DETERMINATION OF TISSUE-LEVEL STRAINS IN TRABECULAR STRUCTURES WITH A 3-D DIGITAL IMAGE CORRELATION TECHNIQUE

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INTRODUCTION

Knowledge of strains in trabecular bone tissue is of importance for a better understanding of trabecular bone failure. Recently, a digital image correlation technique was introduced for strain measurement in trabecular bone by comparing CT-images of deformed and undeformed bones (Bay et al., 1999). However, this technique correlated the trabecular texture and was therefore limited to continuum-level strains.

In the present study a novel 3-D digital image correlation technique is presented for strain measurement in individual trabeculae in situ from high-resolution CT-images. The goal of this study was to determine the accuracy of this novel technique.

MATERIALS AND METHODS

The 3-D digital image correlation technique is based on an earlier 2-D one (Sutton et al., 1986). To enable strain measurements in porous structures a number of additional steps were added. First, the trabecular structure is meshed with tetrahedral elements. With the image correlation technique displacements are calculated in each of the element nodes. Secondly, a deformation tensor is estimated in the element centers from the surrounding displacement data (Peters, 1987). Not only is the deformation tensor used to calculate the Green-Lagrange strain tensor, the tetrahedral mesh is also deformed according to this tensor.

RESULTS

Typical values for the standard deviation in the displacement and strain tensor components were 2µm and 1%, respectively. Rigid translations/rotations and different image resolutions do not significantly affect these values.

DISCUSSION

We conclude that the accuracy of the strain determination is sufficient for bone failure studies, where strains are rather high. It should be noted that the accuracy of the approach might be further improved when using real bone specimens rather than aluminum foams since CT-images of aluminum show little variation in gray-values within the solid structure, which complicates the correlation procedure.

REFERENCES

Sutton et al., Image Vision Comp 4:143-150, 1986