ANALYSIS OF CORONAL BALANCE AND LAST LEVEL OF ARTHRODESIS IN LENKE TYPE 5 IDIOPATHIC SCOLIOSIS: SPECIFIC RADIOGRAPHIC PARAMETERS

ANÁLISE DO EQUILÍBRIO CORONAL E DO ÚLTIMO NÍVEL ARTRODESADO EM ESCOLIOSE IDIOPÁTICA LENKE 5: PARÂMETROS RADIOGRÁFICOS ESPECÍFICOS

ANALISIS DEL BALANCE CORONAL Y ÚLTIMO NIVEL ARTRODESADO EN ESCOLIOSIS IDIOPÁTICA LENKE 5: PARÁMETROS RADIOGRÁFICOS ESPECÍFICOS

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ABSTRACT

Objective: To determine the postoperative changes produced in coronal balance of patients with adolescent idiopathic scoliosis (AIS) and Lenke type 5 curves, carrying out a pre- and postoperative analysis of the following radiological parameters: last arthrodesed vertebral level, L4 tilt, translation of the apical vertebra, lumbosacral obliquity, Cobb angle, and previous coronal balance. Methods: 20 patients with a diagnosis of AIS with Lenke type 5 curves, in mean follow-up of 36 months (Range: 24 to 48), were evaluated. The mean age at surgery was 15.3 years (Range: 13 to 20 years), and the distribution by sex was 16 women and 4 en. Results: In our series, we found a direct correlation between AVTL and LSTOA, and postoperative coronal balance, both in the group of patients that improved (14 patients) and in those with worsening of coronal balance (six patients). Conclusion: in the case series evaluated, AVTL and LSTOA were the specific radiographic parameters.

Keywords: Spinal curvatures; Scoliosis; Postural balance; Spinal fusion.

RESUMO

Objetivo: Determinar as modificações pós-operatórias produzidas no equilíbrio coronal dos pacientes com escoliose idiopática do adolescente (EIA) e curvas de Lenke tipo 5, realizando uma análise pre e pós-operatória dos seguintes parâmetros radiológicos: último nível vertebral artrodesado, inclinação de L4, translação de vértebra apical, obliquidade lombossacral, ângulo de Cobb e equilíbrio coronal prévio. Métodos: Foram avaliados 20 pacientes com diagnóstico de EIA com curvas de Lenke tipo 5, acompanhados em média por 36 meses (R: 24 a 48). A média de idade no momento da cirurgia foi de 15,3 anos (R: 13 a 20 anos), sendo a distribuição por sexo de 16 mulheres e 4 homens. Resultados: Em nossa série detectamos correlação direta entre AVTL e LSTOA com o equilíbrio coronal pós-operatório, tanto no grupo dos pacientes que melhoraram (14 pacientes), quanto nos que tiveram piora do equilíbrio coronal (6 pacientes). Conclusão: Na série avaliada, AVTL e LSTOA foram os parâmetros radiográficos específicos.

Descritores: Curvaturas da coluna vertebral; Escoliose; Equilíbrio postural; Fusão vertebral.

RESUMEN

Objetivo: Determinar las modificaciones postoperatorias que se producen en el balance coronal de los pacientes con escoliosis idiopática del adolescente (EIA) con curvas de Lenke tipo 5, realizando un análisis pre y postoperatorio de los siguientes parámetros radiológicos: último nivel vertebral artrodesado, inclinación de L4, traslación de vértebra apical, obliquidade lumbosacra, ángulo de Cobb y balance coronal previo. Métodos: Se evaluaron 20 pacientes con diagnóstico de EIA con curvas de Lenke tipo 5, con un seguimiento promedio de 36 meses (R: 24 a 48). La edad promedio al momento de la cirugía fue de 15,3 años (R: 13 a 20 años), siendo la distribución por sexo de 16 mujeres y 4 hombres. Resultados: En nuestra serie hemos detectado una correlación directa entre el AVTL y el LSTOA con el balance coronal postoperatorio, tanto en el grupo de los pacientes que mejoraron (14 pacientes), como en aquellos en los que el balance coronal empeoró (6 pacientes). Conclusión: De la serie evaluada, fueron el AVTL y el LSTOA, los parámetros radiográficos específicos.

Descriptores: Curvaturas de la columna vertebral; Escoliosis; Postural balance; Fusión vertebral.

INTRODUCTION

One of the main surgical objectives in the treatment of Lenke type 5 of idiopathic scoliosis is to determine the distal level of fusion, stabilize it, and improve the patient's coronal balance. This work aims to bring elements through the analysis of specific pre- and postoperative radiographic lumbar parameters, and analyze how these impact on patients' final coronal balance.

