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STRESS-UNILATERAL MODELS OF A HUMAN SPINE

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ABSTRACT

Various two-dimensional models of lumbar spine segments, that is, lumbar functional spinal units (FSU) have been developed and studied here. FSU is the smallest part of the spine that has all the important features that the whole spine has [1]. It consists of two adjacent vertebrae with the intervertebral disc between them and the surrounding ligaments. Although the literature review shows that a lot of three-dimensional models have been used in the last decade, the reliable application of highly nonlinear models, like the nonsmooth models, requires first a thorough investigation on two-dimensional, simplified cases. Since the spine segment has a symmetrical structure, the 2D model in the sagittal symmetry plane seemed to be useful. The numerical analysis aimed to increase the efficiency of the traction treatments, by simulating hydrotraction therapies, in comparison with physiologic compressive loadings [2], [3].

At this stage of the research the FSU was analyzed only in the elastic range where the no-tension and the no-compression (unilateral contact) effects have been taken into account. Figure 1 shows the finite element mesh of the model including the internal boundaries between the different subdomains. Both unilateral effects are treated with the theory of nonsmooth mechanics and calculated by either complementarity or mathematical programming techniques [4].

The first results follow, at least qualitatively, the experimental measurements. For example, Figure 2 shows the calculated stresses for compression of intervertebral dics. The solid line represents the σ_y vertical, while the dotted line the σ_x horizontal stresses along the middle horizontal sagittal line of lumbar disc. Due to the hydrostatic compression along the middle positioned nucleus pulposus in a healthy disc, the vertical and horizontal stresses are equal to each other, seen in Fig. 2a. For a damaged, degenerated disc, the hydrostatic state starts to disappear, and the stresses increase in the

edge positioned anulus fibrosus, seen in Fig.2b. The results show satisfactory agreement with the experimental ones [5].

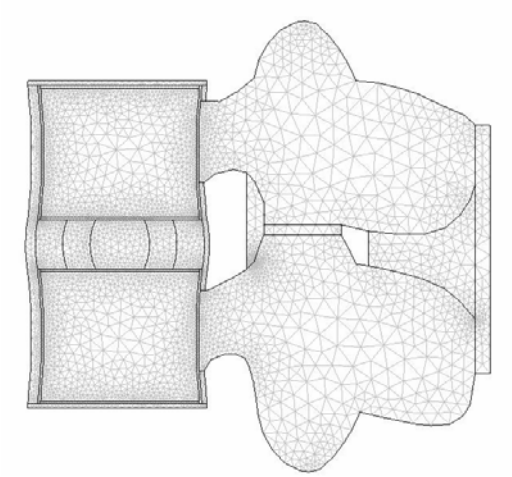

Figure 1: A two-dimensional finite element model of the lumbar functional spinal unit.

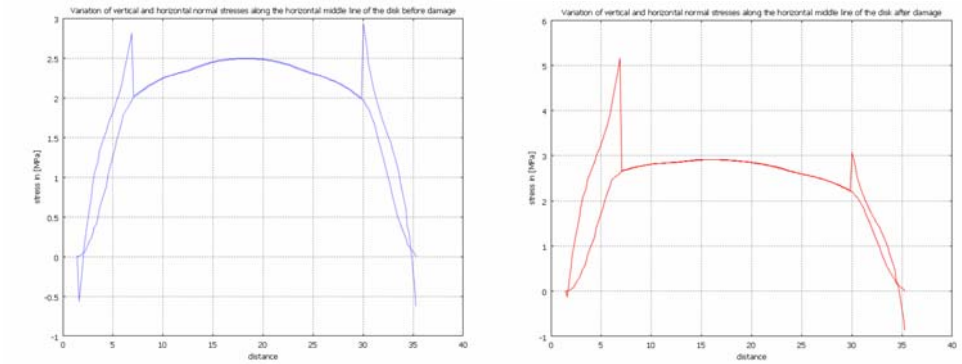

Figure 2: The calculated stresses along a cross-section of the model for a healthy and a damaged disc.

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