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M. Fortina
S. Carta
D. Gambera
E. Crainz
P. Pichierri
P. Ferrata

Total hip arthroplasty with a ribbed anatomic HA coated stem

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M. Fortina (✉) • S. Carta • D. Gambera
E. Crainz • P. Pichierri • P. Ferrata
Department of Prosthetic Orthopaedics
University Hospital
Siena, Italy
E-mail: tia1974@katamail.com

Abstract In total hip arthroplasty, a straight stem seems to provide better results than an anatomic one. A new generation of anatomic stems is under evaluation, so the follow-up is still short and cannot compare with studies of straight stems. The clinical and radiographic results of 176 patients who underwent 189 primary total hip arthroplasties using an anatomic, collared, proximally hydroxyapatite (HA)-coated femoral component were prospectively determined from 1 to 6 years follow-up. The stem is ribbed in the metaphyseal region, allowing to decrease the elasticity modulus, to augment the surface for bone ingrowth and to preserve the space needed for the circulation of the inner half side of the corticalis. The average postoperative Harris hip score was 96.7 points. All femoral components had radiographic evidence of bone ingrowth fixation at the final follow-up. There were no cases of loosening for any reason. The strength of the study is limited by the short follow-up, but our preliminary excellent clinical results with stable bone ingrowth fixation allow us to continue to use this stem following patients over time.

Key words Anatomic stem • Total hip arthroplasty • Hydroxyapatite • Bone ingrowth

Introduction

As Charnley hypothesized more than thirty years ago [1], total hip arthroplasty (THA) has become a common operation in our days. Many different types of THA are available and differ in the materials used, prosthetic design, and types of fixation and coating [2, 3]. In cementless THA, the life of the prosthesis is determined by stability, the structure of the device, and the type of coating. The choice between anatomic and straight stems continues to be a subject of debate in the orthopaedic community [4], even if most clinicians agree that the former are not recommended in "stove pipe" femura.

The purpose of this study was to review and report the results of a prospective series of patients who were followed for one to six years after uncemented THA with an anatomic, titanium alloy, proximally hydroxyapatite (HA) coated femoral stem. Patients with Dorr's type A and B femura were enrolled in the study. The clinical and radiographic findings are presented.

Materials and methods

We reviewed the results of 196 primary cementless THAs, performed in 182 patients between April 1998 and October 2003. There were 72 men (39.5%) and 110 women (60.5%), of mean age 66.3 years (range, 58–89 years) and mean weight 73.2 kg (range, 52–96 kg). THA was indicated for a diagnosis of primary osteoarthrosis in 112 hips (57.2%), medial femoral neck fracture in 28 cases (14.3%), rheumatoid arthritis in 19 hips (9.7%), avascular necrosis in 18 cases (9.2%), post-traumatic arthritis in 14 cases (7.1%), developmental hip dysplasia in 3 cases (1.5%), and Legg-Calvè-Perthe arthritis in 2 cases (1.0%).

All the operations were performed by a single surgeon (PF). Bauer's direct lateral approach was used. All patients received long-term antibiotic prophylaxis and low molecular-weight heparin for postoperatively 4 weeks. We allowed protected weight bearing with two crutches starting the second day after surgery.

All patients received a hemispherical porous-coated acetabular cup and the Ribbed System total hip prosthesis (Waldemar-Link, Hamburg, Germany). The prosthesis is made of Tilastan (Ti6Al4V) and has a 200-μm HA coating, applied with a plasma spraying process, circumferentially to the proximal section of the stem as well as to the undersurface of the neck plate. HA consists of calcium and phosphorus in a 5:3 ratio. The coating contains both microporosities (3–5 μm) and macroporosities (50–100 μm). The stems are available in left and right versions; they are available in nineteen widths and 150-mm lengths. Two cervicodiaphyseal angles, 126° and 135°, are available, with 19° anteversion. The stem has a proximal posterior bow and a distal anterior bow. Stems are prominently ribbed to avoid excessive stiffening of the proximal femur caused by implantation of metal. Modular cobalt-chromium and Biolox aluminum oxide ceramic heads are available in four and three neck lengths, respectively.

