

Wear of the Christiansen hip prosthesis

The wear was examined in 39 Christiansen total hip prostheses, which were removed because of mechanical loosening after being used 5 (3-11) years. In the polyacetal acetabular cups, the head had made an eccentric defect, the mean volume of which was 680 (180-3310) mm³. The mean penetration of the head into the wall of the cup was 0.8 (0.1-3.2) mm. In two additional cups the head had penetrated right through the wall of the cup. In three prostheses the polyacetal sleeve of the trunnion was so worn that the head bore directly on the stem. There was a positive correlation between wear and the time the prostheses had been used before symptoms of loosening presented.

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The Christiansen total hip was widely used in Scandinavia, with satisfactory short-term results (Goldie & Raner 1979). However, in a comparative clinical long-term study, the Christiansen THA failed eight times as often as the Charnley THA (Sudmann et al. 1983); the Christiansen device is no longer being produced.

Very extensive wear is sometimes seen when Christiansen prostheses are removed. We have measured the wear of the polyacetal parts in failed Christiansen devices.

Patients and methods

From September 1980 to June 1983, 52 Christiansen total hip prostheses from 50 patients were removed because of mechanical loosening. The prostheses had been used for 5 (3-11) years. The patients had been without pain for 3 (0-7) years after the operation. Their mean age were 71 (44-80) years, and their mean weight 70 (45-90) kg.

Cups. Six acetabular cups were so damaged during removal that measurements were impossible. In two cups the wear extended directly through the wall of the cup (Figure 1). Five cups with centric wear were excluded from the examination. Thus, 39 cups remained for assessment of wear. Because the inner depth varied up to 0.8 mm in six unused cups, the total inner volumes of the cups were considered too inaccurate for the assessment of wear.

There was a well-defined area without wear in 39 cups in which the head could easily be positioned.

This was assumed to be the peroperative centric position of the head.

When the head of the prosthesis was placed in the centre of the cup, against the unworn area, a cavity appeared between the head and the cup (Figure 2). This cavity was assumed to be the sum of wear, creep and original incongruity. An exact silicone rubber cast was made by the flask technique. The specific weight of the silicone rubber was assessed by pycnometry, and the volume of the silicone rubber cast was calculated from its weight.

To determine the original incongruity of the prosthetic components, i.e. the play, three unused cups were measured as above. The mean of the measured play in these unused prostheses was subtracted from the volumes of the casts to determine the wear/creep.

The maximum thickness of the silicone rubber cast was measured by a micrometer. The thicknesses of the casts from *unused* prostheses were assumed to be the incongruity of the prosthetic parts. This play was subtracted from the values for the *used* prostheses to find the penetration of the head into the acetabular wall.

The roughness of the corresponding surfaces of the cup and the head in one unused and one used prosthesis was measured with a Perthometer.

Stems and sleeves. The stems and the respective polyacetal sleeves were inspected for wear. This included possible metal-to-metal contact between the head and the stem proper.

Radiographs. Radiographs of the patients were examined, and the varus or valgus angle of the stem (Sudmann et al. 1983) and the angle of inclination of the cup were measured.

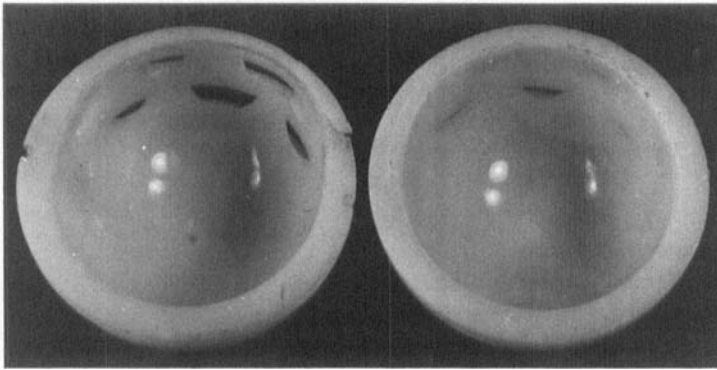


Figure 1. Christiansen cups with excentric wear and perforation due to wear.

Statistics. The precision of the measurements was assessed by repeating the complete measuring procedure twice in 6 prostheses. It was better than 10 per cent. Correlation between the findings was expressed by the Spearman Rank correlation. Results were considered significant when $P < 0.05$.

