Ten-year socket wear in 66 hip arthroplasties

Ceramic versus metal heads

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Radiographic measurements of polyethylene socket wear were performed in 33 hip prostheses with an Al_2O_3-ceramic head and 33 prostheses with a metal head. At 9–11 years, the average reduction of the diameter of the polyethylene was 0.26 and 0.96 mm, respectively, in the ceramic and the metal group. However, the number of clinically proven or radiographically suspected loosenings did not differ between the two groups.

Wear of polyethylene sockets in total hip arthroplasty has been measured from radiographs by several authors following implantation of different types of prostheses (Charnley and Cupic 1973, Charnley and Halley 1975, Scheier and Sandel 1976, Griffith et al. 1978, Weber 1981, Buchhorn et al. 1984, Paschen 1986, Schneider 1987, Weber 1988). Most of these studies concerned metal-on-polyethylene prostheses, but some ceramic-on-polyethylene prostheses as well. This last combination seems to decrease the wear of polyethylene (Weber 1988); however, comparative studies have not been published. Because excessive wear of polyethylene in the long run may be one of the causes of prosthetic loosening (Willert et al. 1978), reduction of wear rates may be important.

We have compared wear of polyethylene sockets from radiographs 9 to 11 years following hip arthroplasty with metal and ceramic heads. Also, the rate of aseptic loosening was recorded in both groups.

Patients and methods

The radiographs of all 48 patients who between 1977 and 1980 underwent total hip replacement in our department and who had been operated on by the senior author (RKM) were studied. All the inserted prostheses were of the Weber type (Allo Pro, Baar, Switzerland), with a 32-mm-metal (Protasul®; Sulzer, Winterthur, Switzerland) rotating head. A comparison was made with the 46 patients who were operated on during the same years in private practice by the senior author using the same prosthesis, except that a 32-mm Al_2O_3 (Biolox®; Feldmühle, Plochingen, West Germany) rotating head was used. The rotational surfaces of the head around the neck were the same (metal-on-metal) in both types, the ceramic ballhead being mounted on a metal cylinder (Weber 1981); thus, the differences between the two types of prosthesis may be considered to be caused in the head-acetabulum articulation alone. At follow-up of the metal group, 6 patients had died and 2 had moved, while in the ceramic group 6 had died; thus, the number of patients available for study was 40 in both groups. In all of these patients the diagnosis had been arthrosis, either primary or secondary to dysplasia.

Postoperative radiographs at 6 weeks to 3 months and radiographs at follow-up were studied. All the radiographs had been made standing (weight bearing) with the central ray centered over the hip joint (Goergen and Resnick 1975). Measurements of polyethylene deformation (Figure 1) were made according to the method of Scheier and Sandel (1976) as modified by Buchhorn et al. (1984). Examples of 2 cases are shown in Figures 2 and 3. Because measurement in the y-direction is influenced by the degree of anteversion of the socket (Buchhorn et al.

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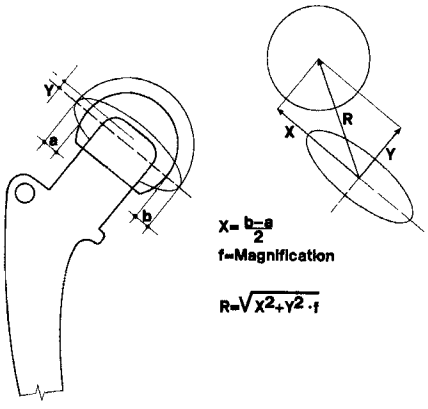
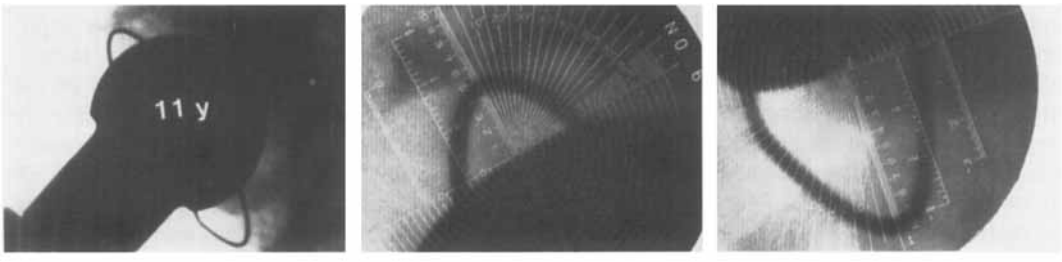