MATERIALS AND METHODS

A retrospective radiographic study of the case series type, with a minimum 2-year follow-up. We evaluated a total of 20 patients diagnosed with Lenke type 5 AIS curves, and average follow-up of 36 months (Range: 24 to 48 months). The average age at the time of surgery was 15.3 years (Range: 13 to 20 years), and the distribution by sex was 16 females and 4 males. Specific pre- and postoperative

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radiographic measurements were performed in all patients. Improvement in coronal balance was defined as patients who achieved correction of more than 2 cm, compared with the preoperative value.

Patient with a diagnosis of Lenke type 5 AIS curves treated surgically with posterior instrumentation, in which we conducted radiographic evaluation of specific parameters.

Radiological Parameters

- Pre-and postoperative spinograms, front and profile, with the patient standing;
- Dynamic X-ray (bending and traction);
- Convex bending: vertebral derotation;
- Concave bending: stable vertebral level identification;
- Lumbar curve angle;
- Tilt L4;
- Apical Vertebral Translation - Lumbar (AVT L); (Figure 1)[1]
- Lumbosacral take off angle (LSTOA) formed by the CSVL and the line that bisects the apex of the curve; (Figure 1)[2]
- Global Coronal Balance C7-CSVL;
- Apical Vertebral Translation - Lumbar (AVT L). (Figure 2)[2]

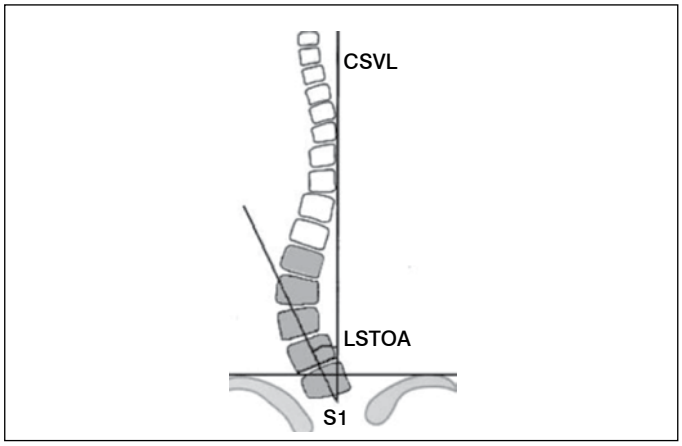

Figure 1. LSTOA measurement.

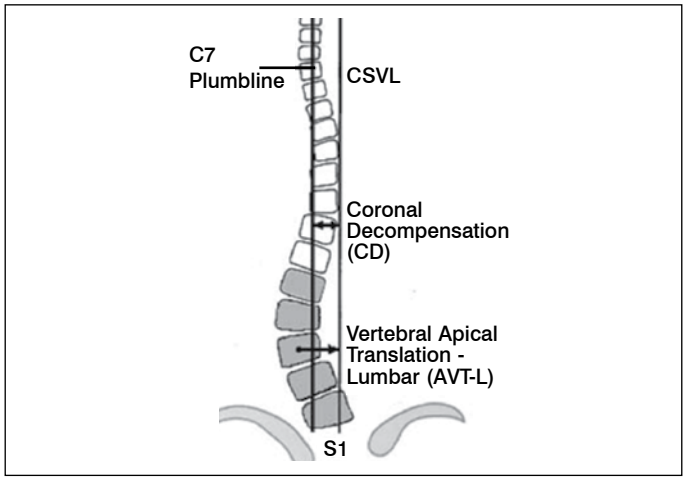

Figure 2. AVTL measurement.

RESULTS

A total of 20 patients were evaluated; 6 women and 4 men, with pre-and postoperative radiological analysis of lumbar curve. The results were as follows (Table 1):

Of the total series, performing analysis of the postsurgical coronal balance and their follow-up over time (Table 2) we found that seven of these patients suffered some degree of coronal imbalance, or had less than 2 cm of correction in relation to the preoperative values. The majority of patients in our series (n= 13), achieved optimum coronal balance or correction of more than 2 cm in relation to the preoperative value.

Table 1. Analyzing the overall lumbar curve angle.

Lumbar Curve	Results
Preoperative Global Angle	54.25º (R: 45º to 70º)
Percentage Correction (Bending)	58.72% (R: 25% to 89.58%)
Postoperative Global Angle	15.44º (R: 5º to 33º)
Postoperative Percentage Correction	71.18% (R: 41.07% to 91.37 %)

Table 2. Pre-and postoperative coronal balance.

