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Clinical Study

Axial plane analysis of Lenke 1A adolescent idiopathic scoliosis as an aid to identify curve characteristics

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Abstract

BACKGROUND CONTEXT: Adolescent idiopathic scoliosis (AIS) is a complex three-dimensional (3D) deformity of the spine involving deviations in the frontal plane, modifications of the sagittal profile, and rotations in the transverse plane. Although Lenke classification system is based on 2D radiographs and includes sagittal thoracic and coronal lumbar modifiers, Lenke et al. suggested inclusion of axial thoracic and lumbar modifiers in the analysis.

PURPOSE: To analyze axial plane of Lenke 1A curves to identify curve characteristics.

STUDY DESIGN: Retrospective study.

PATIENT SAMPLE: Seventy patients (49 women, 21 men) with Lenke Type 1A idiopathic scoliosis were analyzed.

OUTCOME MEASURES: Coronal, sagittal, and axial parameters were measured from plain radiographs that were obtained at initial medical examination of the patients.

METHODS: Coronal and sagittal plane and whole spine segmental vertebra rotations from thoracic 1 to lumbar 5 were evaluated in 70 AIS patients with Lenke 1A curves by using Drerup method. Three different subgroups were identified according to magnitude and direction of lower end vertebra (LEV) rotation.

RESULTS: In Group 1 (Lenke 1A1), the direction of LEV rotation was same with other vertebrae in the main curve and the magnitude of the LEV rotation was less than −0.5°. In Group 2 (Lenke 1A2), the rotation of LEV was between −0.5° and 0.5° and so was accepted as neutral. In Group 3 (Lenke 1A3), the rotation of LEV had opposite direction with vertebrae in the main curve and the magnitude of LEV rotation was more than 0.5°. The mean thoracic Cobb angle of patients with Lenke 1A idiopathic scoliosis was 51.1° (range 37°–80°), whereas the mean lumbar Cobb angle was 16.4° (range 0°–32°). The mean angle of trunk rotation of the patients was 5.7° (range 1°–16°). In terms of maximum thoracic vertebra rotation, the mean rotation angle of Lenke 1A idiopathic curves was −18.9° (range −(9.8°–44.7°)). The mean maximum lumbar vertebra rotation was 4.5° (range −7.2° to 15.1°).

CONCLUSIONS: Addition of axial plane analysis to conventional coronal and sagittal evaluations in patients with Lenke 1A curves may reveal inherent structural differences that are not apparent in single planar radiographic assessments and may necessitate a different surgical strategy.

Keywords: Lenke 1A; Idiopathic scoliosis; Lower end vertebra; Axial plane analysis; Vertebra rotation; Trunk rotation

Introduction

Adolescent idiopathic scoliosis (AIS) is a complex three-dimensional (3D) deformity of the spine involving deviations in the frontal plane, modifications of the sagittal profile, and rotations in the transverse plane [1–3]. Because of this altered morphology, axial plane analysis became popular [4–9]. Because Cobb [10] and Nash and Moe [11] presented documented methods for the measurement of

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axial vertebral rotation in coronal radiographic images, studies aimed to evaluate vertebra rotation using plain radiographs [4,5,7,9,12,13], 3D bone models [8,14], rasterstereography [15–17], and computed tomography (CT) [18–21].

Although Lenke classification system is based on 2D radiographs and includes sagittal thoracic and coronal lumbar modifiers, Lenke et al. suggested inclusion of axial thoracic and lumbar modifiers in the analysis [22]. Notwithstanding all previous studies had sufficient data regarding vertebra rotation in patients with AIS, none of them mentioned vertebral rotation with respect to the curve type in AIS.

The Lenke classification consists of six curve types, a lumbar spine modifier, and a sagittal thoracic modifier. The Lenke 1A curve was reported to be the most frequently evaluated curve type with a range of 25% of adolescent idiopathic curves [22]. According to our hypotheses, Lenke 1A curves differ from each other with respect to magnitude of segmental rotation of vertebrae although curves in this group have similar coronal and sagittal curve characteristics. Also these rotational differences may give ideas to surgeons whether requirement of different surgical strategies to avoid early and/or late postoperative complications. In this study, axial plane of Lenke 1A curves were analyzed by using Drerup method [12,13] to identify curve characteristics that would help determine optimum surgical correction strategies.

