VALIDATION OF FINITE ELEMENT MODELS OF THE MOUSE TIBIA FOR PRECLINICAL APPLICATIONS

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In vivo micro-Computed Tomography (microCT)-based micro Finite Element (microFE) models of the mouse tibia are useful to predict non-invasively the effect of bone diseases and interventions on the structural and local mechanical properties of bone and on bone remodelling [1]. However, it is necessary to validate their local predictions against experimental measurements. The Digital Volume Correlation (DVC) approach can provide measurements of the three dimensional internal displacements of bone specimens under loading and has been used to validate models of trabecular bone [2].
The aim of this work was to compare the predictions of local displacements by microFE models of the mouse tibia under compression with the corresponding experimental measurements performed with the DVC method.
Six mouse tibiae were stepwise compressed within a microCT system. MicroCT images were acquired in four loading configurations: preload (0.5N), loaded at 6.5N (LS1), 13N (LS2) and 19.5N (LS3). Each image of the loaded sample was registered to the preloaded one using a DVC algorithm (ShIRT-FE) with a nodal spacing of 50 voxels. The images of the preloaded tibiae were converted into a Cartesian mesh with isotropic linear elastic material properties ($E=14.8GPa$, $\upsilon=0.3$). Boundary conditions at the proximal and distal ends were interpolated from the displacements measured by the DVC. Experimental and numerical displacements were compared at corresponding locations [2].
Fair to good correlations were found between experimental measurements and numerical predictions of local displacements (R^2 = 0.69-0.92 in the longitudinal direction). MicroFE models tended to overestimate local displacements in the loading direction (slope equal to 0.50-0.97). Errors increased with load level (RMSE up to 7µm in LS1, up to 23µm in LS3). Local errors varied according to the spatial location over the tibia.
A general good agreement between experimental and numerical displacements was found. Further investigations are currently running in order to evaluate the effect of different FE modelling approaches (e.g. the implementation of heterogeneous material properties and smooth tetrahedral mesh) on local predictions.

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