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ORIGINAL STUDY

Cementless total hip arthroplasty with a double chevron subtrochanteric shortening osteotomy in patients with Crowe type-IV hip dysplasia

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The authors describe a modified double chevron subtrochanteric shortening osteotomy combined with cementless total hip arthroplasty for Crowe type-IV hip dysplasia. Shortening the femur allows to relax the shortened musculature. This operation was performed in 18 patients (22 hips) between January 2000 and February 2006. The mean follow-up period was 5.6 years (range : 3 to 8 years). The mean amount of femoral subtrochanteric shortening was 38 mm (range : 25 to 60 mm). The mean Harris hip score improved from 47 (range : 35 to 65) preoperatively to 88 points (range : 75 to 97) at final follow-up. The Trendelenburg sign was corrected from positive to negative in 12 of 22 hips. No acetabular or femoral components loosened or required revision during the follow-up period. All osteotomy sites healed in 3 to 6 months without complications. Cementless total hip arthroplasty using the modified double chevron subtrochanteric osteotomy provided good short- to mid-term results in all 22 Crowe type-IV hip dislocations. Moreover, it restored the anatomic hip center and the limb length, which contributed to correction of the preoperative limp.

Keywords : hip dysplasia ; cementless arthroplasty ; chevron shortening osteotomy.

INTRODUCTION

Patients with untreated Crowe type-IV developmental dysplasia of the hip (DDH) (Fig. 2) frequently develop symptomatic secondary arthritis at a relatively young age (*8*). Treatment of this severe hip dysplasia with total hip arthroplasty (THA) presents a broad spectrum of technical challenges. High location of the hip center, poor acetabular bone stock, altered proximal femoral anatomy, soft-tissue contracture, and abnormal muscle development dramatically increase the complexity of hip reconstruction (*7,8,11,18,22,27,29*).

One major technical problem encountered in the surgical treatment of DDH is the reconstruction of the acetabulum. Placement of the acetabular component at the level of the true acetabulum has consistently yielded excellent and reproducible results of cementless THA in patients with DDH (*22,28,32,*

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35). However, in Crowe type-IV dysplasia, severe soft-tissue contractures due to the chronic dislocation make it difficult to reduce the prosthetic femoral head into the acetabular component in the anatomical position (5,31). Hip reduction in this situation may result in excessive limb lengthening and may increase the risk of neurologic traction injury (4,8,23).

Several operative strategies have been proposed. One option is to combine restoration of the anatomic hip center with a subtrochanteric shortening osteotomy in order to relax the musculature (31). The shortening osteotomy allows hip reduction without sciatic nerve stretching, and correction of the proximal femoral anteversion. It further restores the abductor mechanism and decreases limb-length discrepancy. The *subtrochanteric* femoral shortening osteotomy, rather than *trochanteric* osteotomy with proximal femoral shortening, provides specific benefits in preserving the proximal femoral metaphysis, facilitating a cementless femoral reconstruction, and avoiding the problems associated with reattachment of the greater trochanter (3,6,24,33).

Double chevron subtrochanteric osteotomy, initially described by Becker *et al* (1) in 1995, has been introduced for the treatment of patients with severe grades of DDH. Preliminary results were encouraging, but its popularity remained limited since the technique generally required complicated preoperative templating and did not allow intraoperative adjustments once the osteotomy had been made. The authors describe their technical modifications, and review the short- to mid-term outcomes of this modified technique.

MATERIALS AND METHODS

Eighteen consecutive patients (22 hips) with Crowe type-IV DDH were treated with a modified double chevron subtrochanteric osteotomy at the time of THA in two institutions, between January 2000 and February 2006. Patient demographics, preoperative clinical data, surgical data, and postoperative clinical data were collected prospectively on a routine basis for all patients. No previous hip operation was recorded in this group of patients. There were 15 females and 3 males, with a mean age of 53 years (range, 41 to 76) at the time of the index procedure. The indications for arthroplasty were severe pain and/ or considerable difficulty in walking and performing daily activities. Eight patients had the procedure on the right side, 6 on the left side, and 4 bilaterally. No patients were lost to follow-up, with a mean follow-up of 5.6 years (range ; 3 to 8 years). The study was approved by the institutional committee for clinical research ; informed consent was obtained from the patients.

