



Predictors for Postoperative Shoulder Balance in Lenke 1 Adolescent Idiopathic Scoliosis: A Prospective Cohort Study

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Abstract

Study Design: Prospective cohort.

Objectives: To determine the predictors of the shoulder balance after main thoracic (MT) fusion in patients with Lenke 1 adolescent idiopathic scoliosis (AIS).

Summary of Background Data: Imbalanced shoulders are a major cause of dissatisfaction in AIS patients. In Lenke 1 curves, MT curve fusion is supposed to lead to spontaneous correction of the proximal thoracic (PT) curve and thereby promote shoulder balance. However, this is not always observed.

Methods: Fifty-two Lenke 1 AIS patients who underwent MT fusion by a posterior AIS approach were prospectively evaluated preoperatively, immediately postoperatively and two years after the surgical procedure. The shoulder balance was determined using the biacromial angle. The clinical results were examined for their correlation with several radiographic measurements.

Results: Spontaneous correction of the PT Cobb angle after MT fusion was noted in 52% of cases, similar to that observed on preoperative bending films. A total of 51% of patients had unbalanced shoulders before surgery (right side higher). Two years after surgery, 30.77% showed unbalanced shoulders ($p < .001$). However, 17.1% of patients presented with a higher left shoulder, a reversion of the initial deformity. This phenomenon was more common among the patients with mild or no shoulder asymmetry (biacromial angle inferior to 1°) before surgery ($p < .001$). It was also determined that for each degree measured for the clavicle angle, there was an elevation of 0.14° for the ipsilateral shoulder.

Conclusions: In Lenke 1 cases with higher right shoulder and absence of abnormalities in the sagittal plane view, the correction of the main right thoracic curve could be enough to balance the shoulders. No correlation was found between shoulder balance and the amount of correction of the PT and MT curves.

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Keywords: Scoliosis; Treatment results; Shoulder; Pedicle screw

Introduction

Shoulder balance is one of the major indicators of success after surgical treatment in patients with AIS [1-5]. In Lenke 1 [6] curves, spontaneous correction of the proximal curve is expected to occur after main thoracic (MT) fusion, leading to balanced shoulders. However, this is not always

observed [7]. Furthermore, improper choice of the levels of fusion can lead to iatrogenic shoulder imbalance [8]. The prognostic factors for the postoperative shoulder balance and the indications for proximal extension of the fusion in Lenke 2 curves have been widely described in the literature [1,9-12]. However, there are limited data available regarding Lenke 1 patients.

The present study aimed to analyze the predictors of the shoulder balance after surgery in Lenke 1 patients. Several radiographic measurements were carried out to test the following hypotheses: (1) the presence of symmetrical shoulders prior to surgery leads to a higher probability of iatrogenic elevation of the contralateral side after the MT fusion; (2) preoperative rotation of the proximal thoracic curve predicts

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postoperative shoulder imbalance; and (3) the radiographic clavicle angle correlates with the clinical biacromial angle.

Materials and Methods

Design, patients, and procedures

In this prospective cohort study, all consecutive patients with Lenke 1 AIS, operated in two institutions between July 2009 and July 2011, and who had been participants in a previously published [13] randomized clinical trial (RCT), were included. The previous RCT aimed to assess the effects of different screw density constructs in the surgical correction of AIS. All patients were treated at the two institutions by the same surgical team. The ethics committee of the main institution approved this study, and all subjects provided informed consent forms.

The inclusion criteria for this study were (1) Lenke type 1 AIS; (2) age between 11 and 18 years (at the time of surgery); (3) Cobb angle between 40 and 90°; and (4) treated using pedicle screw-only constructs. The exclusion criteria were (1) proximal thoracic curve fusion; (2) main thoracic curves to the left; (3) preoperative traction or the use of the anterior approach; (4) higher left shoulder preoperatively; and (5) reoperations.

Surgical intervention

The proximal and distal neutral vertebrae were used to determine the fusion levels. All patients were treated with pedicle screws—only constructs. The correction of the MT curve was obtained by the concave rod derotation maneuver [14]. After this, the convexity rod was positioned, generally, in alignment with the coronal plane. A distraction of the concave side of the curve was performed, starting from the apex of the deformity toward the edge of the main thoracic deformity. Cranially, the amount of compression

and distraction required to obtain shoulder leveling was determined by the severity of preoperative clinical shoulder imbalance. Thus, in patients with higher right shoulder before surgery a more substantial distraction of the upper part of the left side and compression of the right side were necessary. After the correction, an intraoperative anteroposterior radiograph was performed to verify the position of the most cranially instrumented vertebrae, which should be horizontally aligned. Direct vertebral derotation was not used because such implants were not available at the time of the procedures. In all cases, local and autologous (iliac) bone grafts were used.

Clinical and radiographic evaluations

The medical records and imaging examinations of all participants were reviewed in this side analysis about shoulder balance. Clinical and radiographic assessments were performed preoperatively, immediately after the operation (10 days after surgery) and 24 months postoperatively. All of the assessments were performed by two independent evaluators with an intraclass correlation (ICC) of 0.991 (95% CI 0.984 to 0.995). Curves were classified according to the system described by Lenke et al. [6].

All patients underwent clinical photography in the standing position with a digital camera positioned on a tripod at a distance of 3.0 m from the torso and 0.5 m high. The shoulder balance was determined using the biacromial angle [15]. Measurements were performed using the Surgimap Spine Software (Fig. 1). Imbalanced shoulders were considered to be present in those who presented with a biacromial angle $>2^\circ$ (2.1+). By convention, right shoulder elevation received positive values and left shoulder elevation received negative values.

Radiographic evaluations were performed using panoramic films (30 × 90 cm) in the posteroanterior and lateral



Fig. 1. Examples of the biacromial angle measurement. The patient on the right have unbalanced shoulders.

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