Patient	Preoperative	1 year post-operative	2 years post-operative	3 years post-operative	4 years post-operative
1	2.5 cm left.	1.5 cm left.	3 cm left.		
2	4 cm left.	3.7 cm left.	3.3 cm left.		
3	3 cm left.	0.5 cm left.	0.5 cm left.		
4	2.2 cm left.	0	0	0	
5	2.3 cm left.	0.5 cm left.	0	0	
6	1 cm left.	1.5 cm left.	0		
7	0	0	0		
8	2.5 cm right.	0.5 cm right.	2 cm right.		
9	3 cm left.	0	0		
10	2.5 cm left.	0	0		
11	2 cm left.	0	0		
12	1.2 cm left.	0	0		
13	2 cm left.	0	0		
14	3 cm left.	0	2		
15	2.5 cm left.	4 cm left.	4 cm left.		
16	2.5 cm left.	1.5 cm left.	1.5 cm left.	1.5 cm left.	1.5 cm left.
17	2.5 cm left.	4 cm left.	3.8 cm left.		
18	5.5 cm left.	1 cm left.	0		
19	2.5 cm right.	1 cm right.	0.5 cm right.		
20	4.5 cm left.	0	0		

The percentage of correction of the coronal angle in the patients with improved final coronal balance was 74% (R: 43% to 91%), while in the group of patients who did not improve, this angle was 62% (R: 41% to 71%).

Analyzing the levels of arthrodesis performed in our patients, we see that the distribution of the Lowest Instrumented Vertebra was as follows: 6 Patients Cobb +1, 1 patient Cobb -1, 12 patients and one patient Cobb and Cobb +2.

If we take into account the distribution of the lowest instrumented vertebra, according to the distal lumbar level, we find the following results.

No clearly-defined pattern is seen between the patients' final coronal balance and the instrumented distal level, as evidenced by the fact that in the group where the imbalance did not improved or worsened, the constructions were Cobb and Cobb +1.

In one of the patients studied (Patient No. 15), coronal decompensation was achieved at the expense of inadequate selection of arthrodesis levels.

In the patients (n=2) submitted to fixation to L5, this was done by determining that the value of the tilt of LIV was greater than 25°, consistent with the tilt of L4.

One of the radiographic parameters analyzed in this work was the Lumbosacral Take-Off Angle (LSTOA). This is the angle formed by the lines that make up the CSVL and a line that bisects the apex of the lumbar curve. We shall analyze the behavior of the LSTOA in the group of patients whose balance improved postoperatively (Table 3), and in the group of patients whose balance did not improve. (Table 4)

Based on this analysis, it was observed that the average percentage of correction of the postsurgical LSTOA of the patients who achieved good final coronal balance was 85% (range: 56% to 100 %), while in the group of decompensated patients, this percentage was 33% (range: 0% to 47%).

Another of the analyzed parameters was the apical translation (Tables 5 and 6), adopting the same type of analysis in the patients.

Analysis of this parameter in both groups shows that the percentage of correction of the AVTL achieved by the group of patients with good postoperative coronal balance was 39 % (range: 31% to 50%), while in the group of patients who did not achieve good postoperative coronal balance, this percentage was 79% (range: 58% to 89%). The average apical translation in the patients whose balance improved was 4.3 cm (range: 3.2 cm to 5.5 cm), while this measurement in the patients who did not improve was 5.8 cm (range: 3 cm to 8 cm).

Another parameter analyzed was the angular tilt of the last instrumented vertebra, both preoperative and postoperative and in follow-up (Tables 7 and 8).

The overall postoperative average percentage of correction of tilt of the last instrumented vertebra in the patients whose coronal balance did not improve was 60% (range: 52% to 80%), while in the group whose coronal balanced improved, this percentage was 85% (range: 53% to 100%).

Table 3. LSTOA group of patients with improved coronal balance.

Patient	Preoperative	Bending correction	Postoperative correction	Percentage correction
3	23°	0°	14°	60%
4	10°	0°	2°	80%
5	24°	0°	0°	100%
6	17°	0°	0°	100%
7	18°	0°	0°	100%
9	18°	5°	0°	100%
10	13°	0°	0°	100%
11	20°	0°	0°	100%
12	20°	20°	5°	75%
13	28°	18°	0°	100%
18	20°	20°	8°	60%
19	23°	10°	10°	56%
20	21°	5°	5°	76%

Table 4. LSTOA group of patients without improved coronal balance.

Patient	Preoperative	Bending correction	Postoperative correction	Percentage correction
1	20°	0°	12°	40%
2	20°	18°	21°	0%
8	18°	0°	10°	44%
14	30°	10°	18°	40%
16	21°	15°	15°	28%
17	40°	23°	21°	47%

DISCUSSION

Nowadays, the specific radiographic parameters that best correlate the position of the last instrumented vertebra and coronal balance in patients with Lenke type 5 AIS following posterior instrumentation with pedicle screws are controversial. One of the main goals of surgery is to stabilize and flatten the last instrumented vertebra and improve coronal balance.[2] There is still much disagreement as to the best way to objectively determine the level of distal fusion.[3]

Another major therapeutic goal is to spare distal fusion levels. It is known that posterior fusion with pedicle screws is a surgical technique that produces the greatest stress on the adjacent segment.[4]

Although there are some general guidelines for determining the ideal instrumented vertebra, each surgeon determines the last instrumented vertebra according to their own criteria and experience.[5] Some authors suggest that a residual tilt of the last fused vertebra of more than 15° could be an important factor for caudal decompensation in artrodesis.[6]

The tilt of the lowest instrumented vertebra is one of the most important preoperative radiographic parameters to consider in the preoperative planning in Lenke type 5 curves.[7] This study aims to

Table 5. Apical vertebral translation. Group of patients with improvement in coronal balance.

