VALIDATION OF OSTEOPOROTIC SYNTHETIC FEMORA – A MORE REALISTIC ALTERNATIVE TO EPOXY BONES?

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Introduction

The treatment of osteoporotic femoral fractures remains a challenging problem. Poor bone quality often leads to secondary loss of reduction and implant failure. Therefore, the development of new implants and their biomechanical testing is crucial (1). Besides human specimens, epoxy-based synthetic bones are considered the gold standard for mechanical testing of osteosyntheses, however, standard composite femurs provide unrealistically stable constructs and fail to realistically simulate bone-implant-interaction (2).

As an epoxy alternative, we have developed polyurethane-based synthetic bone materials for open-cell cancellous bone (3) and cortical bone (4) in previous studies and validated them in compression and a screw-cut-out setting against human specimens. As a next step, the goal of this study was to merge the approved cancellous and cortical materials into osteoporotic femoral models and mechanically validate them against human specimens.

Methods

Silicone molds were casted from a 3D printed model of a femur. Synthetic femora (PuReBone) were then cast in these molds in a 2-step process. First, molds were filled with polyurethane mixtures for cancellous bone (3) and were then encased with cortical mixtures (4) (Fig. 1).

Figure 1: Four point bending of a synthetic femur (left); the inner cancellous structure (right)

PuReBone (n=8) were tested in four-point bending (BEND, Fig. 1) in two planes (AP: anterior-posterior, ML: medial-lateral), and axial loading (AXIAL) as described in the studies by Heiner et al. and Gluek et al. to achieve comparability to their results with human healthy (5, n=6) and osteoporotic specimens (6, n=5). Corresponding stiffnesses were used as reference parameters.

Analysis of variance followed by Tukey post-hoc test was used for statistical analysis to examine differences among groups (SPSS Statistics v.19, IBM, Amonk, USA).

Results

Bending stiffnesses of PuReBone were slightly, but not significantly higher than human osteoporotic bone (AP: $p=0.91$, ML: $p=0.41$). The same accounts for the axial stiffness, which do not show statistical differences between PureBone and human osteoporotic bone ($p=0.85$). Bending and axial stiffnesses of PureBone are statistically different to human healthy bone ($p<0.005$, Fig. 2).

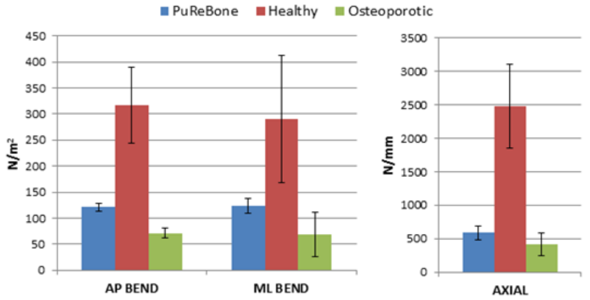

Figure 2: Results of bending (BEND) and axial compression (AXIAL) test of synthetic (PuReBone), healthy and osteoporotic human bones

Discussion

Osteoporotic polyurethane-based femurs showed mechanically similar behavior to human osteoporotic bones, but were significantly less stiff than healthy ones. However, by adapting the filler materials of the cancellous and cortical polurethane layers and using a 3D print negative created from a CT of a patient, the population variability of humans will be better addressed in biomechanical testing in the future.

References

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