Relationship between rotational angle of vertebral body on frontal spinal X-ray and Cobb angle

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Abstract

We studied the relationship between the Cobb angle and the degree of spinal rotation measured by using a method that we developed, and we established an index of the degree of spinal rotation. The subjects were 39 patients with idiopathic scoliosis (two male, 37 female; age 16.1 ± 2.8 years). The focus of our measurements was the body of the apical vertebra of the vertebral curve. We used a method normally used to measure the ratio between heart and chest dimensions to measure the vertebral body rotation on frontal X-ray images. We determined the relationship between this average value and the average Cobb angle for statistical processing; this was performed in both the supine position and the standing position. No correlation was observed between the degree of vertebral body rotation and the Cobb angle in the supine position. ($r = 0.272$, $P < 0.09$). In the standing position the Cobb angle was 41.6° ± 8.0° and the degree of vertebral body rotation was 19.2% ± 7.2%. The two were significantly positively correlated ($r = 0.43$, $P < 0.01$). In scoliosis, the thorax on the convex side generally projects backward, and the projecting part decreases both lateral curvature and rotation when it touches the X-ray table. We are of the opinion that we failed to find a correlation in the supine position because of this difference in the flexibility of the thorax.

Introduction

Scoliosis was traditionally defined as a disease in which the spine curves laterally, but image analysis today has clarified that it is a three-dimensional rotation deformity. It is caused by various factors, and recent studies indicate that genes have something to do with its occurrence.[1), 2)] The prevalence of scoliosis is 1% to 2%, although this value varies among reports. Idiopathic scoliosis accounts for 80% to 90% of all scolioses. The prevalence of idiopathic scoliosis is high,

and it is especially high among adolescent female childrens. The most common form is a convexity of the thoracic vertebrae to the right side. There is always a vertebral rotation accompanied by secondary curvatures.[3] For this reason, primary physical examination requires postural observation and analysis from the feet to the top of the head three dimensionally. In addition, it is common to conduct a forward bending examination in both the standing position and the sitting position, to observe the backward displacement of the ribs caused by the spinal rotation, and to measure the angle of trunk rotation with the help of a scoliometer (Fig. 1).

For definitive diagnosis, we take a full-length X-ray image in the standing position. We can examine lateral curvature and rotation on a frontal X-ray image. In scoliosis curves, the apical vertebra is the point of the curve that projects most laterally. The inclination of the body of the apical vertebra is horizontal, and the rotation is maximal. The inclination of the other vertebral bodies increases gradually and craniocaudally. The vertebrae making up the sides of the curve are the transitional vertebrae, and the vertebral body that has the largest inclination, and where rotation is minimal, is called the end vertebra. Generally, to determine the degree of scoliosis we measure the degree of scoliosis (Cobb angle). The Cobb angle is the angle made by the superior margin of the upper end vertebra of the curve and the inferior margin of the lower end vertebra.

Figure1. angle of trunk rotation

We tend to focus on the Cobb angle as an indicator of the extent of scoliosis, but the degree of vertebral rotation is also very important. In general, we use the method developed by Nash and Moe,[4] which displays the degree of rotation as the degree of shadowing of left-right asymmetry of the vertebral pedicles on frontal X-rays (Fig. 2). This method, however, does not give detailed information on rotation because it only classifies the results into four stages. The method developed by Perdriolle[5] uses angles to measure rotation, but it cannot be used easily on digital images because we need to place the specialized template directly on to the X-ray image. Therefore, we have developed a method that allows us to figure out the angle of vertebral body easily by comparing

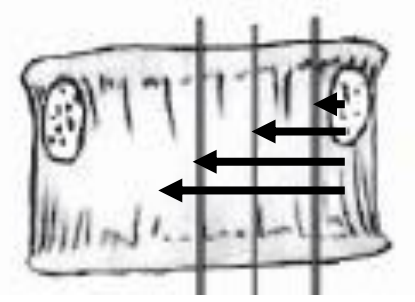

Figure2. degree of vertebral rotation (Nash and Moe)

CT images with an X-ray image of the front of the vertebral body, and we use it in our clinical practice.

The medical effects of exercise therapy for the treatment of idiopathic scoliosis have not been determined.[6] However, we use exercise therapy to improve lateral curvature and rotation of the spine. In clinical practice, we think that the pattern and degree of scoliosis vary with the individual, and no relationship exists between lateral curvature and the degree of rotation. We therefore studied the relationship between Cobb angle and vertebral rotation in both the supine position and the standing position by using the method of measuring rotation that we developed. Our aim was to study the characteristics of changes in alignment of the thoracic vertebrae of patients with idiopathic scoliosis in the frontal and horizontal planes with a view to applying these characteristics to exercise therapy. Here, we report our research results.

