Uncemented Total Hip Arthroplasty With Subtrochanteric Derotational Osteotomy for Severe Femoral Anteversion

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Abstract: Total hip joint arthroplasty (THA) in the presence of severe femoral anteversion (>50°) is technically demanding. This problem is often encountered in patients with osteoarthritis secondary to hip joint dysplasia or congenital dislocation. We describe a method of THA in which an uncemented femoral prosthesis is used in conjunction with subtrochanteric derotational osteotomy. This technique allows the restoration of the normal proximal femoral anatomy, including the abductor muscle lever arm without resorting to greater trochanteric transfer. Correction of the excessive femoral anteversion avoids the tendency for postoperative anterior instability. The osteotomy site may also serve as the site for femoral shortening or angular correction when required, which preserves the normal femoral flare. The prostheses used were custom CAD/CAM (computer-assisted design/computer-assisted manufacturer) in design and had the following features: a close intramedullary proximal fit, with collar, lateral flare, and hydroxyapatite coating to achieve early proximal fixation, and longitudinally cutting fluted stem to provide immediate rotational stability across the osteotomy site. Although we used CAD/CAM custom prostheses, off-the-shelf uncemented hip prostheses with similar design features have become available. We report on 7 patients who underwent THA using this technique. The average patient age was 49 years (range, 34–61 years) with a mean follow-up period of 31 months (range, 16–60 months). To date, all cases have had a satisfactory outcome with evidence of union at the osteotomy site. Harris hip scores improved from an average of 44 preoperatively to 91 by the end of follow-up period. One case was complicated by delayed union at the osteotomy site, which was successfully corrected with bone grafting and temporary plate stabilization. Key words: Total hip joint arthroplasty, femoral anteversion, hip joint dysplasia, osteoarthritis, subtrochanteric derotational osteotomy, uncemented fixation, CAD/CAM prostheses.

Hip joint osteoarthritis in the presence of severe femoral anteversion is not easily amenable to surgical correction (Fig. 1) [1–6]. This condition is often associated with congenital dislocation of the hip (CDH) or acetabular dysplasia. The surgeon faces a number of technical problems when contemplating arthroplasty in these circumstances (Fig. 2). The abnormal upper femoral anatomy often necessitates the use of miniature or custom-made prostheses [2–6,7]. Femoral prosthesis insertion without correction of the excessive anteversion may result in postoperative anterior dislocation [7]. Furthermore, the likely eccentric loading of the acetabular component may lead to component toggle and early aseptic loosening.
In cases with a high false acetabulum, restoration of the normal anatomic position of the acetabular component is generally recommended [8]. In these cases, simultaneous femoral shortening is required to avoid sciatic nerve injury by excessive traction [4,6,9]. In severe femoral anteversion, the greater trochanter is often displaced superiorly and posteromedially [1,7]. Failing to restore the normal offset may lead to impingement of the greater trochanter on the pelvic wall and result in an inefficient abductor lever arm [7,10].

The traditional and most widely reported method of total hip joint arthroplasty (THA) in cases of CDH or subluxation has been the use of a transtrochanteric approach with cemented implants [1-6,9]. During this procedure, osteotomy of the greater trochanter is performed; the upper femur is shortened to the desired length; and after insertion of the femoral prosthesis and reduction of the components, the greater trochanter is wired onto the femur in a more anatomic orientation. Although this technique offers excellent exposure of the hip joint and allows simultaneous correction of the femoral length and the greater trochanter position, it has a number of disadvantages. First, the abductor insertion is violated during the trochanteric osteotomy, and this may result in abductor weakness or greater trochanteric detachment [2,3,9]. Second, excision of the intertrochanteric bone mass and calcar during femoral shortening destroys the proximal femoral flare, and this removes the best-quality bone available for achieving a stable proximal fixation against torsional stresses, especially when using one of the latest-generation uncemented implants. We therefore looked for a method other than the transtrochanteric approach.

