Femoral shortening and cementless arthroplasty in Crowe type 4 congenital dislocation of the hip

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Received: 17 April 2011 / Accepted: 25 May 2011 / Published online: 11 June 2011
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Abstract

Purpose In reconstruction of congenital hip dislocation by total hip arthroplasty (THA), positioning of the acetabular component in the true acetabulum is sometimes accompanied by shortening of the femur. Shortening of the femur is of importance for minimising risk of damaging neurovascular structures due to excessive limb lengthening. Furthermore, reduction of the femoral head into the true acetabulum remains challenging without shortening of the femur.

Methods We performed a consecutive case series of cementless THA with femoral shortening and Crowe type 4 congenital dislocation. All acetabular cups were placed in their original anatomical location. In all cases a proximal diaphyseal step-cut shortening osteotomy was performed and stabilised with two to three titanium cerclage bands.

Results At an average of 60 months follow-up (range 36–96), 12 patients (13 THA) were scored clinically by the Merle D'Aubigne and Harris hip scores. In ten cases good to excellent outcome scores were observed. During the follow-up period no cases of aseptic loosening, nerve palsy, nonunions or dislocations were found.

Conclusions This technique seems to be an excellent treatment option in the case of Crowe type 4 hips presenting with endstage osteoarthritis.

Introduction

In surgical reconstruction of congenital hip dislocation, positioning of the acetabular component in the true

acetabulum can only be accomplished by shortening of the femur [1–4]. Resection of several centimetres of the proximal end of the femur and cemented fixation of the stem has been previously reported [1, 3, 5–8]. Cemented components have failed because of metal fatigue of small-sized stems or failure of the narrow cement mantle [1]. Aseptic loosening has been reported to be a considerable problem in young and middle-aged patients without congenital dislocation of the hip [1].

Crowe et al. [9] classified developmental dysplasia of the hip according to the magnitude of subluxation of the femoral head as indicated by the proximal migration seen on an anteroposterior radiograph of the pelvis. The Crowe classification includes four types: I (<50% subluxation), II (50–75% subluxation), III (75–100% subluxation), and IV (100% subluxation). Total hip arthroplasty (THA) has been reported to provide a high rate of functional improvement and pain relief for most patients with symptomatic end-stage arthritis secondary to Crowe type-I, II, or III developmental dysplasia of the hip. However, the pathoanatomy of a severely dysplastic hip (Crowe type IV) increases the complexity of reconstruction and is surgically challenging for an arthroplasty surgeon. Placement of the acetabular component in the true acetabulum has yielded the most durable results of total hip arthroplasty in patients with developmental dysplasia of the hip [5, 10–12]. In Crowe type IV dysplasia, the best bony support for an acetabular component is usually at the anatomical hip centre.

For these reasons in high-riding congenital dislocation of the hip, we have chosen the treatment of cementless THA with femoral shortening osteoplasty.

Earlier reports of subtrochanteric shortening osteotomy included heterogeneous groups of cemented and cementless acetabular and femoral components [8, 13].

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The purpose of our study was to review the clinical and radiographic outcomes and report the major complications of patients presenting with Crowe type IV developmental dysplasia of the hip that underwent reconstruction with a cementless THA and a subtrochanteric z-shaped (step cut) shortening osteotomy. We evaluated the rate of mid-term complications and survivorship.

Materials and methods

We retrospectively reviewed 12 patients (13 hips) in whom THA was performed for Crowe type IV dysplasia from 1996 to 2007. The average age was 58 years (range, 20–67 years) with ten females and two males. The indications for arthroplasty were severe pain and/or functional impairment with difficulty in walking and performing daily activities. The minimum follow-up was three years (mean, 60 months; range, 36–96 months).

Patients were evaluated using the Harris hip score [14] and the Merle D'Aubigne [15] score. Clinical evaluation also included the measurement of preoperative and postoperative leg length, and the Trendelenburg sign was used to measure muscle strength. Routine radiographic examination included anteroposterior and lateral hip radiographs. Radiographic analysis of the prosthesis was performed according to DeLee and Charnley [16] for the acetabulum and Gruen et al. [17] for the femur. The medialisation of acetabular component was measured by the difference between the most medial edge of the acetabulum and Kohler line (ilioischial line) and the postoperative horizontal distance between the most medial edge of the component and Kohler line [1]. The abduction of the acetabular component was measured from the horizontal line connecting both ischial tuberosities and a line parallel to the lateral opening of the component. The arc of the cup covered by the graft was measured as an angle, and this angle was divided into 180°. Hence coverage by the graft was recorded as the percentage of coverage [1].

