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ORIGINAL ARTICLE

Direct comparison of polyethylene wear in cemented and uncemented acetabular cups

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Abstract
Background It has been indicated that, in the long term, the rate of wear and the degree of osteolysis observed with uncemented acetabular components are greater than those associated with cemented cups, but most studies which compare the wear characteristics of cementless with cemented cups have used historical controls. We report a direct comparison of wear of a cemented and an uncemented cup with similar design, polyethylene, and sterilization method.
Materials and methods The study cohort includes 92 patients who were operated in 1997 with primary total hip replacement and have been followed for a period of 9–10 years. All patients were operated by posterolateral approach. In patients 70 years or older we used a cemented cup, in those 60 years or younger we used an uncemented cup, and in patients between 60 and 70 years we used either a cemented or uncemented cup as decided by the surgeon. At follow-up, radiographic imaging was obtained as standard anterioposterior view of the pelvis, and mean wear was determined as described by Livermore et al.
Results The overall wear of the cemented acetabular components was 1.07 ± 0.78 mm, and that of the uncemented cups was 1.18 ± 0.61 mm ($P = 0.529$). Wear was significantly associated with male sex ($P = 0.003$), younger age ($P = 0.003$), and degree of inclination ($P < 0.001$), but wear was not significantly associated with cemented versus uncemented cup ($P = 0.437$).
Conclusion Our findings in this 9–10-year follow-up study suggest that cementless cups wear no more than cemented cups of similar design.

Keywords Hip · Polyethylene · Prosthesis · Wear

Introduction

In total hip arthroplasty, polyethylene debris is mainly responsible for the development of osteolysis with subsequent loss of bone stock and implant fixation [1–3]. In the early 1980s several reports showed that, in the long term, the rate of wear and the degree of osteolysis observed with uncemented cups were greater than those associated with cemented components [4–11], but in one study this could not be proved [12]. As no studies have reported direct comparison of long-term results of cemented versus uncemented acetabular components, the question of whether a cemented all-polyethylene cup has better behavior than an uncemented one has not been fully clarified. This study was undertaken to compare wear of a cemented and an uncemented cup with similar design, polyethylene, and sterilization method. Our hypothesis was that there is no difference in the rate of wear of polyethylene between a cemented and an uncemented cup with similar design, polyethylene, and sterilization method.

Materials and methods

The study was approved by the local ethical committee and performed in accordance with the ethical standards of the

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1964 Declaration of Helsinki as revised in 2000. All patients gave informed consent. The study cohort included 92 patients who were operated in 1997 with primary total hip replacement (THR) due to osteoarthritis and have been followed for a period of 9–10 years. All patients were operated by posterolateral approach. In patients 70 years or older we used a cemented cup, in those 60 years or younger we used an uncemented cup, and in patients between 70 and 60 years we used either a cemented or uncemented cup as decided by the surgeon. The cemented cup was an all-polyethylene UHMWPE Reflexion Cup (Smith & Nephew Richards Inc. Memphis, TN, USA), and the uncemented cup was a TI-6AL-4V Reflexion Porous Acetabular Shell with a UHMWPE Reflexion Microstable Acetabular Liner (Smith & Nephew Richards Inc. Memphis, TN, USA). The polyethylene was machined using ram extrusion and sterilized with ethylene oxide (EtO). In all patients we used a cemented Co-Cr Biofit Femoral Component (Smith & Nephew Richards Inc., Memphis, TN, USA) and a 28-mm Co-Cr Universal Head (Smith & Nephew Richards Inc., Memphis, TN, USA).

In the cemented group there were 12 males and 50 females, and in the uncemented group there were 10 males and 20 females ($P = 0.141$). The age of the patients in the cemented group was 72 ± 6 [95% confidence interval (CI) 71–73; range 60–84] years, and the age of the patients in the uncemented group was 64 ± 2 (95% CI 63–66; range 57–70) years ($P < 0.001$). The size of the cemented cups was 53 ± 2 (95% CI 52–54), and the size of the uncemented cups was 54 ± 3 (95% CI 53–55) ($P = 0.017$). The inclination of the cemented cups was 50 ± 9° (95% CI 48–52°), while the inclination of the uncemented cups was 53 ± 8° (95% CI 48–59°) ($P = 0.123$).