Patients were evaluated clinically for pain, function and range of motion, according to the Harris hip score [5]. Clinical failure was defined as revision of one of the components or fair or poor results.

Standard anteroposterior radiographs of the pelvis and lateral radiographs were taken immediately after the operation, at 2, 6 and 12 months, and annually thereafter. Variations in magnification were corrected using the known diameter of the femoral component head as an internal reference. The most recent follow-up radiograph was compared with the initial postoperative radiograph. Femoral anatomy was classified according to Dorr et al. [6].

Radiogaphs were analyzed to evaluate the presence of contact between the collar of the femoral prosthesis and the medial femoral neck (calcar) and for the fit of the cylindrical portion of the femoral prosthesis within the isthmus of the femur, as viewed on the anteroposterior radiograph. The results were classified as good if there was contact between the prosthesis and the femur, fair if there was a 1- to 2-mm space between the calcar or the cortex and the prosthesis, and poor if there was a space of >2 mm.

Varus or valgus stem alignment in relation to the long axis of the femur was registered. Any radiolucent line around the prosthesis was assessed according to the three DeLee and Charnley zones [7], for the cup, and to the Gruen zones for the stem [8]. Heterotopic ossification was graded according to Brooker et al.'s classification [9].

Subsidence of the femoral component was evaluated measuring the distance from a point at the midpoint of the lesser trochanter to the shoulder of the femoral prosthesis.

We defined components as radiologically loose if they had migrated 2 mm or more. Radiolucent lines of 2 mm or more in any zone adjacent to the HA-coated portion of the implant, any lytic lesion or subperiosteal formation of new bone around the distal stem were also considered to indicate loosening.

The final radiographs were graded according to the criteria of Engh et al. [10] for the type of fixation.

Results

Of the original 182 patients (196 THAs), one patient was lost to follow-up and five patients died during the follow-up period from causes unrelated to their hip and were excluded from analysis. The remaining 176 patients (189 THAs) were available for review and were followed for 14–81 months (mean, 41.2 months). No intraoperative or postoperative complications were recorded.

Preoperatively, patients had a mean HHS of 39.2 points (range, 31–65). The mean HHS at the latest follow-up evaluation was 96.7 points (range, 71–100) (p<0.05). At the last follow-up, 176 hip results (93.1%) were classified as excellent, 10 (5.3%) as good, and three (1.6%) as fair; none was classified as poor. At the final follow-up, thigh pain was registered in three patients (1.6%).

All the hips had radiographically stable acetabular components, and no radiolucent lines were detected. According to the Dorr classification 106 femura (56.1%) were type A and 83 femura (43.9%) were type B. The roentgenographic signs related to the femoral component are shown in Table 1.

Table 1 Roentgenographic evaluation of the femoral component. Values are number (percentage) of 176 hips

Contact collar-calcar		
Good	147	(77.8)
Fair	42	(22.2)
Poor	0	(0)
Contact prosthesis-isthmus		
Good	158	(83.6)
Fair	31	(16.4)
Poor	0	(0)
Varus-Valgus	0	(0)
Reactive lines (<2 mm)		
Zone I	36	(19.1)
Zone III and V	48	(25.4)
Heterotopic ossification		
I	39	(20.6)
II	12	(6.3)
III	5	(2.6)
IV	1	(0.5)
Subsidence (<2 mm)	36	(19.1)
Pedestal		
Incomplete	64	(33.9)
Complete	0	(0)
Spot welds	149	(78.8)

Fig. 1 Radiograph taken at the 5-year follow-up. Spot welds are visible, there is a little pedestal, but no reactive lines are detectable

Bone ingrowth fixation was observed in 153 hips (80.9%) (Fig. 1). The remaining 36 hips (19.1%) presented a definitive subsidence less than 2 mm, non-progressive reactive lines in the upper one-half of zone I and in zones III and V, and a pedestal. Even though in 11 of these hips (30.5%) spot welds were not visible, reactive lines corresponding to the HA coated surface were absent in all the 36 hips. None of the hips of the study presented complete signs of stable fibrous fixation, nor signs of unstable fixation. There have been no cases of revision for loosening of the stem.

