The Long-Term Wear of Retrieved McKee-Farrar Metal-on-Metal Total Hip Prostheses

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Abstract: Twenty-four cobalt-chrome alloy McKee-Farrar matching acetabular and femoral components were retrieved at revision total hip arthroplasty. The average time *in situ* was 16 years. Wear and loss of sphericity was very low. Polishing wear (type 1), fine abrasive (type 2), multidirectional dull abrasive (type 3), and unidirectional dull abrasive wear (type 4) of the articulating surfaces were identified. The mean percent area of femoral heads occupied by types 2, 3, and 4 wear was 18%, 5%, and 2%, respectively. There was no association between the type and distribution of wear and the time in situ. Impingement damage was evident on 9 implant pairs. The extent and types of wear described in this paper will be useful when analyzing the patterns of surface damage of newer designs of metal-on-metal articulations.
Key words: hip arthroplasty, prosthesis, metal-on-metal, wear, electron microscopy.
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The biological response to wear debris plays an important role in periprosthetic osteolysis and aseptic loosening of joint arthroplasty prostheses. There is particular concern about the amount of polyethylene wear [1-6], and efforts to limit the amount of wear have focused attention on alternative bearing materials. Recently, this has led to a renewed interest in metal-on-metal articulations for total joint arthroplasty [7,8].

The early clinical results of previous metal-on-metal hip designs were often inferior to the contemporary metal-on-polyethylene designs [9,10], leading to the adoption of high-molecular-weight polyethylene as the bearing material of choice. However, a significant number of metal-on-metal implants have provided reasonable function [11-15], and good results at more than 20 years have been reported [16,17]. However, there are concerns about the biological effects of cobalt-chrome alloy wear particles [18]. These include the potential long-term adverse effects of the release of wear debris into the tissues [8,19] and the increased risk of hemopoietic and other cancers

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in association with elevated metal ion levels in the blood of patients with metal-on-metal implants [20,21]. Because there have been few reports of the long-term wear behavior of metal-on-metal prostheses, and these have often not been reports of similar designs [22,23], we undertook to characterize the type and distribution of wear, to determine the mechanisms of wear, to examine the loss of sphericity, as an indication of the amount of wear, and to analyze the designs of retrieved McKee-Farrar metal-on-metal total hip implants with long-term survival.

Materials and Methods

Since 1981, 24 cobalt-chrome cast alloy McKee-Farrar matching femoral and acetabular components were retrieved at revision for aseptic loosening from twenty patients. Eleven implants were manufactured by Howmedica Limited (London, UK), 4 by Zimmer Orthopaedic Ltd (Bridgend, Glam, UK), and 3 by Downs Surgical (Sheffield, UK). Records relating to the manufacturer of 6 Vinertia implants were not available. The date of primary and revision surgery was established for each implant, indicating that the average survival was 16 years, with a range of 9 to 25 years. Most implants were retrieved at the time of revision by the senior author (DWH), although other surgeons retrieved some of the implants as part of our retrieval program. The median patient age at revision was 69 years, with a range of 43 to 87 years. The grade of loosening at the prosthesis-cement and cement-bone interfaces of the acetabular and femoral components [24] was recorded at operation in most cases.

Retrieved implants were washed with nonabrasive detergent, catalogued, and stored to prevent any damage or collection of debris on the bearing surface. An unused McKee-Farrar implant (Howmedica, Staines, UK) from the same period of manufacturing was examined and served as a control for the study.

Characteristic markings on the stem and cup of the implants allowed identification of the manufacturer. The cups were examined to ascertain whether there was a polar recess, in the form of a shallow spherical relief, at the pole of the head of the femoral component. Both components were examined for evidence of impingement and the position recorded. The contact area of the bearing surfaces was determined using the technique of transference of engineers blue to differentiate between polar and equatorial bearing implants. The maximum angle of contact from the apex of the sphere was determined.

The articulating surfaces were examined by several means. Initially, the surfaces of implants were examined using visual inspection and low-power light microscopy, with 10 times magnification, to identify wear patterns. Scanning electron microscopy (SEM) (Camscan CS44FE; Camscan Ltd, Cambridgeshire, UK) was performed on selected areas of implants, which showed characteristic wear patterns to establish the mechanism of wear and to correlate the SEM findings to those of light microscopy. After defining a number of distinct wear surface patterns, all implants were then reexamined under low-power light microscopy. A specially built jig was used to map the area and location of each wear type on the articulating surfaces. The average error of this technique was 4%. After mapping the wear types seen on the implants, SEM was repeated on randomly selected areas of different types of surface damage, and this confirmed that the type of wear could be correctly identified. Surface profilometry (Form Talysurf; Rank Taylor Hobson Ltd, Leicester, England) was used to quantify the surface roughness of each of the representative wear areas. The resolution of this technique was 0.01 μm. It was difficult to measure the extent of each type of wear on the acetabular components because the light was reflected from the concave surface of the component. Measurements of the extent of each wear type were therefore only considered reliable on the femoral component. However, the proportion of acetabular and femoral components having a particular wear type could be described.

Surface debris deposited on the bearing surface was mapped and examined by SEM with energy-dispersive spectroscopy (EDS). Energy-dispersive spectroscopy was used to analyze the composition of the surface and wear track debris. Scanning electron microscopy was used to examine the sites of impingement.

The bearing surface geometry was examined using a 3-dimensional coordinate-measuring machine (Brown and Sharpe Microval; Browne & Sharpe Manufacturing Company, North Kingston, RI). The resolution of this technique was 1 μm. It provided a measure of sphericity on the basis of the deviation of 28 standardized surface points from the least-square fit parameters of a perfect sphere. This gives the form error, that is, the deviation of the actual form from the ideal spherical surface. This analysis avoided the polar region of the cups at the site of the polar recess.

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