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SHORT REPORT

Biomechanical Characteristics of Kissing Spine During Extension Using a Human Cadaveric Lumbar Spinal Model

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Introduction: Although kissing spine syndrome in the lumbar spinal region is a relatively common condition in older adults, no study examining its biomechanical characteristics has been reported. We hypothesized that kissing of the spinous processes during extension causes an increase in the flexural rigidity of the spine and significantly limits the deformation behavior of extension, which in turn might cause lower back pain.

Methods: Three test models (human cadavers A, B, and C) were prepared by removing supraspinal/interspinous ligaments between L4 and L5. The dental resin was attached to the cephalocaudal spinous process so that the spinous processes between L4 and L5 were almost in contact with each other to simulate the condition of a kissing spine. The flexion-extension direction's torque–range-of-motion (torque–ROM) curve was generated with a six-axis material tester for biomechanical measurements.

Results: In all three models, the maximum ROMs at the time of extension were smaller than those at the time of flexion, and no sudden increase in torque was observed during extension.

Conclusion: The results indicated no apparent biomechanical effects of kissing between the spinous processes, suggesting that the contact between the spinous processes has little involvement in the onset of lower back pain.

Keywords: kissing spine syndrome, Baastrup's disease, biomechanical study, low back pain, lumbar spine

Introduction

Kissing spine syndrome, or Baastrup's disease, is a pathological condition that leads to symptoms such as edema, cystic lesions, sclerosis, flattening and enlargement of articulating surfaces, bursitis, and occasionally epidural cysts or midline epidural fibrotic masses occurring around the spine due to degeneration of bone/soft tissue caused by contact between spinous processes of adjacent vertebrae in the lumbar spine.[1,2] It is one of the causes of lower back pain, often occurring at lumbar vertebrae L4–L5.

Although kissing spine syndrome in the lumbar spinal region is a relatively common condition in older adults,[3,4] no study examining its biomechanical characteristics has been reported. Generally, when an object is subjected to a bending load, tensile stress acts on the convex side, and compressive stress acts on the concave side. Therefore, compressive stress acts on the spine's spinous process side when bent posteriorly. This compressive stress reduces the distance between the spinous processes, and it is thought that the spine's flexural rigidity against posterior bending movement increases because it limits posterior bending movements strongly after the spinous processes come into contact with each other. We hypothesized that the increased flexural rigidity of the spine by kissing might cause lower back pain. To support this hypothesis, we prepared kissing spine models using the lumbar region of human cadavers to conduct biomechanical experiments; here, we report the results of our experiments with relevant discussions.

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Materials and Methods

Lumbar vertebrae (L4–L5) of three (A, B, C) human cadavers were used as models in this study. Model A was from a woman who died at 79 years of age from pneumonia, model B was from a man who died at 83 years of age from senile decay, and model C was from a man who died at 75 years of age from cardiac infarction. Their bodies were donated to the Department of Anatomy of Khon Kaen University based on their legal will or their family's consent, and brains and abdominal organs were removed from their bodies and stored at room temperature after preservative treatment. Upon receiving consent from the Department of Anatomy, lumbar vertebrae units (L4–L5) were collected from their bodies without damaging the stabilizing elements of the spine, including the supraspinous ligaments.

Test models were prepared by removing supraspinal/interspinous ligaments between L4 and L5, and dental resin was attached to the cephalocaudal spinous processes so that the spinous processes between L4 and L5 were almost in contact with each other to simulate the condition of kissing spine.

A six-axis material tester with a serial mechanism developed at Mie University, Japan, was used for biomechanical measurements. The device has a multi-articulated robotic mechanism in which multiple links connect relevant components in series from the base structure to the tip. The mechanism lets it control the position, force, moment, and velocity with six degrees of freedom. The tester used a robot arm (VS087A4-AV6, DENSO WAVE INCORPORATED) and a capacitive 6-axis force sensor (WEF-6A500-10-RC24, WACOH-TECH Inc.).

A test model (Figure 1) replicating a kissing spine was mounted on the six-axis material tester (Figure 2), and a series of bending tests under three degrees of freedom, which represent pure bending in one plane, were performed on each test model (A, B, and C). The test conditions were as follows: two cycles of torque loading with an angular velocity of 0.1 deg/s were applied in the flexion-extension direction until a force level of 5 Nm was reached because Panjabi et al[5] stated that in biomechanics experiments on the human spine, a load of 5 Nm or more would enter the elastic zone and provide relatively stable results. A torque–range-of-motion (torque–ROM) curve was generated in the second cycle. This study was approved by the Ethical Committee for Human Research at Khon Kaen University (Approval no. HE611293).

