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ORIGINAL PAPER

Hip arthroplasty in patients younger than 30 years: excellent ten to 16-year follow-up results with a HA-coated stem

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Abstract It is well accepted that youth and high activity levels are among the factors that increase the risk of mechanical failure of total hip prostheses. However, there are few reports of long-term results in very young patients. In this study, we evaluated the results of total 49 hip replacements (THRs) using an uncemented total hip prosthesis in 44 patients (28 females) who were 30 years or younger (range: 15–30 years). The diagnosis was ostearthritis due to congenital dislocations in 28 patients, with the remaining patients having diagnoses of sequelae of fracture, infection, Calve-Legg-Perthes disease, avascular necrosis, chondrodystrophia and epiphyseal dysplasia. In all cases we used an uncemented straight stem fully coated with hydroxyapatite (HA). In 36 cases we used a hemispherical cup inserted with press fit, and in seven cases we used a hemispherical screw cup. The patients were evaluated ten to 16 years (mean: 13 years) after the operation by radiographic and clinical examinations, including the Harris Hip, WOMAC and EuroQol-5D scores. In a sub-group of nine patients with a unilateral prosthesis, the muscle strength of the quadriceps and hamstrings was tested using a Cybex 6000. None of the stems were revised at the follow-up examination, and all were classified as well integrated, with no signs of radiological loosening. Twenty-four hips had revision of the acetabular component due to mechanical failure. The Harris Hip score was, on average, 88 (range: 62–100), the WOMAC score 80 (range: 37–100) and the EuroQol score 0.68 (range: −0.14–1). Isokinetic muscle strength testing showed that seven of the nine tested patients were weaker on the operated side. In conclusion, we found mechanical failures at the acetabular side, but excellent results with a fully HA-coated femoral stem, with no revisions after ten to 16 years.

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Résumé Il est habituel de penser que le jeune âge des sujets et leur haut niveau d'activité sont parmi les facteurs les plus importants d'échecs des prothèses totales de hanche. Peu d'études font part des résultats à très long terme chez les patients jeunes. Nous avons réalisé une étude des résultats chez des patients âgés de moins de 30 ans et traités par une prothèse sans ciment. Cette étude a porté chez 44 patients dont 28 femmes porteurs de 49 prothèses totales de hanche. L'âge des patients s'est étalé de 15 à 30 ans. Le diagnostic le plus fréquent a été la coxarthrose secondaire liée à une luxation congénitale chez 28 patients les autres étiologies étant surtout secondaires à des séquelles de fractures, d'infection, de maladies de Legg Perther Calvé, de nécroses avasculaires, de chondrodystrophies ou de dysplasies épiphysaires. Dans tous les cas nous avons utilisé une prothèse non cimentée avec une pièce fémorale droite recouverte totalement d'hydroxyapatite. Nous avons également utilisé dans 36 cas une cupule hémisphérique implantée en press fit, dans 7 cas une cupule hémisphérique vissée. Les patients ont été suivis 13 ans en moyenne (de 10 à 16 ans), la surveillance a été radiographique et clinique avec évaluation du score de Harris, de Womac et de l'Euroquol-5D. Dans un petit sous groupe de

9 patients nous avons testé la force du quadriceps et des ischio jambiers en utilisant un appareil de type Cybex 6000. Sur un long suivi, aucune pièce fémorale n'a été révisée, toutes ont été parfaitement intégrées sans aucun signe de descellement. 24 hanches ont subi une révision du composant acétabulaire pour des problèmes mécaniques. Le score de Harris a été en moyenne de 88 (de 62 à 100), le score de Womac de 80 (de 37 à 100) et l'Euroquol de 0,68 (0,14 à 1). Pour sept patients, la force musculaire est moins importante du côté opéré. En conclusion, cette série de patients a montré une faillite mécanique de l'implant acétabulaire mais une excellent résultat au niveau de la pièce fémorale recouverte d'hydroxapatite, sans aucune révision entre 10 et 16 ans.

Introduction

The age of patients having total hip replacement (THR) has decreased as implant technology has improved. However, it is well accepted that youth and high activity levels are among the factors that increase the risk of mechanical failure [5]. The definition of young in patient outcome studies of hip arthroplasty in the literature varies, but in this contex, young generally refers to patients younger than 50 years, and there are few reports of hip prosthesis in patients younger than 30 years of age at the time of implantation [6]. The use of a hydroxyapatite (HA)-coated cementless stem in THR is well established [15], and our clincal experiences with a HA-coated stem are, in general, very good [21]. The aim of this study was, therefore, to evaluate the long-term clinical and radiological outcomes of a HA-coated femoral stem implanted in young adults.