Subjects

The subjects were 39 patients with idiopathic scoliosis (two male, 37 female; age 16.1 ± 2.8 years). The apical vertebra in one patient was the fifth thoracic vertebra; in eight it was the sixth thoracic vertebra; in 20 the eighth thoracic vertebra, in nine the ninth thoracic vertebra, and in one the 10th thoracic vertebra. In one of the 39 patients the convexity was to the left, and in the remaining 38 it was to the right. For our research we used X-rays taken as part of the patient workup, and no surgery was performed especially for our research purposes. We made every possible effort to prevent the identification of personal information.

Methods

We used frontal spinal X-ray images taken on the same day to measure Cobb angles and rotation angles, and measured them on a digital screen.

The Cobb angle was measured as follows: We drew a line parallel to the upper border of the highest vertebral body of the thoracic curve and another line parallel to the lower border of the lowest vertebral body of the curve, and we extended these lines to make them intersect. The resulting angle was then measured.

To measure rotation angles we used a method designed originally for measuring cardiothoracic ratio. In the case of a vertebral body that rotated rightward, we divided the distance between the right edge of the vertebral body and the center of the right pedicle of the vertebral arch (a) by the distance between the two edges of the vertebral body (b), and we expressed the value as a percentage (hereafter referred to as the degree of rotation of the vertebral body) (Fig. 3). The same examiner measured

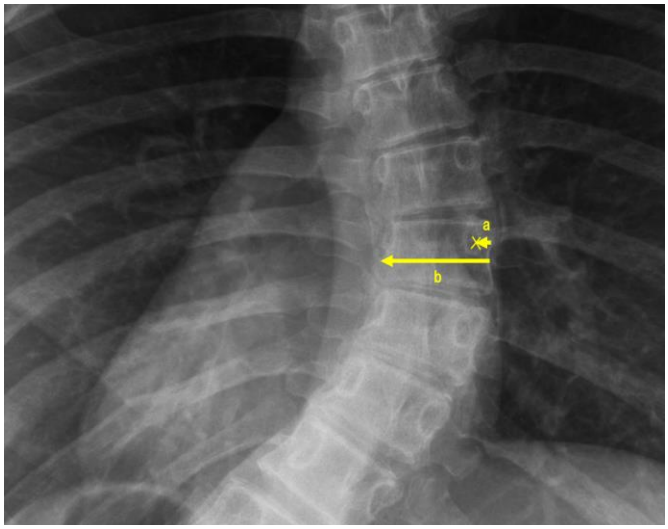

Figure3. degree of rotation of the vertebral body

the Cobb angle and the degree of rotation of the vertebral body three times, and we adopted the averages of the three values. We used SPSS (version 21.0, IBM) and set the significance level at 1%. We used the intraclass correlation coefficient to examine the reliability of the examiners. We used Pearson's coefficient of correlation to figure out the relationships between each Cobb angle and rotation angle of the vertebral body measured in both the supine position and the standing position.

Results

In the supine position, the Cobb angle was 33.3° ± 6.0° and the degree of rotation of the vertebral body was 17.9% ± 6.2%; no correlation was observed ($r = 0.272$, $P < 0.09$) (Fig. 4a). In the standing position, the Cobb angle was 41.6° ± 8.0° and the vertebral rotation was 19.2% ± 7.2%; there was a significant positive correlation between the two ($r = 0.43$, $P < 0.01$) (Fig. 4b).

Discussion

Scoliosis is a generic term for the condition in which the spine bends laterally while rotating for some reason; it is caused not by one disease but by a wide variety of diseases. Scoliosis observed in children is usually classified into three kinds: idiopathic scoliosis, which is frequently found among slender girls, inborn scoliosis caused by abnormal vertebral shape, and syndromic scoliosis caused by various syndromes.7) Scoliotic deformity is classified into functional and structural, each of which has its own treatment. Functional scoliosis arises for some reason and is sometimes temporary. Characteristically, it has neither rotation deformity nor wedge-shaped deformity.1) On the other hand, in the case of structural scoliosis, the deformity can be observed in the connective tissue, cartilage, and bone, and vertebral body rotation and wedge-shaped deformity can be observed. Structural scoliosis is classified into two kinds: One arises for known reasons, and the other for unknown reasons. The latter is called idiopathic scoliosis; that is, idiopathic scoliosis is a disease in which the spine deforms for unknown reasons. In Japan, both orthotic treatment and operative treatment are used effectively, and a wait-

