



ISSN: 0975-833X

International Journal of Current Research  
Vol. 11, Issue, 03, pp.2058-2060, March, 2019

DOI: <https://doi.org/10.24941/ijcr.34618.03.2019>

## RESEARCH ARTICLE

# BIOMECHANICAL INFLUENCE OF THE THERAPEUTIC POSITION ON THE EFFICACY OF CHINESE MANIPULATION IN TREATING LUMBAR DISC HERNIATION

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### ARTICLE INFO

#### Article History:

Received 06<sup>th</sup> December, 2018

Received in revised form

17<sup>th</sup> January, 2019

Accepted 03<sup>rd</sup> February, 2019

Published online 31<sup>st</sup> March, 2019

#### Key Words:

Lateral position, Sitting position,  
Manipulation, Lumbar disc herniation (LDH)

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### ABSTRACT

**Purpose:** To determine the favorable therapeutic position for Chinese manipulation in treating lumbar disc herniation. **Methods:** We developed a three-dimensional finite element model of L3-5 for the normal spine, along with a mild degeneration and a moderate degeneration model, and carried out a comparative study between the manipulation with lateral position and that with sitting position. The displacement and stress distribution in the intervertebral disc of L4 were investigated. **Results:** A displacement and stress directing forwards concentrated on the left rear of L4 disc were found in the three models under the two manipulations. The values of displacement and stress under the manipulations with lateral position are larger than those with sitting position in the three models. **Conclusion:** Lateral position has a better biomechanical effect than sitting position in treating lumbar disc herniation.

## INTRODUCTION

Low back pain is a great social and economic problem in the world (Tang *et al.*, 2018; Chen *et al.*, 2016). Lumbar disc herniation (LDH) is the common cause of low back pain (Zhang *et al.*, 2015). Many surgical procedures have been carried out for its treatment, but conservative treatment, with a high success rate<sup>4</sup>, is regarded as the primary option to treat LDH. Chinese manipulation is a common conservative method for the treatment of low back pain (Choi *et al.*, 2007). Its rotation manipulations are often performed for LDH, in which some manipulations such as oblique pulling manipulation are carried out when patients lie in lateral position, while some such as lumbar erection and rotation manipulation are carried out when patients in sitting position. In clinical practice, the selection of therapeutic position is usually attributed to the personal preference of physicians. However, the upper body weight imposed on the lumbar spine in sitting position will inevitably affect the stress conduction and distribution of displacement in lumbar structures, and subsequently may have some influence on the effect of manipulations. Hence, the efficacy may be different between the two positions. However, which position is better, sitting or lateral position? No studies have been published on the issues and the answer is still unclear. Therefore, in this study we developed a three-dimensional finite element model of L3-5 for the normal spine, along with a mild degeneration and a moderate degeneration model, and our aim was to conduct a comparable study to determine which therapeutic position of manipulation is better for the treatment of LDH.

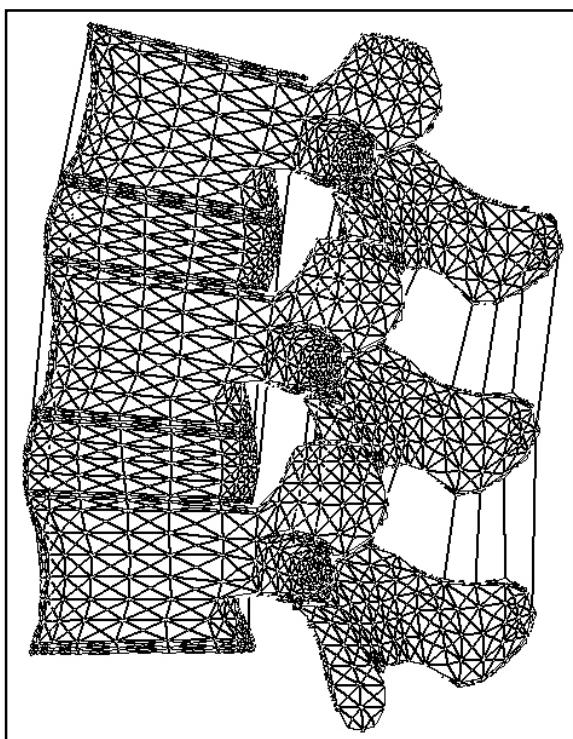
## MATERIALS AND METHODS

Lumbar disc degeneration is a common phenomenon in patients with LDH, so we used three models including one normal model, one mild degeneration and one moderate degeneration model of L3-5 to perform the current study. The models were developed and validated in our previous study (Fig. 1) (Tang and Rebholz, 2013). The degeneration models were modified from the normal model by adjusting disc space height, endplate contour and material properties of L4-5 segment (Tang and Rebholz, 2011). In clinical practice, lumbar rotation manipulation is much less carried out for patients with severe degeneration, so no severe degeneration models were analyzed in this study. The material properties of the models were defined based on our previously studies (Shang *et al.*, 2015; Tang and Rebholz, 2013). In the study, the disc herniation was assumed to be on the left rear of L4 disc, and the manipulations were performed on the right. The degrees of freedom of inferior surface of L5 endplate was completely fixed in all directions. To simulate lateral-position manipulation, a 15 Nm right axial rotation moment and a 150 N compressive loading were imposed on superior surface of L3 upper endplate (Sheng *et al.*, 2002). To simulate sitting-position manipulation, a 15 Nm right axial rotation moment plus a 300 N compressive loading were imposed on the superior surface of L3 upper endplate (Wu *et al.*, 2010). The time at the end of loading was defined as 0.25 second in each model (Wu *et al.*, 2010). The calculations were performed using two-step mode (Shu *et al.*, 2017), and the displacement

