Analysis of the Relationship between Facet Joint Angle Orientation and Lumbar Spine Canal Diameter with Respect to the Kinematics of the Lumbar Spinal Unit

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Introduction
Facet joint orientation has been described as a causative factor of lumbar spine degeneration. Some studies have suggested an association of sagittal facet orientation with degenerative spondylolisthesis. This study aimed to elucidate the relationship among facet orientation, kinematics of a functional spinal unit, and change in lumbar spine canal diameter in weight-bearing and flexion-extension positions by using the Kinetic MRI technology.

Material and Methods
Participants
From February 2006 to August 2007, 316 consecutive patients underwent lumbar spine Kinetic MRI; 305 (190 males and 115 females) had mild back pain associated with movement, with or without radiculopathy. Their mean age was 42.80 ± 12.70 years (range, 16–85 years).

Procedure
Patients were placed in upright axially loaded neutral position (T1- and T2-weighted images) and upright axially loaded flexion and extension positions (fast spin-echo T2-weighted images only). All radiological data (MRI) were obtained using computer-based measurements, and calculations were performed using an MRI analyzer Version 3 (Truemetric Corp., Bellflower, CA), which is an anatomical software in true MRI. Sagittal MR images were obtained in 3 positions—flexion, neutral, and extension—and midsagittal images were obtained in the position in which the spinal processes and vertebrae were most clearly visible.

Classification of study groups based on facet orientation
A facet line was drawn between the 2 margins of each of the articular facets on the T2-weighted axial images at the L4–L5 disc level. The facet angle between the facet and midsagittal lines was measured bilaterally. The mean facet angles on the right and left sides were 43.68 ± 10.46° and 43.77 ± 10.38°, respectively; the total mean angle was 43.73 ± 10.50°. Facet angle types were divided as follows on the basis of the facet angles: type A, narrow facet angle of <38.48° (average – 1/2 SD); type B, normal facet angle ranging from 38.48° (average – 1/2 SD) to <49.98° (average + 1/2 SD); type C, wide facet angle of >49.98° (average + 1/2 SD).

The participants were classified into 6 groups—AA, BB, CC, AB (BA), BC (CB), and AC (CA)—on the basis of the types of right and left facets.

Assessment of the degenerative changes in the functional lumbar spinal unit
Intervertebral disc degeneration and facet joint degeneration were independently graded by 3 spine surgeons (2 orthopedic surgeons and 1 neurosurgeon). Disc degeneration was classified into 5 grades on the basis of the T2-weighted sagittal images by following the grading system used by Pfirrmann et al. Facet joint degeneration was classified into 4 grades by using the method proposed by Fujiwara et al.

Results
Comparison among the study groups
The study groups were compared with respect to the number, sex, and age of the subjects, disc degeneration, and facet joint degeneration. No significant differences were observed among the groups.

Anatomical measurement of each parameter
No statistical differences were observed in the L4 and L5 anterior and posterior vertebral body heights. However, L4 and L5 canal diameters at the pedicle level were significantly smaller in Group AA than in Group BB (p < 0.05), while these were significantly larger in Group CC than in Group BB (p < 0.05).

Spinal canal diameter at the L4–L5 disc level
In all the groups, spinal canal diameter at the L4–L5 disc level tended to be larger in the flexion position than in the neutral position, while it tended to be smaller in the extension position than in the neutral position. Interestingly, spinal canal diameter at the L4–L5 disc level was significantly smaller in Group AA than in Group BB (p < 0.05), while it was significantly larger in Group CC than in Group BB in all 3 positions (p < 0.05).

Translational motion at the L4–L5 level in each group
The translational motion was significantly more in Group AA than in Group BB (p < 0.05), while it was significantly lesser in Group CC than in Group BB (p < 0.05). No statistical differences were observed in the translational motion between other groups and Group BB.

Disc bulging at the L4–L5 level in each group
In all the groups except Group CC, disc bulging tended to be lesser in the flexion position than in the neutral position, while it tended to be more in the extension position than in the neutral position in Group BB; however, there were no statistical differences in the L4 and L5 anterior and posterior vertebral body heights. With regard to kinematics, patients with coronally oriented facets had stable and wider osseous canals with mobility, implying that they may be predisposed to lumbar spine canal stenosis due to developmental and dynamic factors. However, patients with coronally oriented facets had stable and wider osseous canals, implying that they may be predisposed to lumbar spine canal stenosis due to static factors, e.g., osteophyte formation in the vertebral bodies and facet joints, disc bulging, and ligament flavum hypertrophy. In this study, we found that spinal canal diameter at the L4–L5 disc level with sagittally oriented facets was significantly smaller than that with normal facets, while it was significantly larger with coronally oriented facets than with normal facets in all 3 positions.

Discussion
It is important to consider the stage of disc and facet degeneration while studying spinal kinematics, because changes in these parameters influence the kinematics. Although, the present study was a retrospective cross-sectional study, we could differentiate almost the same degenerative stages.

Lumbar facet orientation is commonly discussed with regard to segmental instability and degenerative spondylolisthesis. We found that translational motion significantly increased in patients with sagittally oriented facets than in those with normal facets, while it significantly decreased in patients with coronally oriented facets than in those with normal facets.

Our anatomical measurements revealed that L4 and L5 canal diameters at the pedicle level were significantly smaller in Group AA than in Group BB, while they were significantly larger in Group CC than in Group BB; however, there were no statistical differences in the L4 and L5 anterior and posterior vertebral body heights. With regard to kinematics, patients with sagittally oriented facets had stable and wider osseous canals, implying that they may be predisposed to lumbar spine canal stenosis due to static factors, e.g., osteophyte formation in the vertebral bodies and facet joints, disc bulging, and ligament flavum hypertrophy. In this study, we found that spinal canal diameter at the L4–L5 disc level with sagittally oriented facets was significantly smaller than that with normal facets, while it was significantly larger with coronally oriented facets than with normal facets in all 3 positions.

Conclusively, we demonstrated the relationship between facet orientation and osseous canal diameter and that between facet orientation, kinematics of the lumbar spinal unit, and change in lumbar spinal canal diameter. Further, patients with sagittally oriented facets had narrow osseous canals with mobility, implying that they may be predisposed to lumbar spine canal stenosis due to static factors. However, association between the development of facets and spinal canal has not been elucidated in detail. Further studies are required to identify appropriate treatment methods for lumbar spine canal stenosis and degenerative lumbar spondylolisthesis.