INITIAL STABILITY OF CEMENTLESS FEMORAL STEMS: AN IN VITRO TECHNIQUE TO MEASURE MICROMOTION AND GAP AROUND THE LOADED STEM

Valérie Malfroy Camine1, Hannes A. Rüdiger2,3, Dominique P. Pioletti1, Alexandre Terrier1

1Laboratory of Biomechanical Orthopedics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland
2University Hospital of Lausanne (CHUV), Lausanne, Switzerland
3Schulthess Klinik, Zürich, Switzerland

Introduction

- Excessive interfacial micromotion after implantation has been directly related to a poor initial stability of the stem and aseptic loosening of the implant [1]
- Currently available techniques used to measure experimentally micromotion directly at the bone-implant interface rely on LVDT sensors [2]. They allow a good precision but they also include the bone deformation between the device fixation point and the measurement site. Moreover, the reported maximum number of simultaneous measurement points on bone with sensors was six [3].

Objective

Extend a μ-CT-based technique to measure interfacial micromotion and gap around the whole length of a cementless femoral stem.

Methods

- Stainless steel bone markers were press-fitted on the endosteal surface of a cadaveric femur while tantalum markers were stuck on the surface of an anatomical stem (SPS, Symbios, Switzerland) [4], [5] (Fig. 1).
- The femur, implanted by a senior orthopedic surgeon, was placed inside a loading device (Fig. 2), designed to apply a pure compression of 1800 N [6] inside a μ-CT scanner.
- Micromotion corresponded to the 3D displacement of bone markers between the loaded and unloaded scans (Fig. 3). Gap was defined as the closest distance between the reconstructed stem surface and the bone surface.

Results

- Over 600 points were measured around the whole stem. The tip of the implant was the region with the highest micromotion amplitude. The highest gap was measured on the upper lateral part of the posterior face of the stem and on the posterior part of the stem tip.

Discussion

- The obtained range of micromotion was consistent with measurements obtained with LVDT sensors [3] where comparisons were possible.
- The metaphyseal part of the stem presented with the lowest micromotion, which is consistent with a femoral component designed to achieve a pure metaphyseal fixation.
- This study will be further extended with more samples and loading types such as pure torsion.

Conclusion

- This technique offers new insights into the analysis of cementless implants initial stability by providing the location of micromotion along the stem directly after implantation. This information could be used to validate numerical models or to improve implant design and surgical techniques.

References