Subin P George

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3D Imaging and Additive Manufacturing Lab
Department of Engineering Design

IITM

EDUCATION

Program	Institution	%/CGPA	Year of completion
PhD in Spine Biomechanics* (Since 2019)	Indian Institute of Technology, Madras	8.5	
M.S. in Engineering Design	Indian Institute of Technology, Madras	9.0	2012
B.Tech in Mechanical Engg	TKM College of Engineering, Kollam	7.71	2007
XII	Good Shepherd Public School, Kottayam	89.8	2003
X	Good Shepherd Public School, Kottayam	89.8	2001

WORK EXPERIENCE

- Worked as a Lecturer in Saintgits College of Engineering(2007 Sep to Dec 2008)
  - Delivering lecture to Mechanical Engineering students
- Research assistantship under Dr.G.Saravana Kumar, Professor, Engineering Design, IIT Madras (2009 to 2012).
  - TA for Dual Degree Students of Engineering Design
- Worked as Developer in General Motors, Bangalore (2012 Sep to 2013 June).
  - Worked towards building custom CAD applications through programming
- Assistant Professor at Amal Jyothi College of Engineering, Kanjirappally, Kerala.(2013 Dec to 2019July)

JOURNAL PUBLICATIONS

[1] Subin P George, and Saravana Kumar G., Patient-specific parametric geometric modeling and finite element analysis of cement less hip prosthesis, Virtual and Physical Prototyping, Vol. 8, No. 1, 2013, pp. 65-83

[2] Subin P George, and Saravana Kumar G. Optimization of custom cement-less stem using finite element analysis and elastic modulus distribution for reducing stress-shielding effect. ProcIMechE Part H: J Engineering in Medicine Vol 231, Issue 2, 2017 pp.1–11

PATENT & BOOK PUBLISHED

- A patent published in Indian Patent Journal titled ‘A DISPENSER FOR PREPARING AND DISPENSING FRESH LIME JUICE’(Application No.201641044525 A ,Publication Date:21/04/2017).

- Authored a book titled ‘Design and Engineering for First Year B Tech students of Kerala Technological University (Over 8000 copies sold).

Development and Validation of a Lumbosacral Spine FE Model for Simulating Fusion Constructs

Objectives

- Understand kinematic changes cause due to instrumented fusion constructs in the spine using computer simulations
- To develop a Lumbosacral Finite Element morphological base mesh model for simulations.
- Validation and benchmarking of the developed FE model for physiological loading using in-vitro experimental corridor data from the literature.
- Perform a sensitivity analysis to evaluate the role of morphological parameters on kinematic output parameters of the vertebral column
- Analyze unilateral vertebral fusion technique for different spine morphologies and compare its outcomes with bilateral fusion technique using simulations.

Results

Clinical study: A pilot study was undertaken on 69 patients who had undergone single-level L4L5 fusion. The purpose of the study was to assess the range of movement in the adjacent segments following single-level L4L5 fusion for degenerative spondylolisthesis as compared to their pre-operative values. The Cobb angle reading between the bottom plate of the superior vertebra and the top plate of the inferior vertebra is taken as the measure for quantifying the lumbar range of motion. Differences in disk angles between pre-operative and post-operative data were found and statistically analyzed.

