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The progression of lumbar curves in adolescent Lenke 1 scoliosis and the distal adding-on phenomenon

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ABSTRACT

Introduction: The postoperative deterioration of the curve below spinal fusion instrumentation resulting in a distal adding-on (AO) phenomenon in idiopathic adolescent scoliosis (IAS) frequently requires surgical revision with disappointing secondary clinical results.
Hypothesis: Analysis of AP (coronal) range of motion (cROM) and lateral (sagittal) range of motion (sROM) on dynamic (side-bending, flexion, extension) X-rays to determine the choice of the lowest instrumented vertebra (LIV) can help reduce distal adding-on. The goal of this study was to study the postoperative progression of the lumbar curve in Lenke 1 scoliosis operated on with a LIV based on dynamic X-ray results.
Materials and methods: Right-sided Lenke 1 IAS that was treated surgically by posterior arthrodesis alone with a follow-up of at least 2 years was included in the study. The following radiographic parameters were evaluated: the Cobb angles of the curves, reducibility of the curves, the apex of the scoliosis, the central sacral vertical line, the stable vertebra (SV), the neutral vertebra (NV), the distances between the CSVL and the centroids of the LIV and of the first vertebra below instrumentation, as well as the tilt of the superior endplates. sROM and cROM were determined on dynamic X-rays.
Results: Fifty IAS were evaluated/185 files. Only three cases fulfilled the criteria for AO including two that were secondary to peri- or postoperative complications. The lumbar curve presented with a loss of correction of 0.9° at one year and 1.14° at the final follow-up. None of the parameters studied were correlated to the deterioration of the lumbar curve.
Discussion: The choice of the LIV has been shown to influence the deterioration of the lumbar curve and the development of AO. The choice of the LIV based on an analysis of AP (coronal) and lateral (sagittal) range of motion seems to prevent the development of AO.
Level of evidence: 4, retrospective study.

1. Introduction

Preservation of range of motion of the lumbar spine is the main goal of treatment of Adolescent Idiopathic Scoliosis (AIS).

Thus, to preserve function, the number of lumbar vertebrae included in arthrodesis should be limited. However, in this case, patients are at an increased risk of developing the Distal Adding-On phenomenon (AO) [1].

AO is defined in the literature as the postoperative deterioration of the curve below spinal fusion instrumentation associating:

- increase in the Cobb angle of the lumbar curve;
- and/or an increase in the number of vertebrae included in this curve;
- after a minimum follow-up of one year (Fig. 1) [2];
- a deviation of more than 5 mm in the lowest instrumented vertebra (LIV) from the central sacral vertical line (CSVL) [3];
- an increase in the narrowing of the first vertebra below instrumentation of more than 5°.

The incidence of AO in the literature is between 2 and 51% depending on the studies (Lehman: 2% [4]; Matsumoto: 18.8% [5]; Suk: 33.3% [6]; Wang: 51.1% [2]). This complication frequently requires surgical revision with disappointing clinical results.

To limit the risk of this complication, we determined the LIV for arthrodesis on dynamic AP (coronal) and lateral (sagittal) X-rays.

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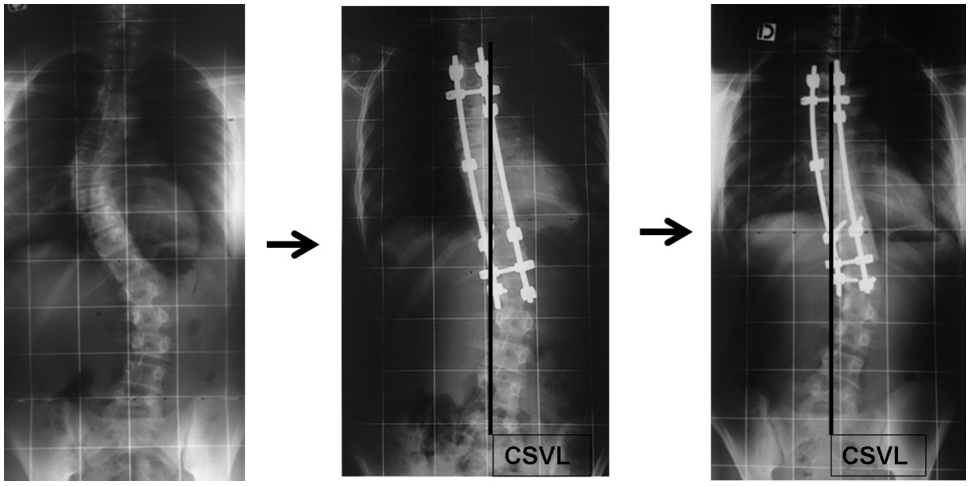