Figure 1. Technique of measuring wear of the polyethylene socket. The migration of the center of the ball head along the long axis of the elliptical wire marker and the perpendicular to this axis are measured. Under consideration of the magnification of the radiograph and using the Pythagorean theorem, the amount of polyethylene deformation is calculated. The difference between the follow-up and the postoperative radiograph is noted.

Table 1. Number of aseptic loosenings and wear in hip arthroplasties with ceramic and metal heads

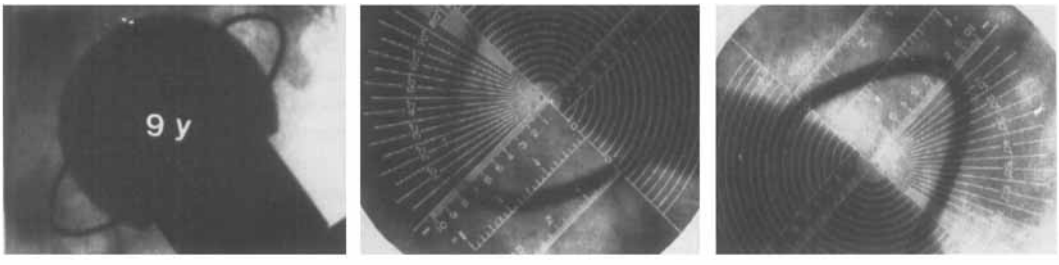
		Ceramic	Metal
Number		33	33
Wear* *SD* at follow-up (mm)		0.26 *0.13*	0.96 *0.51*
Average wear/year (mm)		0.03	0.10
Aseptic loosening			
Revisions	cup	1	1
	stem	1	2
Radiographic loosening	cup	2	2
	stem	1	2
Average wear (loosenings) (mm)		0.34	1.40



A B C

Figure 2. A. An 85-year-old woman, right hip, 11 years postoperatively, metal head. From first sight, it is clear that the head has shifted within the elliptical wire marker of the polyethylene cup.

B and C. Details as seen through the measuring device. Measurement in the x–direction (long axis of the ellipse): the distance *a* (See Figure 1) is 4.1 mm, and the distance *b* 9.3 mm. In the y-direction, a 0.2-mm shift was measured. Using the formula of Figure 1, the overall reduction of polyethylene was measured to be 2.4 mm.



A B C

Figure 3. A. A 73-year-old man, left hip, 9 years postoperatively, ceramic head. Without special devices, no shift of the head can be seen.

B and C. Under magification the distance *a* was measured to be 6.6 mm and the distance *b* 6.9 mm. In the y–direction, 0.2 mm was measured, and using the formula the reduction in diameter of the polyethylene was calculated to be 0.2 mm.

1984), sockets with more than 20° anteversion were excluded (ratio of maximum and minimum diameters of the wire marker less than 3.0; McLaren 1973). In both groups, seven prostheses were excluded from the study for this reason. Thus, in both groups 33 prostheses remained for study after 10 (9–11) years.

The female:male ratio was 7:1 in the ceramic and 6:1 in the metal group. The mean age was 69 (61–78) and 66 (48–78) years, respectively. The mean body weights were 71 and 69 kg. The degree of daily activities was comparable between the groups; most female patients were housewives, most men were retired. In both groups there were 6 patients who were still working at the time of the operation; none, however, performed heavy labor.

