

# LONG-TERM FOLLOW-UP OF AIS TREATED SURGICALLY WITH PEDICULAR SCREWS

SEGUIMIENTO A LARGO PLAZO DE EIA INTERVENIDA QUIRÚRGICAMENTE CON TORNILLOS PEDICULARES

ACOMPANHAMENTO A LONGO PRAZO DE EIA TRATADA CIRURGICAMENTE COM PARAFUSOS PEDICULARES

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## ABSTRACT

**Objective:** In the last three decades, there have been great advances in the surgical treatment of adolescent idiopathic scoliosis. There are few studies that focus on the long-term clinical and radiographic results of AIS operated on with pedicle screws that also consider psychological repercussions. **Methods:** We conducted an observational longitudinal study. We reviewed the AIS cases that were operated on with pedicle screws in our center between January 2009 and December 2010. We conducted follow-up until July 2019. A short questionnaire was administered to assess patient satisfaction and the long-term impact from both psychological and functional points of view. **Results:** A total of 19 patients met the inclusion criteria. The mean preoperative Cobb was 58°, the postoperative was 23° and at the end of follow-up it was 26°. No major complications were reported. Ninety percent were very satisfied with the overall results of the surgery. Ninety-five percent had no limitation for sports or daily activities and 90% were satisfied with the cosmetic results. **Conclusion:** The short- and long-term radiographic evolution in patients treated with third generation material presented good clinical results. In 3 cases (16%) loss of correction greater than 10% was reported. The overall satisfaction index and cosmetic results were very good at the end of follow-up despite the low correction rate (60%). There were no major complications and the incidence of functional limitation and pain at the end of the follow-up was very low. **Level of evidence IV; Review article.**

**Keywords:** Scoliosis; Adolescent; Surgery; Bone Screw.

## RESUMO

**Objetivo:** Nas últimas três décadas houve grandes avanços no tratamento cirúrgico da escoliose idiopática do adolescente. Existem poucos trabalhos que estudam os resultados clínicos e radiográficos a longo prazo de EIA, tratados cirurgicamente com parafusos pediculares que também considerem a repercussão psicológica. **Métodos:** Realizamos um estudo longitudinal observacional. Analisamos a EIA de pacientes operados entre janeiro de 2009 e dezembro de 2010 que receberam parafusos pediculares em nosso centro. Realizamos o acompanhamento até julho de 2019. Foi realizado um breve questionário para avaliar a satisfação dos pacientes e a repercussão a longo prazo do ponto de vista psicológico e funcional. **Resultados:** Um total de 19 pacientes satisfizeram os critérios de inclusão. A média de Cobb pré-operatório foi de 58° e o pós-operatório foi de 23° e ao final do acompanhamento, de 26°. Não foram registradas complicações relevantes. Quanto à satisfação, 90% estão muito satisfeitos com o resultado geral da cirurgia, 95% não têm limitações para esportes ou atividades diárias e 90% estão satisfeitos com os resultados estéticos. **Conclusões:** A evolução radiográfica a curto e longo prazo nos pacientes tratados com material de terceira geração apresentou bons resultados clínicos. Em 3 casos (16%), registrou-se perda de correção superior a 10%. O índice geral de satisfação e resultado estético é muito bom no final do acompanhamento, apesar da baixa taxa de correção (60%). Não se constataram complicações importantes e a incidência de limitação funcional e dor ao final do acompanhamento foi muito baixa. **Nível de evidência IV; Artigo de revisão.**

**Descritores:** Escoliose; Adolescente; Cirurgia; Parafusos Ósseos.

## RESUMEN

**Objetivo:** En las últimas tres décadas han habido grandes avances en el tratamiento quirúrgico de las escoliosis idiopática del adolescente. Existen pocos trabajos que estudien el resultado clínico y radiográfico a largo plazo en las EIA intervenidas con tornillos pediculares que además contemplan repercusión psicológica. **Métodos:** Realizamos un estudio longitudinal observacional. Revisamos las EIA intervenidas entre enero de 2009 y diciembre de 2010 con tornillos pediculares en nuestro centro. Realizamos seguimiento hasta julio de 2019. Se realizó un breve cuestionario para evaluar satisfacción de los pacientes y la repercusión a largo plazo de punto de vista psicológico y funcional. **Resultados:** Un total de 19 pacientes cumplieron los criterios de inclusión. La media del Cobb pre operatorio fue de 58° y el post operatorio de 23° y al final del seguimiento, de 26°. No se registraron complicaciones mayores. El 90% está muy satisfecho con el resultado global de la cirugía. El 95% no presenta limitación para el deporte o actividad cotidiana y el 90% está conforme con resultado cosmético. **Conclusiones:** La evolución radiográfica a corto y largo plazo en pacientes tratados con material de tercera generación presentó buenos resultados clínicos. En 3 casos (16%) se registró pérdida de corrección mayor a 10%. El índice de satisfacción global y resultado cosmético es muy bueno al final del seguimiento a pesar de la baja tasa de corrección (60%). No se constataron complicaciones mayores y la incidencia de limitación funcional y dolor al final del seguimiento fue muy baja. **Nivel de evidencia IV; Estudio de revisión.**

