Oral Presentation
Thread 1: Computational Methods in Biomechanics and Mechanobiology
T1.11 Computational Biomechanics of the Spine

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Finite element simulation for the prediction of mechanical failure in the lumbar spine surgery

T. Mosnier[1], V. Lafage[1], L. Rillardon[2], J. Dubousset[1], J. Pratt[3], W. Skalli[1]

[1] *Laboratoire de BioMécanique, Paris, France*
[2] *Hopital Beaujon, Clichy, France*
[3] *Institut de Biomecànica de Valencia, Spain*

Introduction: Mechanical complications of lumbar spine surgery are sometimes related to the difficulty of adequate surgery planning. The aim of this study is to provide a patient specific finite element model of the lumbar spine with simulation of the surgical gesture and to use it as a predictive tool of mechanical failure for lumbar spine surgery.
Materials and Method: A 3D finite element model of the lumbar spine with geometrical personalization was considered. Posterior implants and main characteristics of degenerative pathologies were modeled. After validation with regard to in vitro data (24 specimens and 4 instrumentations), the model was used to simulate real cases. Applied loads depended on patient characteristics (weight, imbalance), and simulation results were post-processed to assess stresses in the discs and the implants. For purpose of validation, pre and post-operative data were collected for 66 patients instrumented with rigid screw-rod systems, either at the L4-Sacrum (24 patients) or at L5-Sacrum levels (42). Two subsets were considered: ``non complicated cases'' (53), and ``complicated cases'' with an implant mechanical failure (13, i.e. 11 screw breakage and 2 screw loosening). Blind comparison was performed between simulations results and clinical outcome.
Results and Discussion: Among the 66 patients, results highlighted the specific behaviors of 9 patients (3 at L4/S and 6 at L5-S levels) for which mechanical loads on implants were markedly higher. The analysis of the clinical outcome indicated that all of them were ``complicated case''. None of the ``non complicated cases'' demonstrated numerical results with particularly high stresses.
Conclusion: Finite element simulations allowed to predict 9 on 13 failure cases among a total of 66 patients. This is a promising step towards the possibility to use finite element modeling as a clinically relevant simulation tool for surgery planning.