3.3 28mm Head in Ceramic/Ceramic Total Hip Replacement

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Introduction

Total Hip Replacement is a successful procedure with relative low complications.

With improvements in fixation, implant design and the introduction of minimally invasive techniques, the goal in THR today is to minimize wear and osteolysis avoiding loosening of the components.

Alumina on Alumina and Metal on Metal bearings are the most suitable solutions especially for young patients. The potential trouble using ceramic is the increased risk of fracture and the higher incidence of dislocation when small size heads are used. Furthermore alumina avoids the risk of ions release connected with M/M bearings.

The purpose of our study was to evaluate the clinical and radiographic outcome of the alumina bearing using a 28 mm femoral head in young patients.

Materials and Method

In 2000 we introduced in the First Orthopaedic Clinic of the University of Florence the use of ceramic bearing in THR for patients younger than 65 years.

In our experience CLS, Heritage and Conus stems with Trilogy cups (Zimmer, Inc., Warsaw, IN) showed excellent results thus we used them as our choise of implants.

With Trilogy cup the employment of 32 mm liner is only possible with large cups size (up to 56 mm). In most cases patients required a smaller cup size, for this reason we used a ceramic bearing with a 28mm head.

Between November 2000 and December 2005, 151 patients received 164 ceramic/ceramic THR with a 28 mm head.

The mean age of the patients was 54.8 yrs (range 25 to 74).There were 53 men and 98 women.

The preoperative diagnosis were primary osteoarthritis in 81 (Fig. 1a, b), secondary osteoarthritis to CDH in 40 (Fig. 2a, b), secondary osteoarthritis for other causes in 21, osteonecrosis in 11, femoral neck fractures in 8 and surface hemiarthroplasty failure in 3.

149 procedures were performed without cement (145 hips with CLS and Trilogy, 4 hips with Conus and Trilogy) and 15 were performed with hybrid fixation with cemented stem and a cementless cup (Heritage and Trilogy).

Patients were classified according to Charnley classification: class A (involvement of only the ipsilateral hip), class B (involvement of the contralateral hip), class BB (THR in both hips) and Charnley class C (involvement of other joints or systemic problems limiting activities) [1].

Figure 1a:
Preoperative radiograph of a fifty-eight-year-old woman showing primary osteoarthritis of left hip.

Figure 1b:
Radiograph, made four years postoperatively.

Figure 2a:
Preoperative radiograph of a forty-four-year-old woman showing bilateral CDH (previous bilateral surgery).

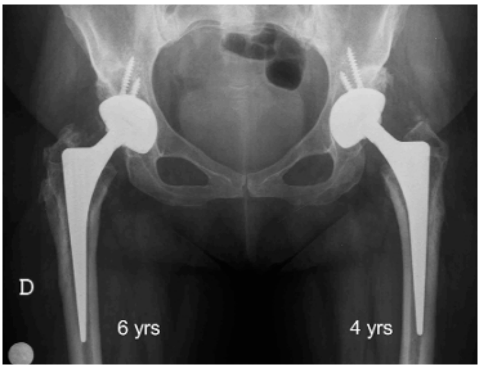

Figure 2b:
Radiograph, made six years (right side) and four years (left side) postoperatively.

The clinical evaluation was performed with use of the Charnley score. Patients were assessed for pain, function and motion. A maximum score of 6 points represented normality (no pain, normal gait, free ROM) while 1 represented a poor condition (severe pain, bedridden or able to walk for only a few yards, ankylosis). Patients were questioned about the presence of thigh or groin pain.

Anteroposterior radiographs of the pelvis and hip and lateral radiographs of the hip were obtained before surgery. A preoperative planning was performed for all patients to determine the size and orientation of cup and stem with the aim to restore the normal biomechanics of the hip through the femoral offset, the center of the femoral head and the leg length discrepancy.

Surgery was performed through a posterolateral approach with excision of the external rotator muscles and the posterior capsule. This were reconstructed at the end of the operation.