Patients and methods

Between 1989 and 1996 we performed 49 primary THRs in 44 young adults (28 females). The age of the patients ranged from 15 to 30 years (mean: 25 years). The left hip was replaced in 22 cases; the right in 15, and six patients had both hips operated up on. The diagnosis was secondary osteoarthrosis due to congenital dislocation in 24 hips, avascular necrosis in six, coxitis in four, acetabular fractures in four, Calve-Legg-Perthes disease in three, epiphyseal dysplasia in two and chondrodystrophia in one.

In all cases we used a straight stem designed for press fit insertion (Landos Corail; Landanger, Chaumont, France). The component was made of grit-blasted $TiAl_6V_4$, and the outer surfaces were entirely plasma-sprayed with a 155±35 -μm layer of HA. The purity of the HA was reported to be greater than 97%, the density between 1.2 and 1.6 g/mL, the crystallinity greater than 50% and the porosity less than 10%. The surface roughness of the coating was characterised by an Ra (arithmetical mean roughness value) between 7.5 and 9.5 μm and the Rt (maximum profile height) was between 50 and 65. The surface roughness of the grit-blasted metal was characterised by an Ra between 4 and 6 μm and an Rt between 25 and 40. The bonding strength of the coating to the metal was reported to be more than 10 MPa. The technical data were provided by the manufacturer.

In 36 cases we used a hemispherical HA-coated cup inserted with press fit, and in seven cases we used a HA-coated screw cup (Landos Corail). In six cases we used a hemispherical cup designed for press fit insertion that was made of $TiAl_6V_4$ and coated with a mesh of pure titanium (Harris Galante 1; Zimmer, Warsaw, Ind.).

We used stems of sizes 10–14 and cups of sizes 48–58. The head was made of stainless steel (Inox) with a diameter of 28 mm in all cases. The polyethylene (PE) liner was reported to fulfil ISO standards F648. Sterilisation had been carried out by gamma irradiation at a dose of 25–35 kGy in air.

Surgery was standardised, using the posterior or direct lateral approach, without trochanteric osteotomy. Partial weight bearing (15–20 kg) was allowed during the first three months postoperatively, with progression to full weight-bearing in the weeks thereafter.

The patients were evaluated ten to 16 years (mean: 13 years) after the operation by radiographic and clinical examinations. During the observation period one patient had emigrated and was therefore lost to follow up. One patient with myelomenigocele refused to participate in the clinical examination, but reported no pain or discomfort from her hip. Another patient was not able to answer questions because of mental retardation, but was followed up by radiographic examination.

Radiographic evaluation included assessment of bone remodelling, osteolysis and fixation of the stem. Subsidence of the femoral component was referenced by the vertical distance from the tip of the trochanter to the lateral shoulder of the prosthesis, using a variation of more than 5 mm. This limit of migration was arbitrarily set, but it was based on analysis of manual measurements of migration of hip prostheses [16]. Alignment of the femoral component was classified as valgus (the tip of the stem engaged the medial cortex), neutral or varus (the tip of the stem engaged the lateral cortex). Femoral zone analysis was performed as described by Gruen et al. [10]. The status of the biological fixation of the stem was assessed by a modification of the criteria described by Engh et al. [8]. Radiographic bony incorporation was defined as extensive intimate bone-implant contact, periprosthetic bone formation and remodelling, and the absence of migration. Femoral remodelling was assessed as a change in bone density, either as cortical or endosteal bone formation. A decrease in bone density

was recorded as atrophy and an increase as hypertrophy. Radiodense lines that roughly paralleled the surface contour of the implant, but separated from it by a total radiolucent zone (line) of varying thickness were classified as fibrous ingrowths. The focal area of cortical or trabecular bone loss was considered evidence of osteolysis [23].

Clinical rating was according to the Harris Hip score (HHS). In addition, pain was measured on a visual analogue scale (VAS) from 0 (strong pain) to 100 (no pain). The WOMAC score for osteoarthritis was used to assess the functional results [2]. WOMAC is a well-validated, 24-item instrument which assesses pain (five items) on a scale of 0 (best outcome) to 8 (worst possible outcome), stiffness (two items) from 0 (best) to 8 (worst possible outcome) and physical function (17 items) from 0 (best) to 68 (worst possible outcome), with a total score from 0 (worst) to 96 (best). Quality of life was measured by the EuroQol instrument (The EuroQual Group 1990). The EuroQual-5D descriptive system comprises five dimensions of health (mobility, self-care, usual activities, pain/discomfort anxiety/depression). Each dimension comprises three levels (no problems, some/moderate problems, extreme problems). A unique health state is defined by combining one level from each of the five dimensions, with +1 as the best and −0.594 as the worst possible outcome.