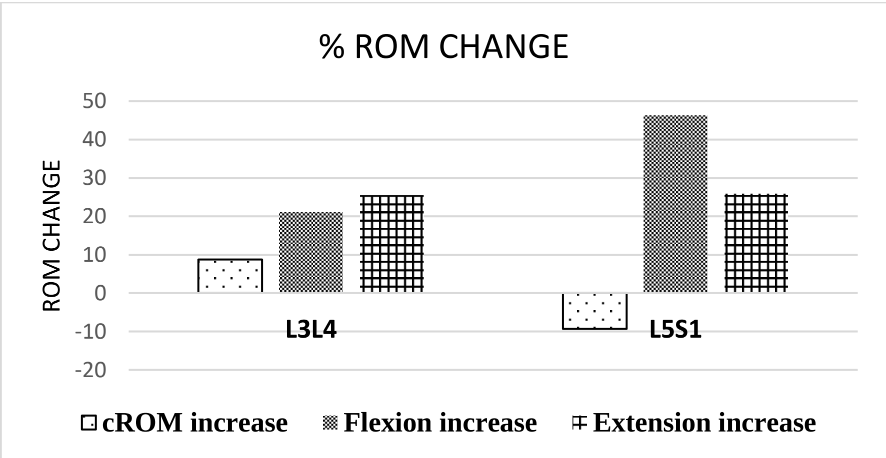

Fig1. ROM changes in superior L3L4 and inferior L5S1 segments

A statistically significant change in the combined range of motion (flexion-extension) is observed both in L3L4 ($p=0.4786(>0.05)$ the superior segment and the inferior segment L5S1 ($p =0.219(>0.05)$) postoperatively (Fig. 1). The corresponding increase is 8.77% and the decrease is 7.5% in magnitude respectively. The flexion increase was 46% higher at the inferior segment and the extension increase was 25% higher at the superior segment, in terms of disk angle. The change in the range of motions, in the adjacent segments, shows that predictions on degeneration can be made based on disk wedging angle measurements. This method of measurement shall be used to benchmark as well as correlate clinical outcomes using simulation results.

Lumbosacral FE Model development: The work has developed a Lumbosacral Finite Element model utilizing the potential of Direct morphing feature in ANSA META CAE^{TM} with accurate hexahedral meshes. The mesh density is five times lesser compared to a recent model[1]. This is due to the fact that when a structured hexahedral element is used with proper meshing technique it can yield better accurate results. This would ensure faster computation in explicit simulations as the model involves Geometric, material and boundary condition nonlinearities.

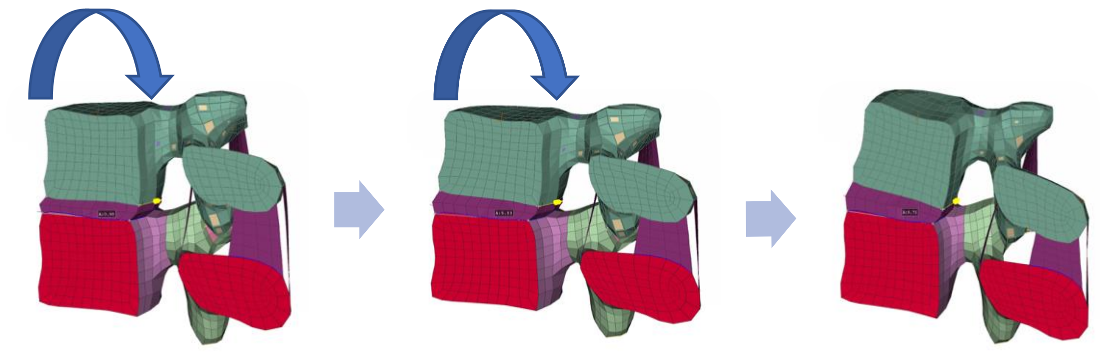

Fig 2. Geometrical morphing operation on the disk for changing sagittal alignment in FE model.

The geometrical morphing operation on a single FSU, to calibrate the geometric nonlinearity of the soft tissues is shown in Fig 2. Here the soft tissues (ligaments and intervertebral disk) are morphed from no Lordosis to hyper Lordosis. The angular movement of the FSU for simple moment loading was monitored to calibrate the disk angle. The solver used for this was LS Dyna^{TM}. Simple moment was applied on the Lumbosacral model by constraining the sacrum in all directions and applying the moment in all anatomical directions through top plate of L1. Fig 3 shows the nonlinear flexion-extension curve for a single FSU validated with experimental and numerical results. As can be seen the initial large displacement at the start of the flexion/extension is captured by the curve. As moment increase, in flexion the angular displacement also reduces and the posterior ligaments constrain further flexing of the vertebra. For extension, the motion is arrested by the facet joints and the anterior longitudinal ligament, as the spine moves posteriorly. The disc displacement for follower pure compression load of 1200 N, is shown in Fig 4. All the disc displacements were within the ranges for the developed model. Facet contact forces were monitored to find whether it exceeded the experimentally predicted ranges (Fig 5). Extension and axial rotation were only considered here as significant values were found only in these motions[2]. In combined loading (280 N follower load and 7.5 Nm moment), the total range of motion of the L1L5 spine in flexion, extension, bending, and axial rotation was 20^{o}, 13^{o}, 15^{o}, and 8.3^{o} (Fig 5.), and this correlates well with the data reported by Rohlmann et al.[3] (corresponding values being 23.4 ± 8 °, 8.1 ± 2.8 °, 15 ± 5 °, and 5.2 ± 1.8 °, respectively). The model thus developed is being developed further to be used for instrumentation study. The pedicle instrumentation in FE model is in progress. The instrumented FE model is to be used for unilateral fusion study for predicting its biomechanical efficacy.

