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Clinical Study

Reliability of a new method for measuring coronal trunk imbalance, the axis-line-angle technique

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Abstract

BACKGROUND CONTEXT: Accurate determination of the extent of trunk imbalance in the coronal plane plays a key role in an evaluation of patients with trunk imbalance, such as patients with adolescent idiopathic scoliosis. An established, widely used practice in evaluating trunk imbalance is to drop a plumb line from the C7 vertebra to a key reference axis, the central sacral vertical line (CSVL) in full-spine standing anterioposterior radiographs, and measuring the distance between them, the C7–CSVL. However, measuring the CSVL is subject to intraobserver differences, is error-prone, and is of poor reliability. Therefore, the development of a different way to measure trunk imbalance is needed.

PURPOSE: This study aimed to describe a new method to measure coronal trunk imbalance, the axis-line-angle technique (ALAT), which measures the angle at the intersection between the C7 plumb line and an axis line drawn from the vertebral centroid of the C7 to the middle of the superior border of the symphysis pubis, and to compare the reliability of the ALAT with that of the C7–CSVL.

STUDY DESIGN/SETTING: A prospective study at a university hospital was used.

PATIENT SAMPLE: The patient sample consisted of sixty-nine consecutively enrolled men and women patients, aged 10–18 years, who had trunk imbalance defined as C7–CSVL longer than 20 mm on computed full-spine standing anterioposterior radiographs.

OUTCOME MEASURES: Data were analyzed to determine the correlation between C7–CSVL and ALAT measurements and to determine intraobserver and interobserver reliabilities.

METHODS: Using a picture archiving and communication system, three radiologists independently evaluated trunk imbalance on the 69 computed radiographs by measuring the C7–CSVL and by measuring the angle determined by the ALAT. Data were analyzed to determine the correlations between the two measures of trunk imbalance, and to determine intraobserver and interobserver reliabilities of each of them.

RESULTS: Overall results from the measurements by the C7–CSVL and the ALAT were significantly moderately correlated. Intraobserver assessments by measuring the C7–CSVL and by doing the ALAT failed to find any significant differences between the findings from the first and second assessments by the same radiologist. Interobserver assessments significantly differed between radiologists 1 and 2 for the first assessment measuring the C7–CSVL, and between radiologists 2 and 3 for the second assessment measuring the C7–CSVL. Interobserver assessments by doing the ALAT failed to find any significant differences among the three radiologists for either of the two assessments.

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CONCLUSIONS: Our results indicated that using the ALAT, which is simple and convenient, is of great value in measuring trunk imbalance. For measuring trunk imbalance, the ALAT has essential advantages compared with measuring the C7–CSVL. We encourage spine surgeons to consider using the ALAT in evaluating trunk imbalance.

Keywords: Central sacral vertical line; Coronal trunk imbalance; C7–CSVL; Intraobserver reliability; Interobserver reliability; Radiology

Introduction

Trunk balance, including global and regional balance, refers to the results of coordination of different parts (shoulder, spine, pelvis) of the body to achieve the balance. It is the manifestation of a postural strategy conditioned by anatomic and functional characteristics [1]. When a person is standing up straight with the legs fully extended, the head should usually be centered over the pelvis when viewed from the front.

Trunk imbalance presents as spine inclination, as the head tilting over the center of the pelvis, or as unequal heights of the shoulders or of the sides of the pelvis. It is evaluated clinically by measuring trunk shift over the central sacral line. A widely used practice to evaluate trunk imbalance is to drop a plumb line from the C7 vertebra to a key reference axis, the central sacral vertical line (CSVL) in full-spine standing anterioposterior radiographs, and measuring the distance between them, the C7–CSVL, as defined by the Scoliosis Research Society [2] and such as done previously [3–5].

A trunk shift noted on physical examination or radiologically that exceeds 20 mm has been considered as trunk imbalance [3–5], which is caused by many disorders, such as spinal curvature, leg length discrepancy, spine fracture and pelvic obliquity, and the most common cause, scoliosis [6]. The CSVL also plays a significant role in the Lenke classification of the lumbar modifier (A, B, C) [7]. However, Sangole and colleagues [8] reported substantial intraobserver differences in repeated drawings of the CSVL. Furthermore, Thawrani et al. [9] found that drawing the CSVL is error-prone and of poor reliability.

Scoliosis is well correlated with left-right trunk imbalance, and scoliotic curve progression induces changes in the morphology of the spine and the trunk [10]. Also, trunk deformity is closely related to scoliotic deformity in both the thoracic and thoracolumbar curves [11]. Eighty percent of cases of idiopathic scoliosis occur in adolescents, and the risk of idiopathic scoliosis in 10- to 16-year-old adolescents is 1%–3% [12–16]. Thus, trunk imbalance is fairly common in patients with adolescent idiopathic scoliosis. Especially for adolescents, trunk imbalance in scoliosis contributes to disturbance of body morphology, loss of self-confidence, depression, and impaired breathing [17].

The purpose of treatment for scoliosis is to gain correction, achieve stability, and restore and maintain balance. Treatment includes physical therapy and corrective bracing or surgery, and each treatment has its advantages and disadvantages. For example, surgery can result in substantially reduced pain and decreased disability [18–22]. However, postsurgical coronal decompensation occurred in as many as 41% of patients in two series [23,24]. Fischer and Kim [25] indicated that in selective thoracic fusion, coronal trunk imbalance is a greater risk than sagittal imbalance. Therefore, accurate assessment of trunk imbalance is greatly important in treatment decision-making.

Grivas et al. [26] reported that of about 3,550 school students ages 6- to 18-years old, the trunk inclination angle was ≥7° in about 320 (9%; including about 55 with scoliosis and about 265 without). The widely used three-dimensional orthopedic spine system has obviously improved curvature correction [25], whereas improper use or inappropriate choice of fusion vertebra might result in trunk imbalance [27]. Liu et al. [28] demonstrated that postoperative coronal balance is significantly associated with preoperative coronal balance. Therefore, in cases of spinal curvature, accurate evaluation of trunk imbalance is essential for deciding on treatment and determining the likely prognosis.

We have been investigating measures in evaluating and treating scoliosis. In our previous study, we [29] introduced a method—the axis-line-distance technique—in which an axis line is drawn from the vertebral centroid of C7 to the middle of the superior border of the symphysis pubis, and the distance between this axis line and the center of the curved vertebrae was used to assess the extent of spinal curvature measured. We found that this technique was more reliable, reproducible, straightforward, and less error-prone than the Cobb method for measurements of spinal curvature [29]. We also found that it was better than the Cobb method for therapeutic evaluation of scoliosis during treatment and at follow-up visits [30]. Inasmuch as we take it as a given that incorrect measurements inevitably lead to less reliable assessments of trunk imbalance, we developed a new technique for assessing coronal trunk imbalance—the axis-line-angle technique (ALAT)—and we compared its reliability with an established technique, that is, measuring the C7–CSVL. We report on our findings here.

Materials and methods

Subjects

The study was approved (8657788002560) by the institutional review board of the Second Affiliated Hospital of Wenzhou Medical University, and the patients provided informed consent. From January 2012 to December 2013, patients of either sex, aged 10–18 years, and having trunk imbalance, defined as C7–CSVL longer than 20 mm, were