Results

Figure 3A–C show the torque–ROM curves for models A, B, and C, respectively. In all three models, the maximum ROMs at the time of extension were smaller than those at the time of flexion, and no sudden increase in torque was

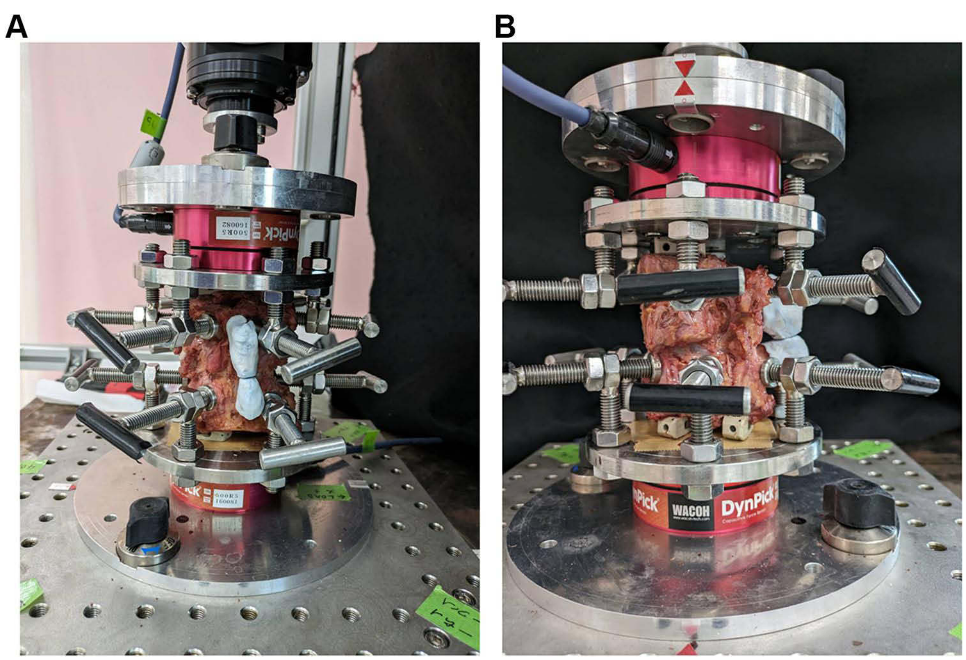

Figure 1 A test model replicating a kissing spine (**A**) Posterior view (**B**) Lateral view.

Figure 2 A test model mounted on the six-axis material tester.

observed during extension. In other words, despite the apparent contact between the upper and lower spinous processes, there were no noticeable changes in the torque-ROM curve, and the kissing spine did not increase the flexural rigidity of the lumbar spine during extension.

Discussion

Lower back pain caused by kissing spine syndrome, or Baastrup's disease, occurs on the posterior midline. Characteristically, pain increases during extension movement (stretching) and decreases during lumbar spine flexion movement (bending).[2,4] However, the mechanism that causes lower back pain has yet to be elucidated. Although several treatment methods have been reported, including local injection using lidocaine or dexamethasone,[6,7] kissing spine osteophyte resection,[8,9] and decompression using a spacer or interspinous posterior device,[10,11] no effective treatment method has been established.

The causes of low back pain may be derived from the intervertebral disc, facet joints, vertebral bone, muscle and myofascial, ligaments, or nerve roots. The authors hypothesized that the contact between the spinous processes in the kissing spine increases the flexural rigidity of the spine, which may cause low back pain. And, if the flexural rigidity of the spine increases, the contact between the spinous processes (bone origin), the mechanical stimulation of the facet joint capsule (facet joint origin), and the change in the pressure inside the spinal muscle compartment (muscle and myofascial origin) will be enhanced, resulting in low back pain. We also thought that the strength of the flexural rigidity caused by kissing influenced whether the patients with the kissing spine had lower back pain; some people with the kissing spine might have lower back pain, and others did not. However, in this study, we did not observe any apparent increase in the flexural rigidity of the spine due to kissing, and our hypothesis could not be proven. The reasons for this are thought to be that in addition to problems with the experimental conditions and model creation in the present study, Baastrup's disease is not a simple pathology,[1,2] such as spinous processes kissing each other. Therefore, an MRI should be performed before spinal surgery to identify inter-spinous