Since 2002 a minimally invasive approach was adopted.

The target cup position were 40° of abduction and 15° of anteversion and, when possible, the stem at 10-15° of anteversion.

Joint stability was evaluated: in extension and in concomitant external rotation, at 90° of hip and knee flexion with concomitant internal rotation and with the shuck, dropkick and resident test. A release was done in presence of improper soft tissue balance.

Clinical and X-Ray evaluations were performed after surgery, at 6 weeks, at 4 months and yearly.

Postoperative radiographs were evaluated for heterotopic bone, according to the classification of Brooker et al [2].

Cup position was measured in reference to the teardrop line. The horizontal reference line was drawn by connecting the inferior apex of the teardrops. The acetabular cup angle was measured from the horizontal reference line.
Radiolucency of >1 mm was assessed in the three zones defined by DeLee and Charnley [3].

If a complete radiolucent line was found, the cup was considered to be probably loose, a change in the position of the cup was considered surely loose.

The position of the femoral component was assessed with use of a fixed point of reference on the prosthesis and the femur (the lesser and the greater trochanter). Component orientation was neutral if the center lines of the component and the femur were within an angle of 5°; otherwise, the component was designated as having varus or valgus alignment. All changes around the femoral component were documented according to the method of Gruen [4]. The stem was considered loose in presence of a complete radiolucency all around and/or in presence of subsidence.

Results

At a mean F.U. of 3.2 yrs (range 4 months to 5 yrs and 3 months) we review 149 patients (162 hips). Two patients were lost at follow up. 78 patients were classified as Charnley class A, 33 as Charnley class B, 30 as Charnley class BB (13 received alumina bearing bilaterally), 8 as Charnley class C.

The mean preoperative Charnley score was 2.8 points for pain, 2.7 points for function, and 3.2 points for motion. At the time of the final follow-up, the mean scores were pain 5.98, function 5.98 (class B and C were not considered because of problems relative to other hip or other disease limiting activities), and motion 5.81.

At the time of the final follow-up 98.65% of our patients were pain free (in 2 cases diagnosis were transient bursitis). None showed thight or groin pain; satisfaction were recorded in 99.38%.

Leg length discrepancy > 5 mm and < 10 mm was recorded only in 5 patients (3.3%): 4 was class B and 1 was class C (in all cases this was secondary to pathology of the contralateral hip). The average cup abduction was 40.9° (range 32° to 51°).

All femoral components alignment was within 5° of the neutral in the coronal plane.

At the latest radiographic follow up 4 hips had radiolucency in zone 1 (2.5%). Periprosthetic osteolysis and loosening were not detected around any component, all the cups and stems were stable.

Etherothopic ossification was detected in 23 hips (14.1%); 12 were at stage one, 9 at stage two and 2 at stage three.

Recurrent joint dislocation occurred in one patient (0.61%) and required revision surgery.

A single episode of dislocation (caused by a fall) occurred in one patient three days after surgery. (0.61%)

Discussion

Ceramics were introduced in THR to address the problems of friction and wear that were reported with metal on polyethylene articulations. Alumina shows excellent tribologic properties, extra low debris generation and low tissue response.

Previous experiences with the first generation alumina bearing have been controversial because of accelerated wear and component fracture [5].

Over the last decade, many improvements have been made in ceramic manufacture and design that lead to increased resistance to mechanical stress and lower wear [6,7].

The outstanding tribologic properties are related to a low surface roughness (Ra=0.02 micron) because of the low grain size; high hardness is responsible for major scratch resistance; high wettability results in low friction, low wear and fluid film lubrification [8].

In vitro wear testing of alumina on alumina showed two phases of wear rates. The first phase or "Run in" Phase concerns the first million cycles during which volumetric wear rate measures 0.1 to 0.2 mm^3. During the second phase, or "Steady State" Phase, volumetric wear rate decreases at less than 0.01 mm^3 per million cycles [8].

