COMPARISON OF THIRD BODY DAMAGE ON THE FEMORAL HEAD CAUSEDBY BONE AND BONE CEMENT

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Relevance to Musculoskeletal Conditions

The roughening of the femoral head can increase the polyethylene wear volume and the number of wear particles generated. This study addressed how bone and bone cement particles affect the surface roughness of the femoral head .

Introduction

The damage of femoral heads can caused by third bodies, including bone, bone cement, metal and hydroxyapatite. It has been reported that particles of bone and bone cement are embedded into the acetabular cup and scratch or damage the polished femoral head[1,2,3]. The damaged femoral heads can increase the wear volume and the number of wear particles of the ultra-high molecular weight polyethylene (UHMWPE). These UHMWPE wear particles produce adverse tissue reaction which induces loosening of prostheses. The objectives of this study were to characterize and compare the damage of the stainless steel counterfaces by different bone and bone cement particles.

Materials and Methods

The particles used in this study are listed in Table 1. Two types of bone and three types of polymerized bone cement were used. The bone cements were polymerized according to the manufacturer's instructions. Bone cement particles were prepared by hand grinding in a glass motor and pestle. Finally, the particles were sieved using a 500 μm sieve. Bone particles were prepared using the same techniques as that used in the preparation of the bone cement particles. Extreme care was taken for the preparation of particles in order to avoid the inclusion of foreign bodies.

Particles of each type were embedded into different UHMWPE pins. The UHMWPE pins had a truncated cone at one end with a contact surface which was microtomed. Two different types of pin were used which had 3 mm and 5 mm in diameter of contact surfaces. Particles were dispersed in deionized water and filtered onto a 10 μm filter in order to distribute them on the filter uniformly. The UHMWPE pin was placed on the particles and the particles were embedded into the pin. Consequently the particle sizes embedded the surface of the pin were in the 10 to 500 μm size range[4].

The Howden machine was used to characterize the third body damage. Stainless steel 316 plate was used as a femoral head material. It was highly polished to surface roughness R_a better than 0.01 μm. The lubricant used in this test was 25% bovine serum. The load was applied 80 N on the each pin (contact stress was 11.3 Mpa for the 3 mm diameter pin and 4.1 Mpa for the 5 mm diameter pin). The sliding speed of the plate was 8 mm/min. Each pin with embedded particles was slid five times on the same track. Scratches were analyzed using a non-contacting laser profilometer. The maximum spatial resolution was 0.5 μm. Each wear track was analyzed at five positions.

Results

Fine scratches were analyzed from each trace of the wear track on the plate. Figure 1 shows the number of scratches per mm of the wear track for the tests. BCA produce no scratch and BCC produced the greatest number of scratches on the stales steel counterface. The differences were statistically significant. The higher stress contacts produced more scratches for each type of particles than that for the lower stress contacts. The height of lips and the depth and width of valleys of scratches were similar for the different types of particles.

Discussion

BCC with zirconium as the hardest radiopaque additive produced the most number of scratches. This study has also shown the freeze dried bone produced more damage on the stainless steel counterface than the fresh bone. It is recommended that the freeze dried bone should be used rehydrated for 24 hours before use. This appears to be of considerable importance with respect.

Contact stress was also an important factor in the third body damage. This study indicated that the number of scratches was dependent on the contact stress applyed in the tests.

Table 1 Materials of particle

Bone (Femoral head of human)	
Fresh bone (soaked in the formaldehyde)	
Freeze dried bone (not rehydrate)	
Bone cement	
Bone cement A	: Bone cement without additive
Bone cement B	: Bone cement with barium sulfate
Bone cement C	: Bone cement with zirconium

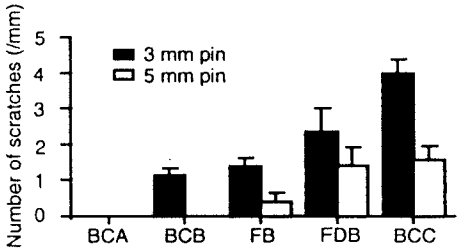

Figure 1 Number of scratches per mm of the wear track +/- 95% confidence limits

References

1) Atkinson J.R. et al. *Wear*, 217-224, 1985
2) Issac G.H. et al. *Engineering in Medicine*, 19-22, 1986
3) Issac G.H. et al. *Engineering in Medicine*, 167-173, 1987
4) Cooper J.R. et al. *J. of Med. Eng. & Tech.*, 63-67, 1991

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