KING II ADOLESCENT IDIOPATHIC SCOLIOSIS (LENKE B AND C): PREDICTION OF CORONAL DECOMPENSATION

Osmar Avanzi, Elcio Landim, Robert Meves, Maria Fernanda Silber Caffaro, Ricardo Umeta, Jose Thiago Portella Kruppa

ABSTRACT

Objective: To identify the predictive radiographic signs of trunk decompensation in King II AIS patients (Lenke B and C) who underwent selective thoracic arthrodesis with third generation material. Methods. A retrospective analysis was carried out of the preoperative radiographies, and those from the most recent follow-up, of twenty-two patients. The sample was divided in two groups: patients compensated after treatment (n=18) and patients who presented coronal decompensation (n=4). The two groups were compared to analyze possible postoperative predictive radiographic criteria of trunk decompensation. Results: The patients who developed coronal trunk decompensation showed a greater angular value, greater apical vertebral translation (AVT) and rotation (AVR) of the lumbar curve, and greater L4 obliquity in relation to the pelvis. Furthermore, the relationship between the thoracic curve AVT and AVR, for the angular value criteria, was smaller than for the patients with good evolution. Conclusions: Compensatory lumbar curves with similar angular value to the main thoracic curve, with greater translation and rotation of the apical vertebra and greater L4 slope, have a high probability of trunk decompensation after this surgical treatment. The small number of decompensated patients did not enable any predictive values of these variables to be defined.

Keywords: Scoliosis. Scoliosis/radiography. Adolescent.

Citation: *Avanzi O, Landim E, Meves R, Caffaro MFS, Umeta R, Kruppa JTP. King II Adolescent idiopathic scoliosis (Lenke B and C): Prediction of coronal decompensation. Acta Ortop Bras. [online]. 2010;18(5):277-83. Available from URL:http://www.scielo.br/aob.*

INTRODUCTION

Right thoracic adolescent idiopathic scoliosis (AIS) with flexible lumbar curve is the deformity that has generated the most controversy in literature. This controversy concerns when the selective arthrodesis of the thoracic curve should be performed. Theoretically, after this procedure, the compensatory lumbar curve will accommodate itself spontaneously in relation to the position of the corrected thoracic curve. Although selective arthrodesis has the advantage of preserving the lumbar segments, in some cases it results in coronal decompensation of the trunk after surgery.[1-4] The most common causes of this complication have been attributed to the wrong identification of the type of curve (true double curve) and to the hypercorrection of the main thoracic curve, supplanting the compensatory capacity of the lumbar curve.[1-5]

In 1983, King et al.[6] described a classification to help identify the types of curves that could be treated with selective arthrodesis. They recommended that King II curves (main thoracic curve-compensatory lumbar curve) be treated with arthrodesis only of the thoracic curve, while King I curves (true double curve), both the right thoracic curve, and the left lumbar curve, would undergo arthrodesis. The criteria to consider King type II scoliosis are: right thoracic curve larger and less flexible than the left lumbar curve. This classification was based on the surgical treatment of scoliosis with second generation instruments.[6]

Due to the increase of the incidence of postoperative coronal trunk decompensation, with the use of third generation instruments, Lenke et al.[7] published instructions for the performance of selective arthrodesis in King type II scoliosis. It was proposed that, only when the main thoracic curve were at least 20% larger than the lumbar curve, had at least 20% more of apical vertebral translation (AVT) and at least the same apical vertebral rotation (AVR), selective thoracic arthrodesis would be possible with this type of instrument.[1,4,7-9]

All the authors declare that there is no potential conflict of interest referring to this article.

Faculdade de Ciências Médicas da Santa Casa de São Paulo.

Study conducted in the Department of Orthopedics and Traumatology of Santa Casa de São Paulo - Pavilhão Fernandinho Simonsen.
Mailing address: Departamento de Ortopedia e Traumatologia – Pavilhão Fernando Simonsen, Rua Cesário Motta Júnior, 112. CEP: 01221-020; São Paulo, SP. Brazil .E-mail:; robertmeves@hotmail.com

Article received on 7/13/09 and approved on 2/9/10

Richards et al.[10] verified that the spontaneous correction capacity of the compensatory lumbar curve after selective thoracic arthrodesis was due to the proximal region of the former, and that the pelvic tilt in relation to the fourth lumbar vertebra ("L4 tilt") would be a radiographic criterion for prediction of left trunk decompensation in patients with King II AIS, treated with selective arthrodesis.[10-13]

In 2001, Lenke et al.[14] described a new classification for AIS that specifically quantifies the structural aspects of each curve (proximal thoracic, main thoracic and thoracolumbar/lumbar) of scoliosis. They established structural criteria to consider a structured main or unstructured compensatory curve. In this system scoliosis is classified according to: 1) type of curve; 2) translation of the lumbar apical vertebra; and 3) saggital alignment. Only the curves considered structured should be included in arthrodesis.[1-3,9,14]

Nevertheless the controversy regarding whether to perform selective thoracic arthrodesis on King II curves or not remains. Therefore, the aims of this study are to: 1) Identify the predictive radiographic signs of trunk decompensation in patients with AIS treated surgically and 2) study the behavior of the compensatory lumbar curve when selective thoracic arthrodesis is performed.

