1.3 A Ten Years Experience with Alumina-Alumina Hip Replacement

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Introduction

Polyethylene wear, due to a cascade of events activated from macrophages, is the main reason of bone resorption and periprosthetic osteolysis and usually takes to the failure of the implant.
This has pushed bioengineers to research new materials to reduce friction, wear and tissutal reaction: considering that nowadays many younger and younger people are operated of hip arthroplasty with higher mechanical and functional requests, the target of research is to increase longevity of implants.

Since sixties, Sir John Charnely, the father of modern hip arthroplasty surgery, had already realized that ceramic had a low friction coefficient, foreseeing its use in the future when technology would have been able to produce better ceramics for biological use.

In fact, ceramics with its low friction resistance, with its high hydrophilic properties, with its particular hardness and considering its low reaction to its wear debris, could be the best bearing surface for hip arthroplasty.

The surgical technique needs to be optimal and precise and components geometry needs to respect cinematic and articular biomechanical theories.

The alumina-alumina replacement is agree with *Low-Frictional Torque Arthroplasty* theories of Sir J. Charnely who announced that frictional torque (M_t) occurring between two components is directly proportional to the head diameter (D), to the articular charge (W) and to the friction coefficient between components (μ).

$$M_t = \mu WD/2$$

The friction coefficient of Alumina-Alumina replacement ($\mu_{ce/ce}$= 0,035) is about three times less than the one of Metal-Polyethylene ($\mu_{me/pe}$ = 0,1): this means that to have the same frictional torque value of Metal-Polyethylene replacement of 22,25 mm, we could use a 67 mm head articulating within an acetabular diameter 2 mm larger.

Materials and Methods

Nowadays in the I^ Clinica Ortopedica of University in Bari (Italy), in patiens who need a biological fixation, we use mainly the Cerafit M cup manufacted by Ceraver Osteal (Roissy, France).

The press-fit cementelss titanium shell consisted of a pure titanium core with a titanium alloy mesh to allow bone ingrowth: its design consisted of an hemispherical shape with a flattening in the polar region and circumferential gutters (Triradius Cup). For these reasons the cup is inserted in 2 mm underreamed acetabulum. There are 3 holes: 2 for additional screw fixation and 1 on the apex for the peg of the liner which is held in the metal back by a conical sleeving and combined with a 32 mm alumina femoral head.

From January 1994 to April 2003, 121 consecutive alumina-alumina hip replacement in 74 females and 47 males were performed. The median age of patients at the time of surgery was 58 (range 25-74 years). The initial diseases inducing hip replacement were: primary coxarthrosis in 67 (55,4%) hips, atraumatic avascular necrosis in 26 (21,5%), fracture of the upper femur in 18 (14.9%), coxarthrosis after hip dysplasia in 8 (6.6%), rheumatoid arthritis in 2 (1.6%). All the operations were primary procedures, performed or supervised by the senior author (G.B.S.).

Two additional screws have been used in 19 cases (15.7 %).
Three different stems were used: a cemented collared smooth anodized Ti stem in 40 cases (33%), two cementless (one anatomical and one HA-coated straight, fig. 1) Ti stems in 81 cases (67%).

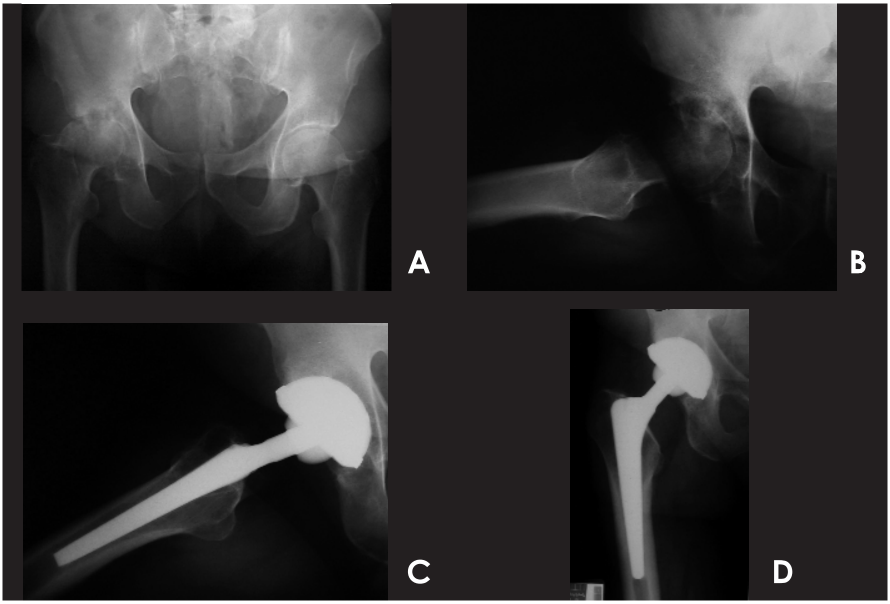

Figure 1:
Pre-operative AP and axial x-ray; C-D: X-ray control at a 36 months follow-up.