We have addressed these problems by using an uncemented CAD/CAM (computer-assisted design/computer-assisted manufacturer) custom femoral prosthesis in conjunction with subtrochanteric derotational osteotomy. This technique allows easy correction of the abnormal position of the greater trochanter, and the osteotomy level may also serve as the site for femoral shortening or angular correction when required. We report here our preliminary experience with this operative technique and implant design.

Patients and Methods

Seven patients received a hip joint replacement of this type during the period 1993–1997. The average age of the patients was 49 years (range, 34–61 years). There were 2 men and 5 women. The original diagnosis in 6 patients was CDH and in 1 patient was childhood septic arthritis. In 2, the dysplasia was associated with high dislocation and in 5 cases with subluxation. According to Crowe’s classification [2], the joint dysplasia was graded as grade I in 1 case, grade II in 4, and grade IV in 2. Four of the 7 patients had previously undergone
Fig. 2. (A) Insertion of the femoral prosthesis in excessive anteversion risks postoperative anterior dislocation. Furthermore, the eccentric loading of the acetabular component may result in early aseptic loosening because of component toggle. (B) Insertion of the femoral prosthesis in normal anteversion avoids the problems encountered with anterior instability. An efficient abductor lever arm may not be achieved, however, because the abnormal offset and posteromedial position of the greater trochanter remains unchanged. Note the smaller canal diameter in the upper femur when the femoral component is inserted in normal anteversion ($a > b$), necessitating at times the use of miniature or custom-made prostheses.

Various operations for underlying hip joint conditions.

Preoperatively, all the patients had anteroposterior and lateral radiographs of the hip as well as measurement films of the lower limbs. To standardize the radiographs for the magnification factor, a radiopaque ruler was placed adjacent to the pelvis and the lower limbs when taking the measurement films. Computed tomography (CT) scans of the pelvis and knees were used to measure the angle of anteversion. The mean anteversion angle was $68^\circ$ (range, $50^\circ$–$90^\circ$). The superior displacement of the femur was determined by measuring the vertical distance between the teardrop and the superomedial corner of upper femoral metaphysis on anteroposterior pelvic radiographs. The mean superior displacement was 31 mm (range, 3–55 mm). Because it is our practice to restore the anatomic position of the acetabular component, if the estimated leg length increase was more than 20 to 30 mm, we shortened the femur to avoid sciatic nerve injury. In this series, 3 cases required femoral shortening during THA, in 1 by 10 mm and in 2 by 30 mm. In 1 other case, angular correction was performed at the site of a previous subtrochanteric osteotomy.

Using specialized computer software and the data obtained from the aforementioned investigations, an accurate 3-dimensional computer model of the upper femoral anatomy was constructed. The CAD/CAM custom prostheses were manufactured at the Centre for Biomedical Engineering (Stammore Implants World Wide Ltd, Middlesex, United Kingdom). The prostheses were made from titanium alloy with cobalt–chrome or ceramic interchangeable heads (22 or 28 mm diameter). The prostheses used had the following design features (Fig. 3): Proximally, there was a close intramedullary fit, with collar, macrogrooves, lateral flare, and hydroxyapatite coating, and distally the stem had longitudinally cutting flutes with a polished finish at its tip.

