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Original article

The effect of upper instrumented vertebra level on cervical sagittal alignment in Lenke 1 adolescent idiopathic scoliosis

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ABSTRACT

Background: This study aimed to evaluate the relationship between upper instrumented vertebra (UIV) level and cervical sagittal alignment (CSA) in Lenke 1 adolescent idiopathic scoliosis (AIS) patients, treated with posterior instrumentation. The hypothesis was that higher level of UIV would cause decreased cervical lordosis.

Methods: Sixty-three Lenke 1 AIS patients that underwent posterior fusion with pedicle screw instrumentation were retrospectively evaluated. Patients were divided into three groups according to UIV level (T2, T3, T4). Twenty patients without spinal deformity made up the control group. Patients were compared at two years follow-up according to radiographic changes in coronal and sagittal planes. Main sagittal parameters were C2–C7 cervical lordosis (CL), T1 slope, T1–T5 and T5–T12 kyphosis. Clinical outcomes were assessed using scoliosis research society (SRS)−22, short form (SF)−36 and neck disability index (NDI) questionnaires.

Results: Preoperative sagittal plane values of AIS patients were similar to the control group. C2–C7 CL, T1–T5 kyphosis and T1 slope significantly decreased postoperatively in T2 and T3 groups ($p < 0.05$). These parameters were not changed significantly in T4 group after the surgery. T5–T12 kyphosis did not change significantly in all groups. SRS–22 and SF–36 scores significantly improved ($p < 0.05$), while NDI scores were not changed significantly after the surgery.

Conclusions: In Lenke 1 AIS, treated with segmental all pedicle screw instrumentation using precontoured rods and rod rotation maneuver, postoperative decreased CL is more likely to occur if the UIV is selected as T2 or T3. Decreased CL seems to be caused by reduced T1–T5 kyphosis and T1 slope. However the decrease in CL did not effect clinical outcome scores, including NDI, adversely. Hence, extending the fusion to appropriate level for shoulder balance seems reasonable.

Level of evidence: IV.

1. Introduction

In adolescent idiopathic scoliosis (AIS) surgery, the goals are correcting the deformity, maintaining coronal and sagittal balance, producing level shoulders and saving motion segments. Therefore, choosing the appropriate levels for instrumentation and fusion is important as well as controversial. Classification systems and certain radiologic criteria are used to select the upper and lower instrumented vertebrae [1,2].

Upper instrumented vertebra (UIV) selection is mainly based on coronal parameters, such as proximal thoracic curve flexibility, T1 tilt and shoulder balance [2]. For Lenke type 1 curves, shoulder balance is the main determinant, since the proximal thoracic curve is nonstructural [1].

It is generally accepted that posterior surgery in AIS with all pedicle screw instrumentation is highly successfull in coronal and transverse plane correction, while it causes flattening of thoracic sagittal profile [3]. These changes in thoracic spine may affect the cervical region by compensatory mechanisms[4]. Such a misalignment may cause neck discomfort and decreased quality of life.

The effect of UIV on thoracic kyphosis (TK) and cervical lordosis (CL) is controversial, and has been discussed in previous studies [4–7]. Our aim in this study was to evaluate, how UIV selection affects CSA in Lenke 1 AIS patients. We hypothesized that extending the fusion to more proximal levels would flatten the thoracic sagittal profile by decreasing the proximal TK, which would cause decreased CL. We also aimed to analyse, how these changes would effect the quality of life of the patients.