MATERIAL AND METHODS

The radiographies of patients with King type II AIS that underwent selective thoracic arthrodesis with third-generation metallic implant in the period from 1993 to 2007 in a single service were evaluated retrospectively.

Patients between 11 and 19 years of age at the time of surgery, treated with selective arthrodesis by a single posterior route, with association of autologous graft, were included in this series. The lower limit of the arthrodesis did not exceed the first lumbar vertebra (L1). The minimum follow-up period was 12 months, with mean period of 65 months.

Panoramic orthostatic preoperative radiographies with anterior posterior (AP) and lateral (L) views as well as AP views with lateral inclinations in a supine position, were evaluated in the study. To identify scoliosis and King type II the right thoracic curve should be equal to or larger and less flexible than the left lumbar curve. Both curves should cross the central sacral line.[5,6] The patients selected were also classified according to the criteria of Lenke et al.[14]

Radiographies were evaluated in AP and P views in the initial postoperative period (up to one week after surgery) and in the most recent follow-up. The proximal and distal levels of arthrodesis were identified.

A total 22 patients fulfilled these criteria, of which two were male and 20 female. The mean age was 14.63 ± 2.47 years.

Measuring of the curves

We took the measurements of the right thoracic and left lumbar curves, using the Cobb method[15] in the orthostatic AP and L preoperative radiographies, lateral inclinations, initial postoperative AP and L and most recent follow-up radiographies. Using these we determined the percentage of curve flexibility, percentage of postoperative correction and of loss of correction in the most recent outpatient follow-up.

We also evaluated, according to the criteria of Lenke et al.,[14] the measurements of thoracic and lumbar apical vertebral translation (AVT) in millimeters (mm), from the vertical line of C7 and the central sacral line, respectively; the thoracic and lumbar apical vertebral rotation (AVR) using the Nash and Moe method[16], both pre- and postoperatively. Through these measurements we calculated the thoracic curve over lumbar curve ratio in the criteria of magnitude (Cobb T/L), T/L AVT and T/L AVR. Moreover, we evaluated the L4 vertebra tilt in relation to pelvis, measured in degrees, in the AP and right lateral tilt radiographies, thus determining its flexibility.[10]

Coronal and saggital trunk compensation

According to the Scoliosis Research Society (SRS), coronal trunk compensation is defined as the alignment of the central line of C7 with the central sacral line.[17] Decompensation is determined when the distance between these two lines is above 20mm. The same institution also defines as trunk decompensation the situation where the thorax is not centered over the sacrum, and can be measured by the lateral trunk shift method.[17] Both measurements were analyzed in the patients included in this series.

The patients were then divided into two groups: A) compensated; B) decompensated. Coronal decompensation was defined as deviation above 20mm between the central cervical line and the central sacral line. The analysis was conducted to determine which criteria measured had statistical difference between the two groups.

The statistical analysis was carried out with the application of the Mann-Whitney test, with the intention of verifying a possible difference between the two groups considered, for the variables of interest. Version 13.0 of the SPSS (Statistical Package for Social Sciences) program was used for the obtainment of results, utilizing a level of significance of 5% (0.050), for application of the statistical tests.

RESULTS

Twenty-two patients with AIS, all with type II of the classification of King et al.,[6] were included in the study. They were also classified according to the system of Lenke et al.,[9] as follows: eight 1BN, one 1B+, 12 1CN and one 2CN. All the patients underwent selective thoracic arthrodesis by a single posterior route, using third generation instruments: Coutrel-Dubousset instruments were used in 11 cases and hybrid assembly (distal pedicle screws and proximal hooks) in 11 cases. The distal level of arthrodesis was in eight cases at T12 and in 14 cases at L1. The results are listed in Tables 1 to 4.

Preoperative analysis

The main thoracic curve measured on average 56.61° ± 7.59°, decreasing to 32.57° ± 7.06° in the radiography with right lateral tilt, showing flexibility of 42% ± 10%. The thoracic AVT was 47.79 ± 13.36mm on average.

The compensatory lumbar curve was 40.4° ± 8.51° on average, decreasing to 8.54° ± 7.19° in the left lateral tilt, with flexibility of 81% ± 17%. The lumbar AVT was 22.18 ± 8.70mm.

Comparing the two curves the thoracic/lumbar ratio was 1.45 ± 0.31 for the magnitude (Cobb) of the curves, 2.33 ± 0.89 for the AVT and 1.63 ± 0.49 for the AVR on average.

The L4 obliquity in relation to the pelvis was 11.50° ± 6.43°, reaching -0.22° ± 3.63° in the left lateral tilt, with mean flexibility of 114% ± 36%. The coronal balance was 5.86 mm (±11,80) to the left on average.