A lateral Hardinge approach was used in all hips, with the patients in the lateral decubitus position (15). The elongated hypertrophic joint capsule was completely resected, and all fibro-fatty tissues within the acetabulum were removed. The proximal parts of the pubic and ischial bones and the acetabular notch were exposed for identification of the true acetabulum (Fig. 1A) and for evaluation of the bone stock. Once the location of the best bone stock in which to place the prosthetic cup was marked, the true acetabulum was prepared with the smallest reamers, and then enlarged with progressively larger reamers, to the largest possible size without breaching the anterior or posterior border of the innominate bone. In most instances, sufficient lateral coverage of the socket was obtained with placement of the cup at the level of the true acetabulum and with adequate reaming. In 4 patients less than 70% coverage of the cup by native bone remained : structural bone-grafting of the true acetabulum was carried out with the excised femoral head. Porous-coated acetabular components with dome screws were used in all hips, including a Duraloc Sector cup (DePuy, Warsaw, USA) in 8 hips, a Pressfit SII cup (LINK, Hamburg, Germany) in 10 hips, and a Reflection cup (Smith & Nephew, Memphis, USA) in 4 hips. The median outside diameter of the acetabular component was 46 mm (range : 42 to 48 mm).

The femoral head was resected through the femoral neck approximately 1 cm proximal to the lesser trochanter, and the femoral canal was prepared using tapered pin reamers followed by rasps. Preoperative templating aiming at restoration of the anatomic hip center resulted in 3 to 4 cm limb lengthening or more, and a subtrochanteric shortening osteotomy was therefore performed with an oscillating saw after preparation of the femoral canal. The exact site of the shortening osteotomy varied according to the patient's anatomy ; it was generally 2 to 3 cm distal to the lesser trochanter. A transverse subtrochanteric osteotomy was initially performed in each case, and the femoral trial stem was inserted into the proximal fragment of the femur. After reduction of the femoral trial stem into the acetabular cup, mild traction was applied on the leg to confirm the level of the distal femoral osteotomy. The amount of bone to be resected from the distal fragment was determined by overlapping the proximal and distal fragments of the femur (Fig. 1B).

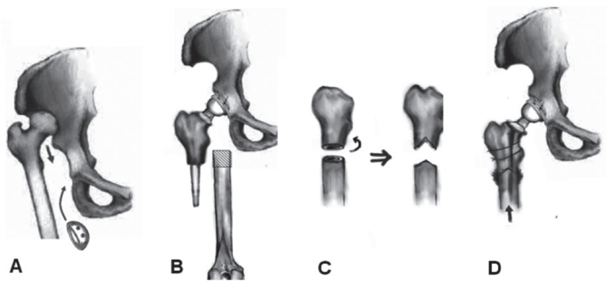

Fig. 1. — Modified technique. A) Placing the cup at the level of the true acetabulum. B) Transverse subtrochanteric osteotomy ; the amount of shortening required is determined by overlapping the proximal and distal fragments of the femur. C) Rotational correction of the proximal femur, and double chevron osteotomy at the site of the previous transverse osteotomy. D) Split of the narrow femur secured by cerclage wires. Bone-grafts around the osteotomy sites.

Prior to subtrochanteric osteotomy, a longitudinal line (Fig. 1C) was marked on the femoral shaft with the electrocautery to permit rotational orientation. With the guidance of these marks, the rotational alignment of both the proximal fragment and the distal fragment was adjusted to allow approximately 15° of anteversion of the femoral component. Once the desired anteversion was achieved, the cautery was used again to mark the double-chevron osteotomy on the ends of the two femoral fragments. A double chevron osteotomy, requiring resection of about 5 mm of bone, was performed at the site of the previous transverse osteotomy. Then the final femoral stem was inserted into the femur, across the osteotomy site. The fixation of the osteotomy was achieved by the double chevron geometry of the osteotomy and the prosthetic stem. In 8 hips the medullary canals of the femoral shafts were too narrow for the smallest stem, the femurs had to be split anteriorly and posteriorly for 4 to 10 cm (Fig. 1D). Cerclage wires were then tightened to allow adequate expansion of the femoral canal, and the final femoral stem was inserted in a press-fit fashion. A variety of cementless femoral stems were used : an Anatomic Medullary Locking (AML) stem (DePuy, Warsaw, USA) was used in 4 hips, a Summit stem (DePuy, Warsaw, USA) in 4 hips, a Ribbed stem (LINK, Hamburg, Germany) in 10 hips, and a Synergy stem (Smith & Nephew Richards, USA) in 4 hips. Bone grafts from the acetabular or femoral reaming were applied around the subtrochanteric osteotomy and the gap created by the split. After trial hip reduction, an appropriate femoral head was chosen. The use of different neck lengths allowed minor adjustment to compensate for the leg-length loss of the secondary osteotomy. The diameter of the femoral head was 22.225 mm or 28 mm. The bearing combinations included cobalt-chromium metal-on-ultra-high molecular weight polyethylene (UHMWPE) in 10 hips, and ceramic-on-UHMWPE in 12 hips.

Antibiotic prophylaxis and low-molecular-weight heparin were administered routinely during the hospital stay. Postoperatively, early passive mobilization was encouraged. Six weeks after surgery, the patients were allowed partial weight bearing. Gradually progressive weight bearing was permitted upon radiographic evidence of osteotomy union.