**Descritores:** Escoliosis; Adolescente; Cirugía; Tornillos Óseos.

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<http://dx.doi.org/10.1590/S1808-185120212002236330>

Received on 04/08/2020 accepted on 09/28/2020

Coluna/Columna. 2021;20(2):132-6

Reviewed by: Pedro Pohl

## INTRODUCTION

Scoliosis is a pathological condition of the spine characterized by a spinal deformity in three planes and with curvature greater than  $10^\circ$  in the coronal plane. This disease affects patients between 10 and 18 years of age. Its prevalence ranges from 2% to 4% in patients between 10 and 16 years of age and is more common in females (70%). Although there are multiple known causes that provoke this change, 80% of cases are idiopathic. Cases are classified into infantile, juvenile or adolescent idiopathic scoliosis according to age. However, currently the terms early onset or late onset are used, depending on the age at appearance, using 4 years of age as the cutoff point. The natural history of scoliosis is variable and depends on the etiopathology and the type of curve. Idiopathic scoliosis can progress to being painful and to limit physical function and mobility. In severe cases, it can significantly compromise cardiorespiratory function. It is also viewed as negatively affecting the mental self-image, causing problems for interpersonal development among other psychological consequences. In the last 30 years, big advances have been achieved in the surgical treatment of adolescent idiopathic scoliosis (AIS). In 1962, Harrington described the scoliosis correction technique using rods. This technique was widely used, achieving correction by means of elongation and placing a rod in the concavity. Later, in 1967, the Harrington-Luque technique used a molded L-shaped rod secured by sublaminar wires. Both techniques required the use of a postoperative brace for several months. The long-term review of this technique showed that there was improvement in the coronal plane but not in the sagittal plane. It also presented complications derived from the use of sublaminar wires. It was not until 1988 that Cotrel-Dubousset presented their segmental instrumentation system consisting of hooks and contoured longitudinal rods. This system of pedicle and laminar hooks enabled better correction and stability in the three planes. In addition, lower rates of pseudoarthrosis and implant failure than in previous techniques were recorded. Later they began to use hybrid assemblies, i.e., hooks in the proximal sector and pedicle screws in the lumbar sector. Pedicle screws had been used in Europe since the 1960s by Roy Camille, Dick and Margel for fractures. However, they were not widely used in idiopathic scoliosis until the 1990s. In 1999, after several successes, the FDA approved the use of pedicle screws in the treatment of AIS in the United States of America. That same year, Suk et al. demonstrated its safety and low rate of complications in a series of 203 AIS cases. Subsequently, multiple studies showed its safety and efficiency from a biomechanical perspective. Pedicle screws allow a high rate of correction to be obtained as they are capable of correcting deformities in three planes with very stable systems. Among other advantages, they also are able to reduce the number of fused spaces. It is currently the treatment of choice for this pathology. In 2009, third generation material began to be used in Uruguay and by the surgeons in our center in the treatment of adolescent idiopathic scoliosis.

Although there are long-term studies of surgical results in AIS, most of them are with Harrington rods, CD instrumentation, or hybrid assemblies in some cases. These studies mainly contemplate the clinical and radiological results. With regard to radiographic evolution, they generally focus on results in the coronal plane without considering the sagittal plane. In recent years, the impact on the psychological sphere and the quality of life have begun to be investigated, highlighting their importance in the overall outcome. The objective of this study is to assess the clinical and radiographic long-term outcome of patients who underwent surgery with pedicle screws for AIS and its long-term psychological impact.

## METHODS

The patients authorized publication of the data in a scientific journal with prior informed consent. Technical management of the spine deformity center authorized this study under resolution no. 122.