Patient	Preoperative AVTL	1 year postoperative	2 years postoperative	3 years postoperative	4 years postoperative	Correction percentage
3	4 cm	2.3 cm	2.3 cm			58%
4	5.5 cm	1.3 cm	1.2 cm	1.2 cm		78%
5	4 cm	1.5 cm	1 cm	1 cm		75%
6	4.5 cm	1.2 cm	0.5 cm			89%
7	4 cm	1 cm	1 cm			75%
9	4 cm	0.5 cm	0.5 cm			88%
10	4.5 cm	0.5 cm	0.5 cm			89%
11	3.2 cm	0.5 cm	0.5 cm			84%
12	4 cm	0.6 cm	0.5 cm			89%
13	4 cm	0.8 cm	1 cm			75%
18	5 cm	1 cm	1 cm			80%
19	4.5 cm	1 cm	1 cm			77%
20	5 cm	1 cm	1 cm			80%

Table 6. Apical vertebral translation. Group of patients without improvement in coronal balance.

Patient	Preoperative AVTL	1 year postoperative	2 years postoperative	3 years postoperative	4 years postoperative	Correction percentage
1	5.3 cm	2.1 cm	3 cm			43%
2	8 cm	5 cm	5.5 cm			31%
8	6 cm	2 cm	4 cm			33%
14	3 cm	1 cm	2 cm			33%
16	4.5 cm	2 cm	2 cm	2 cm	2 cm	44%
17	8 cm	2.8 cm	3.8 cm			47%

Table 7. Lowest instrumented vertebral tilt. Group of patients with improvement in coronal balance.

Patient	LIV	Preoperative LIV	Correction of bending	1 year postoperative	2 years postoperative	3 years postoperative	Correction percentage
3	L3	22°	8°	0°	0°		100%
4	L4	37°	15°	0°	0°	0°	100%
5	L5	27°	0°	5°	0°	0°	100%
6	L4	29°	0°	13°	5°		82%
7	L4	22°	15°	0°	0°		100%
9	L4	23°	12°	8°	10°		56%
10	L4	25°	0°	10°	10°		60%
11	L3	17°	0°	0°	0°		100%
12	L4	30°	15°	0°	0°		100%
13	L4	23°	10°	0°	0°		100%
18	L4	27°	11°	5°	5°		81%
19	L3	28°	0°	5°	5°		82%
20	L4	15°	0°	7°	7°		53%

Table 8. Lowest instrumented vertebral tilt. Group of patients without improvement in coronal balance.

Patient	LIV	Preoperative	Correction of bending	1 year postoperative	2 years postoperative	3 years postoperative	4 years postoperative	Correction percentage
1	L4	35°	8°	10°	15°			57%
2	L4	44°	20°	30°	23°			52%
8	L3	30°	0°	10°	15°			50%
14	L4	25°	10°	10°	10°			60%
16	L4	26°	5°	8°	5°	5°	5°	80%
17	L5	28°	18°	10°	11°			60%

demonstrate which radiographic elements have greater relevance in the decision-making, and how these elements affect the patient's coronal balance.

We attempted to compile the most significant radiographic parameters, and how these affect the final coronal balance of operated patients. From the series studied, we conclude that the parameters most directly related to the modification of postoperative coronal balance are AVTL and LSTOA, both in the group of patients who improved and in the group of patients whose coronal balance did not improve, or worsened.

CONCLUSION

The group of patients with the least correction of LSTOA was the group in which the coronal imbalance did not improve or increase.

The group of patients with the least correction of AVTL was the group in which the coronal imbalance did not improve or increase.

In the group of patients whose coronal balance did not improve, both LSTOA and AVTL were corrected by less than 50%.

The general average preoperative AVTL was greater in the patients whose coronal balance did not improve.

The tilt of the lowest instrumented vertebra showed less angular correction in the patients whose coronal balance did not improve, or worsened.

No clear patterns were found in terms of the lumbar lowest instrumented vertebra and coronal balance.

In our case series, AVTL and LSTOA were the two specific radiographic parameters that most affected the patients' final coronal balance.

All authors declare no potential conflict of interest concerning this article.

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