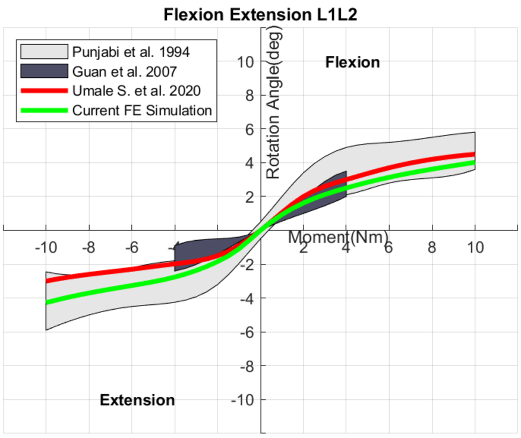

Fig 2. Flexion extension response of L1L2 FSU

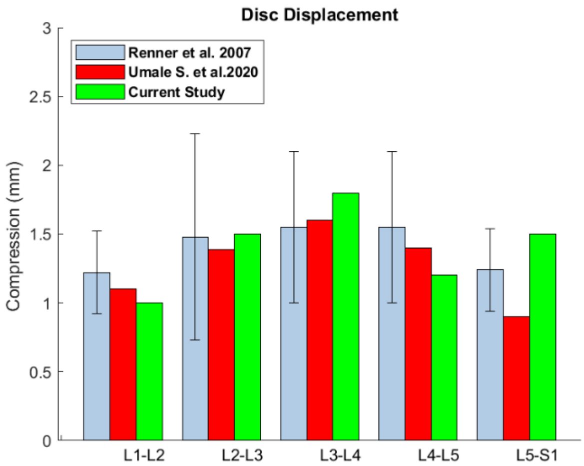

Fig 3. Follower compressive load response

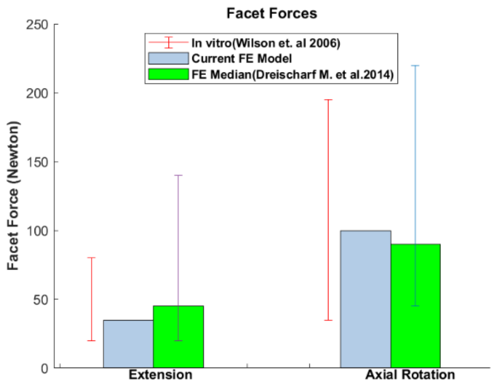

Fig 4. Facet peak contact forces validated with in vitro results

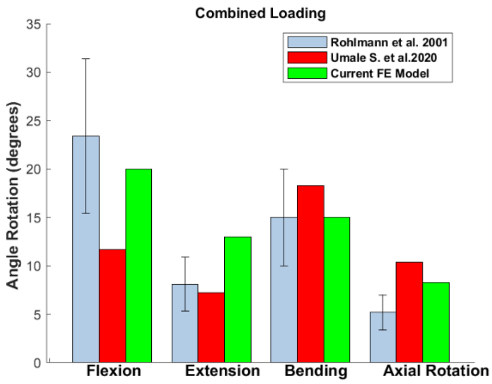

Fig 5. Combined Loading Lumbar column(L5-S1) response

References

[1] S. Umale, N. Yoganandan, and S. N. Kurpad, “Development and validation of osteoligamentous lumbar spine under complex loading conditions: A step towards patient-specific modeling,” *J. Mech. Behav. Biomed. Mater.*, vol. 110, no. May, p. 103898, 2020, doi: 10.1016/j.jmbbm.2020.103898.

[2] M. Dreischarf *et al.*, “Comparison of eight published static finite element models of the intact lumbar spine: Predictive power of models improves when combined together,” *J. Biomech.*, vol. 47, no. 8, pp. 1757–1766, 2014, doi: 10.1016/j.jbiomech.2014.04.002.

[3] A. Rohlmann, S. Neller, L. Claes, G. Bergmann, and H. Wilke, “Influence of a Follower Load on Intradiscal Pressure and Intersegmental Rotation of the Lumbar Spine,” vol. 26, no. 24, pp. 557–561, 2001.