Circumferential osteotomy of the medial acetabular wall in total hip replacement for the late sequelae of childhood septic arthritis of the hip


From West China Hospital, Chengdu, China

We performed 52 total hip replacements in 52 patients using a cementless acetabular component combined with a circumferential osteotomy of the medial acetabular wall for the late sequelae of childhood septic arthritis of the hip. The mean age of the patients at operation was 44.5 years (22 to 66) and the mean follow-up was 7.8 years (5 to 11.8). The mean improvement in the Harris Hip Score was 29.6 points (19 to 51) at final follow-up. The mean cover of the acetabular component was 98.5% (87.8% to 100%). The medial acetabular wall was preserved with a mean thickness of 8.3 mm (1.7 to 17.4) and the mean length of abductor lever arm increased from 43.4 mm (19.1 to 62) to 54.2 mm (36.5 to 68.6).

A cementless acetabular component combined with circumferential medial acetabular wall osteotomy provides favourable results for acetabular reconstruction in patients who present with late sequelae of childhood septic hip arthritis.

Sepsis involving the hip in childhood is very destructive and may produce significant anatomical deformity and premature secondary osteoarthritis requiring total hip replacement (THR). Long-standing deformity and growth adaptation create a shallow vertical acetabulum with the femoral head articulating at its superior or superolateral edge. The aim of acetabular reconstruction is to obtain normal biomechanics with adequate bony cover for the acetabular component. The high rate of complications, including intra-operative femoral fracture, infection and loosening presents a particular surgical challenge.

In order to achieve satisfactory fixation of the acetabular component, many methods have been described including the use of a small-diameter cemented component, medial displacement by controlled fracture of the medial wall of the acetabulum in conjunction with bone graft or cement, and acetabuloplasty with femoral head auto- or allograft. Dunn and Hess described a comminuted fracture of the medial wall of the acetabulum in conjunction with bone graft or cement, and acetabuloplasty with femoral head auto- or allograft. Hartofilakidis et al described a comminuted fracture of the medial acetabular wall for medial displacement to obtain adequate bony cover. However, the weakened acetabular wall was prone to subchondral bone resorption. Hartofilakidis et al created a lengthened abductor lever arm using radial fracture and medial displacement of the acetabular component within the true acetabulum. Dorr et al described a medial protrusion technique which displaced the centre of rotation of the acetabular component but neither maintained the integrity of the acetabulum nor preserved adequate bone stock for further revision. In addition, this method may cause fracture and medial displacement of the acetabular component, and damage to the iliopectas.

It is important to re-establish the normal centre of hip rotation. The non-anatomical placement of the component is an important predictor of acetabular loosening. In patients with dysplasia of the hip who have undergone THR, rates of loosening have been reported up to 42.3% when the centre is not anatomically placed. We examined the mid-term outcome of patients with late sequelae of childhood septic arthritis of the hip treated by THR with a cementless hemispherical acetabular component, implanted with a circumferential osteotomy of the medial wall of the acetabulum.

Patients and Methods
Between October 1993 and October 2000, 56 patients (56 hips) whose history and clinical...
and radiological findings suggested the late sequelae of septic arthritis of the hip, underwent primary THR with a hemispherical, cementless acetabular component and a circumferential medial wall osteotomy. The data from four patients were excluded because of loss of follow-up in three, and unrelated death in one. This left 52 patients, 15 men and 37 women, eligible for study. The mean age of the patients at the time of THR was 44.5 years (22 to 66). The mean interval between the resolution of active infection in the hip and THR was 36.8 years (15 to 58).

The severity of the acetabular dysplasia was graded according to the classification of Hartofilakidis et al.\textsuperscript{14} with 16 hips having type I dysplasia, 11 type II (low dislocation) and 25 type III (high dislocation). In all 16 hips with type I changes, the femoral head, despite some degree of subluxation and destruction, was still contained within the original acetabulum, or was located at the superolateral edge of the acetabulum. The acetabulum was shallow with osteophytes covering the fossa. In all 11 hips with type II, the acetabulum had a deficiency of the anterior and posterior segments and was very shallow. The femoral head or neck had articulated with a false acetabulum that partially covered the true acetabulum. Of 25 hips with type III, seven had complete destruction of the femoral head and neck to the intertrochanteric line. The remaining 18 hips with type III changes completed destruction of the femoral head with a stable neck or an unstable neck fragment that had migrated superiorly and posteriorly and articulated with the false acetabulum at the level of the iliac wing. All hips with type III had a shallow and vertical acetabulum with segmental deficiency of the entire acetabular rim.

