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Long Term Outcomes of Total Hip Arthroplasty With Custom Made Femoral Implants in Patients With Congenital Disease of Hip

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ABSTRACT

We evaluated the outcomes of total hip arthroplasty in 67 patients (86 hips) with congenital hip disease and excessive abnormal anatomy of the proximal femur with the use of custom-made femoral stems. The design of the stem was based on CT data following the principles of CAD-CAE-CAM technique. No serious complications attributed to the femoral stem were seen. Within a median follow-up of 127.5 months the 10-year survival of any of the components was 95.4% and respective value when aseptic loosening of the stem was considered was 98.1%. Patients with high dislocations had a 10-fold risk for loosening compared to those with low dislocations. No other parameter was associated with outcomes. The clinical and radiological evaluation was in consistency with the above outcomes.

Congenital hip disease (CDH) is a common cause for the development of secondary degenerative arthritis of the hip. The surgical management of this arthritis includes various procedures, with total hip arthroplasty (THA) being the commonest. However, THA in patients with CDH remains a challenge due to the severe distorted anatomy of the hip joint in the majority of these patients along with previous femoral or acetabular osteotomies and the retained hardware in several patients that further complicate THA [1]. Common anatomical diversities presented in these patients include excessive proximal femoral anteversion, narrowing of the medullary canal, acetabular anteversion, the height of the center of rotation, hypoplasia and incongruity, pseudoacetabulum formation, leg length discrepancy and neurovascular bundle tension and tethering [2–6].

Adequate preoperative planning in patients with CDH that undergo THA is essential for the optimal implant selection [7–9]. Commonly, the severely distorted anatomy of the proximal femur in these patients impedes the use of classical industry designed femoral stems. In such cases a customized femoral implant can be used in order to optimize the fit of the stem to the femur, to improve the strain distribution and to reconstruct the hip biomechanics [10].

In the present study we report on long term outcomes regarding custom made femoral components in THA for CDH treated under the same protocol.

Materials and Methods

Between January 1999 and August 2009 650 THAs due to congenital hip disease were performed at our unit. Among these THAs, 80 patients with CDH underwent a primary THA with a customized femoral component due to severe distorted anatomy of the proximal femur. The inclusion criteria in the present study were (a) primary THAs in patients with CDH with the use of a custom made femoral component regardless of previous hip surgery and (b) minimum follow-up of 5 years. Based on these inclusion criteria, among the 80 patients that were initially considered eligible to be included in the study 4 patients were excluded due to no follow-up data and 9 patients were excluded due to limited follow-up data of less than 5 years. Eventually, 67 patients with 86 hips that had a primary THA with a custom-made femoral component due to CDH and a minimum of 5-year follow-up were included in our analysis. The study had institutional ethics committee approval.

The median age of patients included in our analysis was 48 years [inter-quartile range (IQR) 40.75–54.50 years] and the median BMI (body mass index) was 26.81 (IQR 24.00–30.26). Seventy-seven arthroplasties were performed in females and 47 were left sided. Nineteen patients had a bilateral THA at separate stages. The classification of CDH was based on the Hartofilakidis classification [11]. Sixty-five hips had a low dislocation, while in 21 hips the dislocation was high. The median preoperative femoral anteversion was 33° (IQR 20.00°–45.25°). Seventeen patients had previous corrective operations consisted of 14 pelvic osteotomies and 3 femoral osteotomies. The main patient characteristics are presented in Table 1 (Table 1).

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Table 1
Characteristics of Patients Included in the Analysis.

Median age (IQR)	48.0 (40.8–54.5)
Female patients (%)	89.5%
Side of THA (N)	
Right	39
Left	47
Type of dislocation	
Low	65
High	21
Type of acetabular cup	
Hedrocel	16
Symbios Hilock	70
Median cup size (IQR)	46 (42–50)
Screw use, N (%)	78 (90.7%)
Reconstruction of the acetabulum with autograft, N (%)	17 (19.8%)
Type of head (N)	
Ceramic	31
Metallic	55

Preoperative Protocol

The standard preoperative protocol included clinical history, physical examination, radiographic evaluation (anteroposterior view of the pelvis with the central beem toward the symphysis pubis and lateral view of the hip, lumbar spine x-rays and knees x-rays), CT evaluation (hip, femur, femoral condyle and foot) and CT topogram to reveal the true leg-length discrepancy and the length of shortening osteotomy when this was necessary. The positioning of the patients in hip x-rays was according to standard protocols, although violations of protocol were common due to the distorted anatomy of the hip joint and the lack of rotational movements from the severity of arthritis that precluded internal heel rotation. In order to determine the optimum femoral stem, a three-dimensional reconstruction of the femoral canal using CT data and computer-aided design (CAD) was matched with a three-dimensional geometry of several stem designs and sizes obtained from a CAD system. In cases with severe distorted anatomy of the femur, where no femoral stem from the available industry could fit perfectly and restore the hip biomechanics, the implantation of a customized cementless prosthesis was decided. Written informed consent regarding the risks and benefits of THA and the use of a customized femoral component with no clinical track record was obtained from all patients prior to further prosthesis design and implantation.