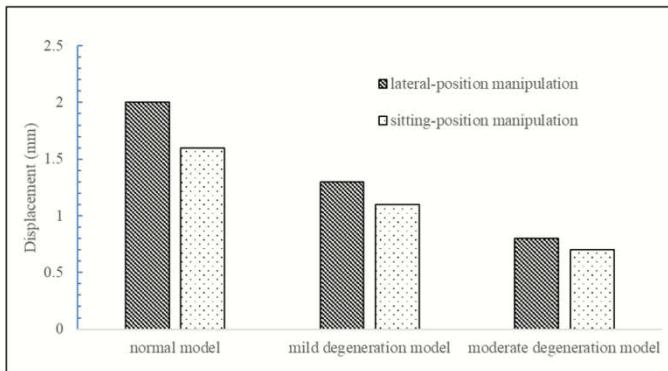
and stress distribution in the intervertebral disc of L4 were investigated.

## RESULTS

Figure 2 displays the distribution of displacement at the back of L4 disc in three models under two manipulations. A displacement which directs forwards and concentrates on the left rear of L4 disc was found in all the models. The displacement in lateral-position manipulation was larger than that in sitting-position manipulation in different models. Figure 3 shows the stress at the back of L4 disc in the models under two manipulations. The distribution of stress was consistent with the displacement. Also, similar as the displacement, the stress under lateral-position manipulation was larger than that under sitting-position manipulation in different models. In addition, with the degeneration grade increased, the displacement or stress decreased gradually in all models.



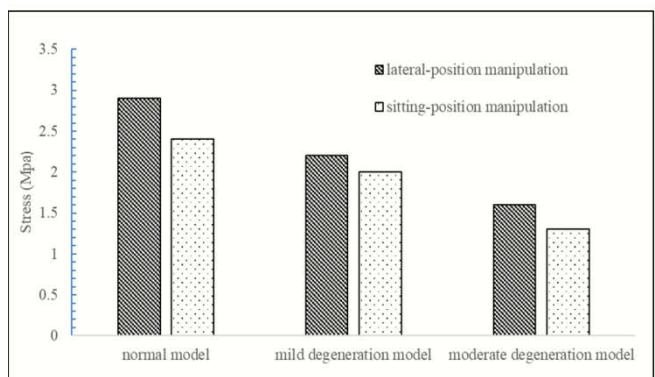
**Fig. 1. The normal model in the study**



**Fig. 2. The displacement in left rear of L4 disc**

## DISCUSSION

Physicians in the field of Chinese manipulation suggests that some displacement and stress between nerve roots and



**Fig. 3. The stress in left rear of L4 disc**

protruded intervertebral discs are produced during rotation manipulation (Sheng *et al.*, 2002; Hai-tao *et al.*, 2011), which can reduce compression, alleviate edema and relieve adhesion of corresponding nerve roots, and subsequently result in the improvement of symptoms in patients with LDH (Hu *et al.*, 2012). Hence, we investigated the stress and displacement in intervertebral disc to compare the efficacy of the two manipulations with different therapeutic positions. In the current study, we found a displacement and stress which direct forwards and concentrates on the left rear of L4 disc. This confirmed the previous viewpoints in terms of the mechanism of manipulations. In addition, the displacement and stress under lateral-position manipulation are larger than those under sitting-position manipulation in different models, demonstrating that from the angles of biomechanics, the lateral-position manipulation may result in a better clinical efficacy than sitting-position manipulation, because a larger stress or displacement may more easily relieve the adhesion between nerve roots and protruded discs. In addition, with the degeneration grade increase, the displacement or stress decrease gradually in three models. Lumbar disc degeneration, resulting in disc height loss and alterations in material properties, may lead to decreased elasticity and increased stiffness, affects the biomechanics in lumbar spine greatly<sup>7</sup>. The current results indicate the same viewpoints and we suggest that the decreased stress and displacement may be attributed to the increased stiffness of intervertebral disc.

In short, we conclude from the current study that Chinese manipulation using lateral position has better effect than sitting position in treating LDH. However, our study has its limitations. Many factors play an important role on the final efficacy of LDH. In addition, although a finite element study presents with many advantages (Tang and Rebholz, 2013; Tang and Rebholz, 2011), from the angle of Evidence Based Medicine (EBM), a large-scale, randomized and controlled clinical study can provide the most reliable evidence. Hence, to further clarify this issue, more clinical studies need to be performed in the future.

## Acknowledgement

This study was supported by the Science and Technology Plan Projects of Guangzhou, China, NO.201607010252.

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