Given the previous history of septic arthritis THR was not performed until the patients had been free of any sign or symptom of infection for at least ten years. All patients were evaluated pre-operatively with technetium-99 and gallium bone scans, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and a full blood count for evidence of continuing infection. At operation, antibiotics were withheld until deep-tissue samples had been obtained for culture. The smears and specimens were cultured for aerobic, anaerobic and tuberculous bacilli. Frozen sections were performed intra-operatively on suspicious tissue for evidence of active infection. Post-operatively, we administered 4 g cephalosporin daily in divided doses by intravenous injection for five days, then orally for one week.

Any patient for whom less than 70% cover of the acetabular component would be obtained, judged from the pre-operative radiographs, and where the medial thickness of the acetabulum exposed during surgery was not less than 8 mm, was eligible for circumferential medial acetabular wall osteotomy.

**Surgical technique.** In order to prevent damage to the medial wall of the acetabulum from excessive expansion during reaming, a circumferential osteotomy was devised. This technique maintains the thickness of the true medial wall, providing compressive fixation of the acetabular component, and allows medial displacement of the centre of the hip for biomechanical balance.

All cases were performed via a posterolateral approach. The scarred capsule was resected and the severely contracted iliopsoas and adductor tendons were released. The true acetabulum was exposed by locating the pubic and ischial rami, and then obtaining radiographs of the pelvis with an acetabular reamer appropriately positioned to confirm the site of the true acetabulum. The acetabular cartilage was resected with a small reamer, following which a 2 mm hole was drilled into the centre of the medial wall to measure the thickness of the acetabulum. Based on the centre of the true acetabulum, a circle was marked which remained equidistant from the acetabular margin (Fig. 1). Following this line an osteotomy was performed with the osteotome inclined 20° towards the centre of the acetabulum. The osteotomised medial wall was impacted medially by two-thirds of the thickness of the acetabular wall. The cavity was then reamed to enable a cementless hemispherical acetabular component to be press-fitted after underreaming by 2 mm. The component was inclined at about 40° to 45° and anteverted by 15° (Fig. 2). If a superolateral deficiency of the true acetabulum remained so that 80% cover of the component could not be achieved, the inclination of the component was increased and in six patients a structural bone graft using their femoral head was performed to ensure adequate bone cover. Severely contracted soft tissues in 11 patients required a distal femoral shortening osteotomy to prevent injury to the sciatic nerve and to correct abnormal anteversion. In five patients with an internal rotation deformity arising at the hip a distal femoral...
corrective osteotomy was performed. In two patients an advancement of the greater trochanter was needed to increase the power of the abductors.

Cementless hemispherical acetabular components were used in each hip, with the following distribution: The Harris-Galante-II component (Zimmer, Warsaw, Indiana) in 25 hips, the Trilogy component (Zimmer) in 26, and the Omnifit component (Stryker, Allendale, New Jersey) in one. The mean size of the acetabular component was 52.4 mm (46 to 64). In order to ensure immediate stability, screws were used in all cases. One screw was used in three hips, two in 17 hips, three in 28 hips, four in two hips, and five in two hips. Hybrid fixation, with a cementless acetabular component and a cemented CDH stem (DePuy Johnson & Johnson, Warsaw, Indiana), was used in five hips. Five different types of cementless femoral component were used: a PFC component (DePuy Johnson & Johnson) in 19 hips, a Versys component (Zimmer) in 20, an ANA component (Zimmer) in four, a Harris-Galante component (Zimmer) in three and an Omnifit component (Stryker) in one. A 28 mm diameter femoral head was used in 37 hips and a 22 mm head in 15. Of 52 hips, 49 (94.2%) were paired with metal-on-polyethylene bearings, two hips had a zirconium femoral head (Zimmer) articulating with polyethylene, and one had an aluminium ceramic-on-ceramic bearing (Stryker).

**Post-operative evaluation.** The mean follow-up was 7.8 years (5 to 11.8). Clinical and radiological follow-up was performed at six weeks, three months, six months, and one year after surgery, and yearly thereafter. Anteroposterior (AP) frog lateral and cross-table lateral views were taken at each follow-up. The clinical ratings were evaluated pre-operatively and at each post-operative stage using the Harris Hip Score (HHS) rating system. A clinical score was considered to be excellent if it was greater than 90 points and a score between 80 and 89 points was rated as good. The excellent and good scores were considered to represent a successful outcome. Scores between 70 and 79 points were classified as fair and those less than 70 were considered to be poor.

