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Case Series

A Preliminary Study of Estimation of Cobb's Angle From the Spinous Process Angle Using a Clinical Ultrasound Method

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Abstract

Background: Over a lifetime of having radiographs, a patient with adolescent idiopathic scoliosis (AIS) can be cumulatively exposed to high doses of ionizing radiation. Therefore, radiation-free, effective, and low-cost methods to screen and diagnose scoliosis have been sought for years.
Purpose: This study aims to investigate the correlation between the Cobb's angle and the spinous process angle (SPA) and to study the feasibility of using clinical ultrasound images to estimate the Cobb's angle by measuring the SPA.
Study Design: This manuscript includes a retrospective and a prospective study.
Methods: In the retrospective study, radiographs from 43 subjects with AIS were used to investigate the correlation between the Cobb's angle and the SPA at the pre-brace and in-brace stages. Following this study, a prospective clinical ultrasound study was conducted on 33 subjects with AIS at the pre-brace stage to measure the SPA.
Results: High intra-rater and inter-rater reliabilities of radiograph measurements were found (ICC[3,3] = 0.97, ICC[2,3] = 0.91, $p < .05$). The clinical ultrasound measurements were also found to be highly reliable (ICC[3,3] = 0.91, $p < .05$). There was a significant correlation ($r = 0.80$ at the pre-brace stage and $r = 0.87$ at the in-brace stage, $p < .05$) between the Cobb's angle and the SPA measured from the radiograph measurements, whereas the SPA measured from ultrasound images were found highly correlated with that measured from the radiographs at the pre-brace stage ($r = 0.90$, $p < .01$).
Conclusions: The findings of this study could support the new parameter (SPA) in the estimation of the Cobb's angle of a scoliotic curve in the coronal plane, and clinical ultrasound imaging could be developed and applied to assess scoliosis in a fast and noninvasive fashion.
Level of Evidence: Level III.

Keywords: Adolescent idiopathic scoliosis; Cobb's angle; Spinous process angle; Clinical ultrasound

Background

Scoliosis is considered to be a three-dimensional (3D) spinal deformity with lateral curvature and vertebral rotation [1-7]. Most cases have an unknown cause and are found in adolescence; thus, it is termed adolescent idiopathic scoliosis (AIS). The prevalence of AIS has been reported from 2% to 4% [8], and the estimated figure in Hong Kong is around 2.5% (3.59% for girls and 1.34% for boys) according to a retrospective cohort study conducted to investigate the school scoliosis screening program [9,10], which screened 115,190 students in 1995 and traced their medical records until they reached 19 years old.

Routine radiographs are required to monitor and diagnose the progression of scoliosis as often as three to four times per year in patients at high risk of progression. Although Cobb's angle measured from radiography is a

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standard way to diagnose scoliosis, assess the severity of the deformity, and evaluate the curve progression, over a lifetime of having radiographs, a scoliosis patient can be cumulatively exposed to high doses of ionizing radiation [11-13]. In particular, radiography exposes sensitive breast tissues to ionizing radiation. Females comprise about 80% of cases followed for scoliosis. The breast cancer rate has been reported to be higher in females who have been followed for scoliosis [14,15]. Thus, any technique for imaging the spine that can potentially minimize an individual's exposure to radiation should be investigated.

The spinous process angle (SPA) was suggested to measure scoliotic curves via identifying the spinous processes of all the vertebrae along the curve and then drawing lines to join all the tips of spinous processes. Every two points form a line and every two lines form an angle. The summation of all the angle values becomes the SPA. With reference to Herzenberg's finding [16], there is a high correlation between the Cobb's angle and the SPA (coefficient of determination=0.903), and a conversion formula has been developed ($y = -1.0404 + 0.74813x$, where $y =$ SPA, and $x =$ Cobb's angle). The above formula would be verified in this study.

