Observational Study

Medicine® OPEN

The radiographic parameter risk factors of rapid curve progression in Lenke 5 and 6 adolescent idiopathic scoliosis

A retrospective study

Zhikun Li, MD[a,*], Gengwu Li, MD[b], Chao Chen, MD[a], Yifan Li, MD[a], Changwei Yang, MD[c], Ming Li, MD[c], Wei Xu, MD[a], Xiaodong Zhu, MD, PhD[a,b,*]

Abstract

Various parameters related to growth and maturity have been shown to be risk factors for scoliosis curve progression. We previously identified correlations between curve progression and radiographic parameters in clinical practice, but there is a lack of research.

The aim of this study was to investigate and identify the radiographic parameters that are risk factors for rapid curve progression in Lenke 5 or 6 adolescent idiopathic scoliosis (AIS).

A retrospective review of patients who were prospectively enrolled at the initiation of brace wear and followed through completion of bracing or surgery was performed. The inclusion criteria were as follows: a Lenke type 5 or 6 classification, Risser sign grade 0 or 1 at the initial outpatient examination, a follow-up period of 6 months including a minimum of 4 follow-ups, At each visit, the whole spine x-ray was completed, the following data were measured and collected: angle of the lumbar curve (LC), rotation of the apical vertebra (RAV) in the LC, deviation of the apical vertebra (DAV) in the lumbar curve, clavicle angle, L5 tilt angle (TA), body mass index, flexibility of the LC (FLC), and peak angle velocity (PAV). A binary logistic regression analysis was used to assess the contribution of each variable to PAV onset. The touch types for the determination of the lowest instrumented vertebra (LIV) were compared at both the PAV and final follow-up.

Thirty-six AIS patients were recruited. The binary logistic regression model indicated that the following variable values significantly contributed to a high risk of PAV occurrence: LC ≥30° (OR = 6.153, 95%CI = 1.683–22.488, P = .006), RAV ≥III (OR = 15.484, 95% CI = 4.535–52.865, P < .001), DAV ≥40 mm (OR = 8.599, 95%CI = 2.483–29.784, P < .001), and TA ≥10° (OR = 2.223, 95%CI = 3.094–27.563, P < .001). The touch types for LIV determination changed in 12 of 36 patients, with at least 1 segment added as the LIV between the PAV and the final visit.

LC ≥30°, RAV ≥III, DAV ≥40 mm, and L5 TA≥10° were radiographic parameters associated with an increased risk of curve progression in Lenke 5 and 6 AIS. The orthopedic surgery performed at the PAV is the ideal timing, and it will preserve 1 active segment than later surgery.

Level of evidence was 4.

Abbreviations: AIS = adolescent idiopathic scoliosis, AP = anteroposterior, AV = angle velocity, BMI = body mass index, CA = clavicle angle, CI = confidence interval, CSVL = center sacrum vertical line, DAV = deviation of the apical vertebra, DSA = digital skeletal age, FLC = flexibility of the lumbar curve, IS = idiopathic scoliosis, LC = lumbar curve, LIV = lowest instrumented vertebra, MRI = magnetic resonance imaging, OR = odds ratio, PASC = picture archiving and communication systems, PAV = peak angle velocity, RAV = rotation of the apical vertebra, TA = tilt angle.

Keywords: curve progression, idiopathic scoliosis, peak angle velocity, radiographic parameters

Editor: Ou Liu.

WX and LG contributed equally to this work and should be considered co-first authors.

Funding: Health development planning commission of Changning in Changhai, Li Zhikun, 20164Y003; Scientific Research Funds of Shanghai Tongren hospital,Li Zhikun,TRYJ201605.

The authors have no conflicts of interest to disclose.

[a] Department of Orthopedics, Tongren Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, [b] Department of Orthopedics, Panzhihua Central Hospital, Panzhihua, Sichuan Province, [c] Department of Orthopedics, Changhai Hospital, Second Military Medical University, Shanghai, People's Republic of China.

[*] Correspondence: Zhikun Li and Xiaodong Zhu, Tongren Hospital, Shanghai Jiao Tong University School of Medicine, 1111 XianXia Road, Shanghai 200336, China (e-mails: scoliosis_lizk@126.com; scoliosis_zhuxd@126.com).

Medicine (2017) 96:52(e9425)

Received: 22 March 2017 / Received in final form: 15 November 2017 / Accepted: 30 November 2017

http://dx.doi.org/10.1097/MD.0000000000009425

1. Introduction

Idiopathic scoliosis is scoliosis, that is, lateral curvature of the spine, is a structural alteration that occurs under a variety of conditions, for which there is no definite etiology, unlike neuromuscular, congenital, or syndromic types. And adolescent idiopathic scoliosis (AIS), which is IS at age ≥10 years, is the most common form of IS, accounting for between 80% and 85% of cases. There are many methods of AIS classification, but Lenke classification is the most classic, it was developed in 2001 to provide a comprehensive and reliable means to categorize and guide treatment. Lenke classification includes 6 categories; in Lenke types 5 and 6, the thoracolumbar/lumbar curve (LC) is the main curve.