Table 1 – *Individual preoperative data of the patients.*

Case nº	T Cobb	T Tilt	T AVT	T AVR	T Flex.	L Cobb	L Tilt	L AVT	L AVR	L Flex.	Kyphosis T5-T12	Kyphosis T10-L2 Junc.	Coronal Balance (mm)	T shift (mm)	T/L Cobb	T/L AVT	T/L AVR	L4 Tilt	L4Tilt Slope	L4 Tilt Flex.
1	78	40	70	2	49%	50	12	23	2	76%	40	2	-12	20	1.56	3.04	1	10	-5	150%
2	59	30	59	2	49%	42	8	18	1	81%	22	0	-15	-36	1.40	3.28	2	10	0	100%
3	51	26	56	2	49%	20	-5	16	1	125%	15	-2	-30	-7	2.55	3.50	2	3	0	100%
4	60	30	34	2	50%	44	3	38	2	93%	20	1	-16	-3	1.36	0.89	1	20	5	75%
5	52	28	37	2	46%	49	10	37	2	80%	18	-1	4	4	1.06	1.00	1	18	0	100%
6	61	50	52	2	18%	35	12	19	1	66%	22	-2	-9	12	1.74	2.74	2	7	0	100%
7	48	26	33	2	46%	30	7	12	1	77%	15	-5	-5	-3	1.60	2.75	2	3	-3	200%
8	55	27	50	2	51%	32	4	14	1	88%	22	-3	-3	14	1.72	3.57	2	5	-3	160%
9	49	26	48	2	47%	30	0	16	1	100%	16	-4	12	28	1.63	3.00	2	6	-3	150%
10	52	30	50	2	42%	30	3	14	1	90%	54	5	-18	-6	1.73	3.57	2	6	-2	133%
11	50	30	34	2	40%	41	11	14	1	73%	24	6	5	9	1.22	2.43	2	11	2	82%
12	56	40	49	2	29%	45	17	17	1	62%	45	10	-14	4	1.24	2.88	2	8	-5	163%
13	66	30	55	2	55%	44	0	20	1	100%	23	-2	-5	-2	1.50	2.75	2	11	-4	136%
14	60	42	45	2	30%	50	16	24	2	68%	20	-8	0	20	1.20	1.88	1	14	2	86%
15	49	26	35	2	47%	39	11	13	1	72%	22	3	6	10	1.26	2.69	2	9	-5	156%
16	53	40	47	2	25%	36	9	18	1	75%	19	0	-4	14	1.47	2.61	2	9	3	67%
17	65	40	42	2	38%	53	14	35	2	74%	32	3	-3	0	1.23	1.20	1	15	-1	107%
18	58	26	40	2	55%	44	0	26	1	100%	18	-7	-5	6	1.32	1.54	2	15	3	80%
19	47	26	30	2	45%	35	0	16	1	100%	24	-2	4	15	1.34	1.88	2	9	-1	111%
20	55	32	33	2	42%	49	15	31	2	69%	15	5	-15	-11	1.12	1.06	1	30	10	67%
21	65	39	60	2	40%	43	19	30	2	56%	15	0	-25	-5	1.51	2.00	1	14	0	100%
22	63	43	40	2	32%	54	22	37	2	59%	50	20	19	21	1.17	1.08	1	20	2	90%
Mean	56.62	32.57	45.41	2.00	42%	40.05	8.55	22.18	1.36	81%	25.05	0.86	-5.86	4.73	1.45	2.33	1.64	11.50	-0.23	114%
Standard Dev.	7.60	7.07	10.62	0.00	10%	8.51	7.20	8.70	0.49	17%	11.64	6.07	11.81	13.96	0.32	0.89	0.49	6.43	3.64	36%

Source: SAME-SC

In the saggital plane the kyphosis of T5-T12 was 25.04° ± 11.64° on average, with thoracolumbar junctional kyphosis of -0.86° ± 6.06°.

Analysis in the immediate postoperative period

In the immediate postoperative period mean correction of the thoracic curve was obtained for 25.04° ± 7.37°, obtaining a percentage of correction of 56% ± 11%. With the lumbar curve, a mean improvement was obtained for 20.77° ± 7.17°, with a correction percentage of 49% ± 13%.

The coronal balance obtained was 12.95mm (±14.65) to the left on average. In the saggital plane T5-T12 kyphosis of 21.77° ± 7.05°was obtained. The L4 obliquity obtained in the immediate postoperative period was 10.18° ± 6.46°, with a correction percentage of only 14% ± 22%, in spite of the considerable flexibility encountered in the preoperative period (114%).

Analysis in the most recent outpatient follow-up

In the most recent outpatient follow-up the thoracic curve was gauged at 28.45° ± 7.82°, showing a mean percentage of loss of correction of 15% ± 13%. The lumbar curve was measured on an average at 21.27° ± 11.08°, with loss of correction at -1% ± 23%.

The final coronal balance was 10.04mm (±13.34) to the left on average. In the saggital plane, the T5-T12 kyphosis was 22.86° ± 5.33°. The final L4 obliquity was 10.45° ± 6.94° on average.

Comparison of the compensated and decompensated groups

In the initial and late postoperative period we divided the patients into two groups: compensated in the coronal plane and decompensated to the left. We compared these two groups in relation to the preoperative radiographic criteria assessed.

