Treatment of Crowe IV high hip dysplasia with total hip replacement using the Exeter stem and shortening derotational subtrochanteric osteotomy

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doi:10.1302/0301-620X.93B1.24689 $2.00

J Bone Joint Surg [Br] 2011;93-B:34-8.
Received 16 February 2010; Accepted after revision 4 August 2010

We evaluated all cases involving the combined use of a subtrochanteric derotational femoral shortening osteotomy with a cemented Exeter stem performed at our institution. With severe developmental dysplasia of the hip an osteotomy is often necessary to achieve shortening and derotation of the proximal femur. Reduction can be maintained with a 3.5 mm compression plate while the implant is cemented into place. Such a plate was used to stabilise the osteotomy in all cases. Intramedullary autograft helps to prevent cement interposition at the osteotomy site and promotes healing. There were 15 female patients (18 hips) with a mean age of 51 years (33 to 75) who had a Crowe IV dysplasia of the hip and were followed up for a mean of 114 months (52 to 168). None was lost to follow-up. All clinical scores were collected prospectively. The Charnley modification of the Merle D'Aubigné-Postel scores for pain, function and range of movement showed a statistically significant improvement from a mean of 2.4 (1 to 4), 2.3 (1 to 4), 3.4 (1 to 6) to 5.2 (3 to 6), 4.4 (3 to 6), 5.2 (4 to 6), respectively. Three acetabular revisions were required for aseptic loosening; one required femoral revision for access. One osteotomy failed to unite at 14 months and was revised successfully. No other case required a femoral revision. No post-operative sciatic nerve palsy was observed.

Cemented Exeter femoral components perform well in the treatment of Crowe IV dysplasia with this procedure.

Developmental abnormalities of the hip joint in adults can lead to secondary osteoarthritis requiring total joint arthroplasty at a relatively young age.[1] The severity of dysplasia varies widely, and secondary osteoarthritis of the hip presents a broad spectrum of reconstructive challenges.[2,3] Total hip replacement (THR) has a higher failure rate in patients with this condition.[4] A high hip centre, a small femoral canal and increased femoral anteversion with a posteriorly positioned greater trochanter contribute to the complexity of arthroplasty in a severely dysplastic hip.[5] Restoration of the hip centre to the true acetabulum in THR under these circumstances may lengthen the leg excessively and jeopardise neurovascular structures.[6] Femoral shortening may therefore be necessary.[7] The excessive femoral anteversion and the posterior position of the greater trochanter in chronic hip dysplasia contribute to instability and limp, which can be corrected with a derotational osteotomy at the time of shortening.[8]

Cementless femoral components have been used more commonly when a subtrochanteric osteotomy is performed,[5,6,9-19] thereby avoiding the risk of leakage of cement into the osteotomy site, which is a potential problem with cemented components.[6,15] We describe the operative technique employed and the results of all cases of Crowe IV high hip dysplasia1 treated at our hospital by THR using a cemented Exeter femoral component, in which a shortening derotational subtrochanteric osteotomy was necessary.

Patients and Methods

We identified all patients with Crowe IV high hip dysplasia1 treated with a shortening derotational subtrochanteric osteotomy at the time of THR in our unit. There were 18 consecutive procedures in 15 female patients with a mean age of 51 years (33 to 75) between 1993 and 2003, with a minimum follow-up of four years. The mean follow-up was 114 months (52 to 168). Data were collected prospectively in all cases and included patient demographics, clinical, operative and radiological findings, and complications. A cemented Exeter femoral component (Stryker Corporation, Mahwah, New Jersey) was used in all cases. The acetabular component was cemented in 16 patients. A cementless, metal-on-polyethylene bearing was used in both hips in a bilateral procedure, because the acetabula were found to be too small for cemented components. A 40 mm cementless shell reinforced with screws was used on both sides. A common finding in dysplastic acetabula is a narrow anteroposterior diameter with a superior segmental deficiency. Our aim was to position the acetabular component in the true centre of rotation of the acetabulum. Among the 16 cemented acetabular components, autograft in the form of impacted cancellous chips was used for superolateral deficiencies in ten hips. This was contained with either rim mesh in two hips or a small fragment buttress AO T-plate (Synthes GmbH, Solothurn, Switzerland) in the seven cases performed before the mesh became available. One acetabulum was reconstructed with impacted cancellous autograft chips alone without a mesh or plate. A block graft fixed with cancellous screws was used in one hip.

