Dynamic Changes in Spinal Cord Compression by Cervical Ossification of the Posterior Longitudinal Ligament Evaluated by Kinematic Computed Tomography Myelogram

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Introduction: Both static compression of the spinal cord and dynamic factors are known to contribute to the progression of myelopathy in patients with cervical spondylotic myelopathy (CSM) and cervical ossification of the posterior longitudinal ligament (OPLL) (1). Previously, several studies have reported that kinematic (flexion-extension) magnetic resonance imaging (MRI) is a useful modality for investigating dynamic factors in patients with CSM (2). Other studies have shown the efficacy of kinematic computed tomography (CT) myelogram in the evaluation of dynamic changes in spinal cord compression in CSM patients (3).

Kinematic CT myelogram has several advantages over kinematic MRI: a shorter scanning time, a thinner axial slice thickness, and a high image resolution, particularly in bony compressive lesions. However, no studies have evaluated the dynamic factors in patients with OPLL using kinematic CT myelogram. In this study, we investigated the dynamic changes in spinal cord compression in OPLL patients using kinematic CT myelogram.

Methods: From 2008 to 2013, 51 consecutive OPLL patients (39 males, 12 females, 63.5±8.7 years old) who presented myelopathy were prospectively enrolled in this study. The study included 18 patients with segmental-type OPLL, 33 patients with mixed-type OPLL. Neurological dysfunction was assessed using the Japanese Orthopaedic Association (JOA) score. The occupying rate of the OPLL at the most compressed level was measured in the lateral X-ray as follows: thickness of the OPLL/anterior-posterior diameter of the spinal canal x100 (%). After injecting 15 ml of the contrast medium iohexol (Omnipaque, Daiichi Pharmaceutical Co.) into the lumbar cerebrospinal fluid space, a dynamic motion study was performed using multi-detector CT (Aquilion64, TOSHIBA Medical). The CT images were obtained both in neck flexion and extension positions to the greatest extent possible as limited by the patients. The scanning parameters were as follows: 120 kV, 100-300 mA, 0.5 mm thickness for slice data, and 0.5 mm thickness for reconstruction.

From the reconstructed CT images obtained with this method, the range of motion (ROM) at C2-7 from flexion to extension was measured in the mid-sagittal view. The segmental ROM and the anterior-posterior (A-P) diameter of the spinal cord were measured in the mid-sagittal view at the level of the greatest spinal cord compression by OPLL (Figure 1A). Additionally, the cross-sectional area (CSA) of the spinal cord was measured in the axial view at the most compressed level using image analysis software (Figure 1B) (Image J: NIH). The paired t-test, unpaired t-test, and Pearson’s correlation test were used for statistical analysis. P values <0.05 were considered significant.

Results: The JOA score of the neurological dysfunction of the patients included in this study was 10.8±2.4 points. The level of the greatest spinal cord compression by OPLL was C2/3 in 2 patients, C3/4 in 18 patients, C4/5 in 11 patients, C5/6 in 15 patients, and C6/7 in 5 patients. The occupying rate of the OPLL at the most compressed level was 47.1±12.7%. The mean ROM at C2-7 was 23.1±11.7 degrees and the segmental ROM at the most compressed level was 7.1±4.4 degrees. The A-P diameters of the spinal cord at the most compressed levels were significantly decreased during neck extension when compared to neck flexion (p<0.01) (Figure 2A, B). Similarly, the CSAs at the most compressed levels were also significantly decreased during neck extension when compared to flexion (p<0.01) (Figure 3A, B). In this kinematic analysis, the spinal cord was more compressed by OPLL in 86.3% (44/51) of the patients during neck extension (Figure 4A). No close correlation was found between the dynamic change rate of the CSA (flexion/extension) and the severity of neurological dysfunction (JOA score). The A-P diameter and the CSA of the spinal cord were decreased during neck flexion in 13.7% (7/51) of the patients (Figure 4B). Interestingly, all 7 of these patients had massive OPLL with a ≥60% occupying rate. The dynamic change rate of the CSA (flexion/extension) was significantly smaller in patients with a ≥60% OPLL occupying rate compared to the patients with a <60% OPLL occupying rate (p<0.01) (Figure 4C), suggesting that severe spinal cord compression during neck flexion tends to occur more frequently in patients with massive OPLL.

Discussion: Static spinal cord compression factors are important in the development of myelopathy in patients with OPLL, including the occupying rate of the spinal canal by OPLL and the residual space for the spinal cord. Previous studies have shown that patients develop myelopathy at high rates when the space available for the spinal cord was <6 mm. Dynamic factors are also known to contribute to the progression of myelopathy in patients with OPLL. While a larger ROM of the cervical spine is associated with the development of myelopathy, myelopathy does not often develop when the ROM of the cervical spine is highly restricted, suggesting that the dynamic factor also greatly contributes to the development of myelopathy.

In the present study, we evaluated the dynamic factors in OPLL patients using kinematic CT myelogram. In the functional images, spinal cord compression was increased during neck extension in most OPLL patients, similar to the findings in
previous studies evaluating CSM patients using kinematic MRI or CT myelogram. During neck extension, both anterior factors (e.g., OPLL) and posterior factors (e.g., buckling of the ligamentum flavum) contribute to increased spinal cord compression. However, greater levels of compression can be placed on the spinal cord during neck flexion when the patients have OPLL with a high occupying rate. In this study, increased compression was found during neck flexion in 7 out of 11 patients with >60% OPLL. In these patients, the anterior factor (i.e., massive OPLL) can greatly influence the pathogenesis of the increased compression during neck flexion. Previous studies have reported that the surgical outcome after posterior decompression (i.e., laminoplasty) is insufficient in OPLL patients with a large occupying rate, particularly for those with >60% OPLL (4). When surgically treated, posterior decompression, which only removes the posterior elements, can result in residual dynamic spinal cord compression by OPLL during neck flexion. Direct decompression through an anterior approach or posterior decompression with fusion may lead to better neurological recovery for the treatment of OPLL with a high occupying rate.

Significance: This is the first report evaluating the dynamic factors in the pathogenesis of myelopathy in patients with cervical OPLL using kinematic CT myelogram.

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References:
Fig4.