The change in diameter of the polyethylene sockets between the postoperative and the follow-up radiograph was recorded. In both groups, aseptic loosenings as proven by revisionary surgery or as judged from the radiographs were recorded. The cup was considered radiographically loose if there was migration (Callaghan et al. 1985) or if a radiolucent line was present in all three zones (DeLee and Charnley 1976). The stem was considered loose if there was migration exceeding 5 mm or if a radiolucent line surrounding the complete cement mantle was visible in one of the two projections (Harris et al. 1982).

The Student's *t*-test was used.

Results

The ceramic group had on an average 0.26-mm reduction of the polyethylene diameter and the metal group 0.96 mm ($P < 0.001$; Table 1). The rate of aseptic loosening did not differ between the two groups. However, the cases with proven or suspected loosening had higher than average wear rates in both groups.

Discussion

Wear of polyethylene sockets is a major problem in total hip arthroplasty. Excessive wear is thought to be one of the causes of aseptic loosening (Willert et al. 1978); "resting" phagocytotic cells in the cement-bone interface come to participate in a foreign-body reaction leading to the formation of granulation tissue and to resorption of bone.

The accuracy of wear measurements from radiographs is limited. Clarke et al. (1976) have criticized the methods used by Charnley and Cupic (1973) and Charnley and Halley (1975); from their own experiments, they even concluded that wear measurements cannot be made from clinical radiographs at all. However, using the method of Scheier and Sandel (1976) as modified by Buchhorn et al. (1984), it is possible to estimate wear, notably when radiographic techniques are standardized and the anteversion of the cup is only slight. Limitation of the accuracy of measuring wear by this method is mainly due to the following three causes: (1) The dimensional changes of polyethylene cups are caused both by creep—i.e., coldflow or plastic deformation—and by wear (Rose et al. 1980, Rose and Radin 1982). In the first postoperative years, most of the dimensional change is caused by creep, whereas later on, wear becomes more important; it remains impossible to quantify these two separately. (2) Measurements of the dimensional change in the y-direction are influenced by the amount of anteversion of the socket. If there is neutral version, the circular wire marker is presented as a straight line and the real change in the y-direction is measured. The more anteverted the cup is, the straight line becoming a widening ellipse, the less deformation in the y-direction is measured, which means that the wear is underestimated. (3) Even using special measuring instruments and oculars, reproducible measurements are possible within about 0.1–0.2 mm only.

In metal-on-polyethylene hip prostheses, most authors have measured wear rates from 0.13 to 0.20 mm per year (Charnley and Cupic 1973, Charnley and Halley 1975, Scheier and Sandel 1976, Weber 1981, Buchhorn et al. 1984). Only Griffith et al. (1978) measured 0.07 mm per year, a very low rate that the authors could not explain. Wear in ceramic-on-polyethylene hips has been measured to be between 0.05 and 0.15 mm per year (Weber 1981, Paschen 1986, Schneider 1987, Weber 1988).

Although our study was retrospective and the patients were not randomized, we do think that the two groups can be compared. The main difference between the groups was socioeconomic: the private patients were the ones with higher incomes.

The relatively low wear rate in our series may partly be attributed to the rotating, trunnion bearing type of prosthesis in which less forces may be expected between head and socket. In revision operations of these prostheses, this built-in joint has shown consistently to be still functioning; concentric spurs are noticed around the metal cylinder and inside the rotating neck, and are probably caused by

small cement particles that have entered the joint. The amount of metal wear has been measured from the prostheses and has been shown to be low; metallosis has never been found at revision, neither macroscopically nor microscopically. In 1 case the cup of a metal-head prosthesis, which was revised after 11 years, was investigated (Sulzer, Winterthur, Switzerland); 1.7-mm wear was measured by direct methods, whereas on the radiograph 1.6–mm wear had been measured.

Another cause of the relatively low wear in our patients may be that they were somewhat older than in most other studies.

The difference in polyethylene wear between the two types of femoral heads as measured in this study was striking. However, the rate of loosening of stems and sockets did not differ between the two groups. Larger studies with longer follow-up are necessary to decide whether the reduced wear rate in ceramic-on-polyethylene prostheses also leads to a decrease in loosening.

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