THE INFLUENCE OF THE CENTER OF ROTATION POSITION ON FACET JOINT LOADING AND END PLATE LOADING INVESTIGATED WITH MUSCULOSKELETAL SIMULATION

[1, 5] Mark de Zee, [2] Peter Mikkelsen, [3] Christian Wong, [4] Erik B. Simonsen and [5] John Rasmussen

[1] Department of Health Science and Technology, Aalborg University, Denmark; email: mdz@hst.aau.dk

[2] Orthopaedic Department, Glostrup Hospital, Denmark

[3] Orthopaedic Department, Hvidovre Hospital, Denmark

[4] Department of Neuroscience and Pharmacology, Division of Biomechanics, University of Copenhagen, Denmark

[5] Department of Mechanical Engineering, Aalborg University, Denmark

INTRODUCTION

The incidence rate of prosthetic discs implants in the lumbar spine has been increasing as an alternative treatment for lumbar degenerative disc disease. Placements tolerances in the surgical procedure change the center of rotation and its impact on the facet joint loading and end plate loading is unknown. Traditionally, computational studies of facet loads have used the finite element method [e.g. 1,2]. However, muscle forces are not included in these analyses. In this work we investigate the influence of the center of rotation (CoR) position on facet joint loading and end plate loading around L4-L5 using musculoskeletal simulation based on inverse dynamics.

METHODS

The lumbar spine model developed by De Zee et al. [3] formed the basis for the present study. In short this model consists of seven rigid segments with 18 degrees-of-freedom and 154 muscles and was built in the AnyBody Modeling System. Recently facet joints have been implemented in this model [4]. This makes it possible to analyze the effect of whole body movements and loads on facet joint loading.

The model was positioned in a standing position with the spine in 5 degrees extension. The CoR between L4 and L5 was changed systematically 0.5 cm posterior and anterior and 0.5 cm left and right. For each new CoR position the facet joint forces and the reaction forces between the vertebrae were estimated by solving the muscle recruitment problem.

RESULTS AND DISCUSSION

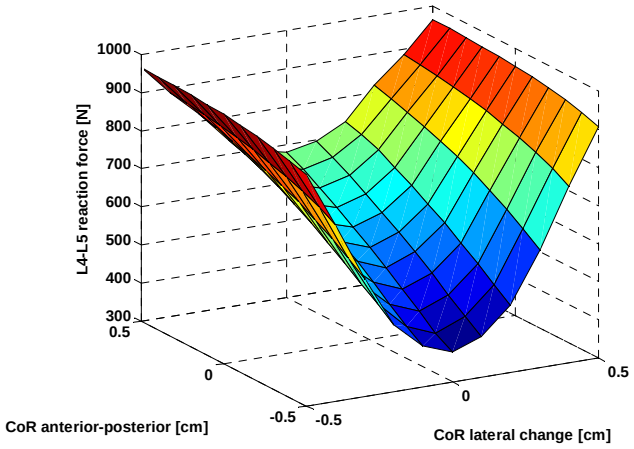

Figure 1: L4-L5 reaction force as a function of CoR position.

Figure 1 and 2 show that the reaction forces between L4 and L5 and the facet joint forces are very sensitive to changes in the CoR position in lateral direction. This suggests that a small error in artificial disc placement in lateral direction has a significant impact on the facet joint loading and end plate loading. The simulation also shows that an anterior shift of the CoR position will lead to higher loads. The results show the same trends as Moumene et al. [2], albeit with different absolute values.

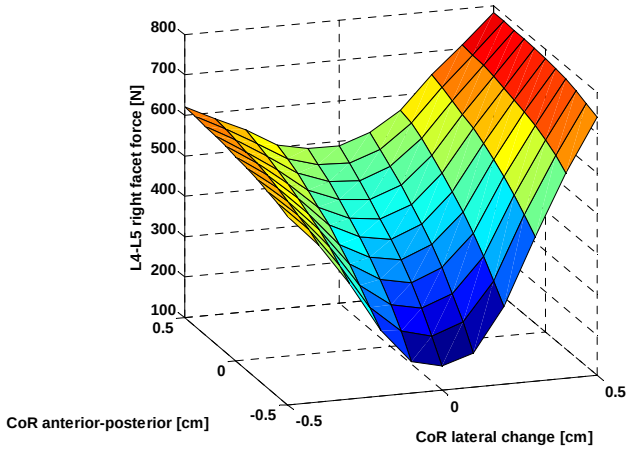

Figure 2: The right facet joint force between L4-L5 as a function of CoR position

CONCLUSIONS

This study provides an insight in the complex relationship between the CoR position and the loading on the facet joints and discs, though the absolute values are difficult to validate. The computation is fast and it is easy to change the simulation to a different situation and conduct parameter studies. The estimation of the muscle forces is part of the simulation, which is a big advantage in comparison to other methods. It is not necessary to create artificial loading scenarios.

ACKNOWLEDGEMENTS

The Danish Research Council for Technology and Production Sciences supported this study.

REFERENCES

1. Schmidt, H et al., *Clin. Biomech.* **23**, 270-278, 2008.
2. Moumene, M, et al., *Spine* **32**, 1840-1851, 2007.
3. de Zee, M, et al., *J Biomech* **40**, 1219–1227, 2007.
4. de Zee, M, et al., *NACOB*, Ann Arbor, Michigan, USA, 2008.