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Development of a finite element spine model to simulate different scoliosis treatment scenarios

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ABSTRACT
Surgical treatment of early-onset scoliosis is challenging since it should simultaneously provide spine stability and facilitate longitudinal growth. Novel UHMWPE wires in a growth-guidance construct may possibly provide a solution. Due to wire passage every instrumented level adds risk of ectopic bone formation and thus spontaneous spinal fusion. A construct with an optimal wire density, which minimizes surgical exposure but still provides stable spinal deformity correction, has to be determined. Range of motion (ROM) has previously been compared in segmental versus multiple nonsegmental wire constructs in an in vitro biomechanical study with porcine spine segments. A preoperative planning tool, based on spinal geometry, could aid in designing optimal patient-specific constructs. In this study, we aim to validate a previously designed parametric finite element (FE) model and implement spinal instrumentation. First, healthy L4-L5 segment behavior was validated by stepwise addition of spinal structures and comparing results with literature values. Global spine behavior was subsequently validated by relating ROM of multiple level spine segments to experimental results from literature. Finally, spinal instrumentation was implemented in the model and the in vitro porcine biomechanical tests were replicated. Single segment behavior was validated successfully, but only reasonable agreement was found at multiple level scale. In comparison to in vitro results, the FE model showed a similar relative decrease in ROM at both local and global level when instrumentation was implemented. The influence of the number of wires on the global ROM was less prominent compared to the experimental study. In conclusion, the first steps in the development of a preoperative planning tool have been taken. Future work includes improving global spine behavior, implant-spine interactions, and implementation of patient-specific geometry, growth and additional instrumentation.