A sub-group of nine patients with unilateral prostheses were tested for the muscle strength of their quadriceps and hamstrings using a Cybex 6000 (Cybex-Lumex, Ronkonkoma, N.Y.). The test protocol consisted of five repetitions at an angular velocity of 60°/s (strength) followed by a one minute rest period and 25 repetitions at 180°/s (endurance) [11]. The parameter used for analysis was total work.

Results

At follow-up, 17 of the 36 HA-coated hemispheric press fit cups were revised: 14 because of loosening (Fig. 1), two because of repeated dislocations and one because of PE wear. Four of the HA-coated screw cups were revised, all because of PE wear. Among the Harris Galante cups, three were revised: two because of PE wear and one because of repeated dislocations. None of the stems were revised.

Clinical outcome

The average HHS was 88 (range: 62–100), the WOMAC score 80 (range: 37–100) (Table 1) and the EuroQol score 0.68 (range: −0.14 to +1). The average VAS pain score was 72 (range: 20–100). There were no differences in clinical outcome scores between the revised and unrevised patients.

Radiographic outcome

We found that all stems were well integrated at follow-up, with no signs of radiological loosening (Fig. 1). No stems had subsided. Radiolucent lines were found around seven stems in Gruen zone 1 and around one stem in zone 5 (Table 2). We found bone atrophy in Gruen zones 1 and 7 in eight stems, while three stems had atrophy in Gruen zone 1, and ten stems had atrophy in zone 7. Endosteal bone hypertrophy was found around 19 stems in Gruen zone 4 and around two stems in zone 5. Ostolysis was observed around six stems in Gruen zones 1 and 7 and around two stems in zone 2 and 6, while one stem had osteolysis in zone 1 and two had osteolysis in zone 7.

Muscle strength

The isokinetic strength measurements showed reduced muscle strength in the operated leg compared to the normal leg for both the quadriceps and hamstrings. The mean deficit for the quadriceps was 31% (−71 to −1); for hamstrings, it was 27% (−84 to +18). The results showed a high degree of dispersion; two patients showed similar strength bilaterally, another patient showed a deficit of 90%.

Fig. 1 **a** A 17-year-old girl with a high dislocation of the left hip. **b** Sutrochanteric resection and implantation of a HA-coated hemispheric cup and stem. **c** After 10 years the stem is fully incorporated, but due to polyethylene (PE) wear and medial detachment at the actabular side, the cup has been revised

Table 1 WOMAC scores[a]

Pain	Stiffness	Function	Total score
15 (5–20)	6 (3–8)	56 (26–68)	80 (37–100)

[a] Data presented as means and ranges (in parenthesis)

Discussion

The excellent results of THR in an elderly and inactive population are generally not replicated in the younger and more active patient group [17]. Reports on the outcomes of cemented implants in the younger patient vary widely. Based on the results of their study of a large series of patients under the age of 50 years with a mean follow-up of 15 years, Wroblewski et al. [22] reported an overall revision rate of 6% at the ten year follow-up, which increased to 15% at the 15-year follow-up. Dorr et al. [5] found a revision rate of 33% in a series of 49 hips in patients under 45 years of age at a mean follow-up of nine years, while Emery et al. [7], in a series of 57 patients with a mean age of 41 years, reported a revision rate of 39% at a mean of 12 years after implantation.

In studies where age was not a criteria, excellent HA-coated femoral stem survival rates have been reported [21]. The promising results produced by HA-coated femoral components have been repeated in the younger patient. Loupasis et al. [15], in a six year follow-up study of 45 patients under the age of 50, reported no revision for aseptic loosening or evidence of stem loosening. Capello et al. [3] reported a low stem failure rate of 2% in patients below 45 years of age when using a proximally HA-coated implant with a minimum follow-up of ten years. This finding was supported in a subsequent paper [4] which reported an aseptic loosening rate of 0.06% in a series of 274 patients (314 hips) with a mean age of 51 years and a minimum follow-up of ten years. Giannikas et al. [9] reported a predicted stem survival rate of 96.9% at the seven year follow-up in a group of 66 patients (71 hips) who had also been given a proximally HA-coated implant.

In our patients, 24 of 49 hips were revised on the acetabular side. Three hips were revised because of repeated dislocation within the first two years. This can possibly be ascribed to rather poor muscle control, which may indicate that total hip arthroplasty in young adults may be associated with a rather high frequency of dislocation.

Table 2 Distribution of femoral bone radiolucency, atrophy, hypertrophy and osteolysis around the stem in relation to Gruen zones

	Zonal area						
	1	2	3	4	5	6	7
Radiolucency	7	0	0	0	1	0	0
Atrophy	11	0	0	0	0	0	18
Hypertrophy	0	0	0	19	2	0	0
Osteolysis	7	2	0	0	0	1	8

The acetabular component designed for press fit insertion and coated with HA has generally shown a very high rate of failure [20, 21] that has been associated with a high degree of PE wear. The main reason for mechanical failure in our young patients was PE wear, subsequent osteolysis and mechanical failure. The prevalence of osteolysis in uncemented prostheses has been reported to vary between 40 and 50% and even up to 60% in the younger age groups [12].

