Can biomechanical studies make no distinction between different lumbar levels?

TO THE EDITOR: We read the article by Fogel et al.\textsuperscript{2} with great interest (Fogel GR, Parikh RD, Ryu SI, et al: Biomechanics of lateral lumbar interbody fusion constructs with lateral and posterior plate fixation. \textit{J Neurosurg Spine} 20:291–297, March 2014). Accurate knowledge about the biomechanics of lumbar interbody fusion with supplemental fixation is crucial in the operative treatment options for lumbar degenerative diseases. Although the authors’ study has greatly improved our knowledge about the biomechanics of lateral lumbar interbody fusion constructs with lateral and posterior plate fixation, we do not completely agree with their conclusions indicating that a combination of lateral and spinous process plate fixation to supplement a laterally inserted interbody cage helps to achieve rigidity in all motion planes similar to that achieved with bilateral pedicle screws.

Firstly, lumbar degenerative diseases are most often found at the lower levels of L4–5 and L5–S1.\textsuperscript{1,4} And recent biomechanical studies have shown distinct behavior at the different lumbar levels. For example, Wu et al.\textsuperscript{8} found that L4–5 had the largest anterior-posterior translation and that L5–S1 had the largest proximal-distal translation, as living patients performed an extension motion from a flexed position of 45° to maximal extension. Moreover, different clinical outcomes following surgical treatment at the different lumbar levels have been reported. For example, fusion of L5–S1 has shown clinical outcomes superior to those at L4–5,\textsuperscript{3} whereas total lumbar disc replacement at L4–5 has shown clinical outcomes superior to those at L5–S1.\textsuperscript{7} Various factors could influence segment-dependent function of the lumbar spine, such as the surrounding ligaments and muscles, the orientation of facet joints, the vertebral geometries, and so on.\textsuperscript{5,6} We believe that the study by Fogel et al.\textsuperscript{2} has some important limitations. For example, the authors only investigated the L3–4 level and did not take the other lumbar levels into consideration, especially the lower lumbar levels of L4–5 and L5–S1.

Further, in their in vitro study, the applied loading conditions could be quite different from in vivo physiological loading, and the surrounding ligaments and muscles were not considered. Additionally, a relatively small sample of specimens (10 cadaveric specimens) were evaluated in their study, and such a small sample size did not allow them to analyze other variables such as patient sex, age, and so on. The conclusions made by Fogel et al.\textsuperscript{2} (the first paragraph) may mislead surgeons about the operative treatment options for lumbar degenerative diseases in the other lumbar levels.

Although Fogel et al.\textsuperscript{2} have done great work in this study, biomechanical studies should make distinctions between the different lumbar levels. Future biomechanical studies of lumbar interbody fusion with supplemental fixation are necessary to consider the other lumbar levels, especially the L4–5 and L5–S1 levels.

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DISCLOSURE
The authors report no conflict of interest.

References
Response

We thank Drs. Shen and Zhong for their interest in our paper. They are correct in their assertion that in vitro biomechanical studies have many limitations; however, we do not believe that these are specific to our investigation. Furthermore, the stated aim of our study was not to investigate many of the parameters mentioned by Drs. Shen and Zhong, such as the effect of different spinal levels, specimen age, specimen sex, and so on. Were that our intention, a very different study design would have been used.

Drs. Shen and Zhong cite a number of in vivo studies pertaining to kinematics and outcomes associated with different spinal levels. However, it is generally understood that the recommended pure moment testing conditions\(^4,7,13\) often applied during in vitro studies are a simplification of in vivo loading to provide repeatable test conditions. Therefore, the relevance of the cited papers is unclear since they do not establish differences between spinal levels under pure moment loading conditions.

Choosing a spinal level for an in vitro biomechanical study may be driven by multiple factors such as specimen availability, a desire to limit variability, or even a desire to compare data with already published data. The literature contains numerous lumbar spinal fusion papers in which fusion devices were tested at L3–4.\(^3,9,10,12\) Wilke et al.\(^13\) recommend testing specimens without significant degeneration and with nonosteoporotic bone. This approach will reduce variability between specimens. However, the lack of pathology is a further limitation that separates the testing model from the clinical situation, which was addressed in our discussion: “Additionally, the interbody cage was inserted into healthy excised spine specimens with good bone quality and no existing pathology. The surgical procedure may therefore not be fully representative of the actual clinical situation.” Some authors have used animal spines (ovine, porcine, bovine) to further reduce variability and increase availability.\(^1,2,11\) Testing fusion constructs at multiple spinal levels is sometimes done to allow the use of more levels from a single specimen;\(^3,6,8\) however, aggregating the data may increase variability, making it more difficult to detect statistical differences. We are not aware of any studies that have tested the same construct at different levels to quantify the differences in construct kinematics at the various levels. While it is an interesting question, it would require a very large sample size and is the most likely reason that it is not common practice.

With regard to specimen number, Wilke et al.\(^13\) recommend using at least 6. Sample size is typically a compromise among statistical power, time, cost, and the ability to procure sufficient cadaveric spines with adequate bone mineral density and no significant degeneration. In our study, the sample size was 10 specimens, which we believe was adequate to meet the aims of the study. While one could argue that additional specimens may have made it possible to detect a statistical difference between the lateral plate plus the spinous process plate construct and the bilateral pedicle screw construct, the subsequent finding may not have been clinically significant.

In conclusion, we appreciate the interest that Drs. Shen and Zhong have shown in our work. The reader must consider the many limitations associated with cadaveric biomechanical studies when interpreting results. These studies use a simplified model to represent the clinical situation. Results are, at best, generalizable to the clinical scenario; therefore, we believe that trends established in our study are also generalizable across different lumbar spinal levels.

DISCLOSURE

Dr. Ryu is a consultant for NuVasive, Inc.

References

7. Panjabi MM: Biomechanical evaluation of spinal fixation


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Published online May 8, 2015; DOI: 10.3171/2014.11.SPINE141156.

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