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Comparison of Eight Published Lumbar Spine Finite Element Models

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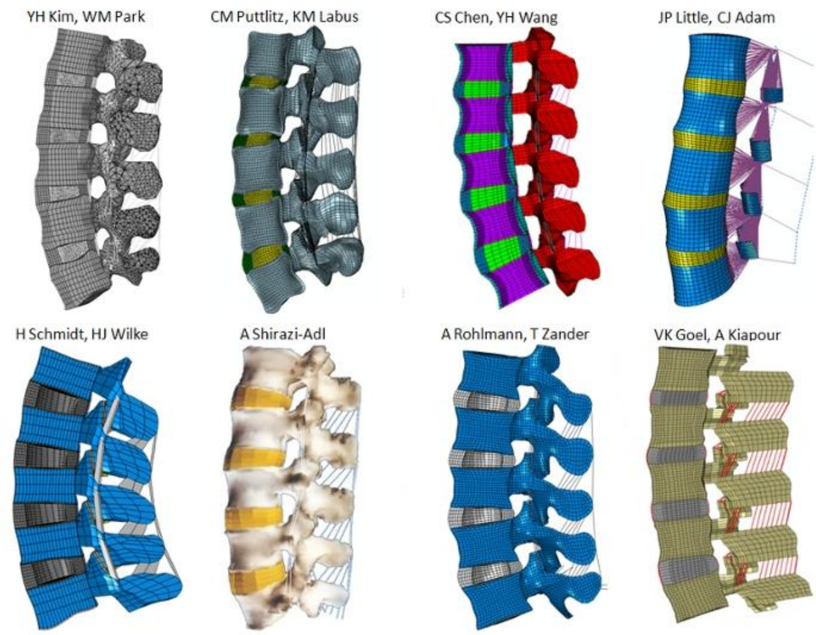
Due to its ability to represent intricate systems with material nonlinearities as well as irregular loading, boundary, geometrical and material domains, the finite element (FE) method has been recognized as an important computational tool in spinal biomechanics. Current FE models generally account for a single distinct spinal geometry with one set of material properties despite inherently large inter-subject variability. The uncertainty and high variability in tissue material properties, geometry, loading and boundary conditions has cast doubt on the reliability of their predictions and comparability with reported in vitro and in vivo values.

A multicenter study was undertaken to compare the results of eight well-established models of the lumbar spine that have been developed, validated and applied for many years (Fig.1). Models were subjected to pure and combined loading modes and their predictions were compared to in vitro and in vivo measurements for intervertebral rotations, disc pressures and facet joint forces.

Under pure moment loading, the predicted L1-5 rotations of almost all models fell within the reported in vitro ranges; their median values differed on average by only 2° for flexion-extension, 1° for lateral bending and 5° for axial rotation. Predicted median facet joint forces and disc pressures were also in good agreement with previously published median in vitro values. However, the ranges of predictions were larger and exceeded the in vitro ranges, especially for facet joint forces. For all combined loading modes, except for flexion, predicted median segmental intervertebral rotations and disc pressures were in good agreement with in vivo values. The simulations yielded median facet joint forces of 0 N in flexion, 38 N in extension, 14 N in lateral bending and 60 N in axial rotation that could not be validated due to the paucity of in vivo facet joint forces. In light of high inter-subject variability, one must be cautious when generalizing predictions obtained from one deterministic model.



This study demonstrates however that the predictive power increases when FE models are combined together. The median of individual numerical results can hence be used as an improved tool in order to estimate the response of the lumbar spine.