolute values but only as approximations demonstrating relative anteversion and retroversion. Version of the cup can be obtained from a true lateral film as the angle formed by the line drawn tangential to the face of the acetabulum and a line perpendicular to the horizontal plane. (Acceptable 0-10°)

**Depth of the cup**: Obtained from the AP of the pelvis. The normal position is with the most medial part of the semicircular wire flush with the lateral border of the tear drop (N : <1cm)

**Height of the cup**: Is the vertical distance from the center of the head of the prosthesis to a horizontal line passed through the inferior aspect of both tear drops

**The Varus-Valgus alignment of the stem**: Is the angle between the long axis of the prosthetic stem and the diaphysis of the femur (Acceptable 0-5° varus or valgus)

**Version of the stem** (Ghelman[14]) These were measured on the lateral roentgenogram. The angle between the long axis of the neck of the prostheses and the coronal plane is measured. The measured angle is plotted against the neck shaft angle to determine true anteversion (Anteversion 0-10°).

In addition, the thickness of the cement mantle was measured (table 3) and any radiological demarcation at the cement-bone interface was noted (table 4). On the acetabular side 3 zones were used, in a manner similar to that of DeLee[9], to allow separate evaluation of the cement-bone interface. The radiological appearance of the socket after surgery was assessed according to the classification described by Hodgkinson, Shelly and Wroblewski[21], Type 0 was assigned to no demarcation, Type 1 was demarcation of the outer 1/3 only, Type 2 was demarcation of the outer 1/3 and middle 1/3, Type 3 was complete demarcation and Type 4 was migration. On the femoral side, radiological changes around the stem were investigated in the 7 zones as described by Gruen[16].

The degree of heterotopic bone was established based on the classification described by Brooker[3]: Grade 0, None; Grade I, islands of bone in the soft tissue about the hip; Grade II, bone spurs from the proximal end of the pelvis or femur; Grade III, occupying more than half of the gap between the femur and pelvis; and Grade IV, bony ankylosis of the hip (Group IV).

All variables among these three approaches were analyzed statistically. The statistical analysis involved comparing various parameters with resultant p values that are given with 95% confidence intervals. Chi square analysis (Saber Software) was performed to determine statistical significance and evaluate the data. When appropriate, Fisher’s exact test was used.
<p>| Table 5: Factors for dislocation |</p>
<table>
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<tr>
<th>Dislocation</th>
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<th>Statistics</th>
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</thead>
<tbody>
<tr>
<td><strong>Cup retroversion &gt;5 O</strong></td>
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<tr>
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<td>10</td>
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<tr>
<td>Absent</td>
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<td>208</td>
</tr>
<tr>
<td><strong>Stem Anteversion &gt;10 O</strong></td>
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</tr>
<tr>
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<td>48</td>
</tr>
<tr>
<td>Absent</td>
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<td>170</td>
</tr>
<tr>
<td><strong>Combined Malalignment</strong>&lt;br&gt;(Cup retroversion &gt;5 O &amp; Stem Anteversion &gt;10 O)</td>
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<td>1</td>
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<tr>
<td>Absent</td>
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<tr>
<td><strong>Trochanteric detachment</strong></td>
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<tr>
<td>No Detachment</td>
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<td>87</td>
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</tbody>
</table>

**p** = Fisher’s exact p value

Note: In 37 patients, version of the cup and stem could not be assessed due to poor quality radiographs.
RESULTS

Overall, there were no significant differences between the Hardinge, Liverpool, and transtrochanteric groups with respect to pre- and post-operative Charnley scores for pain, function and range of motion (Table 1). Using Wejkner's[46] criteria, good to excellent results were seen in 96% in the transtrochanteric, 95% in the Liverpool and 95% in the Hardinge approach (Table 1b). In all parameters there was a marked benefit from surgery. No significant differences were found between the surgical approaches when the efficiency of the hip abductor mechanism was assessed by the Standardised Trendelenburg test (Hardcastle and Nade [17]). A similar conclusion was reached when they were compared in activities of daily living (table 1C).

