# MECHANO-BIOLOGICAL REGULATION OF TISSUE ADAPTATION PROCESSES IN THE LUMBAR SPINE

**Mechanical regulation of Adjacent Segment Degeneration after Lumbar spinal fusion**

***S.A.Swaminathan, S.Checa**, Julius Wolff Institute for Biomechanics and Musculoskeletal Regeneration, Berlin Institute of Health at Charite'–Universitätsmedizin Berlin, Berlin, Germany*

## In Short

- To investigate the tissue adaptation process of adjacent segment degeneration after LUMBAR SPINAL FUSION.
- A finite element (FE) model of the lumbar spine will used to simulate the tissue adaptation process according to the mechanical signals.
- The results will be compared with clinical data which will show how mechanical forces influences tissue regeneration process in the lumbar spine.

Lumbar spinal fusion is one of the most commonly performed surgeries to treat many symptoms such as spondylolisthesis, spinal stenosis, scoliosis, etc. however, the surgical outcome is unpredictable. Adjacent segment degeneration (ASD) is a spinal disorder that may develop after spinal fusion. ASD occurs due to the degeneration of neighbouring segments (vertebrae and intervertebral disks) after spinal fusion. The rate of ASD ranges from 5.2 to 49% in various studies after posterior lumbar fusion surgery and the reported mean annual incidence is of 3.9%. The reason for the degeneration of the adjacent vertebral segments is still unknown, however it has been suggested that it might be due to the increase in the biomechanical stresses on the adjacent segments as a result of the surgical approach. Clinical studies have shown that after fusion surgery a change in the location of the center of rotation leading to increased stresses on the facets and the adjacent mobile segments occurs. In contrast, a few in vivo studies report these increased motion in the adjacent segments and pressure in the adjacent disc is very minimal when compared with cadaveric studies. Although studies report changes in the biomechanical conditions in the lumbar spine after spinal fusion surgery, there is still a lack of understanding of the role of those changes in ASD. In the spine, the use of dynamic computer models to investigate regeneration processes is in its infancy. Previously, 2D axisymmetric FE computer model [1,2] which consists of one vertebra and two cage designs and adapted existing and validated theories of the mechanical regulation of tissue formation [3] to simulate the spinal fusion process. However, they did not investigate adjacent segment responses.

The main goal of this project is to investigate alterations in the mechanical stimuli after surgical intervention in the spine can explain tissue adaptation processes in the adjacent segments.

Finite element analysis will be used to investigate the biomechanics of the lumbar spine after surgical intervention. In addition, computer algorithms describing tissue de(re)generation processes will be used to investigate the mechanical regulation of spinal fusion and adjacent tissue responses after surgical intervention. Clinical imaging data (CT) will be used to reconstruct the geometry of the lumbar spine. The finite element software ABAQUS will be used to develop the finite element models of the lumbar spine including the vertebral bodies, the intervertebral disc, the endplates, posterior bony elements and all major ligaments. ANYBODY software will be used to integrate muscle forces and data into the FE model. A computer algorithm developed in PYTHON programming language will be used to simulate tissue healing (i.e. fusion) and tissue adaptation in adjacent vertebrae and discs during spinal fusion. Computer model predictions of the morphological changes in the different structures of the spine will be compared to radiological data of patients with ASD. Due to the large size (1M element, 500K nodes) and complex geometry of the model, HPC will be used to run the model iteratively to couple the FEA and the tissue healing algorithm.

## WWW

https://www.bihealth.org/en/research/research-group/spine-biomechanics

## More Information

[1] M. Bashkuev, S. Checa, S. Postigo, G. Duda, and H. Schmidt, *J Biomech* **48**, 3274-3282 (2015). doi:j.jbiomech.2015.06.024.

[2] S.Postigo, H.Schmidt, A.Rohlmann, M.Putzier, A.Simón, G.Duda, S.Checa, *J Biomech* **47**, 1514-1519 (2014). doi:j.jbiomech.2014.02.005

[3] L. E. Claes and C. A. Heigele, *J Biomech* **32**, 255–266, (1999). doi:10.1016/S0021-9290(98)00153-5

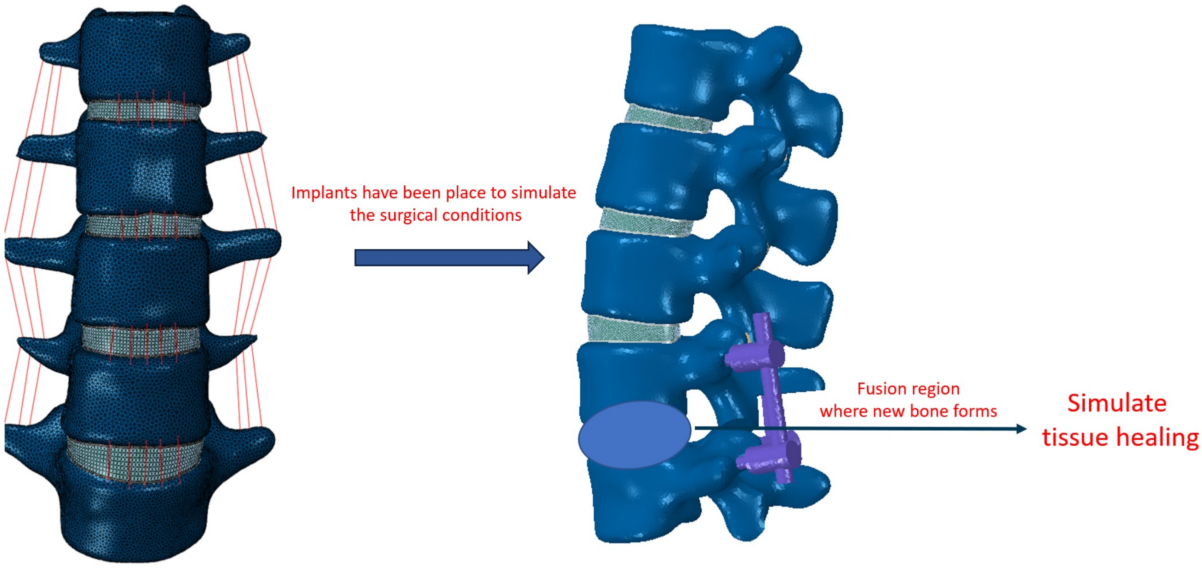


***Figure 1:*** *L1-L5 Lumbar spine model - A schematic showing the fusion surgery on the L4-L5 segment of the lumbar spine with the implants and the region where the fusion occurs as this will simulate by implementing the tissue healing algorithm*

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## DFG Subject Area

205-27 Orthopaedics, Traumatology, Reconstructive Surgery