1.4 Thirty Years Experience with all Ceramic Bearings

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Introduction

To overcome the problem of foreign body reactions to polyethylene debris generated by sliding couple in total hip replacement, we did implant since 1977 an alumina (Al_2O_3) against alumina bearings total hip prosthesis.

The first alumina-on-alumina total hip arthroplasty was implanted in April 1970 by the French surgeon Pierre Boutin. Until 1977, the alumina head was either glued with an epoxy resin or screwed to the femoral stem. However, this method of fixation led to an unacceptable rate of head to stem dissociation, with forty-five cases of 791 (5.7%) hip replacements performed between 1970 to 1977. Moreover, the quality of the alumina ceramic was non-optimal with large grain size and broad grain size distribution, combined with a low purity. All these adverse factors were responsible for ten fractures of the alumina components (six heads and four sockets) of 791 hip replacements (1.3%). Notable progresses were made in 1976 with the introduction of a Morse taper locking mechanism of the alumina head to the titanium stem, together with an improvement in the material manufacturing process, leading to the production of surgical grade dense alumina ceramic. At this time we introduced a new stem design made of titanium alloy smooth and covered with a layer of 5000A° of titanium oxide. The stem was designed to be cemented but also to fill the medullary canal resulting in a thin cement mantle; The idea came from the adverse results obtained with the regular small Charnley stem. We introduced the first alumina on alumina prosthesis in 1977.

The French experience was followed by Mittelmeier, Griss, and Heimke in Germany, Furuya in Japan, Pizziferato in Italy, and Salzer in Austria.

Over this 30 years period a lot of datas were documented concerning tissues reaction , in vivo wear behaviour, fractures, and clinical outcome.

Tissues reactions were documented on animal studies and on histological sections of tissues retrieved during revision procedure. Alumina debris were few appeared as yellow dots of 0,5m in diameter. Usually pure fibrocytic reactions were noticed except when the prosthesis has been loosed for many months or years resulting in massive foreign body reaction related to the amount of mix debris of metal, cement and ceramic. PGE2 studies on retrieved tissues comparing those around metal on polyethylene sliding couple found less production than around ceramic on ceramic sliding. This is in accordance to other laboratory works from I. Catelas or J. Fisher who demonstrated less inflammatory reaction with this couple than with other combinations.

Cementless plain alumina socket was documented after natural death of the patient who had this prosthesis implanted for 12 years. There was no direct bone to alumina contact but fibrous tissues and the bone did enter into alumina grooves resulting in some type of interlocking which explains the good results of this device.

Ceramic materials retrieved at revision were analysed. Sphericity, surface roughness, wear volume were plotted against quality of alumina grain size. There

was a correlation between these parameters: old alumina did wear more than more recent one. In some occasion wear was as low as some microns for a 15 years period in use. This is two thousand times less than a regular metal on polyethylene sliding couple. and 100 times less than a metal on metal prosthesis.

Fracture mechanism is related to crack propagation into the material; This is diminished by using a high quality alumina with high density, high purity, low porosity and small grain size randomly distributed. This has been obtained by improving the manufacturing processes and by applying High Isostatic Pressure (HIP) technique. During the first period fracture rate was in the range of 2%. Then it drops to less than 0,1 %. We suspect the current fracture rate to be in the order of 0,05% for a ten year period of use. Cone technology is also highly relevant and a failure in this technology either at the femur or at the socket level may explain some recent fractures. In our clinical experience we have recently published 13 fractures of an alumina component over a 25 years period. and more than 5500 prosthesis with at least one alumina material implanted. Majority of these events could be easily explained by some mistakes either in component size, cone technology or material quality. Few fractures could not be explained; Even of concern, these events are extremely lo, easy to revise if recognised quickly and have to be compared to the major advantages of this material which authorize a full activity including sports or strenuous activities even in young age and active population. The results we did publish in this population clearly demonstrated these advantages over periods up to 20 years.

Clinical outcome

More than 3500 total hips in selected young and /or active patients were implanted. Many publications concerned this topic. The more recent one concerned a series implanted by P.Boutin in PAU during the year 1980. One hundred and eighteen hips in 106 patients were operated. Mean age was 62 years. There was different fixation systems. Cemented socket in 85 cementless socket in 23 cemented stem in 89 cementless stem in 19.

