INTRODUCTION:

Hip resurfacing with metal-on-metal articulations has been reintroduced since the early nineties. The femoral component is predominantly used in a cemented form. However, the advantage of press fit designs is to omit the weak link of this fixation system - the cement [1]. Primary stability is a prerequisite for the success of cementless hip replacements as osseointegration is only possible with low interface micromotion [2].

The quality of press fit fixation depends on the amount of interference. The interference achieved during implantation is difficult to estimate: impaction during implantation can cause abrasion and result in less interference than intended. Furthermore, manufacturing tolerances of implantation tools and prostheses can also cause deviation of the actual from the nominal interface geometry. Nominally high interference could such lead to small radial fixation forces after implantation.

The aim of this study was to quantify the influence of interference and interface geometry on the press fit fixation of a resurfacing prosthesis.

MATERIALS AND METHODS:

Since the amount of interference achieved can not be measured, a finite element model was used to simulate the nominal situations. The actual situation was determined by experimental measurements. The loosening torque was used to compare the two approaches.

Prototype heads ASR™, size 45, (DEPUY) were used in this study. Different radial interfences fits were achieved by varying the number of porous layers (Porocoat™) on the inside of the prosthesis. One layer and two layers corresponded to 170µm and 420µm of nominal interfence, respectively. The proximal femoral sections (n=3 for each interfence) were embedded in a metal holder using PMMA and additionally fixed with bolts. All bones were reamed with standard implantation tools by the same surgeon. The prostheses were implanted under displacement control (1mm/s) along the reaming axis using a material testing machine (MTS Bionix 858.2). The axial forces were recorded during impaction during implantation. Torsion testing with an axial preload of 1000N was conducted under torque control at 0.5Nm/s until 15° of rotation (Figure 1a).

A validated finite element (FE) model for the estimation of the actual interfence achieved during implantation was used to simulate the nominal situations. The actual interfence achieved during implantation was determined by experiment interference showed no influence (Figure 2). This study was supported by DePuy International.

RESULTS:

Complete seating of the prosthesis occurred with an implantation force of 6172±2126N and 798±2004N (p=0.18) for one and two layers, respectively. The experiment rotation-torque curve always followed the same pattern (Figure 2): a section characterized by complete sticking was followed by a transition phase (where relative motion started locally until loosening occured) and finally by a sliding phase at a rotation angle of about 2°. During the sticking phase the results of the FE calculations for one or two layers matched the experimental torque-rotation curves. After the onset of relative micromotion, the experimental result differs from the calculations. In the FE calculations, the loosening torque showed a linear dependency on the interfence, whereas in the experiment interfence showed no influence (Table 1). The experimental values lay between the calculations for zero and one layer.

DISCUSSION:

The magnitude of the recorded implantation forces cannot be compared directly to data published in literature, as the implantation was carried out quasi-statically. Nevertheless, complete manual seating of a prosthesis with high interfence (2 layers) is questionable as the force a surgeon can apply [4]. The high standard deviation of the implantation forces is probably due to the inacuracy of reaming, bone quality and/or slightly tilted implantation.

With increasing nominal interfence higher implantation and press fit forces are achieved. Although higher interfences required higher implantation forces, the loosening torque of one and two layers were similar. This could indicate that the nominal interfence of two layers was not reached and the actually achieved interfence was about similar. Since for each experiment the same reaming tools were used and the cone angle was shown in the calculations to have little influence on fixation, the main cause for the similar loosening torque is speculated to be abrasion of the bone interface. The large deviation between FE and experimental loosening torque might be an indication for the high loss of fixation caused by abrasion.

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