Case study: Influence of implant size on bone tissue strains

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The influence of implant size on bone tissue strains is investigated in this study. A novel intervertebral disc replacement implant (*FBC Device ApS, Aarhus, Denmark*) is analyzed in two different configurations. The forces acting on L4 and the implant during lifting a box are computed using the AnyBody Modeling System™ (*AnyBody Technology A/S, Aalborg, Denmark*). All forces are subsequently transferred to a Finite Element Model (*Ansys Inc, Canonsburg, USA*) and the bone tissue strains are computed. The general workflow for combining musculoskeletal analysis in the AMS with Finite Element Analysis is shown in Fig. 1.

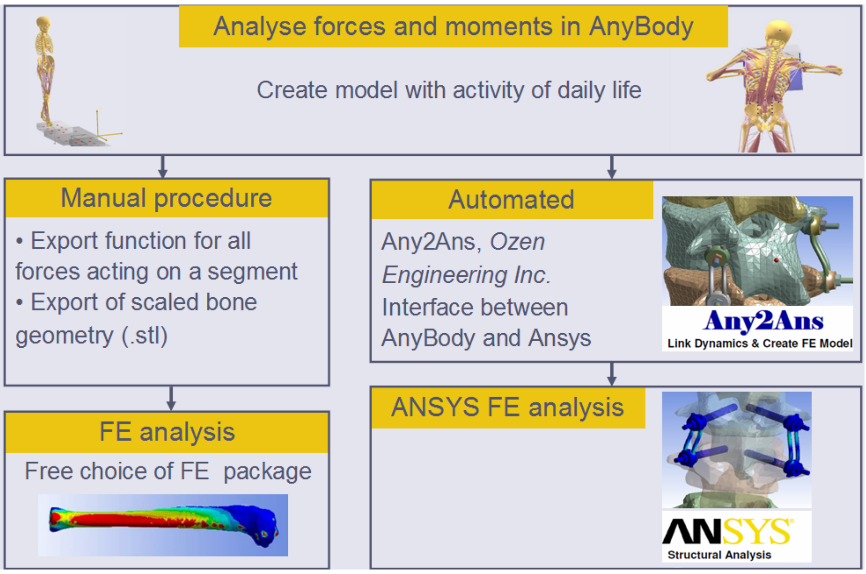

Fig. 1: Workflow AnyBody to FEA.

The standard standing model from the Anybody Managed Model Repository (AMMR) (www.anyscript.org) is used in the musculoskeletal simulation. The spine kinematics and kinetics is altered in order to take into account the mechanical consequences of the implant. In detail, the axial rotation in the L3-L4 joint is suppressed and the transfer of moments along this axis is enabled. The analyzed activity is lifting a weight of 5kg in each hand with a spine flexion ranging from 80 degree (Pelvis-Thorax angle) and 10 degree axial rotation. The muscle forces and joint reaction forces are computed for various time-steps.

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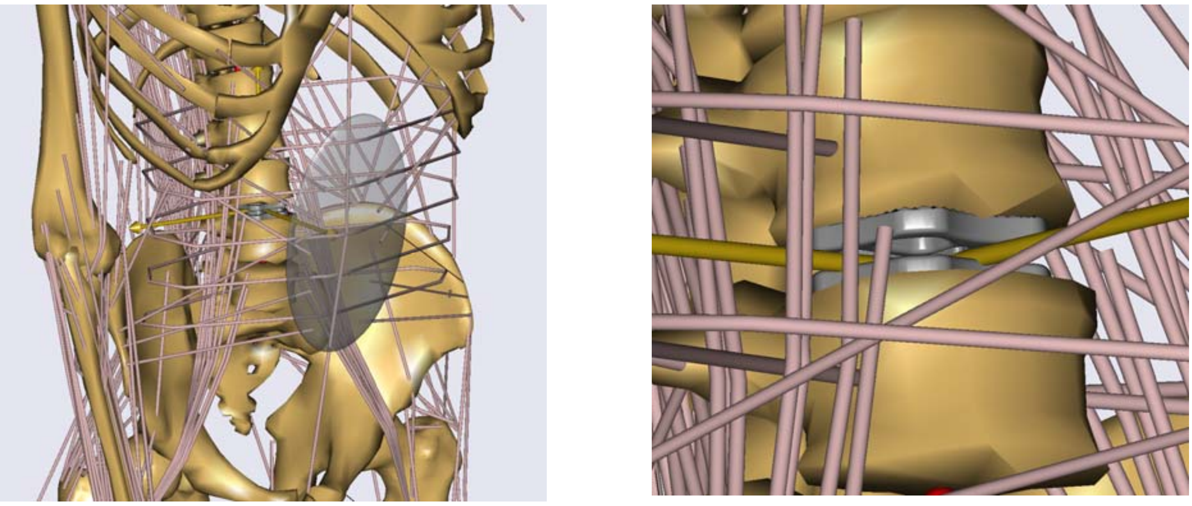

Fig. 2: Musculoskeletal model with disc implant.