At the twenty-year follow-up evaluation, forty-five patients (fifty-one hips) were still alive and had not been revised, twenty-five patients (twenty-five hips) had undergone revision of either or both components, twenty-seven patients (thirty hips) had died from unrelated causes, and nine patients (twelve hips) were lost to follow-up. The mean Merle d'Aubigné hip score was 16.2 ± 1.8 at the latest follow-up. Survival of the cup at twenty years with revision for any reason as the end-point was 85.6 percent (95 percent interval confidence, 72.2 to 99.0 percent) for cementless cups versus 61.2 percent (95 percent interval confidence, 46.8 to 75.6 percent) for cemented cups, respectively. Survival of the stem at twenty years with revision for any reason as the end-point was 84.9 percent (95 percent interval confidence, 71.1 to 98.8 percent) for cementless stems versus 87.3 (95 percent interval confidence, 77.4 to 97.1 percent) for cemented stems. Wear of the prosthetic components was undetectable on plain radiographs. Periprosthetic cystic or scalloped lesions were recorded in three of the 118 hips. No fracture of the alumina socket or head was recorded.

Another study concerned a more recent design of the socket which consisted in a metal back titanium alloy shell covered with a pure titanium mesh with an alumina liner. From 1990 to 1992 71 hybrid alumina on alumina hip replacements

were performed in 71 hips (62 patients) with a mean age of 46 years at surgery. The nine year survival rate was 93% if revision for any cause was the end point and 98,4% if revision for aseptic loosening was the end point. One socket had a complete radiolucent line less than 1 mm thick. There was no component migration nor osteolysis.

It was clear from this long term experience that the weak part was the socket fixation; New systems including metal back alumina with press fit shell covered with a titanium mesh was efficient; We modified it 6 years ago to a rough titanium surface covered with hydroxyapatite. This is our current material which as far as we observe solve the problem.
Since 1997 we moved also to a cementless stem with an identical surface.

Conclusion

31 years experience of this material allows us to draw some firm conclusion; This alumina on alumina bearing system is safe if the material if of high quality, if cone technology is accurate and if the material has a significant thickness. It gives interesting results without any physical limitation specially in young and active patients. Revision is easy due to the lack of foreign body reaction. Concerned are still represented by some risk of fracture and by the cost. Surgical technique is also highly relevant because this material is not as friendly for users as the regular plastic. But long term expectancy without revision may be considered when these aspects are considered.

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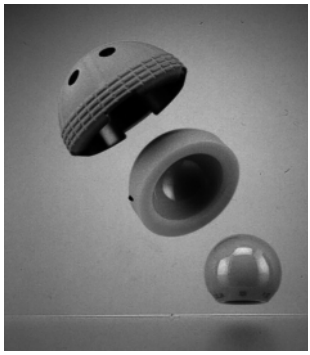

Figure 1:
Metal back alumina socket with an alumina liner.
32 mm head.

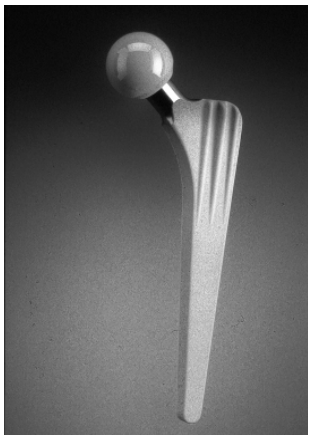

Figure 2:
Cementless stem fully coated HA.

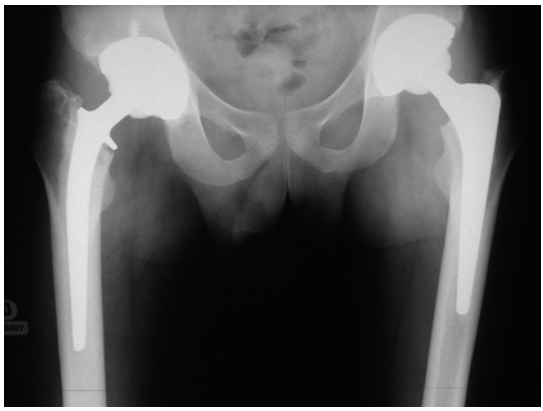

Figure 3:
Bilateral total hip in a 17 years old boy for severe avascular necrosis of the femoral head, 3 years follow up. No pain, can perform some type of physical activities without any limitation.