Results

No correlation was found between penetration or volume of wear and weight of patients, years of use, or age, neither for men nor for women, nor pooled. There was a positive correlation between the wear and the time the prostheses had been used before symptoms of loosening (pain) occurred ($P < 0.01$).

In *used* cups the mean volumes of the casts were 1.2 (0.64–3.8) cm^3 . The mean volumes of play in *unused* cups were 0.5 (0.46–0.53) cm^3 . The volume of the wear/creep, the difference

between the two, was thus 0.68 (0.18–3.3) cm^3 (Figure 4). The maximum thickness of the silicone rubber casts from *used* cups measured 1.3 (0.6–3.7) mm. In *unused* cups the thickness of the silicone rubber casts was 0.50 (0.48–0.53) mm. The difference between the two, the penetration of the head into the wall of the cup, was 0.8 (0.1–3.2) mm (Figure 4).

In the two cups with penetration right through the wall (Figure 1), the penetration was 2.7 mm and 4.0 mm, respectively. The worn surfaces were smoother than the unworn parts both in used and unused prostheses (Figure 3). In three sleeves out of 39 there was extensive excentric wear; the head bore against the stem proper making a groove into the stem below the trunnion.

No correlation was found between varus/valgus angle, inclination of cups, and wear.

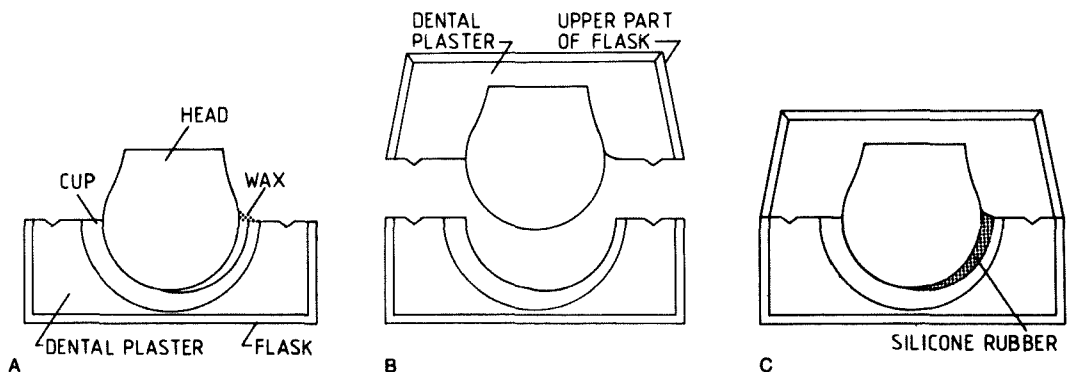


Figure 2. Flask technique used to make a silicone rubber cast of the cavity made by wear/creep.

A. The head was fixed with wax in the centre of the cup, against the unworn area. The two parts the prosthesis were then rigidly fastened with dental plaster to each part of the flask.

B. The flask was then opened and the wax removed.

C. Lastly, the cavity was filled with silicone rubber and the flask reclosed, making a cast of the outworn cavity.

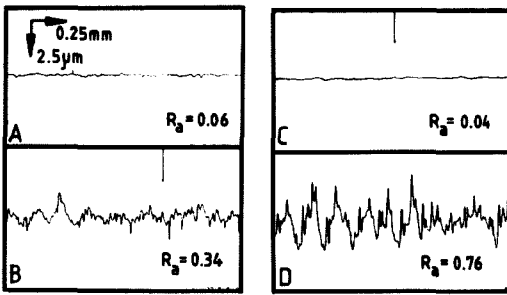


Figure 3. Roughness measurements on one used and one unused Christiansen prosthesis.
 A. Worn area of used cup.
 B. Unworn area of used cup.
 C. Head of prosthesis.
 D. Unused cup.

Discussion

The design of the Christiansen prosthesis differs from that of most other total hip prostheses (Sundal et al. 1974). First, to reduce frictional torque, Christiansen introduced a trunnion bearing between the head and the stem. Secondly, both the cup and the trunnion bearing were made of polyacetal (Delrin 150, Dupont) and not of ultra high molecular weight (UHMW) polyethylene. The metal parts of the Christiansen prosthesis were made of a chrome-molybdene-cobalt alloy. Either this difference in design or the materials used or both appear to have a bearing on the high frequency of loosening (Sudmann et al. 1983).