Surgical technique

All patients were operated upon in the supine position with a straight lateral incision. The joint capsule was exposed and resected, the femoral head was dislocated and the neck osteotomised. The true acetabulum was cleared of soft tissues and deepened posteromedially with reamers. We prefer to underream the acetabulum 1 mm to achieve press fitting of the acetabular component. Zero to three screws were used for each acetabular cup (Trilogy Cup, Zimmer, Warsaw, Indiana, USA). At the anatomical acetabulum, based on the preoperative planning and confirmed by intraoperative stability testing, superior coverage of the

acetabular component was insufficient in 12 cases and required augmentation by a femoral head autograft fixed by two screws into the defect. After the acetabular component had been implanted, the process of femoral intramedullary reaming was started, when maximum cortical contact was noted and confirmed by intraoperative imaging, shortening of the femur was performed by z-shaped (step cut) osteotomy [1] (Fig. 1).

This osteotomy was planned in a manner that the proximal cut is on the lateral side, and the distal cut is on the medial side of the femur. The distance between the lesser trochanter and the distal edge of the medial cut should be two to five centimetres. This osteotomy technique permits coverage of the medial aspect of the stem [1]. The osteotomy level was determined, and the amount of shortening was calculated preoperatively on anteroposterior radiographs of the pelvis. In our experience a high-riding femur can be pulled down a maximum of three to four centimetres without the need to release the iliopsoas tendon. The amount of shortening was calculated by subtracting three to four centimetres from the original height of the femoral head above its original position. The step-cut osteotomy was performed through the same skin and fascia incision lengthened by four to eight centimetres, and the subtrochanteric bone was approached directly through the vastus lateralis muscle. Proximal and distal femoral fragments were reduced and held in place by bone clamps then the osteotomy was secured with two or three titanium bands (CCG system; Smith and Nephew, UK). After having achieved stable fixation of the osteotomy intramedullary reaming was started again until optimal cortical contact was achieved especially distal to the osteotomy site. Every step in the reaming process was verified by intraoperative image intensification before and after the step cut osteotomy was performed. After definitive implantation of the stem a final intraoperative X-ray was obtained. We do not perform

Fig. 1 Illustration of the proximal femoral step-cut or z-shaped shortening [1]

intraoperative X-rays in standard total hip arthroplasty. In contrast to Sener et al. [1] no bone grafting technique was used at any of the osteotomy sites.

If a Schanz osteotomy had been performed previously (two hips), the shortening was combined with correction of the angulation from the previous osteotomy (Fig. 2).

The stems used (SL, SLR; Smith and Nephew, UK) are manufactured from corundum blasted titanium forged alloy giving an average surface roughness of approximately four to six microns. All have a dual-tapered design and a rectangular cross section that provides initial secure axial positioning and rotational stability. Cementless anchoring of the stem is achieved after press-fit implantation in a previously broached femoral shaft. The SLR stem (a longer monoblock revision component) was used in the two cases of previous Schanz osteotomies (Fig. 2) in order to achieve the necessary longer cortical contact distally for better immediate rotational stability. In all cases a minimum of four centimetre tight fit between the implant and the femoral bone below the osteotomy was considered optimal in order to achieve primary rotational and axial stability.

Results

All 13 hips were classified as Crowe type IV high dislocations. One patient had bilateral high dislocations, six had high dislocation of one hip and dysplasia of the other, and five had high dislocation of one hip and normal

development of the other. Before surgery, the mean leg length discrepancy was 3 cm (range, 0–7 cm). No patient was lost to follow-up.

Clinical results with the Merle D'Aubigne [15] scores showed that pain improved from a mean of 2.24 (range, 1–4) to 5.56 (range, 5–6), function improved from 3.49 (range, 3–5) to 5.44 (range, 4–6), and mobility improved from 2.93 (range, 1–5) to 5.87 (range, 5–6). Clinical results with the Harris hip score [14] improved from a mean of 35.9 (range, 20–65) preoperatively to 94.3 (range, 82–100) at the final follow-up. Preoperatively, all patients had a positive Trendelenburg sign. At follow-up, a positive Trendelenburg sign was still present in seven hips. A leg-length discrepancy of less than one cm in eight patients and of more than one cm in four patients (up to 1.5 cm in one case) was present at follow-up. The average length of femoral bone removed by femoral osteotomy was 3 cm (range, 2.5–4 cm).

Radiographically, one femoral stem had radiolucent lines less than 2 mm in zones 1 and 7. No cup showed radiolucent lines suggestive of loosening. No patient had migration or revision of the acetabular or femoral component. Following the preoperative planning and intraoperative stability testing 12 hips had been reconstructed with an autogenous femoral head bone graft, with coverage that averaged 25.7% (range, 14–30%) of the superolateral aspect of the acetabular component. No techniques such as cotyloplasty or protrusio techniques with excessive medialisation were applied in this series.

Fig. 2 **a** Female patient (60 years old) showing Schanz osteotomy on the left and severe Crowe type 3 dysplasia on the right. **b** Radiograph one year after total hip arthroplasty (THA) on the right side without shortening osteotomy. **c** Radiograph seven years after subtrochanteric shortening and correcting osteotomy on the left side (SLR plus stem combined with 3 titanium bands)

In all 13 cases no intraoperative complications were observed.