Operative technique. A posterior approach was used in every case. The acetabulum was prepared after identifying the true acetabular floor, with the transverse ligament confirming an accurate position for the centre of the hip. Depending on the degree of dysplasia, the superolateral deficiency was addressed as described above. The femur was prepared with the entry point on the osteotomy of the neck developed from within the calcar towards the greater trochanter as far laterally as necessary in order to allow the femoral component to be passed directly down the canal. A standard box chisel osteotome was used for this, or a modified long-handled Capener spinal gouge for smaller femora. The femoral canal was entered using tapered pin reamers followed by rasps, where possible preparing the proximal femoral canal until the rasp was seated at the planned position based on pre-operative templating. Sometimes it was not possible to insert the rasps of the appropriate offset prior to a femoral osteotomy. If a rasp could be introduced a trial reduction would then be attempted. In the cases described in this series we were unable to reduce the hip joint owing to the soft-tissue tension produced by lengthening, sometimes combined with excessive anteversion of the femoral neck. A shortening derotational osteotomy was then required in every case.

The lateral surface of the proximal femoral diaphysis was exposed, avoiding unnecessary stripping of the periosteum. A longitudinal line was marked with diathermy and methylene blue to permit later assessment of rotational orientation. Vastus lateralis was retracted and protected by bone levers so that two parallel transverse osteotomies could be made, excising a segment of subtrochanteric bone. The importance of the parallel cuts cannot be overemphasised, as this enhances bony contact between the proximal and distal fragments at the time of fixation, as well as preventing any angular deformity. It was facilitated by using two oscillating saw blades, with the first blade left in the distal osteotomy site once this was almost complete. The second blade was then used to orientate the proximal cut parallel to the distal cut, as indicated by the blade left *in situ*. The length of the fragment to be excised should be carefully considered, minimising the risk of over-resection. A minimum amount of bone was excised to allow correction of leg-length inequality without excessive soft-tissue tension, which could jeopardise neurovascular structures. Having completed the osteotomy, a trial stem was inserted into the proximal fragment only and the hip joint and proximal fragment reduced for the first time. The amount of overlapping bone between the proximal and distal fragments was then assessed. Once this was deemed satisfactory the tip of the trial stem was inserted into the distal fragment. Any excessive anteversion was corrected with guidance from the longitudinal line previously made, resulting in an improved lateral position for the greater trochanter with the attached abductor muscles. The hip was then reduced and assessed for stability, leg length and soft-tissue tension. The osteotomy site was then fashioned to allow as accurate a reduction as possible, and stabilised with a six-hole, small fragment dynamic compression AO plate (Synthes GmbH) placed posterolaterally, using unicortical 3.5 mm screws in order to avoid the stem within the medullary canal. As an added precaution, two pairs of bone-holders were applied to stabilise the plate in position during subsequent preparation and cementing of the femoral component. The position of the trial stem within the proximal femur was marked as a reference for the final seated position of the definitive implant. Adequate reduction of the osteotomy site was then confirmed prior to packing it with cancellous autograft obtained from the femoral head, the acetabulum or the resected segment, sealing the osteotomy from within the canal to minimise the risk of cement leaking during pressurisation. A polymethylmethacrylate (PMMA) Exeter intramedullary plug (Stryker) was inserted after correct sizing and positioned at the desired level, depending on the length of the selected stem. The distal canal was then irrigated and cleansed before Simplex cement (Stryker) was injected in a retrograde fashion, aided by the use of a suction catheter. A contemporary cementing technique was employed, using a cement gun with a proximal femoral seal. During pressurisation it is possible that cement will escape in at least one area of the osteotomy site: this should be allowed while cement continues to be injected in order to maintain pressure in the canal. Attempting to stop cement leakage at one site often leads to it escaping elsewhere, with greater compromise of the opposed bone. Owing to the small size of the canal, the femoral component was inserted sooner than in a standard primary THR, to ensure that the rehearsed position was achieved without difficulty. Cement was then cleared from the osteotomy site so that more cancellous bone could be applied. After further trial reduction an appropriate femoral head was chosen. The use of different neck lengths allowed minor adjustment to the leg length and offset.

