Transverse Subtrochanteric Shortening Osteotomy in Total Hip Arthroplasty for Severe Hip Developmental Dysplasia

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Abstract

Thirty-five total hip arthroplasties (33 patients) were performed in cases of Crowe grade III or IV hip dysplasia using subtrochanteric shortening osteotomy with two kinds of femoral stem: monoblock and modular type. All acetabular components were used with a cementless cup. The average patient age was 47.8 years, and the average follow-up time was 5.1 years. Acetabular reconstruction was performed using autogenous femoral head in 11 hips. Radiologically, hip centres were nearly normalised with vertical heights of 10.6mm elevation and horizontal lengths of 1.7mm compared with uninvolved sites. Leg length discrepancies were improved from 4.7 to 1.5cm. Early post-operative complications included two non-unions at the osteotomy site, one dislocation after monoblock stem, one case of peroneal nerve palsy and one subsidence occurring after modular stem placement. The non-union fractures were managed with bone grafts and modular stems. The dislocation was managed with closed reduction and an abduction brace. The peroneal nerve patient was managed with an ankle stop brace. Late complications included cup loosening, but there was no loosening in the femoral stem. The average Harris Hip Score was improved from 36 to 82.4. These data demonstrate that a cementless modular femoral stem is the more useful device for treating hip dysplasia patients.

Keywords

Total hip arthroplasty, developmental dysplasia, modular femoral stem

The high developmentally dislocated hip involves one of the most challenging reconstructive surgical procedures in total hip arthroplasty. There are many anatomical deformities that contribute to the complexity of arthroplasty. Poor acetabular bone stock, high dislocation of the proximal femur and narrowness of the femoral canal cause technical difficulties during surgery. Soft tissues surrounding the hip joint are frequently contracted because of the chronicity of dislocation.1 The longevity of hip arthroplasty in these patients has improved through restoration of the anatomical hip centre, which decreases the hip joint reaction force and creates an improved lever arm for the abductor musculature.1–3 Restoration of the anatomical hip centre frequently requires limb lengthening in excess of 4cm and increases the risk of neurological traction injury.1,3 Surgical techniques used for high-riding dislocations of the hip are different from those used to correct simple acetabular dysplasia. If shortening of the femur is not performed, reduction of the femoral head into the true acetabulum is impossible, and there is the risk of excessive lengthening of the neurovascular structures. One option for restoring the anatomical hip centre is subtrochanteric femoral shortening osteotomy. Various techniques for shortening osteotomies have been described.1,3 Bruce et al. recently reported on five cases using a modular cementless femoral system combined with a transverse osteotomy for femoral shortening.1

The risk of surgical complications associated with total hip arthroplasty increases as the extent of dislocation according to the Crowe classification1 becomes more severe, depending on the degree of developmental dysplasia of the hip joint. Major complication rates reported in the literature for total hip arthroplasty treatment of severe acetabular dysplasia using shortening femoral osteotomy range from 12 to 41%.1,3–6 Patients with untreated high developmental hip dislocations frequently develop symptoms of secondary arthritis during the fourth and fifth decades of life.1,3,6 These patients presented myriad challenges for total hip arthroplasties. The dysplastic acetabulum is hypoplastic and its bone density is often low because of lack of stress remodelling. The femur is small and often exhibits an excessive neck–shaft angle and increased anteversion, which shifts the greater trochanter to a more posterior position. Femoral shortening osteotomy was described by Klicic and Jankovic7 for high dislocations and was adapted by Crowe et al.1 to include simultaneous hip arthroplasty. The two largest series reported in the literature include a study of 28 hips treated with a step-cut shortening osteotomy based on pre-operative radiographic templating,4 and a report on 25 hips treated with a transverse shortening osteotomy based on intra-operative femoral length.1 The purpose of our study is to present a transverse osteotomy technique and complications related to the femoral stem.

Materials and Methods

From November 1998 to February 2003, we performed 76 total hip arthroplasties for cases of arthritis secondary to hip dysplasia. Of these, 35 hips (in 33 patients) were managed with transverse femoral...
shortening osteotomy reviewed for final evaluation. Two cases had a history of previous pelvic osteotomy, and one had a dislocation due to failure of a previous total hip arthroplasty performed in another hospital. There were 22 women and 11 men with a mean age of 47.8 years (range 22–69 years) at the time of index surgery and the mean follow-up after surgery was 5.1 years (range 2–7.6 years) (see Table 1). No patients were lost in the last follow-up. All operations were performed by the author and attempted to restore the anatomical hip centre. The surgical approaches were anterolateral in 27 hips and posterior in eight hips. All the acetabular and femoral components were cementless. Standard monoblock femoral stems − BiContact® (Aesculap), Duofit® (SAMO) and C2 (DePuy), MP® (Waldemar Link) and Revision modular (Lima) − were used in 16 hips, and modular femoral stems − S-ROM® (DePuy), MP® (Waldemar Link) and Revision modular (Lima) − were used in 19 hips. Porous-coated acetabular components with dome screws were used in all hips (with an average of two screws per hip). A structural femoral head autograft was used in 11 hips for acetabular shelf reconstruction. The other cup was contoured by flying buttress structural femoral head autograft was used in 11 hips for acetabular shelf reconstruction. The other cup was contoured by flying buttress autogenous grafts from acetabular reaming.