The creep in Delrin 150 was 1/10 that of UHMW polyethylene (Dumbleton 1979). This indicates that the considerable in vivo penetration measured in our Christiansen cups – about 3 times greater than that measured in UHMW polyethylene (Griffith et al. 1978) – was mostly due to wear and not to creep. Thus, in our study, up to 3.3 cm³ of polyacetal debris had spread to the surrounding tissues. The tissue reaction around loose Christiansen cups was more pronounced than that around loose polyethylene cups (Mathiesen et al. 1983). Our findings support the contention that this may be caused by the large amount of debris around the Delrin 150 prostheses. In addition, Delrin debris may be more harmful than that of UHMW polyethylene.

Very few investigations of in vivo wear of Delrin prostheses are known. Dumbleton

(1979) found slight wear in only one out of six Christiansen prostheses after up to 6 years of use. Efskind & Lereim (unpublished) found wear up to 1.5 cm³ in 22 cups. Mathiesen et al. (1986) found an average wear of 1.36 (0.80–0.38) cm³ after 6 years. Twelve cups were examined, measuring the total inner volume of used cups and subtracting the inner volume of unused cups. We considered this method too inaccurate, because of the variation (0.8 mm) in depth of the six unused cups we tested.

Tests of in vitro wear have given varying results. McKellop et al. (1981) found the wear of Delrin 150 to be 30 times that of UHMW polyethylene, whereas Shen & Dumbleton (1976) found the wear of Delrin 150 to be slightly less than that of UHMW polyethylene. The findings of neither the present nor a preceding study (Sudmann et al. 1983) agree with those of the latter authors.

After 13 million cycles in a hip simulator, corresponding to 13 years of continuous use, and with 7 per cent sodium chloride as a lubricant, only 0.6 mm penetration was found in the Christiansen prosthesis (Benoist Girard, unpublished). In contrast, we found a median penetration of 0.2 mm *per year* when the same prosthesis was used in vivo. These observations indicate that laboratory tests should be assessed with caution.

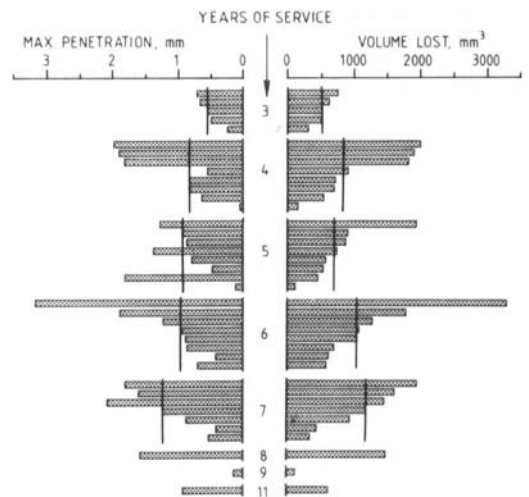


Figure 4. Penetration of the head into the wall of the cup and volume of wear/creep in used Christiansen cups. The measurements are grouped according to years of use and the vertical lines indicate the median in each group.

In the cups tested here, there was no correlation between the wear and the patients' weight, age, or the years of use. When grouped according to years of use, cups with a little and a lot of wear were seen in all groups (Figure 4). This suggests that other factors – including the degree of activity of the patient – affect the rate of wear. This is supported by the positive correlation between wear and the time the patients had without pain. Further, the in vivo lubrication – and accordingly the wear – of the hip prosthesis may differ from patient to patient. At least in vitro, the wear of Delrin varies markedly according to the lubricant used (Shen 1976). Mathiesen et al. (1986) found that the friction in used Christiansen cups was higher than in used polyethylene cups when tested with human plasma as lubricant. This higher friction may also contribute to the high loosening frequency of the Christiansen prosthesis.

The thickness of the two types of Christiansen cups are 5 and 7 mm, but the external grooves reduce the effective thickness to only 2.5 mm and 4.5 mm, respectively. Thus, if the head penetrates more than 2.5 mm it may bear directly on the cement. Cement debris might then work its way into the joint, accelerating the wear.

The trunnion bearing principle was introduced in the Christiansen prosthesis to reduce frictional torque. However, the metal-to-metal contact observed in three prostheses indicates that the trunnion bearings had not functioned as intended.

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