At follow-up, radiographic imaging was obtained as standard anterioposterior view of the pelvis, with the beam centered at the symphysis pubis and the hips corrected for rotation. All measurements were corrected for magnification determined in each radiograph by measuring the diameter of the known implanted femoral head. The images were reviewed by two observers, and the mean wear was determined as described by Livermore et al. [13].

Wear was analyzed in a multivariate model that included sex, age, cup size (mm), and cup inclination (SPSS Inc., Chicago, IL, USA). Data are presented as mean ± standard deviation and 95% confidence interval (CI). Continuous data were compared using Student's *t*-test, and chi-square test was used to compare frequencies. The level of significance was set to $P < 0.05$.

Results

The overall wear of the cemented acetabular components was 1.07 ± 0.78 (95% CI 0.89–1.26) mm, and wear of the uncemented cups was 1.18 ± 0.61 (95% CI 0.91–1.44) mm ($P = 0.529$). Wear was significantly associated with male sex ($P = 0.003$), younger age ($P = 0.003$), and degree of inclination ($P < 0.001$), but wear was not significantly associated with cemented versus uncemented cups ($P = 0.437$) or cup size ($P = 0.451$).

Discussion

This study was undertaken to determine the wear of a cemented versus an uncemented acetabular component with the same design, fabrication, and polyethylene. Our results support our hypothesis that wear rates are equal during a period of 9–10 years. We determined wear using the Livermore technique [13], which has accuracy similar to other manual and computerized wear measurement methods [14, 15]. The complexities of wear measurements and the implications of out-of-plane wear have been extensively discussed in the literature [16–18], but in general the repeatability is acceptable [19].

The major weakness of our study is that it is not randomized. Also, difference in age between the two groups is a clear confounding variable. Younger age was significantly associated with wear, and older age in our patients with a cemented cup is in contradiction to previous reports that a cemented all-polyethylene cup has better behavior than an uncemented in terms of wear.

The strength of our study includes strict patient inclusion criteria, all with a diagnosis of osteoarthritis, undergoing surgery in the same hospital by the same surgeons, with the same surgical technique, and all with the same cemented stem and 28-mm chromium cobalt head. All patients have the same length of follow-up, and also our focus directly on wear of the acetabular component can be considered a strength of the study.

In both the cemented and uncemented components the polyethylene was machined using ram extrusion and sterilized with ethylene oxide (EtO). There are indications that PE components produced using molding provide for less wear compared with extruded components [20], but a main factor responsible for wear of UHMWPE in hip replacements is oxidative degradation, which degrades its mechanical properties [21]. Oxidation is strictly correlated with sterilization using high-energy radiation in air (γ radiation or an electron beam with dose of 25–40 kGy). UHMWPE components sterilized with ethylene oxide (EtO) do not oxidize. Our results, therefore, should be restricted to these methods of production and sterilization of PE.

The modularity of the uncemented acetabular component and its relation with polyethylene wear have been matters of concern. There has been a suggestion that

modularity of an uncemented acetabular component contributes to increase of wear [11, 22–24], and Hernandez et al. [5] conjectured that this may be due to the fact that the cement absorbs some of the stresses and thus reduces the forces on polyethylene. It has been shown that load transfer to cortical and cancellous bone is different after cemented versus uncemented hip prosthesis [25].

The use of an uncemented porous socket in combination with a cemented femoral component was recommended for primary hip replacement in the 1990s [26] and generally in younger age groups. Our patients with an uncemented cup were younger than those with a cemented cup. Multivariate analyses have shown a significant increase in rate of polyethylene wear in patients with excellent Harris hip score and younger age [27], and increased rate of wear has been likely related to level of activity in younger patients. Accordingly, we found a significant association between younger age and wear in our patients. With an assumed higher activity level in the uncemented group, they should have been expected to have higher wear. This underlines that wear of the uncemented cups at least was not higher than that of the cemented cups.

Furthermore, we found an association between male sex and wear, and although not significant, there were relatively more males than females in the uncemented group as compared with the cemented group. And third, there was a significant association between degree of inclination and wear, and the uncemented cups were inserted with higher inclination than the cemented cups. These facts support the notion that uncemented cups do not wear more than cemented cups in the long run.

In conclusion, we performed a direct comparison of long-term wear of cemented versus uncemented types of acetabular component, and there were no significant differences in the rate of wear.

Conflict of interest None.

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