Clinical and radiographic post-operative evaluations were performed after six weeks; three, six and 12 months; then yearly. The clinical evaluation was carried out based on Harris Hip Scores and, subjectively, the surgical outcomes were described on a four-point scale as excellent, good, moderate or not improved, or unsatisfactory. Gait was rated in a manner previously described: none, slight limp (detected by trained observer), moderate limp (detected by patient or family) or severe limp (gait markedly altered). The stability of the femoral component was assessed as bone-ingrown fixation, stable fibrous fixation or unstable fixation according to the fixation/stability score described by Engh et al.

### Results

#### Complications

Intra-operative cracks or fractures of the proximal segment occurred soon after surgery in three hips. All of these fractures were managed with cerclage wires. Early complications during one year post-operatively, in patients with monoblock stems, there were two non-unions and one dislocation in the osteotomy stems. The dislocation was managed with closed reduction under anaesthesia and an

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applied abduction brace, and did not develop further problems. The two non-union cases were managed with a bone graft and the monoblock stem replaced with a modular stem. Among patients with modular stems, one patient developed femoral stem subsidence two months after the operation; the stem was replaced with a larger diameter modular stem. One case of peroneal nerve palsy was revealed after operation, but this patient improved during the follow-up period. Late complications during follow-up period over one year, two cup loosening noted around five years; one was associated with the patient falling down and the other was due to cup migration. These were managed with a hook-plate cup cage, but there was no loosening in the femoral stem at last follow-up (see Table 2).

Clinical Results
The average Harris Hip Score for the patients showed an improvement from 36 points pre-operatively to 82.4 points post-operatively. The post-operative average leg length discrepancy in patients with unilateral dysplasia was 42mm (range 35–60mm). The difference between leg lengths was decreased from an average 4.7cm (range 2.0–6.97cm) to 1.5cm (range 0.7–2.5cm). We also evaluated the complaints of the patients about the surgical outcomes through the administration of a questionnaire that included items in terms of pain (including thigh pain) and functional capabilities. The surgical outcomes were graded as ‘excellent’ for 11 patients, ‘good’ for 18 patients, ‘moderate’ for three patients and ‘unsatisfactory’ for one patient. The presence and degree of a pre-operative limp among the patients was graded as none (0%), mild (17%), moderate (57%) or severe (26%). The post-operative limp was graded as none (30%), mild (49%), moderate (15%) or severe (6%).

Radiographic Evaluation
The mean acetabular component size was 48.46mm (range 44–54 mm). Radiologically, the average horizontal distance of a normal hip centre is 32.5mm (range 27.8–39.4mm) and the vertical distance is 18.3mm (range 13.9–28.2mm) after magnification correction. The average horizontal length of the total hip was 30.8mm (range 21.9–45.2mm) and the average vertical height of the total hip arthroplasty was 28.9mm (range 16.8–40.9mm). The hip centre was nearly normalised, with 10.6mm elevations in vertical height and a horizontal length of 1.7mm compared with uninvolved sites. The mean osteotomy resection was 34mm in length (range 20–42mm). Thirty-three of the 35 osteotomies healed without any complication. The average time for radiographic union was 3.2 months (range 2.0–4.2 months).

Use of Assistive Walking Devices
Assistive devices were not required pre-operatively in 52% of the patients. A cane or crutches were needed by 44% of the patients prior to surgery, and 4% required a wheelchair or were unable to walk. Post-operative use of assistive devices was not required by 85% patients, while 9% needed a cane or crutches and 6% required a wheelchair or were unable to walk.

Revision Surgery
Revision surgery was performed in three patients within one year after the initial operation. The reasons for two revisions were non-unions in the osteotomy site after monoblock stem placement; these were managed by additional bone grafts and distally fixing modular stems. With one modular femoral stem, femoral stem subsidence occurred two months after operation. This was managed with a larger diameter modular femoral stem. During follow-up, cup loosening was observed in two hips. Both were classified as Crowe type IV, and were managed with hook-plate cup cages. During the follow-up period, there was no loosening noted in the femoral stem.