Radiologically, the differences in prosthetic alignment between the approaches were investigated (table 2). An acetabular angle of the cup of less than 30 degrees was seen in nine in the transtrochanteric group and twelve each in the Liverpool and the Hardinge groups. Cup retroversion was seen in 4 in the transtrochanteric, 6 in the Liverpool and 6 in the Hardinge group. Differences in cup alignment in the three groups were found to be not statistically significant. Stem alignment was significantly better in the transtrochanteric and Liverpool approaches.

There was no significant difference in cement distribution (table 3) on the femoral side. However, socket cement distribution was better in the Transtrochanteric and Liverpool groups than in the Hardinge group. In Hardinge, there were 15 cases in which the cement mantle was more than 5mm in one zone only.

On the femoral side, demarcation at the tip was recorded in 4 hips, lateral separation in 4, fracture of the cement in 1 and endosteal cavitation in 4 (Table 4). These findings were seen uniformly in all three approaches. In the Liverpool approach, the number of sockets with Type 3 demarcation occurred twice as commonly as in the other two approaches and this difference was found to be significant (p=0.03).

Of the 94 cases in the transtrochanteric group, 82 (87%) had a bony union in this study. There were 5 complete detachments. Non-union was seen in 13 cases (15%) in the Liverpool approach. Analysis of the incidence of dislocation and heterotopic ossification revealed significant differences among the three approaches (table 4). There were 5 dislocations in the transtrochanteric, 3 in the Liverpool and 1 in the Hardinge approach. Of the nine dislocations, seven had recurrent dislocation. The relationship between the cup alignment and dislocation showed that dislocation occurred when retroversion was more than 5 degrees in six patients. In four patients with dislocation, there was malalignment of both cup and stem (table 5) and this association was found to be very significant (p < .0001). There was associated trochanteric detachment in three patients.

The incidence of heterotopic bone formation varied between the three approaches: 36% in the transtrochanteric approach, 65% in the Liverpool approach, and 24% in the Hardinge approach. Severe HO (grades III and IV) was observed in 11% of the Liverpool approach patients in comparison to 2% observed in the other two approaches.
DISCUSSION
The question of trochanteric osteotomy as an adjunct to hip replacement remains controversial. The primary purpose of this article is to present the clinical and radiological differences observed after three different lateral approaches. The follow-up in this study is only 2 years after operation, which in assessment of the results of joint replacement is short. However, the importance of short term follow-up has been emphasized[9,34,24].

Using d'Aubigne and Postel criteria[4], the present study did not reveal any significant differences in the degree of clinical improvement among the three approaches. The author agrees with earlier reports[22,39,45] that the relief of pain, improved walking endurance and movement are similar regardless of which approach is used for a total hip replacement.

The Hardinge approach and its modifications are popular in the United Kingdom. This approach avoids the complications attributed to standard trochanteric osteotomies while providing adequate exposure for the procedure. One potential drawback, however, is the risk of postoperative gluteal insufficiency. In theory, the superior gluteal nerve is at risk in this approach. A standardized test was used to assess abductor function (Hardcastle and Nade[17]). It is interesting to note that there was no significant difference in the occurrence of a positive Trendelenburg test among the three approaches. Irrespective of the type of lateral approach, 10-15% will have some weakness of gluteal function (Pai [37]).

Malalignment of the prosthetic components may predispose to failure from loosening, fracture of the prosthesis or dislocation. Although a malaligned prosthesis may function for a long period without symptoms, in the present state of knowledge it seems likely that extreme position of the prosthesis does affect long term results[2,6,27,46]. In this series, alignment of the stem was better in the transtrochanteric approach but there was no significant difference in the alignment of the cup in the three approaches.

Although clinical results with respect to pain, range of movement and limp did not differ in cases where there was malalignment, dislocation was found to be common when there was a retroverted acetabular cup, more so when there was associated anteversion of the stem[38].