In the initial postoperative period we obtained 16 patient compensated in the coronal plane and 6 decompensated to the left. Comparing these two groups we observed that in the decompensated group the patients presented greater angular value of the lumbar curve (49.8° ± 3.5° X 37.2° ± 7.6, $p=0.002$) than the compensated patients, a higher AVT of the lumbar curve (33.6mm ± 5.3 X 17.8mm ± 4.9, $p=0.001$) and a higher lumbar AVR (2 X 1.1 ± 0.3, $p<0.001$). We also noticed a statistical difference in the thoracic (T)/lumbar(L) ratio for curve magnitude (decompensated 1.19 ± 0.1 X compensated 1.5 ± 0.3, $p=0.002$), AVT (1.19 ± 0.3 X 2.76 ± 0.6 $p<0.001$). Finally, we noticed a statistical difference in the L4 slope between the two groups (19.5 ± 5.7 X 8.5 ± 3.4, $p=0.001$).

Table 2 – *Individual data of the patients in the In. PO period*

Case nº	T Cobb	% T cor.	L Cobb	% L cor.	Coronal Balance (mm)	T shift (mm)	Kyphosis T5-T12	L4 Tilt	% TL4 Corr.	T AVT	L AVR
1	34	56%	20	60%	8	15	22	8	20%	40	20
2	24	59%	24	43%	-15	-22	18	9	10%	30	25
3	23	55%	14	30%	-13	-19	20	3	0%	18	12
4	40	33%	35	20%	-45	-37	25	18	10%	32	35
5	35	33%	33	33%	-30	-25	26	20	-11%	36	48
6	24	61%	15	57%	2	-3	13	4	43%	20	14
7	20	58%	13	57%	-3	-16	24	2	33%	15	6
8	18	67%	14	56%	-8	-16	20	6	-20%	13	16
9	12	76%	16	47%	-1	-12	18	5	17%	5	5
10	30	42%	10	67%	1	-3	20	1	83%	26	8
11	20	60%	18	56%	-10	-12	20	8	27%	20	18
12	26	54%	22	51%	14	10	10	6	25%	14	14
13	34	48%	20	55%	-15	-14	20	8	27%	40	18
14	22	63%	20	60%	-24	-25	20	12	14%	23	23
15	18	63%	22	44%	-3	-7	24	8	11%	15	20
16	26	51%	23	36%	-18	-16	13	10	-11%	14	25
17	35	46%	20	62%	-22	-20	30	16	-7%	15	30
18	16	72%	14	68%	-15	-18	23	14	7%	22	18
19	16	66%	15	57%	-4	-8	20	8	11%	25	13
20	22	60%	30	39%	-40	-39	24	25	17%	17	41
21	30	54%	24	44%	-19	-18	23	12	14%	20	18
22	26	59%	35	35%	-25	-26	46	21	-5%	25	28
Mean	25.05	56%	20.77	49%	-12.95	-15.05	21.77	10.18	14%	22.05	20.68
Standard Dev.	7.38	11%	7.18	13%	14.66	12.79	7.05	6.46	22%	9.11	10.79

Source: SAME-SC

Table 3 – *Individual data of the patients in the most recent outpatient follow-up*

Case nº	T Cobb	% loss T cor.	L Cobb	% loss L corr.	Coronal balance (mm)	T shift	Kyphosis T5-T12	L4 Tilt	T AVT	L AVT
1	40	18%	23	15%	-4	10	22	8	48	22
2	28	17%	23	-4%	-16	-18	24	10	32	24
3	24	4%	15	7%	-16	-18	22	3	36	6
4	40	0%	37	6%	-30	-30	22	18	38	33
5	45	29%	45	36%	-26	-22	28	20	38	50
6	26	8%	16	7%	4	-3	20	5	17	12
7	20	0%	9	-31%	1	-8	22	2	17	5
8	25	39%	11	-21%	-2	-13	21	6	16	13
9	16	33%	10	-38%	1	-5	20	4	17	3
10	32	7%	9	-10%	3	-1	21	1	27	7
11	30	50%	23	28%	-10	-13	22	12	26	24
12	28	8%	20	-9%	14	10	10	6	15	10
13	38	12%	16	-20%	-10	-8	20	8	45	14
14	24	9%	18	-10%	-18	-19	20	11	25	21
15	24	33%	20	-9%	8	3	22	8	22	15
16	30	15%	20	-13%	-6	-4	20	9	23	15
17	37	6%	20	0%	-17	-18	30	15	17	25
18	18	13%	20	43%	-12	-15	24	14	22	18
19	18	13%	12	-20%	0	2	24	8	21	12
20	23	5%	26	-13%	-35	-34	25	20	18	40
21	32	7%	22	-8%	-18	-19	24	12	20	18
22	28	8%	53	51%	-32	-34	40	30	26	40
Mean	28.45	15%	21.27	-1%	-10.05	-11.68	22.86	10.45	25.73	19.41
Standard Dev.	7.83	13%	11.09	23%	13.35	12.62	5.34	6.95	9.71	12.29

Source: SAME-SC

In the late postoperative period (most recent outpatient follow-up) we verified that the patients that remained decompensated to the left were only four, while the group of compensated patients came to 18. Comparing these two groups we obtained similar results: lumbar Cobb of 49° ± 4° X 38.8° ± 8.5, $p=0.03$; lumbar AVT of 35.7mm ± 3.2mm X 19.1 ± 6.2, $p=0.003$; lumbar AVR of 2 X 1.2 ± 0.4, $p=0.004$; T/L Cobb of 1.18 ± 0.1 X 1.5 ± 0.3, $p=0.014$; T/L AVT of 1.01 ± 0.08 X 2.63 ± 0.7, $p=0.002$; T/L AVR of 1 X 1.78 ± 0.43, $p=0.004$ and finally, L4 obliquity of 22 ± 5.42 X 9.17 ± 3.8, $p=0.002$.

