Influence of Ligament Injury and Disc Degeneration on Rotational Instability in Lumbar Spine

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INTRODUCTION
Spinal instability has been known to be related with low back pain. However, there is a controversy about the evaluation of instability because there is a lack of consensus regarding quantitative clinical or radiological definition of the instability [1, 2]. In addition, the major factors to affect on the instability has not been elucidated although the disc degeneration, disc injury, or ligament injury were considered to result in such instability. Hence, systematic investigation of causes of spinal instability could be meaningful to define and understand the instability applicable to clinical and rehabilitational researches for the patients with low back pain. In this study, we chose the ligament injury and disc degeneration as factors and investigated the single and combined influences on rotational instability in lumbar spine under flexion and extension with a three-dimensional finite element model of a one-level spinal motion segment.

METHODS
A three dimensional finite element model of one spinal motion segments from L4 to L5 in intact lumbar spine was reconstructed from 1-mm thick computed tomography (CT) images. The CT images were taken from a healthy human body whose height and age were 175 cm and 21 years. Two vertebras, one intervertebral disc, and seven major ligaments (anterior longitudinal ligament (ALL), posterior longitudinal ligament (PLL), flavum ligament (FL), inter transverse ligament (ITL), inter spinal ligament (ISL), supra spinal ligament (SSL), and capsular ligament (CL)) were included in the finite element model. Clinical data and results of previous studies were taken for material properties of the model and attachment points of ligaments [3, 4]. In addition, a mildly degenerative intervertebral disc was developed by reducing the height of the disc and changing the material properties based on [5] (Fig. 1).

Then, the model in which the SSL was removed (SSL), the model in which the ISL was removed (ISL), the model in which both the SSL and ISL were removed (SSL+ISL), and the model in which the SSL, ISL, FL, and CL were removed (Isthmic defect) were developed to represent the ligament injury. The 5 Nm of flexion and 5 Nm of extension were applied to the superior vertebra to measure the rotation, which is considered as the rotational instability, under flexion and extension for each model in normal and disc degenerative cases.

RESULTS
The rotation angles were 4.5° and 5.0° in the intact model in normal and disc degenerative cases. The angles were increased to 4.8 ~ 6.6° in the normal case and to 5.3 ~ 6.7° as the more ligaments were removed (Fig. 2). The angles were increased by 6%, 13%, 24%, and 46% in the SSL, ISL, SSL+ISL, and isthmic defect models in the normal case, respectively in comparison with the normal intact case. Similarly, the angles were increased by 17%, 27%, 43%, and 46% in the SSL, ISL, SSL+ISL, and isthmic defect models in the degenerative case, respectively in comparison with the normal intact case. The degenerative case showed larger rotation angles in comparison with the normal case.

DISCUSSION
The results show that the combination of ligament injury and disc degeneration accelerated rotational instability although each factor could affect on the instability. It was reported the increase by 25% of rotation might produce a problem in lumbar spinal motion segment [6]. In this study, the ISL, SSL+ISL, and isthmic defect models were included in the risk range while only the isthmic defect model was in the range in the normal. Hence, the combination of factors could be considered to have higher influence on the rotational instability rather than a single factor. The ligament injury and disc degeneration were selected as factors because the ligament injury and disc degeneration have been reported due to exposure to sports and occupational activities, and the aging effect [5, 7]. Since the facet opening is one of the known factors causing spinal instability [5], considering the facet joint diseases could improve the methodology and technology of this study to investigate the mechanism of spinal instability.

REFERENCES

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