The rationale for employing these features was as follows: The collar was aimed to rest on the calcar to provide immediate resistance against subsidence and to allow impaction at the osteotomy site during implant insertion. Proximally, the prosthesis was designed to fill the intramedullary canal completely and rest directly on the cortical surfaces. The lateral flare was employed to increase further the torsional and axial stability of the implant. The macrogrooves were 1.5 mm in depth, were 3 mm in width, and ran
longitudinally along the intertrochanteric portion of the implant and were aimed to increase the surface area for osseointegration. To promote early osseo-integration, most of the implant surface was coated with plasma-sprayed, highly crystalline hydroxyapatite, 75 μ thick (Plasma Biotat Ltd, Tideswell, United Kingdom). The implant stem was hexagonal in cross-section with 6 1.5-mm high longitudinally cutting flutes. The outer stem diameter with the cutting flutes was designed to be 1.5 mm larger than the femoral canal diameter. During surgery, the femoral canal was reamed to a diameter 2 mm smaller than the outer diameter of the implant stem. We therefore aimed for each cutting flute to embed into the inner cortical surface by 0.75 mm and into the medullary cancellous bone by 0.25 mm. To ensure a stable reduction, a minimum of 60 mm of stem length was required beyond the osteotomy level. The polished tip maintained the sharpness of the cutting flutes and allowed easier insertion of the prosthesis.

The overall aim was to achieve proximal implant fixation with an even stress distribution and load transfer at the bone–implant interface [11]. The cutting flutes provided immediate rotational stability across the osteotomy site, thus allowing easy correction of the femoral length, rotational deformities, and angular deformities.

Surgical Technique

Operative technique involves approaching the hip joint through a standard posterior approach (Fig. 4). This approach allows easy release of contracted tissues, such as piriformis, obturator internus, quadratus femoris, and posterior hip joint capsule. After excising the femoral head, the acetabular cavity was prepared using sequential reamers. We prefer to use an uncemented porous-coated component on the acetabular side, and we try to insert this component as close to the true acetabulum as possible. In 1 case, a cemented polyethylene cup was used. Acetabular bone augmentation was not required in any of our cases.

The distal femoral canal was prepared using the T handled and flexible reamers to a predetermined diameter of 2 mm smaller than the outer diameter of the implant stem. The proximal femoral canal was then prepared using the custom-made rasp, which had the same dimensions as the prosthesis. The rasp was introduced in accordance with the existing femoral anteversion.

After removal of the rasp, the subtrochanteric osteotomy was made just below the level of the lesser trochanter by reflecting the vastus lateralis anteriorly using a bone spike and dividing the bone with an oscillating saw. We tried to maintain the muscle attachments proximal and distal to the osteotomy sites to avoid devascularization of the bone. When required, femoral shortening or angular correction was also performed below this site by resecting an appropriate segment or wedge of bone. The resected bone was used as a graft.

After the osteotomy, the bone ends were held with bone clamps, and the femoral prosthesis was partially inserted. The rotational correction was made just before the final impaction of the prosthesis. The final position of the femoral prosthesis and upper femur was 15° anteverted relative to the knee. We have not experienced any problems with insertion of the prosthesis or closure of the osteotomy site. Further cancellous bone-graft from acetabular or femoral reaming was also applied around the osteotomy site before wound closure. Postoperatively, patients were kept at partial weight bearing for 6 weeks and progressed to full weight bearing thereafter.

Fig. 3. A typical CAD/CAM (computer-assisted design/computer-assisted manufacturer) custom prosthesis.
Fig. 4. (A) The operative technique involves approaching the hip joint through a standard posterior approach. The femoral head is then cut and excised. (B) The femoral canal is prepared using the Thandles and flexible reamers. (C) The custom-made rasp is used to ream the proximal femoral canal accurately. The original femoral anteversion is initially maintained. (D) The rasp is withdrawn, and the osteotomy is made just below the level of the lesser trochanter. If required, femoral shortening or angular correction is also performed at this stage, below the osteotomy site. (E and F) The bone ends are held with bone clamps, and the rotational correction is made just before the final impaction of the prosthesis.