Only one patient that evolved with coronal decompensation to the left required further surgical intervention for extension of arthrodesis, a case elucidated in Figure 1.

DISCUSSION

The objectives of surgical treatment for idiopathic scoliosis are to correct the deformity while maintaining a good coronal and saggital balance, at the same time leaving as many segments as possible free, to avoid complications with the early degeneration of non-arthrodesed segments.[1-3,7,9] The application of the concept of selective thoracic arthrodesis allows the control and the partial correction of the main thoracic curve, maintaining the mobility of the lumbar segments. However, in some cases the lumbar curve not included in the arthrodesis is not able to accommodate itself to the correction of the thoracic curve, leading to decompensation of the trunk in the coronal plane. This decompensation occurs more frequently in patients with King type II AIS.[1-3,7,9] The most common causes of this complication have been attributed to the wrong identification of the type of curve (true double curve) and to the hypercorrection of the main thoracic curve, supplanting the compensatory capacity of the lumbar curve.[1-5] In spite of this, the correction percentage was not a factor associated with trunk decompensation in our series of cases.

In 1983, King et al.[6] described a classification to help identify the types of curves that could be treated with selective arthrodesis. They recommended that King II curves (main thoracic-compensator lumbar curve) be treated with arthrodesis of the thoracic curve only. This classification was based on the surgical treatment of scoliosis with second generation instruments.[6]

With the advent of third generation instruments, which favored a greater correction of the deformity, a series of cases of King II AIS that underwent selective thoracic arthrodesis presented coronal decompensation to the left. It was perceived that the criteria of King were not sufficient to determine when selective arthrodesis could be performed.[1-3,7, 9,11,14,19]

Lenke et al.[7] published instructions for the performance of selective arthrodesis in King type II scoliosis. They verified in their series of cases treated with third-generation instruments that the ratio between thoracic and lumbar curve in the aspects of magnitude (Cobb) of the curves, AVT and AVR was a good predictive criterion for performing selective arthrodesis. The stipulated values were 1.2 for thoracic/lumbar Cobb and thoracic/lumbar AVT and 1 for thoracic/lumbar AVR. When at least two of these ratios between the thoracic and lumbar curve were higher than these values the selective arthrodesis would be viable. The exception to this rule was determined when the lumbar curve had an angular value above 60°, AVT above 40mm and accentuated rotation (above 2.5 by Nash-Moe).

Table 4 – *Comparison between compensated X decompensated in the left initial PO period and late PO period.*

Variable	comp_qual2	N	Mean	Standard deviation	Significance (p)
Cobb thoracic curve	compensated	16	56.06	8.3	0.196
	to the left	6	59.17	4.88	
Tilt thoracic curve	compensated	16	32	7.4	0.091
	to the left	6	35.83	6.59	
AVT thoracic curve	compensated	16	48	11.15	0.06
	to the left	6	38.5	4.68	
AVR thoracic curve	compensated	16	2	0	> 0.999
	to the left	6	2	0	
Flexibility thoracic curve	compensated	16	42.83	10.59	0.338
	to the left	6	39.7	7.89	
Cobb lumbar curve	compensated	16	37.25	7.66	0.002
	to the left	6	49.83	3.54	
Tilt lumbar curve	compensated	16	6.75	6.81	0.059
	to the left	6	13.33	6.38	
AVT lumbar curve	Compensated	16	17.88	4.9	0.001
	to the left	6	33.67	5.35	
AVR lumbar curve	Compensated	16	1.13	0.34	< 0.001
	to the left	6	2	0	
Flexibility lumbar curve	compensated	16	83.74	17.94	**0.209**
	to the left	6	73.83	11.61	
Kyphosis T5 T12	compensated	16	24.75	11.47	**0.882**
	to the left	6	25.83	13.18	
Junctional kyphosis (T10-L2)	compensated	16	-0.06	4.39	**0.336**
	to the left	6	3.33	9.31	
Trunk compensation (mm)	compensated	16	-7.38	11.39	**0.438**
	to the left	6	-1.83	13.01	
Trunk shift	compensated	16	4.56	14.75	0.971
	to the left	6	5.17	12.86	
T/L Cobb	compensated	16	1.55	0.32	0.002
	to the left	6	1.19	0.1	
T/L AVT	compensated	16	2.76	0.59	0.001
	to the left	6	1.19	0.35	
T/L AVR	compensated	16	1.88	0.34	< 0.001
	to the left	6	1	0	
L4 Tilt	compensated	16	8.5	3.44	0.001
	to the left	6	19.5	5.72	
L4 Tilt slope	compensated	16	-1.44	2.73	0.023
	to the left	6	3	4	
L4 Tilt Flexibility	compensated	16	124.21	37.07	0.034
	to the left	6	87.34	14.99	