Clinical ultrasound is a widely used and established technology in the medical field. Nowadays, using clinical ultrasound to image spine has become popular because of increased concerns with excessive radiation exposure to the patients with scoliosis, especially among children. Clinical ultrasound is considered to offer comparable imaging in detecting posterior arch of the spine with either CT or MRI in transverse plane [17-21]. Suzuki et al. [22] investigated the use of ultrasound to measure vertebral rotation in patients with scoliosis, though their procedure required the patients to lie in the prone position and the transducer was placed according to the tilting of each vertebral body. Thus, clinical ultrasound is feasible in detecting the spinous process and being applied to measure the SPA.

This study aims to investigate the correlation between the Cobb's angle and SPA in the radiographs of patients with AIS, and then based on the findings, to study the feasibility of using clinical ultrasound images to estimate the Cobb's angle via measuring the SPA.

Methods

Retrospective radiographic study

The correlation between the Cobb's angle and the SPA measured from the radiographs were examined in this study. The data were obtained retrospectively from a scoliosis clinic. The subject selection criteria were as follows: (1) female subjects with AIS; 2) Cobb's angle: 10°–40°; 3) age: 9–14; 4) Risser's sign: ⩽ 2.

In this study, the quality of the digital radiographs was not adequate for distinguishing all the spinous processes. As a result, Photoshop (CS2 version, Adobe Systems Inc., San Jose, CA) was used to process all the radiographs,

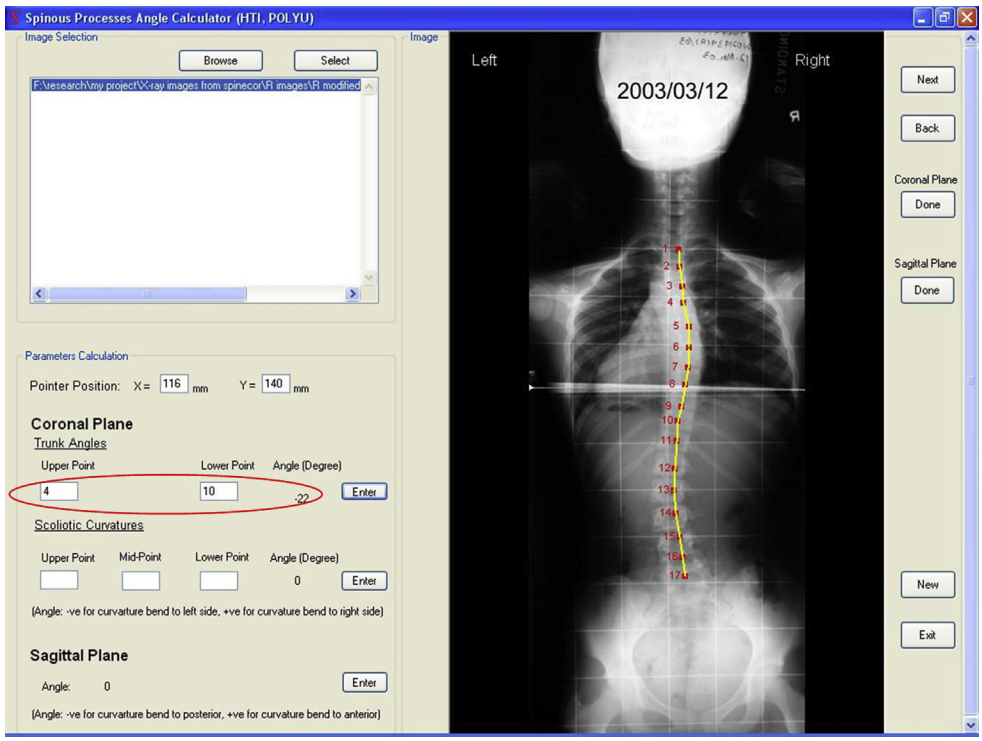

Fig. 1. Spinous process angle calculator for measurements of SPA from radiograph.