Results

98 hips (81%) have been reviewed at an average follow-up of 41 months: 92 (93.8%) have showed no clinical and/or radiological signs of impending failure (Fig. 2), 6 (6.2%) had undergone a revision (2 infections, 2 sinking of the anatomical cementless stems, 1 stem fracture, 1 recurrent dislocation).

None of the implants have been revised due to mechanical failure of the ceramic components.

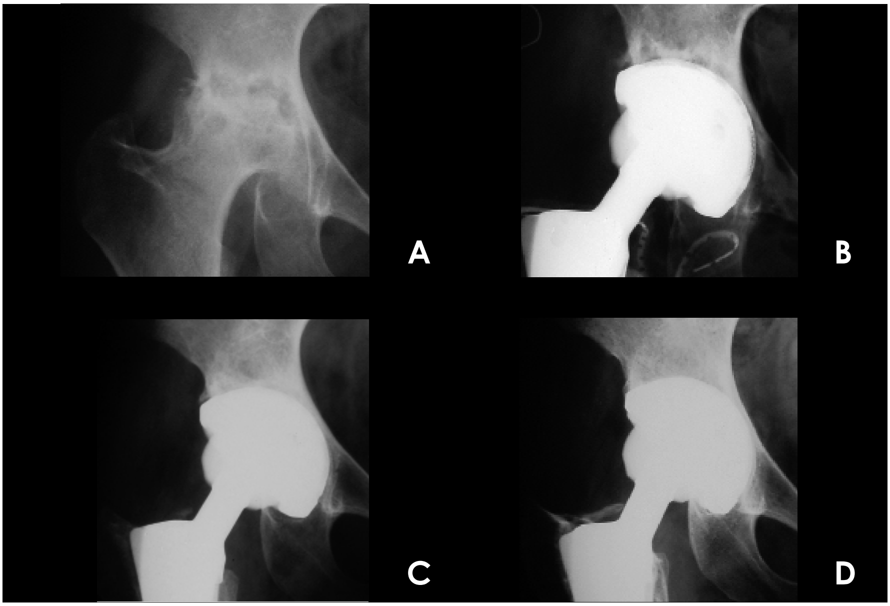

Figure 2:
Alumina-alumina 32 mm cementless implant in avascular necrosis. A: Pre-operative x-ray; B: Post-operative x-ray; C: X-ray control at a 12 months follow-up; D: The X-ray control at a 8 years follow-up shows optimal osteointegration.

Discussion

Alumina-alumina hip replacement have been firstly used from French and German surgeons in the early seventies.

Boutin used alumina cups directly fixed in the acetabular bone or using methyl-methacrylate, leading to a different stiffness in the implant-host system and so producing mobilization of the cup from the bone.

The Mittlemeier system gave troubles with both biological fixation of a alumina screwed-in cup and "mushroom-shaped" heads: this realized easily an impingement of the skirt against the acetabular component giving the chipping and breakage of one ceramic components.

The use, in new acetabular prosthetic designs, of a metal-back (often in Titanium with a porous external surface) represents a shock absorber that reduces the different stiffness between ceramic and bone.

The abandon of skirted heads and the improvement in surgical procedures reduce the impingement risks.

With 32 mm heads used nowadays, resistance to the fracture of materials is increased very much, passing from 38 KN of seventies to the 89 KN: this value is almost the double of the one (46 KN) indicated from the American FDA as a minimal burst strength limit.

A 32 mm head improves both mechanical performance and grants a wider articular range of movement than the one possible with a 28 mm head (8°-10° more, using a 12-14 mm cone).

Wear tests and clinical experiences show linear wear values of 0,001 mm/year in alumina-alumina replacement: this is 200 times smaller than the one of metal-polyethylene (0,1 mm/year) and it explains the drastic reduction of debris.

The biocompatibility of ceramic is demonstrated by the peculiar reaction to its debris, with main presence of fibroblasts, minimal of macrophages and absence of giant-cells, and so by the almost complete absence of periprosthetic osteolysis.

Conclusions

In last years, many improvements on quality of hip arthroplasty materials have been made, especially for sphericity, circularity, insert-head clearance, prosthetic stem and cone.

Anyway it is recommended to use products from the same manufactory, to avoid risk of "mismatch" between components and/or fretting phenomena at the cone-head or shell-insert interfaces.

Worries in the use of alumina-alumina replacement in hip arthroplasty have to be considered over-passed considering studies that suggest us better and better results for mechanical quality and longevity of implants.

According to this, it is reasonable to admit that alumina on alumina bearing surface seems to be a valid alternative in the hip replacement surgery.

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