A Finite Element model is created using the geometry of L4 from the AMMR (Fig. 3). Different material properties are assigned to the cancellous bone (anisotropic) in the vertebral body, the pedicles and the cortical shell. All muscle forces resulting from the AnyBody analysis are directly applied to the model and the joint reaction forces are applied in a distributed manner on the endplate. For the implant-bone interface the geometry of the implant is mapped on the endplates surface and the loading is applied to these.

Two different designs of the implant have been investigated, in one case the original size and a second model with a 20% downscaled geometry. The following results are shown for the one time-step (60 degree flexion, 10 degree axial rotation), Fig. 4-6.

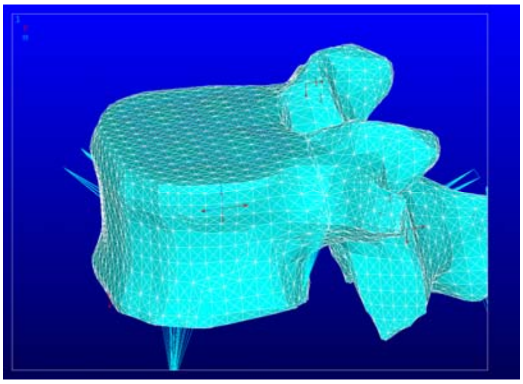

Fig. 3: Finite Element model of the L4 vertebra.

Fig. 4: Analyzed posture of the model

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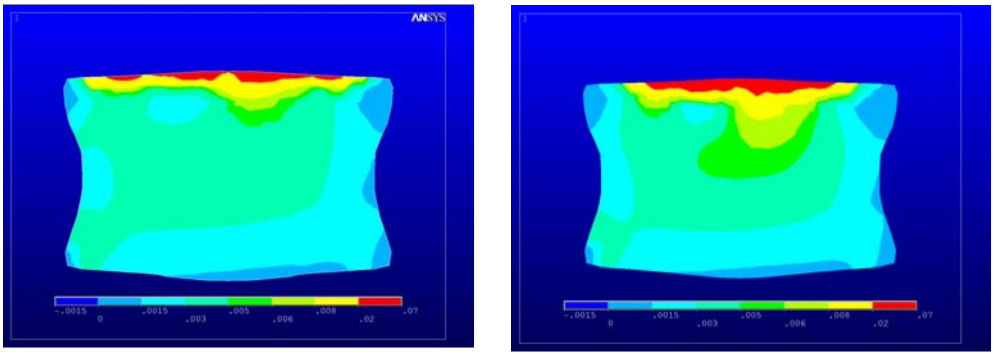
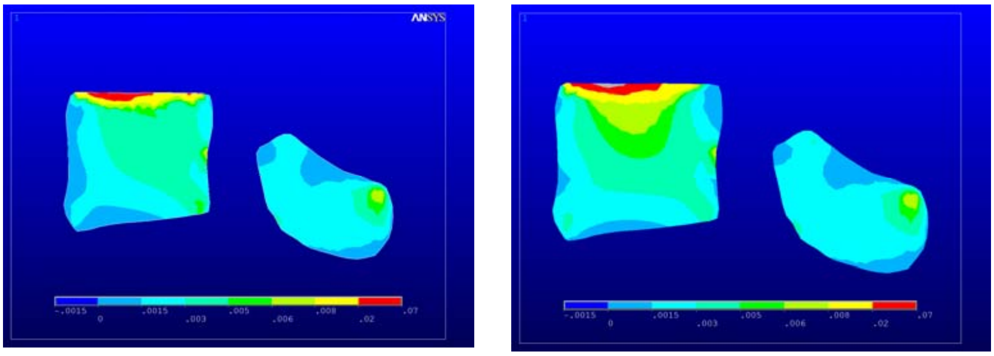


a)

Fig. 5: Von-Mises strain, coronal plane through centre of vertebral body, a) original size; b) 80% size of implant



a) **b)**

Fig. 6: Von-Mises strains, sagittal plane through centre of vertebral body, a) original size, b) 80% size of implant.

The implant size shows a large influence on the acting bone tissue strains. With these models on hand, a systematic assessment of the influence of different designs and sizes of intervertebral disc implant on tissue strains can be accomplished. Especially the incorporation of all relevant muscle forces resulting from activities of daily living leads to improved understanding of the biomechanics of the implant-bone compound.

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