DOES BONE ANISOTROPY INFLUENCE THE MECHANICAL OUTCOME OF AUGMENTATION?

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Introduction

Bone augmentation is a frequently used method for stabilizing fractured vertebrae or prophylactic strengthening of osteoporotic bone. It is performed through the injection of a reinforcing biomaterial into the weakened bone site. In this study, we investigated whether the effectiveness of bone augmentation depends on the morphology of the surrounding trabecular structure, which might affect the cement flow through it and, in turn, the mechanical properties of augmented bone. Specifically, the goal of this study was to investigate the effect of bone anisotropy on the mechanical outcome of bone augmentation. As a reinforcing material, a prototype osteoconductive injectable cement was used, containing 10% calcium aluminate and 90% Portland cement (main constituent calcium silicate).

Methods

Cylindrical bone cores (*D*=8 mm, *L*=20 mm) were harvested from the bovine tibial plateau, parallel to and perpendicular to the principal bone loading direction. Bone marrow removal was performed by placing the bone specimens in an ultrasonic bath with trichloroethylene for 4 hours; any remaining fat was removed using a jet lavage system. For each group, 5 specimens were kept as control (*A ctrl* = parallel, *B ctrl* = perpendicular) while 5 specimens were augmented (*A aug*, *B aug*). To facilitate cement infiltration through the intertrabecular spaces, the specimens were placed on a vibrating plate during augmentation. They were further glued to two endcaps, each with a 2 mm depth, so that an aspect ratio (*L/D*) of 2 was guaranteed. The mechanical properties were assessed through compression loading tests [Keaveny, 1997].

Results

Compressive strength was higher in both augmented groups *A aug* and *B aug* with respect to the control ones (by a factor *k=3* and *2.4*, respectively). Also, yield strength was higher in the augmented specimens (by *k=3* and 2.5 for group *A aug* and *B aug*, respectively). Yield strain was significantly higher only in the augmented specimens cut in the parallel direction. No statistically significant differences in the mechanical properties were found between the augmented groups *A aug* and *B aug (Figure 1)*.

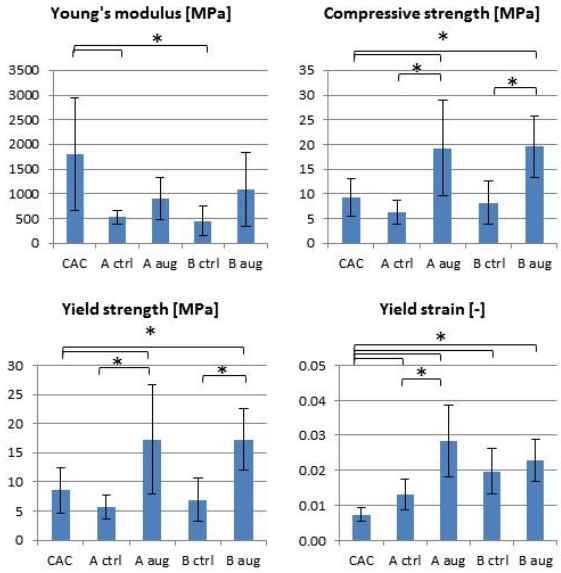

*Figure 1: Mechanical properties (mean ± SD, over 5 bone specimens) of the control (A ctrl, B ctrl) and the augmented specimens (A aug, B aug). The mechanical properties of the cement CAC (mean ± SD, n=6 according to ISO 5883) are included. *p<0.05, from ANOVA.*

Discussion

We found that augmentation with the calcium aluminate cement increased the mechanical properties of trabecular bone. Furthermore, the data indicated that trabecular bone anisotropy did not influence the mechanical outcome of bone augmentation. Further work is planned to precisely quantify the specimen-specific bone density, cement filling degree and independent factors that influence the augmentation outcome.

References

Keaveny *et al*, J Orthop Res,15:101-110, 1997.