The design of both the intramedullary and the extramedullary part of the customized femoral stem was based on data obtained from the CT and followed the principles of CAD-CAE-CAM [10]. The intramedullary femoral anatomy was assessed through scans every 5 mm until the lesser trochanter and then every 10 mm until the middle of the femur. Additional scans include the acetabulum scan to reveal bone stock and scans to determine the anteversion of the prosthetic neck. The offset of the prosthesis was calculated according to the opposite hip. In case of abnormal opposite hip, we accepted a priory a 4-cm offset for small patients with narrow pelvis and a 4.5-cm offset for heavy, obese patients, based on previous preoperative topogram data from anthropometric measurements in patients undergoing THA. Detailed CT data were processed to the manufacturer for the construction of the prosthesis. The custom prosthesis had one custom grit-blasted broach, which is undersized by 2 mm and is used for impaction of the cancellous bone of the femoral canal. The broach is tapered from proximal to distal along its length and had a male trunnion proximal for trial heads to be attached.

Surgical Planning — Operative Technique

All THAs were performed by the same surgeon (TX) under general anesthesia and through a posterolateral approach. The external rotators of the hip were maintained with sutures where possible (39 hips, 45.3%). Initially, the true acetabulum was recognized. The obturator foramen is used to locate the level of the true acetabulum. By placing the hook in the obturator foramen, the socket is always placed in the true acetabulum. In hips with high dislocation, the true acetabulum is identified by using the thickened and elongated joint capsule as a guide. In hips with low dislocation, the true acetabulum is identified underneath the inferior part of the false acetabulum. After excision of the capsule, a small amount of fat is always found in the true acetabulum. The true acetabulum is enlarged and deepened with a small curette and small reamers (diameter, 36–38 mm) directed superoposteriorly where adequate bone stock is found. Caution should be taken to avoid fracture of the thin and hypoplastic anterior wall. Computer tomography scans were used to evaluate the exact morphology and size of the true acetabulum. All patients had a cementless cup fixation. The type of the cup was determined according to the amount and the quality of the acetabulum bone stock. In cases of adequate bone stock that allowed the stable press-fit fixation of the cup, a Hedrocel acetabular cup (Zimmer, Inc, Warsaw, IN, USA) was used, while in cases of excessive bone stock deficiency a Symbios Hilock cup (Symbios, Switzerland) was used (Table 1). The present cup has a hook for anchorage in the obturator foramen and the possibility of screw placement on healthy ilium bone. In 70 hips a Symbios Hilock cup was implanted, while 16 hips had a Hedrocel cup. The median cup size was 46 (range 40–58). Screw use in the acetabular cup was performed in 78 patients. In the vast majority of patients autologous graft from the femoral head was used (79 hips), which consisted of morselized bone graft in 62 patients and a bone block in 17 patients. Additional screw fixation of the cup was performed in the majority of the patients (78 hips). In 31 THAs the head was ceramin and in 55 THAs a cobalt-chrome metal head was used (Table 1). Generally, younger more active patients had a ceramic head. In 61 hips a 22 mm head size was used and in 25 a 28 mm.

All femoral stem prostheses were cementless, manufactured by Symbios (Symbios Inc, Yverdon, Switzerland) from titanium alloy (Ti6Al4V) and a thick layer coating of porous hydroxyapatite at the proximal part (Fig. 1). The hydroxyapatite layer was air plasma sprayed and had a thickness of 75 $\pm$ 25 μm. All femoral stems were designed to restore the prosthetic neck anteversion to normal of 15°. The median femoral neck angle was 130° (IQR 126°–133°) and the median neck length was 48 mm (IQR 41.75 mm–56.00 mm), as provided by the manufacturer of the prosthesis.

Based on the new center of rotation (intraoperatively and from the scanogram), the location of the greater trochanter was decided as well as the desired lengthening. In cases where the femur was substantially longer than the contralateral femur, a distal femoral shortening osteotomy was performed that was stabilized with an LC-DCP plate. The threshold of performing a shortening osteotomy was 1 cm. Axial

Fig. 1. The Symbios custom-made femoral stem.