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COMPARISON OF DIGITAL VOLUME CORRELATION APPROACHES FOR SINGLE TRABECULAR BONE

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Summary: Digital volume correlation (DVC) has in earlier studies been applied to X-ray computed tomography (micro-CT) images of trabecular bone to estimate the 3D deformation fields. However, to our knowledge, no DVC estimations have been performed on single trabeculae to capture their deformation when they are subject to compressvie load. Compared with trabecular bone, single trabeculae have less inherent patterns, which might affect the ability of the codes to track material motion, and DVC codes based on different strategies might show dependency on the patterns. The aim of this study is to compare the reliability of two DVC approaches when applied to single trabeculae.

Single slender trabeculae, isolated from human femoral cores, were subject to uniaxial compression in a loading stage within a synchrotron radiation micro-CT device (TOMCAT, Paul Scherrer Institute). The acquired high-resolution images were reconstructed into 3D volumes and virtually shifted to generate pairs of volumes with known rigid body displacements (2.5-10 voxels) and vanishing strains. Uncertainties due to different sub-volume sizes (28 to 60 voxels) and virtual displacements were tested with two DVC approaches: a classical local correlation algorithm (CLDVC) and an iterative DVC algorithm (FIDVC). Spatial resolutions of the two DVC approaches were evaluated with a pair of artificial volumes.

The results showed that for the CLDVC both spatial resolution and uncertainties of the displacement and strain fields were very sensitive to the sub-volume size. Lager sub-volume size produced more stable results in the zero strain tests, but worse spatial resolution when compared to FIDVC. Dependency of uncertainties on virtual displacements was also demonstrated as both DVC approaches gave more uncertainties when the virtual displacement was relatively large (7-10 voxels). In conclusion, this study provides an evaluation of the DVC approaches applied to human bone tissue on the microscale. Preliminary results on their spatial resolution and reliability proved that caution should be taken when applying DVC-codes and interpreting their results.