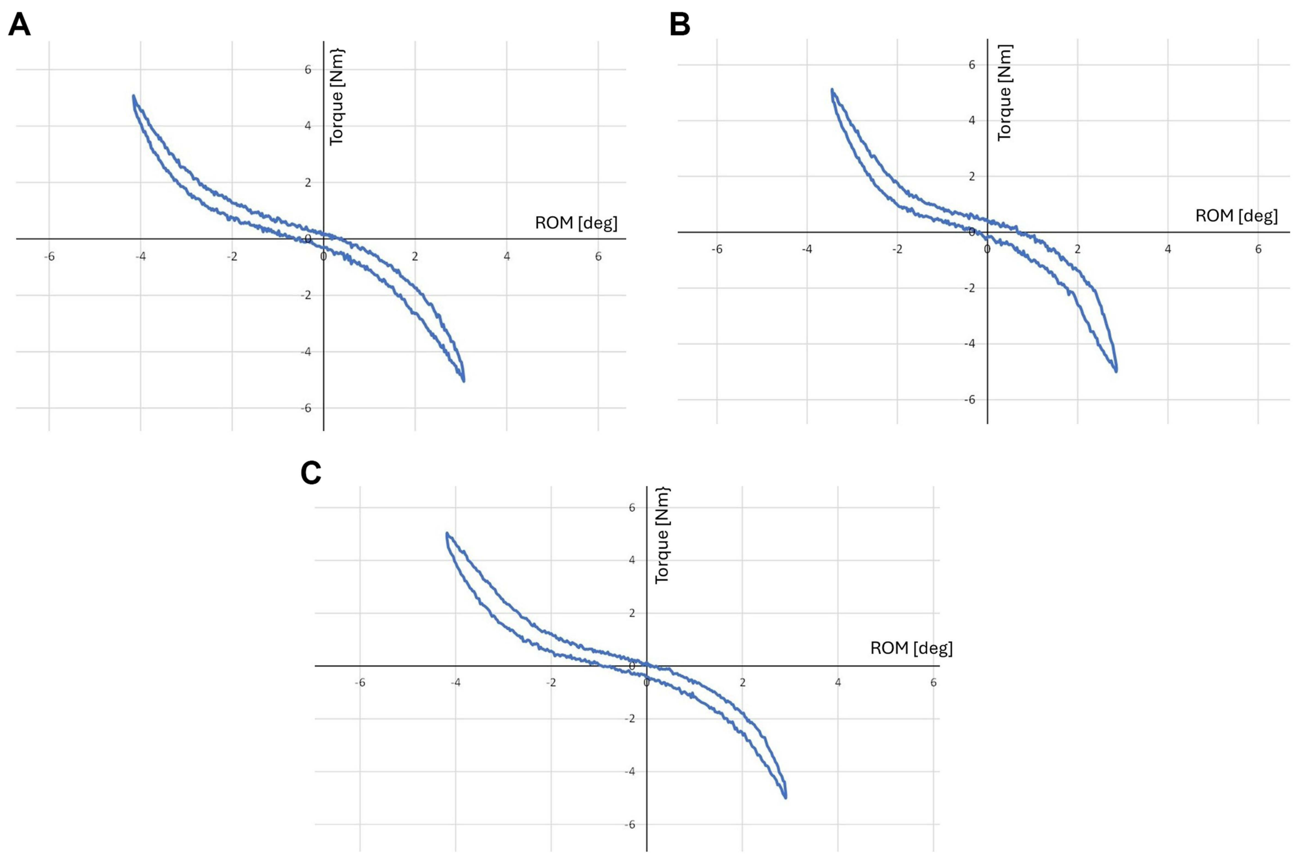

Figure 3 Torque–ROM curves, (**A**) Torque–ROM curve for model A, (**B**) Torque–ROM curve for model B, (**C**) Torque–ROM curve for model C.

cystic lesions, bursitis, epidural cysts, and midline epidural fibrotic masses around the kissing spine. In addition to osteophyte resection of the kissing spine, dissecting surrounding lesions may also be necessary.[11]

The present study had several limitations. First, the number of samples was small. In addition, no comparison was performed with measurements under intact conditions. Also, the measurements were carried out only for a load of 5 Nm. Our authors have only tested the spine's flexion and extension, so we should examine other biomechanical effects such as lateral bending, rotation, compression, and distraction. We plan to conduct further experiments using larger samples to compare intact and kissing spine models under various conditions. Our authors created a kissing spine model in which the upper and lower spinous processes come into contact by molding and covering the spinous process with dental resin. However, dental resin has different physical properties, such as hardness and viscoelasticity from bone, so the model we created this time differs from the actual kissing spine that occurs with aging. We believe it is necessary to thoroughly check the validity of this Kissing model to see if it reproduces the biomechanical situation of the actual Kissing spine.

Despite the limitations stated above, we are confident that our research is the first to examine the biomechanical characteristics of kissing spine syndrome in humans and, therefore, makes a valuable contribution to the field. Moreover, to pursue the relationship between the kissing spine and lower back pain, the authors think it is necessary to conduct research that identifies the cause of pain in patients using dynamic imaging methods such as functional brain imaging rather than biomechanical experiments using cadavers.

Conclusion

We prepared kissing spine models using lumbar vertebrae obtained from human cadavers and conducted biomechanical experiments. The Results indicated no apparent biomechanical effects of kissing between the spinous processes, such as changes in the flexural rigidity of the lumbar spine during extension, suggesting that the contact between the spinous processes has little involvement in the onset of lower back pain.

Abbreviations

ROM, Range of Motion; MRI, Magnetic Resonance Imaging.

Ethics Approval

This study was approved by the Ethical Committee for Human Research at Khon Kaen University (Approval no. HE611293).

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Disclosure

The authors report no conflicts of interest in this work.

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