A longitudinal type of study was conducted with patients with AIS who underwent surgery with pedicle screws between January 2009 and December 2010 as the target population. The plan and surgical region were determined in a preoperative meeting. All were operated

by isolated posterior approach with motor and sensory evoked potentials controlled with continuous electromyography. The cantilever method was used to correct deformity in most cases and the correction was complemented by segmental compression-elongation at the discretion of the surgeon. Prior to surgery, the patients were evaluated clinically and radiographically with front, profile and lateral bending spinography, and in some cases with magnetic resonance imaging of the total spine. In postoperative controls, in addition to clinical assessment serial spinographs were conducted.

We excluded all cases whose imaging or clinical history was insufficient. We defined as sufficient the cases that had the previously mentioned radiographic studies, a spinograph performed a year before and another at the end of follow-up. The final radiographic controls were conducted between April and July 2019. We also excluded cases in which at least 70% of the fixation points were not pedicle screws.

Data was collected from the clinical history and the deformity file, which consists of three parts that complement the clinical history. Age, sex, date of surgery, classification of the curve according to Lenke and arthrodesis levels were recorded. In the coronal plane, the angular value of the largest curve was assessed according to the Cobb method. In the sagittal plane, thoracic kyphosis and the vertical axis were quantified. Kyphosis was classified into hyperkyphosis, normal kyphosis or hypokyphosis, using a normal thoracic kyphosis reference value of between 20 and 40 degrees. We defined as positive balance those cases in which the vertical axis line passes more than 2 cm in front of the posterior superior angle of the S1 body, as negative balance, those where it passes 2 cm behind it, and as neutral, those where the line passes more or less 2 cm from the posterior superior angle of S1. These measurements were taken preoperatively, postoperatively and at the final control.

Using the SRS-23 questionnaire as a reference, we created a questionnaire consisting of 5 questions. In some cases it was administered by telephone and in others face-to-face for patients who attended the control after being called in by telephone. An attempt was made to abbreviate the questionnaire proposed by SRS to evaluate the different areas with a single question.

1. Does your back restrict you from performing daily household or sports activities?  
Always – Almost always – Sometimes – Once in a while - Never
2. How much pain have you had in the last 6 months?  
None – Mild - Normal - Moderate - Intense
3. Are you currently worried about the cosmetic results?  
Extremely – Quite – More or less – A Little bit – Not at all
4. Are you satisfied with the results of the treatment?  
Completely satisfied – Indifferent – Completely dissatisfied – Quite satisfied – Quite dissatisfied
5. Would you accept the same treatment another time if you were in the same situation?  
Yes, definitely – Probably yes – I am not sure – Definitely not – Probably not

It should be noted that although currently all patients who are going to be submitted to scoliosis surgery are evaluated by a psychiatrist from the medical psychology team, during the period analyzed only 4 patients were evaluated. In these cases, personal traits were identified that motivated the request for a consultation.

## RESULTS

Thirty patients underwent surgery for AIS between January 2009 and December 2010, 19 of whom met the inclusion criteria. Of the excluded cases, 4 whose clinical histories were insufficient and 7 who could not be contacted at the end of follow-up. The mean age was 14 years (range 11-17) and 18 (95%) of them were female. The mean follow-up time was 9.5 years (10.4 to 8.7 years). An average of 10 spaces were fused per patient.

The most frequent patterns encountered according to Lenke's classification were types 1 and 3 with 6 cases each, followed by

type 6 with 4 cases and type 5 with 3 cases, as detailed in Figure 1.

The mean preoperative angle value was 58 (ranging from 90-42). The mean postoperative angle value before the end of the first year was 23, for a correction rate of 60%. The mean angle value at the end of follow-up was 26. Therefore, an average correction of 5% had been lost by the end of follow-up. Only 3 cases had lost more than 10%. (Table 1)

Three patients had hypokyphosis of the sagittal plane. At the end of follow-up, 2 of these remained with hypokyphosis, while the others were all within normal values. There were 3 cases of uncompensated curves in the sagittal plane (negative SVA). In two of these three cases normal postoperative values were recorded. As regards complications, no major events were recorded. In one case, a ruptured dural sac was reported. There were no mediated postoperative complications and normal rehabilitation continued. However, at 5 years a broken rod was reported. This case also presented residual pain with psychological repercussions, for which the patient was in psychiatric treatment.

Two cases were reoperated, one for loosened hooks in the proximal sector and the other for loosening of the blocks in the distal sector. This last case was operated on at 3 months. It had a loss of correction of 30%, going from an immediate postoperative angle value of 25 to 40 after reintervention. No major loss of correction was observed in successive controls.