Post-operative regimen. Partial weight-bearing was allowed for six to eight weeks, followed by a gradual increase as comfort allowed, until 12 weeks, when full weight-bearing was commenced.

Table I. Pre- and post-operative scores according to the Charnley modification[20] of the Merle D'Aubigné-Postel system

	Pre-operative mean (range)	Post-operative mean (range)	p-value
Pain	2.4 (1 to 4)	5.2 (3 to 6)	< 0.001
Function	2.3 (1 to 4)	4.4 (3 to 6)	< 0.001
Movement	3.4 (1 to 6)	5.2 (4 to 6)	= 0.001

The patients were reviewed at six weeks, six months, one year and every two years thereafter, with radiographs at each review. The Charnley modification[20] of the Merle d'Aubigné-Postel scoring system was used in the clinical assessment. Non-parametric data obtained were tested using Wilcoxon's signed-ranks test. No patient was lost to follow-up.

Radiological assessment. Pre- and post-operative anteroposterior (AP) and lateral radiographs were available in all patients. The images were analysed jointly by two authors (JAFC, ET). Healing of the osteotomy site was assessed with radiological union being defined as cortical continuity on both the AP and the lateral views. Subsidence of the femoral component within the cement mantle was assessed by measuring changes in the height of the radiolucent line at the stem-cement interface in Gruen zone 1,21 as described by Fowler et al,[22] using the Orthochart software (Ortho-Graphics Inc., Salt Lake City, Utah) and digitised films magnified to 200%. Loosening was assessed by the presence of radiolucent lines in all zones, or by migration of the component.

Statistical analysis. The data was not normally distributed so pre- and post-operative scores were compared using Wilcoxon's signed ranks test for non-parametric paired data. The level of significance was 5% which was adjusted for multiple testing using Bonferroni's method. Scores are presented as means and ranges. Analysis was performed using SPSS version 18.0 for Windows (SPSS Inc., Chicago, Illinois).

Results

The pre- and post-operative clinical scores are shown in Table I and the differences between them were statistically significant. All patients in this series were Trendelenburg positive before operation. At the latest review, six of the 18 hips were Trendelenburg negative, with 12 remaining either Trendelenburg positive or fatigue positive.

Revision of the acetabular component for aseptic loosening was required in three hips, one at 68 months, when the femoral stem was removed to aid exposure, and a new 33 mm offset stem was cemented into the pre-existing mantle. The other two acetabular revisions were at 109 and 135 months, but the original femoral components did not require removal. On review of the primary procedures of the three revised acetabular components, one had autografting contained with a buttress AO T-plate and was revised at 109 months, one had autografting alone, revised at 68 months, and one had no autograft and was revised at 135 months. No patient had aseptic loosening of the femoral component. In all the remaining hips, the acetabular component remained well fixed with radiological evidence of incorporation of the graft when it was used. One femoral osteotomy failed to unite, requiring revision after 14 months, with removal of the femoral component, the plate and most of the cement at the osteotomy site, as well as re-excision of the osteotomy for optimal apposition of the fragments. More autograft was added and the osteotomy united satisfactorily.

Subsidence of the femoral component within the cement mantle was < 2 mm in all cases, and < 1 mm in 13. This is a similar pattern of subsidence to that previously reported for this component.[23,24]

The mean length of the excised subtrochanteric segment was 3 cm (1.5 to 5). The mean lengthening was 3 cm (1 to 4). Adductor tenotomy was required in two cases. No patient had a post-operative sciatic nerve palsy. There was one femoral nerve palsy which recovered spontaneously.

