LOCAL MICROMOTIONS AROUND A CEMENTLESS HIP STEM MEASURED IN COMPRESSION AND TORSION

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Introduction

Excessive interfacial micromotions around the femoral component have been established to affect the initial stability of hip implants by promoting aseptic loosening of the prosthesis [Engh, 1992]. Physical activities such as stair climbing induce high torsional loads that are thought to endanger more the implant primary stability than compressive loads [Kassi, 2005].

The aim of this study was to extend a technique based on micro computed tomography (µCT) [Gortchacow, 2012] to measure simultaneously and at multiple sites the relative interfacial micromotions during compression and torsion.

Methods

A region of interest extending to 40 mm away from the osteotomy site was defined. Tantalum markers were stuck on the implant while stainless steel markers were press-fitted on the endosteal bone surface of a human cadaveric femur. After implantation, compressive (2000 N) and torsional (13 Nm) loads were successively applied using custom loading devices. µCT scans were performed before, during and after loading for each loading case.

Image processing techniques were used to detect bone and stem markers from µCT images. The final unloaded case was used as a reference and the first two scans were rigidly transformed so as to have the stem beads overlapping. Gap was defined as the closest distance between the stem surface and bone markers in the reference frame. Micromotions in the 3 directions were obtained as the difference between the loaded case and the reference positions of the bone beads, while subsidence was obtained from the position of bone markers in the first unloaded scan using the reference frame.

Results

Micromotions, subsidence and gap were simultaneously measured for 384 steel beads spread around the region of interest, during compression and torsion. Maximum micromotions were 95 µm and 170 µm in compression and torsion respectively (Fig. 1). For both load cases, gap was small against the bearing faces of the implant. Mean subsidence was 2190 µm in compression and 630 µm in torsion.

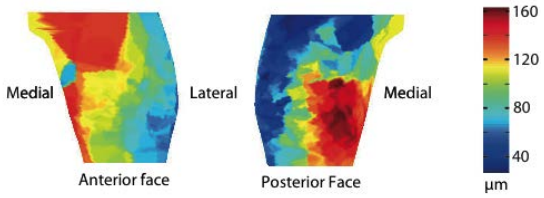

Figure 1: Micromotion distribution during torsion

Discussion

During compression maximal micromotions measured were below the critical value of 150 µm reported to induce aseptic loosening of the prosthesis [Jasty, 1997], while during torsion, local micromotions exceeded this threshold. This result underlines the importance of a simultaneous and multisite measure of micromotions in different load cases.

To conclude, we developed a technique to get a quasi-continuous distribution of interfacial micromotions, gap and subsidence around the femoral stem during compression and torsion. This method can be used to validate results of finite elements studies.

References

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