The radiological assessment was completed by two observers (YYL, SWC), neither of whom was the operating surgeon. The two observers worked together and their level of agreement achieved concordance. They evaluated the fixation status of the components, the bony cover of the acetabular component, the thickness of the medial acetabular wall, the correction of the centre of the hip joint rotation, the bony union and remodelling of the osteotomy site, the presence of radiolucent lines and osteolytic lesions around the acetabular component in the DeLee and Charnley zones, the annual polyethylene liner wear rate using the Livermore technique, and the measurement of migration of the acetabular component using the vertical distance between Köhler’s line and the medial margin of the acetabular component.

The cover of the acetabular component was measured on the AP radiograph of the hip as described by Wilson and Amstutz. The inscribed arc of the perimeter of the acetabular component that is in contact with bone is divided by the total arc of the perimeter (180˚) of the component, and the ratio expressed as a percentage.

The ideal centre of hip rotation was located by drawing the Ranawat triangle. Changes in the centre of hip rotation after surgery were determined by comparing the vertical and horizontal distances of the centre of rotation.

The ratio of the body weight lever arm to the abductor lever arm was determined by the length of the body weight lever arm (the distance between the centre of hip rotation and the central perpendicular axis of the body) divided by the length of the abductor lever arm (the perpendicular distance between the centre of rotation and the axis of abduction).

The following radiological signs were considered to indicate acetabular loosening: migration of the component by > 4 mm in either the horizontal or vertical direction, breakage of screws used for fixation, a change in the orientation of the component by > 5˚ or a radiolucent line > 2 mm wide in all zones.

**Survival analysis.** The Kaplan-Meier survival analysis was used to estimate the probability of retention of the acetabular component in relation to either revision for any reason or definite radiological loosening. The 95% confidence intervals (CI) were calculated.

**Statistical analysis.** This was conducted using SPSS version 13.0 for Windows (SPSS Inc., Chicago, Illinois). The significance of the findings was evaluated with a paired t-test for comparing all paired variables. A p-value < 0.05 was considered statistically significant.
Results
The mean follow-up was 7.8 years (5 to 11.8). The preoperative technetium-99 and gallium bone scan, ESR, CRP level and full blood count were normal in all patients. All intra-operative cultures also excluded bacterial or tuberculous infection. No patient had recurrent infection or delayed wound healing after THR.

At the latest follow-up, the mean HHS was 91.6 points (69 to 100), which improved from a mean pre-operative score of 62 (36 to 76) (t-test, p < 0.05). The outcome was classified as good or excellent in 51 hips (98.1%), in which 38 patients had an HHS > 90 points and in 13 patients it ranged between 80 and 89 points. One hip with radiolucent lines in all zones was rated as poor with an HHS of 69 points. The leg-length discrepancy improved from a pre-operative mean of 34.1 mm (9.7 to 61.3) to a mean of 11.6 mm (0 to 31.7) post-operatively (t-test, p < 0.05).

The mean inclination angle of the acetabular component was 43.0˚ from the horizontal (26.0˚ to 56.0˚). The mean post-operative bony cover of the acetabular component was 98.5% (87.8% to 100%). In the 51 hips with a polyethylene liner, the mean annual wear rate was 0.22 mm (0.00 to 1.51). The mean thickness of the medial acetabular wall pre-operatively was 17.9 mm (10.2 to 34.0) and decreased to a mean of 8.3 mm (1.7 to 17.4) at the latest follow-up. Bony union of the medial wall was observed at a mean of four months and bony remodelling completed at a mean of seven months. The mean displacement of the acetabular component was -0.1 mm (-11.0 to 12.9). The distance was deemed positive if the medial margin of the component was medial to Köhler’s line which occurred in 18 cases. In five patients the medial margin was coincidental with Köhler’s line.

The mean horizontal distance from the pre- and post-operative centre of hip rotation to the ideal centre of rotation was 9.8 mm (-8.1 to 35.7) and 3.0 mm (-10.5 to 19.4), respectively. This change was statistically significant (t-test, p < 0.05). The distance lateral to the ideal centre of rotation was deemed positive. The mean vertical distance from the pre- and post-operative centre of hip rotation to the ideal centre of rotation was 21.6 mm (3.4 to 45.9) and 6.6 mm (-13.1 to 25.7), respectively, which was also statistically significant (t-test, p < 0.05). The distance above the ideal centre of hip rotation was deemed positive. The centre of hip rotation returned to its anatomical location in 37 cases (71.2%) after surgery (Fig. 3).

The mean length of the abductor lever arm was 43.4 mm (19.1 to 62.0) pre-operatively and 54.2 mm (36.5 to 68.6) at final follow-up (t-test, p < 0.05). The mean ratio of body weight lever arm to the abductor lever arm improved from 2.63:1 (1.7:1 to 5.53:1) to 1.88:1 (1.4:1 to 2.7:1) (t-test, p < 0.05), and the mean ratio in the opposite hip was 1.96:1 (1.4:1 to 3.0:1).