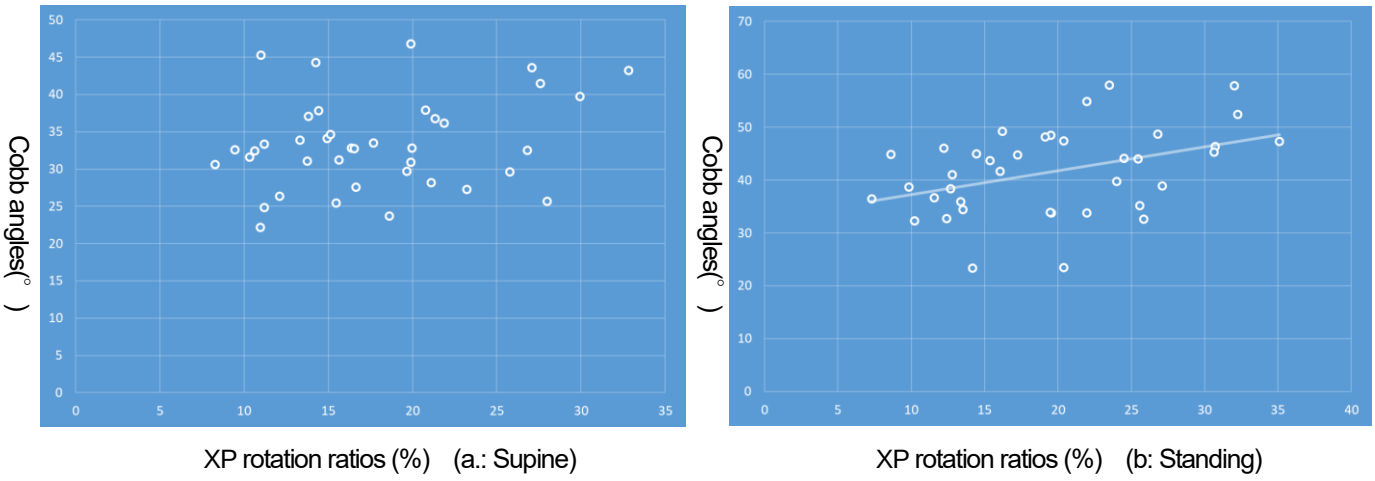

Figure4. Correlation between Cobb angles and XP rotation ratios

and-see approach is taken for mild spinal deformity. The Cobb angle is frequently used to select between orthotic treatment and operative treatment, and the rotation angle is not emphasized.

However, scoliosis is not formed simply by vertebral column flexion but by a coupling motion: Rotation and lateral curvature occur simultaneously. Because scoliosis includes vertebral torsion,9) both rotation and the lateral curvature angle should be examined. In clinical settings, a scoliometer placed on the patient's skin is used to measure the vertebral body rotation angle. This value does not increase with increasing Cobb angle. It is therefore vital to measure both lateral side curvature and the rotation angle to follow up scoliosis patients.

In this research, we did not observe a correlation between lateral curvature and vertebral rotation on frontal X-ray images in the supine position, but we found a positive correlation between the two in the standing position. We have in fact learned that a patient whose scoliosis is serious enough to necessitate surgery has a certain relationship between the Cobb angle and the degree of rotation of the thoracic vertebrae. Tyrakowski at al.10) stated that the Cobb angle as measured on X-rays was positively correlated with the angle of trunk rotation and the rib hump elevation as an indicator of the rotation angle of the spine. This leads us to surmise that a large rotation angle means a large Cobb angle; that is, we surmise that there was no correlation in the supine position because the thoracic vertebrae on the convex side generally project backward in scoliosis, decreasing the rotation when the convexity touches the X-ray table.

No evidence exists regarding the effectiveness of the exercise treatment applied by physical therapists, although the exercise treatments epitomized by the Schroth method and Pilates, which focus on stretching of the trunk, have been practiced lately.7) Because no definitive effect has been established, exercise treatment is rarely practiced for idiopathic scoliosis. However, Karu and others8) recently reported that they decreased the Cobb angle by 2.53° and the rotation angle by 4.23° by applying the Schroth method for 6 weeks (three times a week at 1.5 h per treatment). As this case shows, it is important to examine improvements in scoliosis and rotation independently. Idiopathic scoliosis is a spinal deformity caused by a coupling motion in which rotation and lateral curvature arise at the same time, and the deformity grows more complicated with the progress of the disease.

In a greatly curved spine, the spinous processes rotate and deviate to the concave side, whereas the vertebral bodies rotate to the convex side. The results of this study suggest that the greater the Cobb angle in the frontal plane, the greater the rotation angle of the vertebral body. Taking this into consideration, we need to keep monitoring, and applying exercise treatment for, lateral curvature and rotation simultaneously, instead of treating each of these independently.

Conclusion

For comprehensive treatment it is imperative that we understand and treat three-dimensional spinal deformity in idiopathic scoliosis. We devised a method of measuring

vertebral body rotation by using plain X-rays as a simplified way of assessing serious scoliosis. In future, we intend to further explore the relationship between Cobb angle and vertebral body rotation angle.We have no conflict of interest to disclose in regard to publication of this paper.

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