The pre- and post-operative radiographs of two cases are shown in Figures 1 and 2.

Discussion

In THR for high hip dysplasia, adequate reconstruction with restoration of the anatomical centre of the hip without neurovascular compromise is required.[6] A shortening derotational subtrochanteric osteotomy may be needed to achieve this. Various techniques of subtrochanteric osteotomy have been described, most commonly transverse,[4,5,8,10,25] step-cut,[6,14-16,18] or double chevron.[9,13] These patients have particular anatomical characteristics, such as a narrow canal, a short offset and increased femoral anteversion. The aim is to allow adequate reduction of the hip, accurately restore the rotational alignment of the proximal femur and improve the lever arm of the abductor musculature by restoring the lateral position of the greater trochanter. A transverse osteotomy is the chosen method to address this deformity. Although the exact amount of torsional deformity corrected was not available for each procedure in this retrospective review, restoration of femoral anteversion was achieved.

The Exeter femoral component was the first collarless polished double-tapered stem and has a survival rate of 100% with an endpoint of aseptic stem loosening at 17 years when using a contemporary cementing technique, even in patients under the age of 50 at operation.[23] The mean age of the patients in this series was 51 years (33 to 75). It was therefore

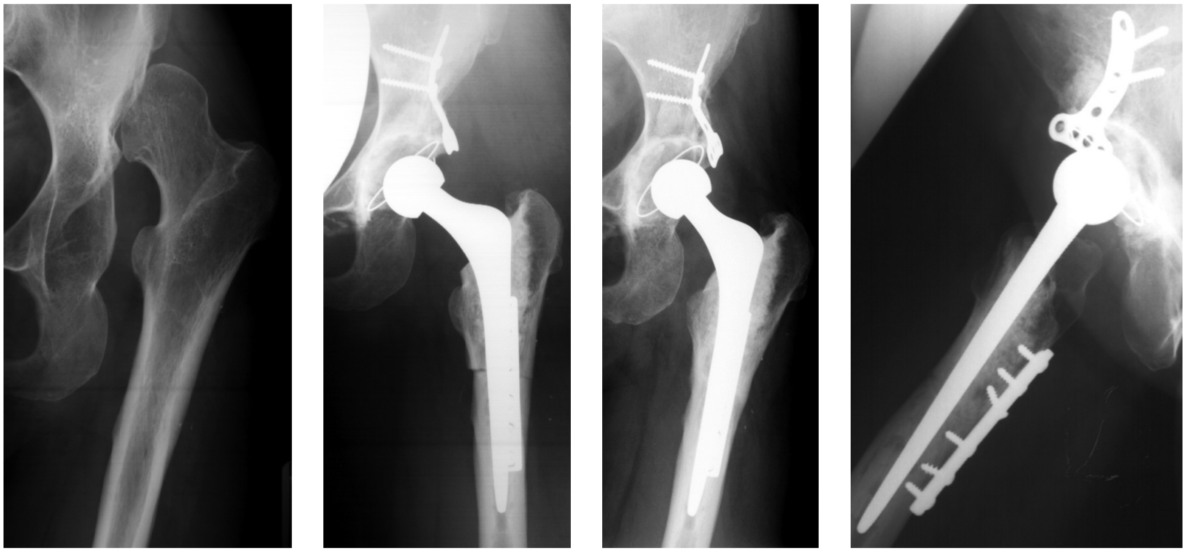

Fig. 1a Fig. 1b Fig. 1c Fig. 1d

Anteroposterior (AP) radiographs of the left hip a) pre-operatively, b) immediately after operation, c) after 12 years and d) lateral view after 12 years.