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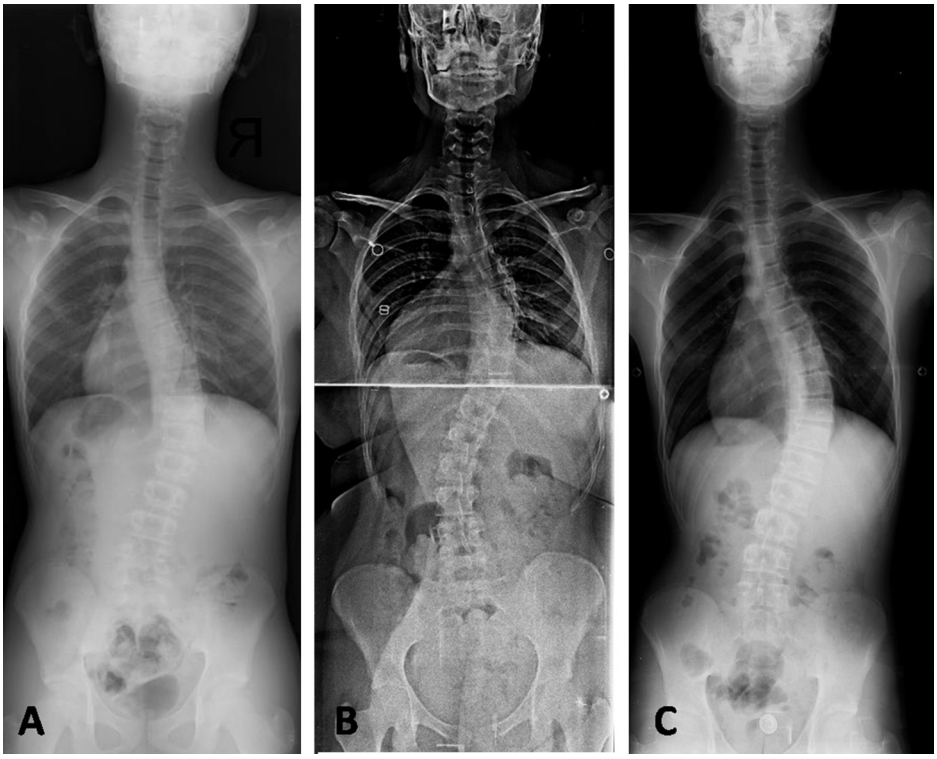

Fig. 1. Summary of surgical strategy for different clinical situations. A. Left shoulder elevation. B. Level shoulders. C. Left shoulder depression.

Table 1
Patient demographics.

Variables	T2 Group $n = 29$	T3 Group $n = 22$	T4 Group $n = 12$	Control Group $n = 20$	p
Age (mean ± sd)	14.8 ± 5.2	15.4 ± 6.3	15.2 ± 3.9	16.1 ± 7.8	0.572
Gender (male/female)	7/22	4/18	3/9	5/15	0.358
Lenke curve type (1A/1B/1 C)	14/6/9	11/4/7	7/2/3		0.627

2. Materials and Methods

2.1. Patients and Groups

After institutional ethics committee review board approval, 74 consecutive patients with Lenke 1 AIS, who were treated by posterior segmental all pedicle screw instrumentation and fusion were recruited in this study and were retrospectively evaluated. Exclusion criteria were patients with a diagnosis other than AIS, age 21 years and older, follow-up period less than 2 years, and having a prior spine surgery. Eleven patients were excluded according to above criteria. Mean age of the 63 patients was 15.1 years (range: 11–20) at the time of surgery.

The control group consisted of 20 patients selected among patients that were evaluated with whole spine radiographs due to nonspecific spinal complaints and had no spinal deformity. Patients were selected by retrospective matching according to age and female/male ratio.

The level of UIV was determined preoperatively according to the shoulder balance (Fig. 1). T2 was selected for preoperative left shoulder elevation, T3 for level shoulders, and T4 for left shoulder depression, as described previously [1]. The demographic characteristics of all patients were listed in Table 1.

2.2. Surgical Technique

All surgeries were performed by the same surgeon, using an identical surgical technique. After a standard posterior exposure segmental all pedicle screw instrumentation was performed. Precontoured rods were inserted. Rod rotation manoeuvre was used for scoliosis correction. No in situ rod contouring was performed in any of the patients. After decortication allograft bone material was used for fusion.

2.3. Radiographic and Clinical Outcome Measurements

Measurements were made on anteroposterior and lateral whole spine radiographs with the patient standing, preoperatively and at two-year follow-up (Figs. 2 and 3). Flexibility of the curves was assessed with left and right active bending radiographs taken in standing position. In order to reduce any inaccuracy caused by head motion, patients were asked to stand in comfortable position and gaze horizontally. Two spinal surgeons that were not involved in the surgeries made all radiographic measurements together deciding a single value.

The parameters examined in frontal plane included coronal Cobb angle of the main thoracic (MT) curve, and shoulder balance as coracoid height difference (CHD). Sagittal assessment included global parameters such as T1-slope, sagittal vertical axis (SVA); regional parameters such as C2–C7 cervical lordosis (CL), C2–C7 SVA, T1–T5 and T5–T12 kyphosis, L1–L5 lumbar lordosis (LL); and pelvic parameters such as pelvic tilt, sacral slope, and pelvic incidence.

CHD was the height difference in millimeters between the horizontal lines passing through the upper margin of each coracoid process (Fig. 4) [8]. CHD $\leq$ 5 mm was accepted as level shoulders. T1-slope was defined as the angle between the superior endplate of T1 and a horizontal line [7]. SVA was measured in millimeters between C7 plumb line and the posterior corner of S1. CL was

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