The hip function was assessed with the Harris hip score (*18*), which was classified into 4 categories : excellent (90 to 100 points) ; good (80 to 89 points) ; fair (70 to 79 points) ; poor (less than 70 points). The gait patterns of the patients were rated as followed : no limp ; slight limp ; moderate limp ; severe limp. The Trendelenburg sign was recorded. The leg length was measured from the anterior superior iliac spine to the medial malleolus with the patient lying supine. Intraoperative or postoperative complications were recorded.

For radiographic evaluation, standard anteroposterior radiographs of the pelvis and lateral radiographs of the affected hip were used. Each radiograph was corrected for magnification by calculating the ratio of the measured diameter of the prosthetic head to its true diameter. The change in the hip center was measured by determining the vertical distance from the ischial tuberosity to the center of the femoral head on both preoperative and postoperative anteroposterior pelvic radiographs as previously described (*26*). Radiolucent lines or osteolysis surrounding the prosthesis were evaluated on postoperative serial radiographs according to the method of DeLee and Charnley (*10*) for the acetabular components, and according to the system of Gruen *et al* (*14*) for the femoral stems. Loosening of the acetabular component was defined as the presence of progressive radiolucent lines of > 2 mm in thickness in all three zones, at least 4° of angle change or more than 3 mm of migration. The femoral stems were classified as bone-ingrowth, fibrous stable, or unstable according to the system of Engh *et al* (*12*). Healing of the osteotomy was evaluated with the criterion of Masonis *et al* (*26*). Heterotopic bone was assessed according to the system of Brooker *et al* (*2*).

After confirming normal distributions and equal variances of the data, a two-sided paired Student's t test was used to analyze the preoperative and the postoperative Harris hip scores, with $p < 0.05$ indicating significance.

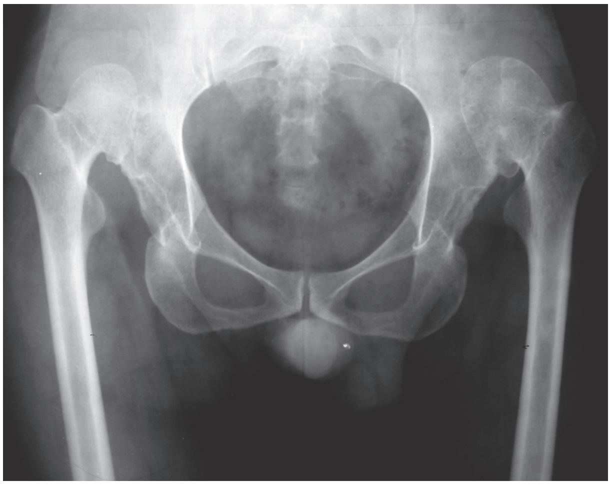

Fig. 2. — 41-year-old man with bilateral Crowe type IV hip dysplasia.

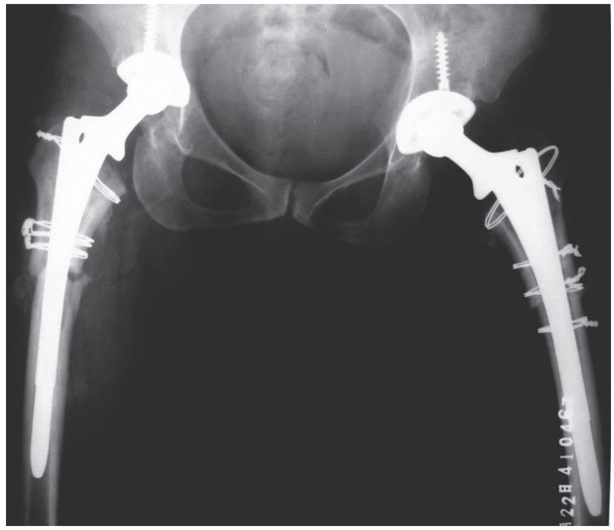

Fig. 3. — Postoperative AP view of the pelvis immediately after one-stage bilateral THA with the modified double chevron subtrochanteric osteotomy.

RESULTS

The mean Harris hip score improved from 47 (range : 35 to 65) preoperatively to 88 (range : 75 to 97) at final follow-up. Preoperatively, the Harris hip score was poor in all 22 hips. At the latest follow-up evaluation, the Harris hip scores were excellent in 10 hips, good in 9, and fair in 3. The preoperative limp was graded as severe in 16 hips, moderate in 5 and slight in one, whereas the limp at final follow-up was graded as absent in 9 hips, slight in 9 and moderate in 4. Each hip had improvement of Harris score and limp by at least one grade. Preoperatively the Trendelenburg sign was positive in all hips ; at final follow-up it was negative in 12 hips but still positive in 10 hips.