Wear particles activate macrophages and possibly osteoclasts, both of which may produce an acidic environment that may cause the dissolution of HA coatings. Resorption of HA may cause micromotion with increased shear stresses, resulting in delamination of the HA. Released HA particles may cause a foreign body reaction. Wear, resorption of HA and osteolysis, consequently, may be factors that influence each other in a continuous process, and the stability of HA coating is a major issue to be considered. As there were no stem revisions in our series, we can provide no answer to the question of the stability of the HA coating on the stem. In a previous study, however, we found a high degree of loosening and dissolution of the HA coating on the cups [20]. This discrepancy in loosening between HA-coated cups and stems may be explained by a higher tendency for dissolution of HA on the acetabular side rather than on the femoral side. Relative to more compact bone, the presence of bone marrow has been shown to increase HA resorption [19]. The wedge-shaped design of the stem may also provide a reliable stability on the femoral side that is difficult to obtain on the acetabular side.

Radiolucency adjacent to the prosthesis has been correlated histologically with a fibrous layer between the bone and the prosthesis [8]. We found radiolucent lines adjacent to the stem in eight cases. In all except one case the radiolucency was located to the proximal Gruen zone 1. The central and distal zones of the prostheses were otherwise well osseo-integrated. Our explanation for the proximal radiolucency is that a well-bonded implant may have some proximal micromovement during loading. However, wear particles with a foreign body reaction at the proximal level of the stem could also be of importance. In any case, these observations indicate that a extensive coating may provide reliable fixation.

Thigh pain has been a considerable problem in both proximally and fully coated uncemented stems. The cause of this thigh pain has been considered to be multifactorial. Cortical hypertrophy of up to 70% has been reported around the distal part of an uncemented press fit stem [1].

This has been thought to be an indication of distal stress transfer to the cortical bone, and an unphysiological load has been considered to be a reason for the mid-thigh pain. The absence of radiolucent lines in the diaphysis suggests a comprehensive diaphyseal bonding. Furthermore, new bone formation adjacent to the prosthesis was associated with a very moderate degree of bone remodelling. The low degree of proximal bone loss in our study and a very low incidence of distal cortical hypertrophy indicate that there has been no significant net transfer of stress proximally to distally and a rather physiological weight distribution from the stem to the femoral bone. The changes in the bone therefore confirm a well-fixed asymptomatic femoral component. Radiographic measurements of bone changes have been considered to be an insensitive method for bone remodelling. However, Kilgus et al. found good correlations between dual energy X-ray absorptiometry and radiography [13].

The clinical, functional and quality of life scores indicated acceptable results. To evaluate the health-related quality of life we used the WOMAC and EuroQol scores. The mean WOMAC score was 80, which is almost identical to those reported in other studies following total hip arthroplasty [18]. EuroQol-5D is a standardised instrument for use as a measure of health outcome. With the exception of nine patients, our patients had a EuroQual between 0.6 and 0.8. For comparison, population sample averages in the UK range from 0.9 to 0.7 in patients aged 30–79 years [14]. Of those who scored less than 0.6, five represent a subgroup with a score of less than 0.16: two of these patients were scored prior to acetabular revision, one suffered from severe knee osteoarthritis and was scheduled for total knee arthroplasty, one had several dislocations and scored 0.09 and the fifth patient (−0.14) was generally depressed at follow-up.

We found a good (0.71) correlation between the EuroQol and WOMAC scores in this study. This may indicate that the two outcome measurements comprise almost the same main dimensions (pain and function) and that it is unnecessary to use both a disease-specific and a generic measure. The mean HHS was 90 (range: 62–100), which is similar to values reported in other postoperative studies. We found rather poor correlations between the HHS and EuroQol/WOMAC scores (0.61 and 0.57, respectively), which indicates that these outcome measures evaluate quite different qualities.

In general, we found reduced muscle strength of the operated side – for both the quadriceps and hamstrings. However, there was a high degree of dispersion: two patients had equal values to the normal side, and one patient had a deficit of almost 90%. This reflects the heterogeneity of the population; many of the patients have underlying diseases that adversely affect the muscular system, and during growth the involved extremity is underdeveloped. Also, many of the patients have undergone several prior surgical procedures, which may had led to further muscle weakness.

In conclusion, this study demonstrates excellent ten to 16-year results for the fully HA-coated femoral stem inserted in young adults.

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