Variable	comp_qual3	N	Mean	Standard deviation	Significance (p)
Cobb thoracic curve	compensated	18	56.78	8.11	0.639
	to the left	4	57.5	4.93	
Tilt thoracic curve	compensated	18	33	7.55	0.488
	to the left	4	33.25	6.7	
AVT thoracic curve	compensated	18	47.5	10.59	0.045
	to the left	4	36	3.16	
AVR thoracic curve	compensated	18	2	0	> 0.999
	to the left	4	2	0	
Flexibility thoracic curve	compensated	18	41.88	10.43	> 0.999
	to the left	4	42.43	7.87	
Cobb lumbar curve	compensated	18	38.83	8.56	0.033
	to the left	4	49	4.08	
Tilt lumbar curve	compensated	18	7.67	6.94	0.286
	to the left	4	12.5	8.02	
AVT lumbar curve	compensated	18	19.17	6.23	0.003
	to the left	4	35.75	3.2	
AVR lumbar curve	compensated	18	1.22	0.43	0.004
	to the left	4	2	0	
Flexibility lumbar curve	compensated	18	82.3	17.39	0.495
	to the left	4	75.36	14.5	
Kyphosis T5 T12	compensated	18	24.89	10.98	0.578
	to the left	4	25.75	16.3	
Junctional kyphosis (T10-L2)	compensated	18	-0.33	4.6	0.114
	to the left	4	6.25	9.5	
Trunk compensation (mm)	compensated	18	-6.72	10.88	0.798
	to the left	4	-2	16.75	
Trunk shift	compensated	18	5.17	14.38	0.609
	to the left	4	2.75	13.62	
T/L Cobb	compensated	18	1.51	0.32	0.014
	to the left	4	1.18	0.13	
T/L AVT	compensated	18	2.63	0.69	0.002
	to the left	4	1.01	0.08	
T/L AVR	compensated	18	1.78	0.43	0.004
	to the left	4	1	0	
L4 Tilt	compensated	18	9.17	3.78	0.002
	to the left	4	22	5.42	
L4 Tilt slope	compensated	18	-1.22	2.69	0.02
	to the left	4	4.25	4.35	
L4 Tilt Flexibility	compensated	18	121.1	36.16	0.036
	to the left	4	82.92	14.93	

Source: SAME-SC

Frez et al[4], Lenke et al[9], Newton et al.[8] and Chang et al.[1] used these criteria and obtained good results in their series of cases of AIS treated with selective arthrodesis.

In our casuistry we observed statistical difference when we compared these ratios between the thoracic curve and the lumbar curve in the two groups studied (decompensated X compensated). The four patients that remained decompensated at the end of the outpatient follow-up obtained on average the ratios T/L Cobb of 1.18 ± 0.1 ($p=0.014$), T/L AVT of 1.01 ± 0.08 ($p=0.002$) and T/L AVR of 1 ($p=0.004$). However, our number of cases does not create conditions for us to determine a cut-off value to establish when the lumbar curve should be included in arthrodesis.

Richards et al.[10] published their series of 24 patients with King II AIS, all with a lumbar curve above 40°, treated with selective thoracic arthrodesis. They verified that the capacity for spontaneous correction of the compensatory lumbar curve after this procedure