The femoral stems of hips that had a 2-5 mm thick cement mantle in the proximal medial region had a better outcome than stems implanted with either a thicker or a thinner cement mantle[7,10,23,29]. Using 5 mm as the desired thickness, there was apparently poor socket cement distribution in the Hardinge group, but the femoral side did not show any statistical difference among the three approaches. The author feels that cement distribution depends on the technique rather than the surgical approach.

The long term fixation of the cemented socket is an unsolved problem[19]. Early radiological signs may predict future loosening[9,21]. In the present study, Grade III cup demarcation was twice as common in the Liverpool approach than in the other two. It has to be noted that in this group, the surgeon was following the original technique of Charnley in which the sockets were fixed after removal of the subchondral bone plate from the acetabular roof. It has been well reported that when the subchondral bone is preserved, cup fixation is better because this bone plate offers resistance to torque[12,28].

The criteria for fixation failure of the femoral prosthesis as determined radiologically were progression of subsidence, demarcation, separation from cement, cement fracture or endosteal cavitation[34]. An isolated finding of one of these five signs was evenly spread amongst the three approaches. This radiological finding could not be blamed by itself for stem failure, when it does not progress (12,27). Therefore it is too early to comment on stem failure in this study with short follow-up.

Complications directly related to the trochanteric osteotomy are: trochanteric tenderness, non-union and total detachment, poor gait and dislocation[5,44]. Broken wires appeared in 44 of the 94 hips (47%) in this study.

Fractures are often seen in the horizontal spring wire. The incidence of non-union has been reported to be between 0.8% and 32% in the transtrochanteric approach[1,8,20,32,48]. In the present study the incidence
of nonunion was 13%. The effect of trochanteric displacement on abductor power has been reported earlier [1,32,37].

The incidence of complications like deep infection, DVT and PE were not much different among the three approaches. It has been suggested that thromboembolism occurs more often in the transtrochanteric group because of the longer duration of anesthesia and operation. This was not studied formally and valid conclusions can not be drawn because different prophylaxis was used and no venogram was performed routinely.

Many factors have been suggested for prosthetic dislocation following total hip replacement[11,13,25]. Dislocation was found to be a greater risk in the transtrochanteric approach when there is prosthetic malalignment than in the other two approaches. The Mayo experience clearly demonstrated a six fold increase in hip instability among those patients with nonunion of the trochanteric osteotomy[31]. In the present study, although alignment of the prosthesis was better in the transtrochanteric group than other two groups, dislocation occurred more often in this group and those with malalignment in this group were much more prone to dislocation.

The etiology and pathogenesis of heterotopic ossification are still obscure, but several factors have been investigated in the literature[9,15,26,40,41]. However, there have only been a few studies about the development of HO on the basis of surgical approach[36,44]. The incidence of heterotopic ossification was 42% in this study. A severe form (Brooker Grade III & IV) of bone formation occurred five times more frequently in the Liverpool approach than in other two approaches. Although the Liverpool and Hardinge approaches were developed from the McFarland and Osborne approaches with subtle differences as far as tissue plane is concerned, it is interesting to note that HO is more common in the Liverpool approach.

Surgical exposure is fundamental to an excellent result in hip arthroplasty. The choice of surgical approach is commonly a function of the surgeon’s experience during training, rather than being based on documented studies. It is author’s contention that good visualization can be obtained in the Hardinge and Liverpool approaches, and this should not be an issue in selecting the surgical approach. Cement distribution and the fixation of prosthesis as well as alignment might be within the surgeon’s control. The transtrochanteric approach is technically more demanding than the other two and recurrent dislocation can still be a problem. Considering the high incidence of heterotopic ossification in the Liverpool approach, the author feels the Hardinge approach is the better lateral approach in primary hip replacement.

REFERENCES


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CONFLICT OF INTEREST

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.