LIGAMENT PRE-TENSION DETERMINES OUTCOME IN SACROILIAC JOINT IN-SILICO MODELLING

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Introduction

Substantial preload in the sacrotuberous ligament (118N±74N; 65N in females; 172N in males [1]) or generally ligament pre-tension changes joint loading. The objective was to investigate the effect of ligament pre-tension on joint surface stress and relative motion using finite element (FE) models of the sacroiliac joints.

Methods

FE models were computed from CT scans of eight patients from a larger cohort (N=818, [2]) with known anatomical variants as well as a typical male (TMJ) and a typical female joint (TFJ). Models included information on isotropic, inhomogeneous bone elasticity (material mapping), (Fig. 1), and stiffness of ligaments/muscles (Fig. 3) from literature [3,4]. Different loading conditions and directions (Fig. 2), (singular, symmetric, and asymmetric) from in-vivo data were implemented (bipedal walking), the sacrum was pinned, and contacts were modelled as pressure-overclosure. A mesh convergence study was performed and yielded relative changes ≤9.0% in translations, ≤6.3% in rotations, ≤12.1% in von Mises stresses, for meshes with element (C3D4) numbers of 75,837, 215,058, and 609,142. Sensitivity analysis of modelling parameters was performed for TFJ with the most sensitive loading scenario (symmetric xyz).

Results

In all load scenarios, stresses were higher in TFJ than TMJ. A loading in anteroposterior direction (y) caused highest stresses and relative mobility. Ligament pre-tension was most sensitive with mean sensitivity factor (change in output / change in input) of 71.04 for translation, 43.09 for rotation, and 2.11 for mean stress.

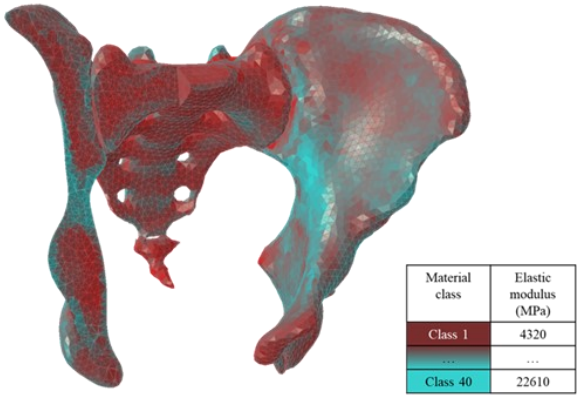

Figure 1. Example of FE-model (TFJ) with density distribution. Please note that the model on the left shows a cut through the right ileum!

Mean sensitivity factor of load intensity was 1.09 for translation, 0.91 for rotation, and 0.54 for mean stress. In general, relative motion was more sensitive to the parameter variations than resultant stress.

Discussion

Modelling results were highly sensitive to a variation of ligament pre-tension. That indicates that the individual preloading of ligaments is crucial. However, this must be validated, and the ligament pre-tensions need to be verified in situ.

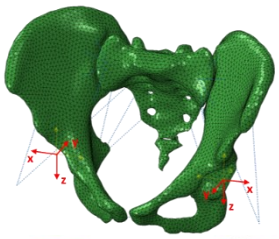

Figure 2: Example of FE-model (TFJ) with load application directions: medio-lateral (x), antero-posterior (y), and cranial-caudal (z).

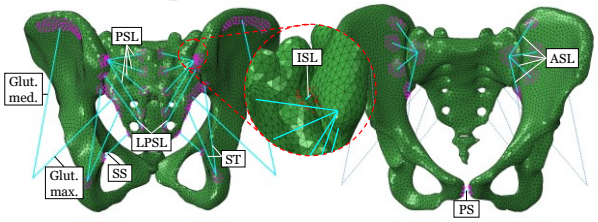

Figure 3. Example of FE-model (TFJ) with ligaments and muscles (frontal plane). left=posterior view; right=anterior view. Glut. Med.=gluteus medius muscle; Glut. Max.=gluteus maximus muscle; SS=sacrospinous ligament; PSL=posterior sacroiliac ligament; LPSL=long posterior sacroiliac ligament; ST=sacrotuberous ligament; ISL=interosseous sacroiliac ligament; ASL=anterior sacroiliac ligament; PS=pubic symphysis.

References

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