INTRODUCTION

Aseptic loosening is a mode of failure in total knee arthroplasty in the long-term. There is a broad consensus that the wear of the ultra high molecular weight polyethylene (UHMWPE) of tibial components is an important cause of osteolysis leading to component loosening. Over the past decade or so a considerable number of studies have analyzed retrieved UHMWPE. However, little interest has been shown in the surface finish of retrieved femoral components in total knee arthroplasty and its role in creation of polyethylene wear. No study has evaluated the surface changes on the articulating areas of retrieved femoral components.

AIM

The aim of our study was to investigate the in-vivo changes in the surface roughness of retrieved femoral components.

Our hypothesis was that the surface finish of the femoral components, articulating with the polyethylene inserts deteriorated in accordance with the duration of implantation.

MATERIALS AND METHODS

22 paired tibial and femoral components were retrieved at revision total knee replacement (TKR) from 20 patients between 1988 and 2000 from 18 males and 4 females who underwent primary procedures at our institution. All prostheses were Freeman - Samuelson femoral and tibial couples (Sulzer, Baar, Switzerland). All revision procedures were carried out by the senior author (GS). The mean age at revision was 68.4 years (range 49-80) and the mean period of implantation was 55.64 months (range 8-103). Revision was performed for aseptic loosening in 18 and infection in 4. The femoral component fixation was with poly-methyl-methacrylate (PMMA) cement in 3 cases, 3 components were hydroxyapatite (HA) coated and 16 femoral components were press-fits. In contrast, tibial component fixation involved PMMA cement in 18 cases, 3 components had HA-coating and only one was a press-fit. All tibial components had metal-back trays. The components were carefully cleaned with aqueous mild detergent before observation.

The Ewald method [8] of examining the orientation of the components and the axes of the femur and tibia were applied to derive the coronal plane. The Ewald method [8] of examining the orientation of the components and the axes of the femur and tibia were applied to derive the coronal plane. The Ewald method [8] of examining the orientation of the components and the axes of the femur and tibia were applied to derive the coronal plane.  

The femoral components were made of cobalt-chromium-molybdenum (CoCrMo) alloy. The condyles had a single continuous radius of 24mm in the sagittal plane and were flat in coronal plane. Both condyles were examined as separate areas articulating with the tibial components from 0° to 60° and 60° to 120° of knee flexion. Surface roughness (Ra) measurements from the sides of the patellar groove at the top of the femoral flange, which do not articulate either with the patella or tibia, were taken as control.

Firstly, the surfaces of femoral components were visually inspected for four modes of damage in the articulating areas. These are as follows:

- **Scratching** – score marks visible as separate lines
- **Burnishing** – areas of multiple fine scratching which had dulled the polished areas
- **Abrasion** – areas which had a tufted appearance
- **Pitting** – depressions in the surface

These modes of damage were derived from an established definition used to describe the damage on the polyethylene inserts. The original definition identified seven modes of damage on the UHMWPE insert but we excluded surface deformation, embedded PMMA debris, and delamination as they were not found in the femoral components.

The surface finish measurements were performed with a contact stylus profilometer (Talysurf™, Mitutoyo, Tokyo, Japan) with a 2-μm-radius stylus tip and a cut-off length of 0.8mm. The surface roughness was characterized by measuring Ra. Mathematically Ra is the arithmetic mean of the absolute values of the measured height deviations taken within the evaluation area and measured from the main line or surface. The advantage of using Ra is that it over one sampling length, it represents average roughness and eliminates the effect of a single spurious, atypical peak or valley. Lower Ra values generally indicate a smoother surface. The Ra (μm) value was calculated as a mean of eight measurements taken in the coronal plane in the areas of surface damage within the articulating arc.

Statistical analysis of the data was performed using SPSS v11.5 (Chicago, USA). The mean Ra-values of the damaged areas on the condyles in the articulating arc were compared to those on the control area. A two-sample t-test assuming unequal variances (Satterthwaite’s approximation) was used.

Visual inspection was made of the UHMWPE inserts looking for damaged areas, which could have caused corresponding attrition to the articulating areas of the femoral components. In particular, we looked for the presence of embedded PMMA debris.

RESULTS

The mean CAK was 7.2° ± 1°. Dull edged parallel scratching and burnishing were the main modes of damage identified on the surface in the articulating areas. Visual analysis of polyethylene inserts failed to identify embedded PMMA debris or any other damage, which matched the location of the altered surface finish of the femoral components.

The mean Ra values recorded are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Control</th>
<th>Medial Femoral condyle (0° - 60°)</th>
<th>Medial Femoral Condyle (61° - 120°)</th>
<th>Lateral Femoral Condyle (0° - 60°)</th>
<th>Lateral Femoral Condyle (61° - 120°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Control</td>
<td>Mean-0.0230 μm, SD-0.00821</td>
<td>0.0225 μm, SD-0.00797</td>
<td>0.0244 μm, SD-0.00532</td>
<td>0.0263 μm, SD-0.00694</td>
<td>0.0253 μm, SD-0.00758</td>
</tr>
<tr>
<td>P=0.832</td>
<td></td>
<td></td>
<td>0.0189</td>
<td>0.078</td>
<td>0.286</td>
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<td></td>
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<td>P=0.189</td>
<td>P=0.078</td>
<td>P=0.286</td>
</tr>
</tbody>
</table>

No statistically significant difference was seen in the mean roughness (Ra) of the articulating areas on the femoral condyles when compared to that of the control (P<0.05).

CONCLUSION

On basis of the results our hypothesis is rejected. This study showed that the surface finish of these implants did not deteriorate during the period of implantation. On this basis we believe that a well-aligned and well-fixed femoral component, without any accumulated wear debris beneath it, does not require mandatory exchange if the revision is carried out for isolated failure of the tibial prosthesis even if the femoral component has fine scratching or burnishing on its surface.

Most of the studies assessing femoral component and polyethylene wear are in-vitro using knee simulators. However, these studies may not reflect the changes that occur in-vivo. Experimental studies have shown that a threefold increase in the roughness of the femoral surface can cause at least a tenfold increase in the rate of polyethylene wear. The surface finish of the retrieved femoral components in our study cannot be considered abrasive.

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