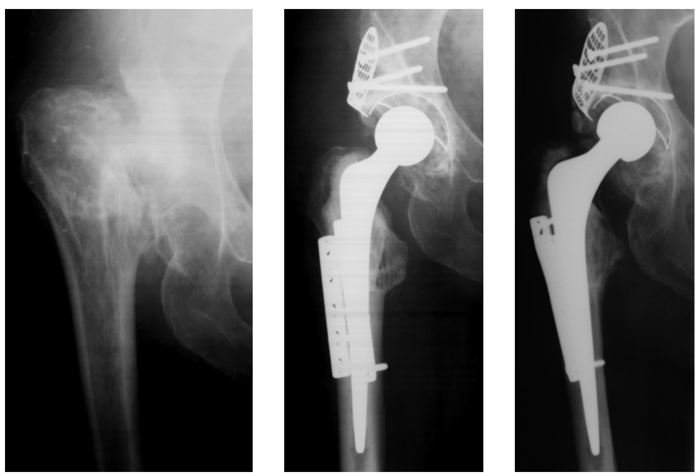

Fig. 2a Fig. 2b Fig. 2c

Anteroposterior (AP) radiographs of the right hip a) pre-operatively, b) immediately after operation and c) after five years.

appropriate to use this component. The wide range of sizes and offsets which are available, in particular the 30, 33 and 35.5 mm offset short stems developed for patients in the Asia Pacific area, are ideal in these cases. Although experience with the use of cemented stems varies,[1,25-29] uncemented stems have been more frequently used when a subtrochanteric osteotomy is performed.[5,6,9-18] Some authors suggest that the use of uncemented stems in these cases is essential,[15] as there is no risk of cement leakage into the osteotomy.[6] Two recent studies[30,31] report satisfactory results with the use of cementless stems in similar groups of patients. Both report femoral revision for nonunion of the osteotomy in at least one hip in each study, and femoral revision for intra-operative femoral fracture in one hip in one of the studies.[31] We experienced no intra-operative fractures and 17 osteotomies united satisfactorily, with one hip requiring a revision of the femoral component for nonunion.

In each of the 18 hips autograft from the resected femoral head was impacted onto the osteotomy from the endosteal side to seal it from penetration by cement and to promote union. A step-cut or oblique osteotomy may increase bony apposition, but with excision of a segment of bone and derotation of the proximal fragment, the size and anatomy of the two surfaces to be opposed is very different, and accurate reduction is extremely difficult. Our technique avoids this problem. Nonunion of the osteotomy requiring revision has also been described in previous studies where uncemented stems were used,[4-6,8,32,33] with some authors recommending augmentation using allograft struts and cables for torsional stability.[4,5,8,9] We found rotational stability to be satisfactory, and reinforcement with allograft struts was not found to be necessary. The presence of a well-fixed cement mantle and a plate contributes significantly to rotational stability. Rather than being a main factor in achieving rigid fixation, the plate maintains reduction of the fragments before the stem is cemented. If any obvious movement or visible gap is noted at the osteotomy site prior to cementing, a second plate must be used or the fixation re-addressed before any cement is inserted. In our series, a second plate was required in three hips, with union in every case. The length of the stem is vital in achieving stability. It must bypass the osteotomy by at least twice the diameter of the diaphysis, especially in cases requiring more robust fixation, such as in young men. If, at the end of the procedure, there is any sign of instability at the osteotomy site, it must be revised or additional fixation used.

Limb lengthening was measured by comparing the pre- and post-operative radiographs, taking into account the resected segment. The maximum lengthening of 4 cm obtained in this series is within the recommended limit of safety from the risk of post-operative nerve palsy.[34,35]

We did not encounter any post-operative dislocations. A conventional trochanteric osteotomy was not chosen, as this manoeuvre increases the risk of nonunion and the incidence of abductor insufficiency.

Our results support the continued use of a shortening osteotomy, combined, where necessary, with derotation of the proximal fragment and insertion of a cemented stem that works on the taper-slip principle.[23,24] We believe that accurate reduction of the osteotomy and the use of autograft at the endosteal surface may be important in promoting healing of the osteotomy.

The authors acknowledge with gratitude the work done in the Exeter Hip Unit at the Princess Elizabeth Orthopaedic Centre by R. Sculpher, S. Wraight, Z. Tippett, S. Kolowska, C. Harris and L. Collett, which included keeping track of every patient, and would like to thank S. L. Whitehouse for her assistance with this study.

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