Materials and methods

A retrospective review of radiographs of patients with AIS at a single center was performed. Seventy patients who had Lenke Type 1A curves with Cobb angles between 30° and 80° were included in the present study. Patients with nonidiopathic or other types of idiopathic scoliosis, patients older than 40 years, and patients who had a previous surgery were excluded.

X-ray and digital technique

The anteroposterior standing whole spine radiograph was taken with the tube 1.5 m from the patient with the arms lying comfortably at the sides. The hips were in slight external rotation with the big toe pointing 15° outward. The heels were 20 cm apart. The lateral radiograph was taken with the tube 2 m from the patient whose arms were folded in front. The radiograms were scanned to a computer workstation by using a transparent media scanner (Mikrotek Scan Maker 9800XL Plus, Mikrotek®, Hsinchu, Taiwan). Digital software (Canvas 9.0, ACD Systems International Inc, Miami, Florida, USA) was used for analyzing the measurements.

Curve classification

All curves were classified as Lenke Type 1A according to the Lenke classification system; Type 1 is the main thoracic curve, and the proximal thoracic and thoracolumbar/lumbar curves are minor nonstructural curves. The lumbar modifier A is used when the center sacral vertical line runs between the lumbar pedicles and the level of the stable vertebra (SV). The curve must have a thoracic apex at or cephalad to the eleventh and twelfth thoracic disc levels. Therefore, modifier A can be used only for a main thoracic curve. It should also not be used when the center sacral vertical line falls directly against the medial aspect of the lumbar apical pedicle [22].

Clinical measurement and radiological analysis of rotation

The angle of trunk rotation (ATR) of all patients were assessed at our department using the same scoliometer (Orthopedic Systems, Inc., Hayward, CA, USA). The patients were instructed to bend forward, standing with their feet together, their knees straight, and their arms dependent with hands together, palms and fingers in opposition. The examiner obtained scoliometer measurements over the prominence of the curve in the thoracic regions.

The radiographic measurements included coronal Cobb angle of the structural curve (thoracic curve), the nonstructural curve (lumbar curve), and the T5–T12 thoracic sagittal Cobb angle (kyphosis angle). Also the upper end vertebrae (UEV) and lower end vertebra (LEV), number of vertebrae in the main curve, and the apical region of the thoracic curve were noted. The degree of vertebral rotation was measured twice at each level from T1 to L5 independently by two authors (HA, MEI) at the different time periods using the technique described subsequently, and the mean values were accepted.

Axial plane analysis was performed with the method described by Drerup [12,13]. Drerup improved the Nash-Moe method by modifying the measurement of the position of the anatomic landmarks, that is, the projections of vertebral pedicles. By using known predefined vertebral shape parameters, namely, the distance from the pedicle to the vertebral body center, a trigonometrical model was used to measure the axial vertebral rotation [23]. According to the Drerup method, the width of the vertebral body (d) was measured and the midpoint of vertebra was detected (d/2). Then the medial borders of both pedicles were marked, and a line was drawn from this point perpendicularly to line "d." The distance from the medial border of the convex-sided pedicle and the point of d/2 was measured as "S1," and the distance between the medial border of the concave-sided pedicle and the point of d/2 was measured as "S2" (Fig. 1). All measures were given in the same unit, that is, either millimeter or centimeter. In general, that is, if rotation angles were not too small, S1 was positive and S2 was negative. Microsoft Office Excel 2007 was used for mathematical application of the Drerup formula. All measured data were written to defined columns in Excel to find vertebra rotations per level from T1 to L5, and also rotational curve of the patients was obtained by using scatter chart tool of Microsoft Office Excel 2007. Rotation of the anterior part of