Fig. 1. Distal adding-on was defined as a progressive increase in the number of vertebrae included within the primary curve distally combined with either an increase of more than 10 mm in the deviation of the first vertebra below the instrumentation from CSVL (center sacral vertical line) or an increase of more than 5° in angulation of the first disc below the instrumentation at 1 year follow-up.

The main goal of this study was to evaluate the deterioration of lumbar curves after posterior arthrodesis of Lenke 1 scoliosis and to determine the incidence of AO [7].

The secondary goals were to study the preoperative sagittal (sROM) and coronal (cROM) range of motions of the first intervertebral disc below instrumentation and study the different risk factors of AO that have been mentioned in the literature (choice of LIV, age, bone maturity).

2. Materials and methods

This was a retrospective, single center, non-comparative study.

The files of patients treated surgically for IAS were taken from the database of our institution. All procedures were performed by a senior surgeon specialized in scoliosis between 1996 and 2009. The indication for surgery was based on conventional criteria of flexibility and the progression of scoliosis. The choice of the level of instrumentation was based on a radiographic assessment including standing AP (coronal) and lateral (sagittal) X-rays and dynamic AP and lateral X-rays.

Patients with Lenke 1 IAS treated surgically by posterior arthrodesis with at least 2 years of follow-up were included in the study [7].

IAS other than Lenke 1, and IAS requiring associated anterior surgery and left convex Lenke 1 IAS were excluded from the study.

The preoperative radiographic assessment included standing AP (coronal) and lateral (sagittal) X-rays as well as dynamic AP and lateral X-rays.

The preoperative choice of the level of instrumentation was based on the following:

- dynamic X-rays and analysis of flexibility – sROM and cROM;
- use of a hybrid instrumentation technique by posterior arthrodesis alone.

A postoperative follow-up assessment was performed on day 45, at 3 months, 6 months and 1 year, then yearly, with static X-rays.

Radiographic parameters included: the Cobb angle of the major thoracic curve and the lumbar curve (Fig. 2A), reducibility of these curves on dynamic X-rays, the apex of the scoliosis, the CSVL, the stable vertebra (SV) and the neutral vertebra (NV) (Fig. 2A).

The sROM and cROM of the first vertebra below instrumentation were measured on dynamic X-rays (Fig. 2C).

The distances between the CSVL and the centroid of the LIV (Fig. 2B) and between CSVL and the first vertebra below instrumentation (LIV + 1) were measured (mm) (Fig. 2B). These values were considered to be positive when the centroid had deviated to the right and negative when they were found to the left of the CSVL.

The tilt of the superior endplate of LIV and LIV + 1 were measured (Fig. 2B). The value was considered to be positive if the endplate was tilted to the right.

2.1. Statistical analysis

Statistical analyses were performed with the Chi^2 and Fisher-Yates for analysis of comparisons. Analysis of variance ANOVA was performed with Statview® software.

Table 1
Demographical data.

	n	(%)
Mean Age (years)	15.1	
0–13 years	5	10
13–15 years	34	68
> 15 years	13	26
Sex		
Female	46	92
Male	4	8
Risser index		
1	4	8
2	11	22
3	12	24
4	19	38
5	4	8
Follow-up (months) (range)	52.5 (24–126)	
24–48 months	23	46
48–72 months	17	34
> 72 months	10	20
Lenke 1 Scoliosis		
A	20	40
B	19	38
C	11	22
Lenke 1 Scoliosis		
–	4	8
N	37	74
+	9	18