The mean amount of femoral subtrochanteric shortening was 38 mm (range : 25 to 60). The mean limb-length discrepancy in 14 patients with unilateral hip dysplasia decreased from 45 mm (range : 30 to 62) preoperatively to 15 mm (range : 0 to 24) postoperatively. Four patients with bilateral involvement retained no apparent limb-length discrepancy.

Postoperative radiographic assessment (Fig. 3) demonstrated that the mean hip center was translated distally 61 mm (range : 52 to 80 mm). At the latest radiographic follow-up, cup migration did not exceed 3 mm, while the change in inclination angle was not more than 4°. All patients had bony ingrowth of the acetabular component, and union of the acetabular bone graft within one year of the operation. Temporary subsidence of the femoral component < 2 mm was observed in 8 hips during the initial 3 months. Eventually, all the femoral components showed radiographic evidence of bone ingrowth at the latest radiographic evaluation (Fig. 4). No continuous radiolucent lines or osteolysis were observed around any prosthetic components. All femoral osteotomy sites healed in 3 to 6 months. No patients experienced infection, nerve palsy, or dislocation after the index procedure. However, 3 patients had asymptomatic grade-I heterotopic ossification on postoperative serial radiographs.

DISCUSSION

For biomechanical and anatomic reasons, the acetabular component of a THA for osteoarthritis secondary to DDH should be placed at the level of the true acetabulum (*6,11,18,19,22,24,29*). However, especially in Crowe type-IV dislocated hips, soft-tissue contractures and concerns about sciatic nerve stretching make it difficult to reduce the prosthetic femoral head with the acetabular component into the anatomical position.

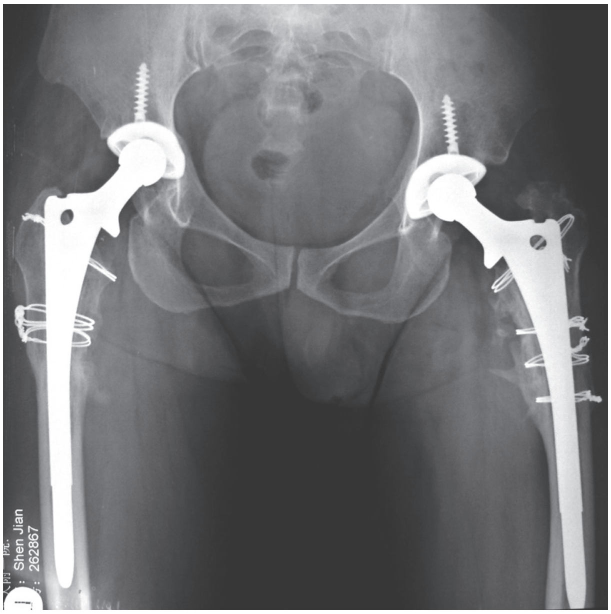

Fig. 4. — Postoperative AP view after 95 months. Stable fixation of the cementless stems with union of the femoral osteotomies.

Various techniques of subtrochanteric shortening osteotomy have been recommended to correct excessive femoral anteversion and to shorten the femur at the same site. Transverse osteotomy is the most commonly used method as it facilitates peroperative shortening and femoral derotation (*3,26,31*). However, inherent rotational instability of the transverse construct may result in nonunion at the osteotomy site after cementless THA. Therefore alternative complex subtrochanteric osteotomy techniques have been developed : double chevron osteotomy and step-cut osteotomy. These complex osteotomy techniques provide specific contact geometry for the osteotomy fragments and enhance torsional stability of the osteotomy site per se (*1,5*), rather than a transverse osteotomy. However, these techniques generally require complicated preoperative measurements and templating, and do not allow intraoperative adjustments once the osteotomy has been made (*3,26*). The authors therefore started with a transverse osteotomy in the subtrochanteric region, after which they performed a stable double chevron osteotomy, once the exact derotation and shortening had been determined . It is also generally agreed that the long stem prosthesis can stabilize the subtrochanteric osteotomy (*1,9,30,34*). Holtgrewe *et al* (*20*) pointed out that in cementless THA, combined with femoral osteotomy, the stem should extend distally to at least two times the diameter of the femoral shaft beyond the site of osteotomy and should fill the narrow cavity. Following this principle, standard cementless stems in our series were implanted in a press-fit fashion. The stem fixation was easy in 14 hips ; the femoral canals in the remaining 8 hips were too narrow for the smallest available stems, so that the femoral diaphysis had to be split both anteriorly and posteriorly for 4 to 10 cm. Subsequently the collared stem was inserted into the proximal femur in a press-fit fashion, and secured distally with several cerclage wires and bone autografts. The subtrochanteric osteotomy sites in the current series united satisfactorily in 3 to 6 months, without complications.

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