Discussion
Total hip arthroplasty in patients with developmental dysplasia of the hip has been associated with many complications and unfavourable outcomes compared with total hip arthroplasty carried out in patients with degenerative disease. The most common problem associated with dysplasia is insufficient acetabular bone coverage, which can compromise the durability of component fixation. One option for restoring the anatomical hip centre is subtrochanteric femoral shortening osteotomy described by Klisic and Jankovic. Other shortening osteotomy techniques have been described, such as step-cut, double-chevron, oblique and transverse shortening osteotomy. Among these procedures, we chose a transverse osteotomy since it is easy to perform intra-operatively.
Dysplasia of the acetabulum leaves deficiency, particularly in the superior acetabulum, in high developmental dislocations as a challenging reconstructive procedure. The location of the acetabular cup in developmental dysplasia of the hip joint has been a controversial matter. According to Linde and Jensen,¹⁹ the severity of femoral head dislocation before surgery is associated with a higher frequency of dissociation of the acetabular cup. We predicted that the frequency of dissociation of the acetabular cup would be higher in cases where the acetabular cup is not positioned within the true acetabulum. If there were inadequacies in the acetabular cup, we tried autogenous bone grafting using a femoral head and medialisation of the acetabular cup that was commonly employed. In this investigation, bulk structural autogenous bone grafting was used in 11 hips, and flying buttress grafting was used in others. The location of the true acetabulum was difficult to determine in most cases, but following the elongated and attenuated capsule down to the true acetabulum was often helpful. During the operations, we frequently used intra-operative C-arm fluoroscopy to find the location of the true acetabulum. Using this method, we successfully placed all acetabular components into the true acetabulum. The average size of femoral and acetabular components was significantly smaller than standard implants. Therefore, detailed pre-operative templating and planning were essential.

Recently, Bruce et al.⁷ and Masonis et al.²⁰ reported on usage of a modular cementless femoral system combined with transverse osteotomy for femoral shortening osteotomy. Major complication rates reported in the literature ranged from 12 to 41%.⁷,²⁰ We tried this technique using two femoral stems, one a primary monoblock femoral stem and the other a distally fluted femoral stem. We observed two non-unions related to osteotomy and one stem subsidence in the early post-operative period with a transverse subtrochanteric shortening osteotomy. Both non-unions were associated with a monoblock femoral stem. Subsidence of a modular femoral stem was caused by a smaller stem rather than a medullary canal. Onodera et al.²¹ reported that the S-ROM modular femoral stem provides sufficient rotational stability in both proximal and distal parts of the osteotomy in 14 hips except one at six months follow-up. Onodera et al.²¹ also concluded that another benefit of the S-ROM design is easy control of anteversion of the stem that should theoretically decrease the rate of dislocation by allowing the surgeon to adjust the version to give a more stable arc of motion. Although with some monoblock stems non-union was revealed at the osteotomy site, we preferred to use a distally fixed fluted stem recently because control of anteversion of the S-ROM was not easily compared with other distally fixed modular stems (such as the Link [see Figures 1 and 2] or Lima [see Figure 3 and 4] modular stems), and there were also difficulties in leg length correction. We observed a distally divergent halo sign around the distal cloth pin of an S-ROM design after three years in one hip. However, the recent development of a short distally fixed modular femoral stem allows initial stabilisation and correction of leg length discrepancy, and does not require additional fixation to the osteotomy site. Other modular distally tapered stems (Lima or Link modular stems) also have the drawback of subsidence compared with the S-ROM modular stem.

In our study, three out of 35 hips required revision surgery one year after the initial operation. This is consistent with the limited number of published reports on this topic.¹⁴,¹² Repeat surgery was directly related to the use of a standard monoblock femoral stem; this stem usually requires metaphyseal fitting, so distal fragments are not tightly fixed. One drawback of the modular stem is mismatching of the medullary canal. We found that transverse osteotomy resulted in a union rate identical to a recent published report using a step-cut method,¹⁴ and was technically easier to adjust intra-operatively to correct rotational abnormalities.

Our data support the use of transverse subtrochanteric femoral osteotomy and cementless acetabular fixation at the anatomical hip centre for correcting high developmental hip dysplasia with secondary arthritis. Subtrochanteric shortening osteotomy appears...
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to be a safe and reliable procedure for restoring the anatomical hip centre and trochanteric rotation without neurological injury. Although the patients in our series experienced substantial improvements in pain reduction and hip function after total hip arthroplasty, their final hip scores were lower than those for patients undergoing hip arthroplasty for degenerative osteoarthritis. Continuous follow-up is required to establish the long-term results of this procedure.