Progression of the curvature during periods of rapid growth can result in significant deformity, which may be accompanied by cardiopulmonary compromise.[1–3] In general, for mild AIS, bracing treatment can control the curve progression, and surgical treatment is required for severe AIS. The treatment recommendations of the system state that major and structural minor curves are included in the instrumentation and fusion and that the nonstructural minor curves are excluded.[4,5] Orthopedic surgery is terrible for both the child and the family, so early treatment is key for AIS.

As growth continues, the curve in AIS progresses. Rapid curve acceleration during puberty presents considerable challenges in the prognosis of IS,[6,7] and previous researched found that the growth peak is the rapid development period of scoliosis, So the key to treating AIS is finding peak angle velocity (PAV).[8]

Previous studies have demonstrated that the risk factors for rapidly increased PAV include chronologic age, digital skeletal age (DSA) score, secondary sexual characteristics, Risser sign, age of menarche, and spinal growth velocity.[7,9–13] However, these risk factors all originate in the growth field. In outpatient follow-ups, we have found that curve progression occurred more rapidly in patients with some parameters about trunk imbalances; thus, we hypothesized that radiographic parameters also is the risk factors for PAV. The present study aimed to investigate and identify radiographic parameters that affect rapid curve progression in Lenke 5 and 6 AIS.

2. Materials and methods

2.1. Study design and setting

In this 2-site cohort and retrospective study, which was approved by the Changhai Hospital and Shanghai Tongren Hospital Ethical Committee (Number: 2016157; Date: 2016-12-9), physically immature Lenke 5 and 6 adolescent IS (AIS) patients were recruited from 2011–2009 to 2015–2012 (LC ≥20°). It is calculated that the sample size needs to be >36.

2.2. Participants

All the participants come from Changhai Hospital and Shanghai Tongren Hospital. All patients met the AIS diagnostic criteria: Cobb angle >10°, age 11–18 years, and the cause of scoliosis is unknown. All of the participants received brace treatment.

The inclusion criteria were as follows: patients undergoing standardized Boston brace treatment[14,15] with >75% compliance, which was ascertained by telephone interview with the parents of the patients: wearing of the brace for at least 10 hours each day was defined as compliance, otherwise, noncompliance was recorded[16]; a Risser sign of 0 or 1 at the initiation of bracing; a follow-up period of 6 months with a minimum of 4 follow-ups; a curve progression of >10° at the final follow-up, the cessation of brace treatment or patient submission to operation; the whole spine x-ray was completed at each follow-up; and a magnetic resonance imaging evaluation of the whole spine that indicated normal findings with the exception of scoliosis. The exclusion criteria included incomplete image data; patients with previous spinal surgery or abnormalities in maturation or height, such as a lower extremity growth deficiency or arrest; spinal cord abnormalities (i.e., tethered cord or Chiari malformations); and cardiopulmonary dysfunction.

2.3. Variables and data sources

The AIS patients were assessed every 6 months. At each visit, x-ray radiographs of the whole spine and left and right bending radiographs were obtained. Data on the following were collected and recorded at follow-up: LC, rotation of the apical vertebra (RAV), deviation of the apical vertebra (DAV), clavicle angle (CA), L5 tilt angle (TA), body mass index (BMI), and flexibility of the LC (FLC).

Note: The vertebra that has the largest rotation is defined as the AV, with the Nash–Moe method used to evaluate the degree of rotation (*I–V*). The rotation of the AV is defined as RAV, and the vertical distance between the geometric center of the AV and the center sacral vertical line is defined as the DAV.

On standing anteroposterior (AP) spinal radiographs during each visit, LC, RAV, DAV, CA, and TA were measured. FLC was measured using a bending radiograph and calculated as (LC–bending curve)/LC*100%.[17] Patient height and weight were used to calculate BMI, and the corresponding percentile categories were determined (1, BMI >85th percentile (high-BMI group); 2, BMI <20th percentile (low-BMI group); and 3, BMI=20–85th percentile (mid-BMI group)).[18,19] The angle velocity was calculated as (angle velocity_n – angle velocity_{n-1})/[time interval (n–(n–1))] (where n represents the 1 visit, and n–1 represents the follow-up preceding n). PAV was defined as the peak of the scoliosis angle velocity curves during the entire follow-up period during puberty; it is a maximum value; PAV's judgment is the key to the study. All of the parameter measurements were performed by 2 independent surgeons with 2 repetitions, and the average value of the 4 measurements was calculated. All of the data were collected using picture archiving and communication systems technology.

For the standing AP spinal radiographs of the PAV and the final follow-up, the touch type (Fig. 1) was recorded to determine the lowest instrumented vertebra (LIV) and the number of different segments. The touch type represents the relationship between the lumbar vertebra and the center sacrum vertical line (CSVL).[20] Type A is touch without pedicle (beside the vertebra), type B is touch with pedicle, and type C is the CSVL in the middle of the pedicles. Touch type is similar to the lumbar modifier of Lenke classification[5]; however, touch type places more emphasis on the position relationship between the CSVL and pedicle, especially the pedicle of the first vertebra, which the CSVL touches from the sacrum to the thoracic vertebra. A typical case is shown in Figure 2A–C.

2.4. Statistical methods

Data were statistically analyzed using SPSS software V.18.0 (SPSS, Inc, Chicago, IL). Descriptive statistics were calculated to describe patient demographics. Quantitative variables are