Bohler et Al. have shown that the concentration of wear particles in the periprosthetic tissues of loosened implants were 2 to 22 times lower with alumina than with M on PE [9].

Alumina wear debris are well tolerated because they are almost bioinert and after an initial inflammatory phase they induce a low cellular response with minor fibrous scar tissue [10,11].

Alumina particulate wear debris are phagocitosed by macrophages which release the chemical mediators IL-1, IL-6, TNFα and PGE_2. The latter are regarded to be the most active. They are capable of inducing cell proliferation, osteoclast formation and thus resorption of adjacent bone.

The levels of PGE_2 and TNFα in tissues surrounding the implants were higher with PE particles than with alumina particles [12,13].

Also, the induction of macrophage apoptosis was faster and more important with alumina than M/PE [14]. Thus apoptosis may be the major internal mechanism that could explain the differences seen in the osteolysis patterns.

For these reasons alumina bearing is the suitable choise for the young and active patient where high functional demand could induce high wear rates.
For good long term results ceramic require particular care.

Walter et Al. reported with alumina, high wear rates for cup abduction of over 60°, these rates decreased for abduction of less than 45°. He showed that stress contact is related to wear debris amount [15].

Large femoral heads and proper surgical technique are both important for good results.

In our experience the 28mm femoral head was the only choice for cups less than size 56, so we evaluated all risk factors related to joint instability.

Increasing femoral head size results in an increase in the PIF-ROM (prosthetic impingement free ROM) and an increase in the VHD (vertical head displacement) thus reducing the rate of component dislocation [16]. In our experience the 28 mm head showed good results with joint instability rates that were lower than those reported in other clinical studies [21].

Despite ceramic implants' design doesn't allow elevated rim borders and head sizes are available only in limited lengths (-3.5, 0 and +3.5 mm), we think that a preoperative planning and a proper surgical technique are essential to provide joint stability.

As reported by several authors, dislocation after total hip replacement has an overall incidence of 2% to 3% [17]. More than half of all dislocation occurs within the first 3 months after surgery and that more than three fourths occur within one year [18].

Patient risk factors are neuromuscular and cognitive disorders including cerebral palsy, muscular dystrophy, psychosis, dementia and alcoholism. Fackler et Al. has reported high risk of dislocation after primary THR [19].

Surgical risk factors are: surgical approach, soft tissue tension, component positioning, head size and surgeon experience [20].

Masonis et Al. reported a dislocation rate of 0.50% for the lateral approach and a rate of 3.2% for the posterolateral approach [21]. However, meticulous reconstruction of the posterior capsule and short external rotators can reduce the dislocation rate [22].

Lewinnek et Al. recommended acetabular abduction between 30° and 50° and acetabular anteversion between 5° to 20° and described it as "safe zone". Positioning cup within safe zone provides the best ROM associated with low dislocation risk [23].

Biedermann et Al. in a recent study showed a six fold higher relative risk of dislocation for cup anteversion of less than 4° or more than 24°. In a large number of patient, dislocation also occurred within the "safe zone". He stated that there is not an absolute safe cup position that prevents joint dislocation [24].

For this reason we think that soft tissue balancing and offset restoration are the main factors for good long term results. The inability to restore femoral offset adequately has been correlated with increased resultatant forces across the hip joint and their associated deleterious effects on wear rates, compromised abductor function and increased joint dislocation rates [18,25,26,27,28]. For these reason we recommend the routine use of high offset stems and proper medialized cups.

Conclusion

Our experience with alumina bearing and 28 mm head (at mean F.U. of 3.2 yrs) revealed excellent radiographic and clinical results. Patients were pain free in 98.65% (no cases showed groin or thigh pain), with satisfaction rate of 99.38%. No mechanical failure or alumina fractures were observed in our study.

Joint dislocation occurred in 1.22% of our patients. These results are superimposable to the dislocation rates observed with large heads employment. We are in agreement with the literature and state that adequate preoperative planning, proper surgical technique and restoration of hip biomechanics are the pillars for good long term results.

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