Results

Postoperatively, all patients were reviewed clinically and radiographically on a 6-week basis until union at the osteotomy site and yearly thereafter. The mean follow-up period was 31 months (range, 16–60 months). All patients considered their operation to have been worthwhile and would undergo the same procedure again under similar circumstances. Six of 7 patients experienced no pain, and 1 experienced mild discomfort on an occasional basis. Five of 7 walked without a limp. The other 2 patients had a mild Trendelenburg gait, but both patients had previously undergone failed pelvic and femoral osteotomies for underlying joint dysplasia. Only 1 of these patients required a walking aid for mobilization outdoors, and the remaining 6 did not use an aid at all. The average Harris hip score [12] improved from 44 (range, 20–71) preoperatively to 91 (range, 78–97) on the latest follow-up (Fig. 5). Radiographically, in all cases, the prosthesis appears to have osseointegrated with no macroscopic evidence of implant migration or significant translucent lines at the bone–implant interface. The osteotomy site united soundly in 6 cases within 3 months and fully consolidated by 1 year. In 1 case, the progress was initially complicated by persistent pain and suspected delayed union. At 3 months after the arthroplasty, a second procedure was performed for application of bone-graft and temporary stabilization with a plate using the Dall-Miles system (Howmedica Ltd, London, United Kingdom). Two screws and 1 cable were employed on either side of the osteotomy, and it united uneventfully within 3 months. The plate was removed 9 months later after consolidation of the osteotomy. In retrospect, the femoral stem length beyond the osteotomy was inadequate in this case (50 mm), and with a longer stem prosthesis, this complication may have been avoided.

Discussion

Although the transtrochanteric approach is the most widely reported technique in THA in patients with CDH or subluxation, we do not favor this technique because of the inherent problems associated with trochanteric osteotomy and excision of calcar, as discussed earlier. In this series, uncemented CAD/CAM custom prostheses were used in conjunction with the subtrochanteric derotational or shortening osteotomy. Off-the-shelf uncemented
Fig. 5. (A) Preoperative radiograph of a 45-year-old patient with osteoarthritis of the right hip joint secondary to congenital dislocation of the hip treated nonoperatively in childhood. (B) Preoperative computed tomography scan. (C) Immediate postoperative radiographs. Femoral shortening was required in this case, and the resected bone was used as bone-graft. After derotation, the normal morphology and offset of the greater trochanter on anteroposterior view has been restored. (D) Radiographs taken 18 months after surgery show sound union at the osteotomy site and osseointegration of the implant.

systems that offer distal rotatory control may also be used in preference to a custom-made prosthesis to provide adequate stability across the osteotomy site. Femoral shaft fracture is a well-recognized complication during insertion of a prosthesis into an underreamed femoral shaft. This problem may easily be avoided, however, by using a fluted stem design with sufficiently sharp and flexible edges. In this series, we did not experience any problems with insertion of the prosthesis into the distal fragment. The flutes provided adequate purchase distally to resist against torsional stresses.

THA with subtrochanteric derotational osteotomy in severe femoral anteversion is not a new concept. Holtgrewe and Hungerford [7] reported their experience with this technique in 2 patients using standard uncemented implants. One of the problems they faced was rotational instability at the osteotomy site, which required temporary fixation with a plate. The plates were removed at a second operation. Sponseller and McBeath [13] in a case report described a similar technique, but because they used a custom-made uncemented prosthesis with a long curved stem, adequate stability was achieved at the osteotomy site, and additional fixation was not necessary. Two further cases were reported by Morscher [14] in a review article. In 1 case, the operative technique was similar to the
cases described by Holtgrewe and Hungerford. In the other, a Wagner Cone Prosthesis (Protek, Berne, Switzerland) was used. Because of the fluted stem design of the Wagner Cone Prosthesis, sufficient stability was achieved across the osteotomy site, and additional fixation was not required. In our series of patients, we also found the fluted stem design to be a reliable means of achieving rotational stability across the osteotomy site, an advantage of an uncemented implant.

**Conclusion**

We find CAD/CAM custom total hip replacement with subtrochanteric derotational osteotomy a useful and reliable technique in THA with concomitant severe femoral anteversion. The early results of this technique to date have been encouraging and are comparable with other published series [1–7,9].

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**References**