Morphometric Analysis of the Intervertebral Foramen in Degenerative Lumbar Scoliosis by Multidetector-row Computed Tomography

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Introduction: Degenerative lumbar scoliosis (DLS) is commonly seen in elderly patients with sciatic pain. The degenerative processes, which cause stenosis of the intervertebral foramen, including disc bulging, facet arthritis, and ligamentum flavum hypertrophy contribute to the development of clinical symptoms in these patients. Pathoanatomical characteristics of nerve-root compression within the intervertebral foramen have been described in previous studies with conventional two-dimensional imaging. However, there has been no report that studied how intervertebral disc wedging, vertebral translation and axial rotation affect three-dimensional (3D) anatomy of the intervertebral foramen, from its inlet to outlet. The purpose of this study is to examine morphology of the lumbar intervertebral foramen in DLS, thereby elucidating correlation between lumbar spinal alignment and 3D multiplanar reconstructed images of the foramen by multi-detector row CT (MDCT).

Materials and Methods: Subjects were 51 females over 50 years of age with the diagnosis of DLS (Cobb angle over 10 degree on plain X-ray). All study participants provided informed consent, and the study design was approved by the institutional ethics review board. Total 306 foramina at bilateral L3-4, 4-5, 5-S levels were scanned with MDCT scanner (GE, Lightspeed-VCT64) and 3D-images were reconstructed with an image processing software (Real INTAGE, KGT). Two parameters, 1) the interval between anteroinferior base of the superior pedicle and the superior articular process of the inferior vertebra (P-SAP) that represent subluxation of the SAP, and 2) the cross-sectional foraminal area (FA), were measured at the inlet, the narrowest part and the outlet of the foramen. 3) The site of minimum P-SAP from the inlet of the foramen was defined as %minimum P-SAP (%mP-SAP). Furthermore, four parameters of lumbar alignment including the angle of intervertebral disc wedging (DW), the degree of lateral translation (LT), anteroposterior translation (APT) at L3-4, 4-5, 5-S on plain X-ray films, and the angle of vertebral rotation (VR) between superior and inferior vertebra on 3D-images, were measured. Correlations between parameters of lumbar alignment (DW, LT, APT, VR) and 3D-reconstructed parameters of foraminal (P-SAP, FA, %mP-SAP) at each level were analyzed using Pearson’s test.

Results: Mean P-SAP decreased at lower lumbar levels. On the other hand, mean FA was smallest at L4/5 level. Mean %mP-SAP averaged about 50% at each level.

1) P-SAP tended to decrease DW at the inlet (r=0.28) of L3/4, the inlet, the narrowest part (r=0.40, 0.29) of L4/5, inlet (r=0.26) of L5/S. LT was slightly correlated with P-SAP only at the narrowest part (r=0.21) of L4/5. A-PT was correlated with P-SAP at L3/4 (inlet, narrowest part, outlet, r=0.29, 0.21, 0.24), respectively), L4/5 (r=0.35, 0.36, 0.37), L5/S (r=0.47, 0.38, 0.24). VR tended to decrease P-SAP at only L4/5 (inlet, outlet, r=0.30, 0.41) in the concave side.

2) FA tended to decrease DW at L3/4 (inlet, narrowest part, outlet, r=0.44, 0.26, 0.17), L4/5 (r=0.36, 0.33, 0.22), L5/S (r=0.22, 0.20, 0.24) in the concave side. There was significant correlation between LT at L3 vertebra and FA at the concavity of L4/5 (inlet, narrowest part, outlet, r=0.42, 0.40, 0.22), likewise LT at L4 vertebra and FA at the concavity of L5/S(r=0.28, 0.25, 0.30). Significant correlation was found between VR at L3 and a decrease of FA at the concavity of L4/5 (inlet, narrowest part, outlet, r=0.49, 0.45, 0.32), likewise VR at L4 and a decrease of FA at concavity of L5/S (r=0.27, 0.26, 0.34).

3) %mP-SAP was correlated with the same side of lateral translation at L3 vertebra (r=0.20), vertebral rotation at L3 (r=0.24), concave side of L4/5 wedging (r=0.21).

Discussion: The results of the present study showed that analyzing MDCT data with 3D volume rendering is useful to quantify morphologic changes of foramen resulting from intervertebral wedging, translation, and rotation in DLS patients. Presence of intervertebral disc wedging appeared to be associated with the reduction in the cross-sectional foraminal area. SAP subluxation tended to be intensive in the concave side of intervertebral disc wedging, the same side of lateral, posterior translation, and vertebral rotation. Therefore, Intervertebral disc wedging with lateral or posterior translation and vertebral rotation are more likely to contribute to symptomatic foraminal lesions causing dynamic nerve-root compression in DLS patients. Also, intervertebral disc wedging was associated with lateral translation and vertebral rotation at the upper vertebra in the concave side. For assessing 3D deformity, Intervertebral disc wedging is thought to be a risk factor of foraminal stenosis due to SAP subluxation in DLS patients. These findings may provide further insight into the pathogenesis of DLS.