Postoperatively all patients were allowed partial weight bearing with two crutches from the third postoperative day up to the sixth postoperative week.

There were no superficial or deep infections, pareses or dislocations during the follow-up period. Every subtrochanteric osteotomy healed within the first three postoperative months.

Discussion

Most authors agree that THA for congenital dislocation of the hip should be performed with the cup placed in the original bony acetabulum. For Crowe type IV hips, which are dislocated more than 4 cm above the level of the acetabulum, shortening of the femur is necessary to bring the prosthetic head to the level of the true acetabulum without sciatic nerve injury [1, 2, 4–8, 13, 18–20]. The acetabular component should be placed in the true acetabulum for mechanical reasons, Bicanic et al. suggested that in patients with secondary osteoarthritis due to hip dysplasia the technique for optimal cup placement should include acetabular placement as far medially as possible which is then followed by more proximal placement. If this is not possible, using techniques such as cotyloplasty, use of small acetabular cup and augmentation with bone grafting should avoid lateral placement of the centre of rotation. This is necessary to prevent the increase in hip load and to allow a good biomechanical environment for longer hip arthroplasty survival [21]. We believe that cementless cups have the advantages of avoiding cement failure and facilitating union of femoral head graft by preventing cement leakage between the host bone and the graft. We have seen no graft resorption, and union of the grafts was satisfactory in the presented time-frame of up to 96 months. However, the authors are aware of the fact that graft resorption can be a problem in long-term follow-up periods of ten years or more.

Common complications in femoral shortening osteotomy are fracture and nonunion at the osteotomy site. Intraoperative fracture during insertion of the femoral component has been reported to range from 5–22% [22], and nonunion has been reported to vary between 8% and 29% [4, 19]. We identified no perioperative fractures or delayed union of the osteotomy. Recently Krych et al. [13] reported femoral fractures occurring in five of 28 hips and nonunions at the subtrochanteric osteotomy site developing in two. Altogether 12 hips (43%) had an early or late complication or reoperation.

In Crowe III and IV hips, several methods are described for shortening of the femur, e.g. proximal femoral shortening

osteotomy with distal advancement of the greater trochanter, splitting the femoral shaft with proximal shortening, a modified lateral approach combined with chisel detachment of the anterior and posterior halves of the continuous tendon of the gluteus medius and vastus lateralis muscle and a step-cut shortening osteotomy with or without angular correction [1, 2, 7, 8, 13, 18, 20]. We used the step-cut osteotomy to secure the fragments against rotation and to obtain correction of antetorsion and angulation combined with shortening if a Schanz osteotomy had been previously performed.

Paavilainen et al. [4] stabilised the step-cut osteotomy by fitting of the prosthetic stem so that it functioned as an intramedullary nail, Symenoides et al. [12] fixed the fragments with a plate and screws and Sener et al. [1] used cables and bone grafting. We fixed the osteotomy with two or three titanium bands, and this technique worked well for us. In dislocated hips, the femur is generally hypoplastic with a narrow canal and often deformed by previous operations. Ito et al. reported on 128 hips (six of them presenting with high dislocation) treated by implantation of a hybrid total hip arthroplasty (cementless cup, cemented stem) based on CT data of femurs obtained from patients with DDH [23]. We used cementless stems for two reasons. First, standard size cementless femoral stems can be used without major technical difficulty. Second, union of the osteotomy is facilitated because the medullary cavity is fitted tightly with a rigid material and there would be no cement leakage into the osteotomy.

Another possible technique for Crowe type 4 dysplasia was described by Holinka et al. [24] such that an iliofemoral monotube soft tissue distraction prior to total hip replacement surgery in high congenital hip dislocation achieved leg-length equality and improved gluteal function. In the six cases presented, limb lengthening was achieved up to 100 mm, two pin infections and one temporary peroneal nerve palsy were reported, and another three cup protrusions requiring hip revision were observed in this study.

We note the following limitations of our study: It was a retrospective evaluation of prospectively followed patients and the study group was small.

The strengths of our study are a minimum of three years of follow-up, a consecutive series of hips presenting with Crowe type 4 endstage arthritis, the same distal taper rectangular cross section stem design, the same press fit cup, the same approach, uniform reaming and implantation techniques, uniform type of step-cut osteotomies and the same type of osteosynthesis involved.

Using a standard size stem with rectangular cross section to achieve immediate primary rotational stability especially distal the osteotomy, together with a step-cut osteotomy made the technique feasible. As we did not observe any palsy, delayed unions or aseptic loosening the procedure

presented seems to be an excellent alternative in the treatment of Crowe type 4 hips.

Finally, the follow-up period is still mid-term, and the durability of these complex reconstructions must continue to be assessed in long-term follow-up studies.

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