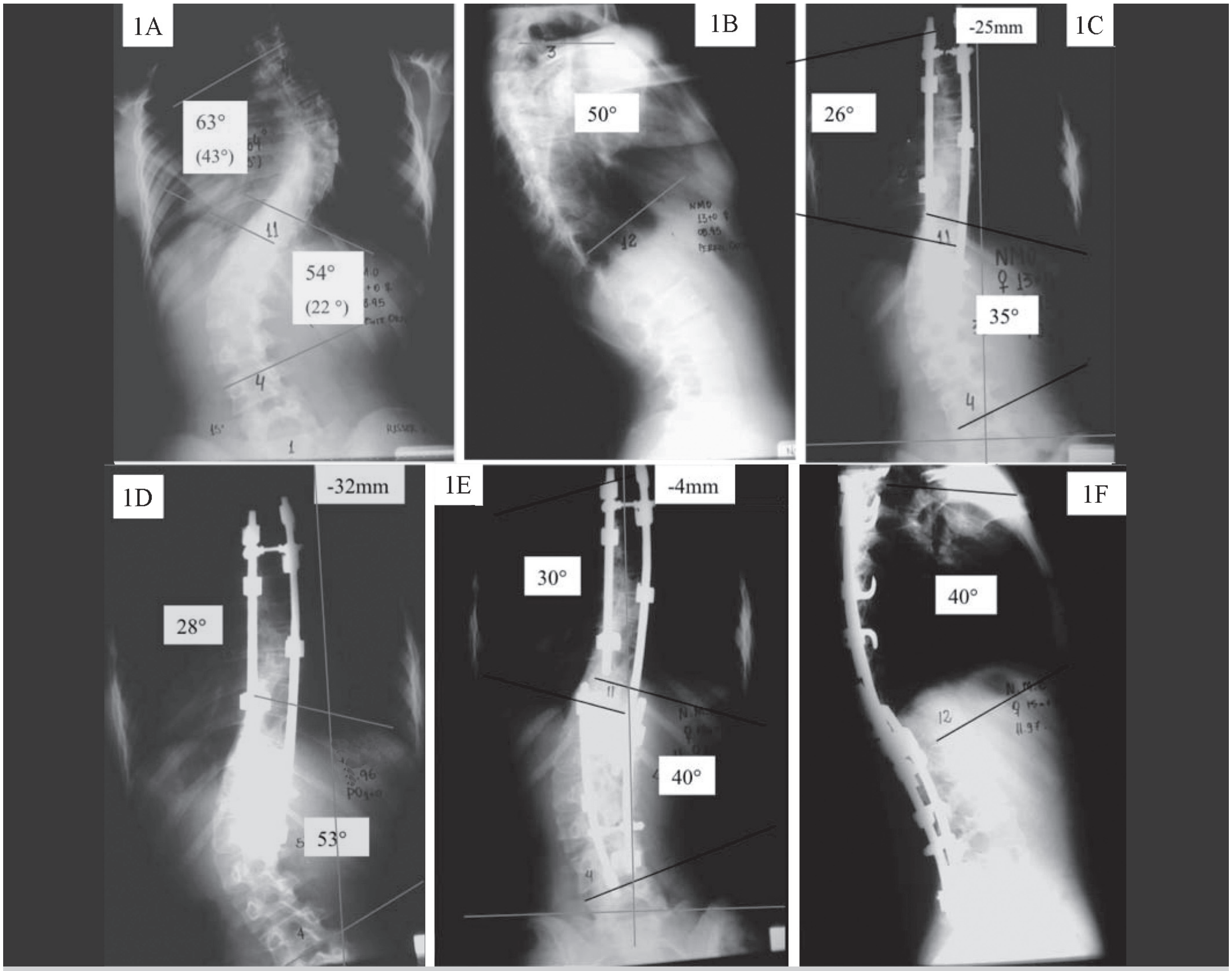

Figure 1 – *Female 13-year old patient: 1A/1B: initial X-rays; 1C: postoperative X-rays; 1D: X-ray after 1 year. 1E/1F: X-ray at the end of the follow-up period.*

was due to the proximal region of the former, and that the L4 tilt in relation to the pelvis would be a predictive radiographic criterion of trunk decompensation to the left in the patients with King II AIS, treated with selective arthrodesis. Scwender et al.,[11] Lodewijk et al.,[12] and Jansen et al.[13] obtained the same findings in their respective series of cases.

We observed in our cases that the L4 tilt in relation to the pelvis, despite appearing extremely flexible in the majority of patients (114% ± 36%), obtained a correction in the postoperative period of only 14% ± 22%, showing the limited capacity of the distal region of the lumbar curve to correct spontaneously. The L4 tilt value also showed statistical difference in relation to the two groups studied. The patients that evolved with decompensation to the left had an accentuated L4 obliquity of 22° ± 5.42° (p=0.002), showing that this radiographic criterion has a predictive ability to determine when thoracic selective arthrodesis may lead to coronal decompensation.

In 2001, Lenke et al.[14] described a new classification for AIS that specifically quantifies the structural aspects of each curve (proximal thoracic, main thoracic and thoracolumbar/lumbar) of scoliosis. They established structural criteria to consider a structured main curve or unstructured compensatory curve. According to this system, scoliosis is classified with a basis on: 1) type of curve; 2) translation of the lumbar apical vertebra; and 3) saggital alignment. Only curves considered structured should be included in arthrodesis.[1,2,3,9,14]

In our casuistry all the lumbar curves were flexible according to the criteria of Lenke: in the radiographies with lateral tilt they all corrected the value of Cobb to less than 25° and none had thoracolumbar junctional kyphosis (T10-L2) of 20° of more. We did not observe any radiographic criterion in the saggital plane that was statistically correlated to the coronal trunk decompensation after performing the selective thoracic arthrodesis.

Dobbs et al.[3] and Edwards et al.,[2] both in 2004, observed in their case series that the presence of a preoperative trunk decompensated to the left is statistically related to the maintenance of the trunk decompensated to the left after surgery, and is therefore an important predictive criterion for performing selective thoracic arthrodesis or not.

We did not manage to make the same discovery based on our series of cases, whereas there was no statistical difference between the preoperative coronal balance of the two groups studied.

CONCLUSION

We can conclude that treatment of King type II adolescent idiopathic scoliosis with selective thoracic arthrodesis favors a good coronal balance providing trunk decompensation predictive criteria are observed. Compensatory lumbar curves with angular value similar to the main thoracic curve, with elevated apical vertebra translation and rotation, and considerable L4 tilt, present a high probability of trunk decompensation after surgical treatment.