Discussion

Some authors have reported bad results with HA coated implants [11, 12] due to particulate separation. Only a correct coating process ensures a homogeneous coating with a uniform thickness and a perfect fixation to the support that allows reaching good results with HA coated prosthesis [13]. Results from the Norwegian Arthroplasty Register confirmed that the risks of having a revision, for loosening and for any cause, adjusted for age, gender and diagnosis, with HA coated implants are less than with porous-coated implants and even less if compared with uncoated or cemented stems [14].

Thigh pain was related to unstable fixation, proximal osteopenia and distal modulus mismatch. Bourne et al. [15] reported thigh pain in 27% of patients who received anatomic stems. Barrack et al. [16] reported that more than twice as many patients with proximally coated stems complained of thigh pain than patients with fully coated or cemented hips (p<0.01). In our study, we registered thigh pain, of mild intensity, in three patients (1.6%). This good result depends on the stem's mechanical and physical characteristics, like the low elasticity modulus and the smooth distal surface. Furthermore, the collar of the prosthesis prevents proximal osteopenia by reintroducing physiological stress transmission to the femur after resection of the femoral head.

Engh and Hopper [17] reported excellent long-term results, 99% at 18 years, with straight extensively coated femoral implants. Previous work on anatomic stems did not support these excellent results [18]. The evolution of proximally coated stems with circumferential coating and improved anatomic design has added an alternative to extensively coated fixation. Compared with an anatomic stem, greater proximal posterolateral femoral cortex removed by milling was required when a straight stem was implanted.

Traditional anatomical press-fit stems fill as much as possible of the medullary cavity of the femur, particularly at the metaphyseal level. During reaming, the surgeon removes spongy bone together with blood vessels. The straight and rectangular type of stems fix in the cortical bone at the level of its four angulations only. This design allows it to leave space for the microcirculation of the inner half of the corticalis, preserving its strength. The stem we adopted had a particular ribbed shape that guarantees stable anchorage to the corticalis, preserving the space needed for the inner circulation. The spaces between the ribs augment the surface structure of the prosthesis, allowing an extensive bony ingrowth and an increase also in stem flexibility. Therefore, it is closer to that of the bone and avoids excessive stiffening of the proximal femur caused by the presence of a metal stem.

Preparation of the bony structures prior to implantation must be carried out with considerable care and precision to insure the most desirable mechanical environment and to reach complete collar-calcar contact. There is a learning curve for the femoral component fit because a higher proportion of the femoral stems had a better fit in the second half of the study period than in the first half.

All the stems that presented some degree of subsidence, 36 hips, presented also reactive lines in zone 1 and an incomplete pedestal at the tip of the stem. The presence of spot welds also in 25 hips (69.4%) of this group confirmed the presence of a stable bone fixation after an initial subsidence. The HA coating stimulates the conversion of initial fibrous tissue to bone around the implant

[19]. All the hips with incomplete pedestal had reactive lines in zones III and V. Reactive lines in these zones owing to the smooth distal surface are not a sign of loosening. Spot welds compare also in this group. We registered a cumulative rate of heterotopic ossification of 30%, only 1 hip reported grade IV and was associated with fair result at HHS.

The limits of our study are a short follow-up and selection bias due to the exclusion of type C femurs. According to other authors [2], we think that an anatomic proximally coated stem is contraindicated in these patients. Kobayashi et al. [20] suggested that two years should be the limit to test a new prosthesis. At two years, the presence of migration of <2 mm and the absence of a radiolucent line of ≤2 mm in the porous coated area of the prosthesis predict a 6% chance of revision over approximately ten years. In our work, 150 hips (79.4%) had a follow-up over two years.

Although the short follow-up limits the strength of the conclusions, our findings do indicate that the ribbed anatomic HA coated stem provides excellent clinical results with a high rate of stable bone ingrowth fixation. Longer follow-up evaluation is needed to confirm the good results and to detect any significant wear and any preliminary sign of loosening.

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