Peri-acetabular osteolysis was found in 14 hips (26.9%) at the final follow-up. In six hips, this was located in DeLee and Charnley zone 1, in two in zone 2, in one in zone 3, in four in zones 1 and 2, and in one hip in all zones. In zone 2 where the osteotomy had been performed, a particularly high incidence of osteolysis was not found. In two hips, which were rated as grade II dysplasia pre-operatively, a radiolucent line was seen in all zones and loosening of the acetabular component, with a change in the inclination angle of the acetabular component was lateral to Köhler’s line which occurred in 18 cases. In five patients the medial margin was coincidental with Köhler’s line.

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angle from 44° immediately post-operatively to 64° at final review in one of them.

**Survival analysis.** Kaplan-Meier survival with revision for any reason was 98.1% at 4.5 years (95% CI, 96.2 to 100) with one hip at risk. With revision or radiological evidence of loosening as an end-point, survival was 94.2% at 7.3 years (95% CI, 85.8 to 100) with two hips at risk.

**Complications.** Several complications were encountered. Femoral nerve injury occurred in two cases as a result of excessive traction to reduce the hip, but both recovered fully. One female patient developed a sciatic nerve palsy, from which she made an incomplete recovery, with persistent mild sensory loss four years post-operatively. A traumatic peri-prosthetic fracture of the femur occurred in one case four years after surgery. It was successfully treated with open reduction and internal fixation. One patient sustained a dislocation of the hip following a fall six weeks after surgery. It was treated with closed reduction. One patient developed severe osteolysis and loosening of the acetabular component 4.5 years after surgery and subsequently underwent revision. In two patients exchange of the polyethylene liner and acetabular bone grafting was performed because of acute liner dissociation at five and eight years after THR, respectively. One case required a change of the fractured alumina ceramic head six years post-operatively. The liner was also exchanged for a polyethylene liner. Lastly, one patient required revision of the femoral component for aseptic loosening eight years post-operatively when the polyethylene liner was also changed.

**Discussion**
In order to resolve the difficult problems of the late sequelae of childhood septic arthritis of the hip, including the destruction of medial wall bone stock, inadequate cover of the acetabular component and mechanical instability, we performed a circumferential medial acetabular wall osteotomy rather than the controlled microfracture cotyoplasty, which has previously been described for the treatment of this condition.

The ideal centre of rotation of the hip using Ranawat's triangle was compared with the vertical and horizontal distances measured in the diseased hip pre- and post-operatively. The results showed that not only was the bone stock of the medial wall preserved, but the procedure also successfully restored the centre of rotation enabling the abductor lever arm to be lengthened.

Primary stability of the acetabular component is related to its bony cover. Jasty, Anderson and Harris advocated reconstructing the acetabulum with an autologous superolateral femoral head graft. However, they cited a 20% rate of bone resorption and acetabular loosening at seven years. Those results suggest that one should avoid acetabular reconstruction with a bone graft when the bony cover is less than 70%. Although the final mean cover of the acetabular component was 98.5% in our study, six cases still required an additional autologous superolateral femoral graft. There was no aseptic acetabular loosening at a mean follow-up of 8.3 years (5.6 to 9.6) in these six cases.

The mean thickness of the medial acetabular wall remained 8.3 mm after surgery in this study, providing adequate bone stock for future revision. The circumferential medial wall osteotomy allowed the use of large-diameter components in most patients. Previously, small-diameter components were typically used in these reconstructions as they could be more easily covered. However, these smaller components do not provide an adequate interface to resist torsional moments and local stresses. In addition, small-diameter acetabular components have a thinner polyethylene liner and require the use of a small femoral head. In the present study, the mean size of the acetabular component was 52.4 mm (46 to 64) and the mean annual polyethylene liner wear rate was 0.22 mm, which was higher than that of 0.08 mm per year reported by Anderson and Harris. There is a strong correlation between osteolysis and an increased rate of wear of the polyethylene liner.

We found a rate of osteolysis of 26.9%, which was lower than the rate of 58.5% reported by Kim et al, but inferior to the 13% reported by Anderson and Harris. Our higher rates of wear may be attributable to the young and active population treated, and the poorer grade polyethylene used for the liner.

In conclusion, we recommend a circumferential medial acetabular wall osteotomy in the reconstruction of severely damaged acetabula for the late sequelae of childhood septic hip arthritis.

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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**