It would be necessary to have a greater number of cases in order to determine the cut-off value in the criteria studied, whereupon selective arthrodesis could not be performed.

We also observed that the spontaneous correction of the lumbar curve after selective thoracic arthrodesis is mainly due to its proximal part, as the L4 tilt changes little after this arthrodesis.

REFERENCES

1. Chang KW, Chang KI, Wu CM. Enhanced capacity for spontaneous correction of lumbar curve in the treatment of major thoracic-compensatory C modifier lumbar curve pattern in idiopathic scoliosis. Spine (Phila Pa 1976). 2007;32:3020-9.
2. Edwards CC 2nd, Lenke LG, Peelle M, Sides B, Rinella A, Bridwell KH. Selective thoracic fusion for adolescent idiopathic scoliosis with C modifier lumbar curves: 2- to 16-year radiographic and clinical results. Spine (Phila Pa 1976).2004;29:536-46.
3. Dobbs MB, Lenke LG, Walton T, Peelle M, Della Rocca G, Steger-May K et al. Can we predict the ultimate lumbar curve in adolescent idiopathic scoliosis patients undergoing a selective fusion with undercorrection of the thoracic curve? Spine (Phila Pa 1976). 2004;29:277-85.
4. Frez R, Cheng JC, Wong EM. Longitudinal changes in trunkal balance after selective fusion of King II curves in adolescent idiopathic scoliosis. Spine (Phila Pa 1976). 2000;25:1352-9.
5. McCance SE, Denis F, Lonstein JE, Winter RB. Coronal and sagittal balance in surgically treated adolescent idiopathic scoliosis with the King II curve pattern. A review of 67 consecutive cases having selective thoracic arthrodesis. Spine (Phila Pa 1976). 1998;23:2063-73.
6. King HA, Moe JH, Bradford DS, Winter RB. The selection of fusion levels in thoracic idiopathic scoliosis. J Bone Joint Surg Am. 1983;65:1302-13.
7. Lenke LG, Bridwell KH, Baldus C, Blanke K. Preventing decompensation in King type II curves treated with Cotrel-Dubousset instrumentation. Strict guidelines for selective thoracic fusion. Spine (Phila Pa 1976). 1992;17(8 Suppl):S274-81.
8. Newton PO, Faro FD, Lenke LG, Betz RR, Clements DH, Lowe TG et al. Factors involved in the decision to perform a selective versus nonselective fusion of Lenke 1B and 1C (King-Moe II) curves in adolescent idiopathic scoliosis. Spine (Phila Pa 1976). 2003;28:S217-23.
9. Lenke LG, Edwards CC 2nd, Bridwell KH. The Lenke classification of adolescent idiopathic scoliosis: how it organizes curve patterns as a template to perform selective fusions of the spine. Spine (Phila Pa 1976). 2003;28:S199-207.
10. Richards BS. Lumbar curve response in type II idiopathic scoliosis after posterior instrumentation of the thoracic curve. Spine (Phila Pa 1976). 1992;17(8 Suppl):S282-6.
11. Schwender JD, Denis F. Coronal plane imbalance in adolescent idiopathic scoliosis with left lumbar curves exceeding 40 degrees: the role of the lumbosacral hemicurve. Spine (Phila Pa 1976). 2000;25:2358-63.
12. van Rhijn LW, Plasmans CM, Veraart BE. No relationship exists between the correction of the thoracic and the lumbar curves after selective thoracic fusion for adolescent idiopathic scoliosis King type II. Eur Spine J. 2002;11:550-5.
13. Jansen RC, van Rhijn LW, Duinkerke E, van Ooij A. Predictability of the spontaneous lumbar curve correction after selective thoracic fusion in idiopathic scoliosis. Eur Spine J. 2007;16:1335-42.
14. Lenke LG, Betz RR, Harms J, Bridwell KH, Clements DH, Lowe TG et al.Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. J Bone Joint Surg Am. 2001;83:1169-81.
15. Cobb JR. Outline for the study of scoliosis. Instr Course Lect. 1948;5: 261-75.
16. Nash CL Jr, Moe JH. A study of vertebral rotation. J Bone Joint Surg Am. 1969;51:223-9.
17. Richards BS, Scaduto A, Vanderhave K, Browne R. Assessment of trunk balance in thoracic scoliosis. Spine (Phila Pa 1976). 2005;30:1621-6.
18. Winter RB, Lonstein JE. A meta-analysis of the literature on the issue ofselective thoracic fusion for the King-Moe type II curve pattern in adolescent idiopathic scoliosis. Spine (Phila Pa 1976). 2003;28:948-52.
19. Lenke LG, Betz RR, Bridwell KH, Harms J, Clements DH, Lowe TG. Spontaneous lumbar curve coronal correction after selective anterior or posterior thoracic fusion in adolescent idiopathic scoliosis. Spine (Phila Pa 1976). 1999;24:1663-71.
20. Suk SI, Lee SM, Chung ER, Kim JH, Kim SS. Selective thoracic fusion with segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis: more than 5-year follow-up. Spine (Phila Pa 1976). 2005;30:1602-9.