Three-dimensional evaluation of dynamic spinal motion during flexion and extension for adult spinal deformity with degenerative scoliosis

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INTRODUCTION: Adult spinal deformity(ASD) with degenerative scoliosis have three-dimensional(3D) deformity. ASD patients are aware of the symptoms when standing and tend to stoop with back pain, whereas the symptoms disappear when lying on a bed. In order to understand the pathology of ASD, it is important to evaluate the dynamic morphological change during standing and supine positions. But there are not many medical facilities which have devices that can scan 3D images in standing position, such as EOS or standing CT. So it is difficult to evaluate 3D morphological change during standing and supine position. The purpose of this study is to evaluate the relationship between flexion-extension CT images and standing-supine X-ray images about scoliotic curvature in ASD, and to evaluate the 3D morphological changes in flexion and extension position.
METHODS: Twenty-one ASD patients (mean age: 73.1 years, range 43–87 years; 17 women) who underwent surgical therapy were included. The Cobb angle was measured in the whole spine X-ray in the standing and supine positions. CT images were taken in flexion and extension in the supine position(Fig. 1), and the Cobb angle was measured for each. We examined the correlation between standing Cobb angle and flexion Cobb angle and the correlation between supine Cobb angle and extension Cobb angle. The axial rotation angle from T10 to S1 in flexion and extension position were measured in CT images. The axial intervertebral rotation angle(AIR) from T10/11 to L5/S1 in each position were calculated. About the adjacent vertebrae which had more than 3mm lateral translation in standing X-ray images, the degree of lateral translation(LT) in standing and supine position were measured in X-ray. We examined the correlation between the standing LT and flexion AIR and the correlation between the supine LT and extension AIR(Fig. 2).
RESULTS:
1. Correlation of Cobb angle in each position
The mean Cobb angle was 31.5° in the standing position, 24.4° in the supine position, 28.7° in flexion position, and 20.6°in extension position. There was a strong positive correlation between the standing Cobb angle and the flexion Cobb angle($r=0.92$, $p<0.001$). And also there was a strong positive correlation between the supine Cobb angle and the extension Cobb angle($r=0.87$, $p<0.001$).
2. Comparison of axial intervertebral rotation
The AIR was greater in flexion position(5.0°) than in extension position (3.7°) ($p<0.001$).
3. Correlation between lateral translation and axial intervertebral rotation
The LT was greater in standing position (8.2°) than in supine position (5.3°)($p<0.001$). The AIR was greater in flexion position(9.3°) than in extension position (6.6°) ($p<0.001$) . There was a strong positive correlation between the standing LT and flexion AIR($r=0.88$, $p<0.001$). The regression line between standing LT (x mm) and flexion AIR(y°) was $y=1.0049x-0.2526$($R^2=0.82$). And also there was a strong positive correlation between the supine LT and the extension AIR($r=0.84$, $p<0.001$)(Fig. 3) . The regression line between supine LT (x mm) and flexion AIR(y°) was $y = 1.1586x - 0.5966$($R^2=0.78$).
DISCUSSION:
According to these results, in ASD, the morphological change of scoliotic curvature in flexion and extension position would approximate that in standing and supine position. Then evaluating the CT images in flexion and extension position would be helpful to understand 3D morphological change during standing and supine position. And in this study, there was a strong positive correlation between LT and AIR. As the LT increased by 1mm, the AIR increased by approximately 1°. From this result, evaluation of LT in simple X-ray would be helpful to estimate the dynamic change about AIR.

SIGNIFICANCE/CLINICAL RELEVANCE: Evaluating the CT images in flexion and extension position would be helpful to understand 3D morphological change during standing and supine position. Evaluating LT in simple X-ray would be helpful to estimate the change of AIR during standing and supine position.

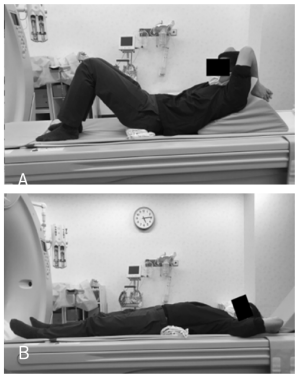

Fig1. Taking CT images in (A) flexion and (B) extension position

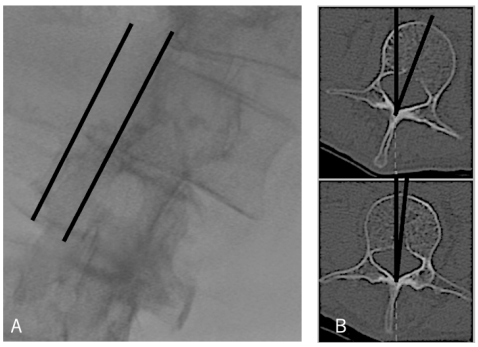

Fig2. (A) lateral translation (mm) and (B) axial intervertebral rotation angle (°)

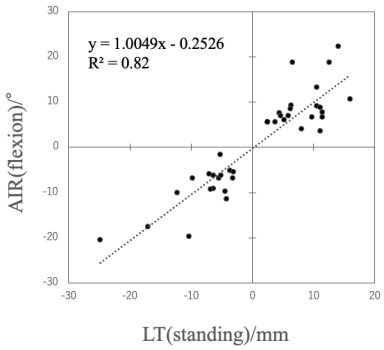

Fig3. Correlation between standing LT and flexion AIR