Regarding the questionnaire, the overall results were very good. Two cases were "a little bit" concerned with the cosmetic results, while 17 (90%) answered "not at all". In both cases the concern was due to the perception about the thoracic hump. One case referred to "intense pain" in the last 6 months, while 18 reported "none" during this period. In terms of function, none of the 18 cases was bothered by their back in sports or daily activities. (Figures 1, 2 and 3)

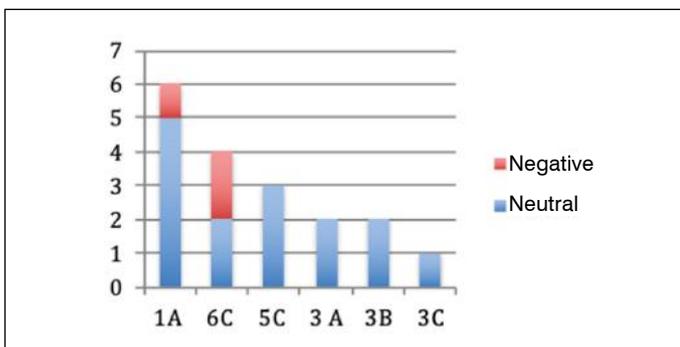


Figure 1. Lenke Classification.

Table 1. Measurement of curves by Cobb method.

	VA pre op	VA post op	VA final	%correction	%loss of correction
1	67	25	25	63	0
2	67	15	20	78	8
3	64	24	25	62.5	2
4	43	25	27	42	5
5	48	12	18	75	13
6	42	8	14	81	14
7	48	18	18	63	0
8	60	24	30	60	10
9	60	25	25	58.3	0
10	62	15	15	76	0
11	54	21	23	61.1	4
12	60	27	35	55	13
13	69	30	35	57	8
14	50	40	40	20	0
15	66	44	44	33	0
16	90	41	40	54.4	1
17	45	10	10	78	0
18	62	25	25	60	0
19	53	22	22	58.4	0
Total	58	23	26	60 %	4.1%

VA: Value of the angle.

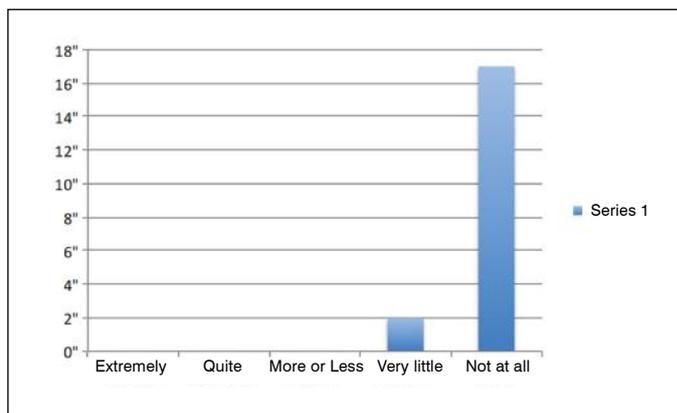


Figure 2. Are you currently worried about the cosmetic result?

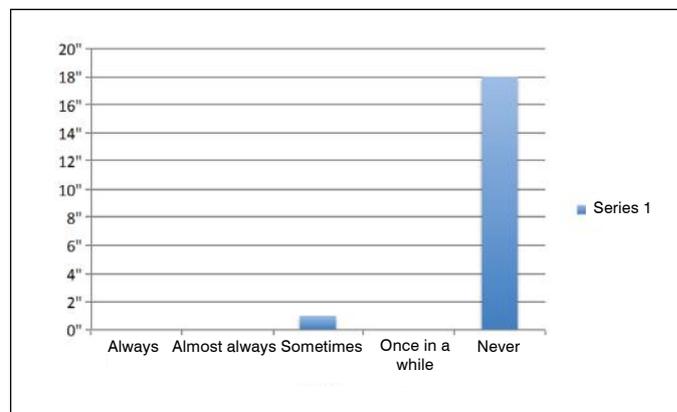


Figure 3. Does your back restrict you from performing daily household or sports activities?

## DISCUSSION

There are few evaluations of long-term clinical and radiological outcomes with modern AIS correction and stabilization systems based on pedicle screws. There are some short- and medium-term studies that show the advantages of these as compared to hybrid assemblies.<sup>1-3</sup>

The advantages of pedicle screws for the correction of idiopathic scoliosis have been well-established for several years. Suk et al.<sup>4</sup> published one of the first studies of the results of thoracic pedicle screws in AIS. The correction in all planes as well as the low incidence of complications are repeated in multiple studies. They also reported little medium-term correction loss in the coronal plane and these results were repeated in short- and long-term studies.<sup>5</sup> The degree of curve correction in the coronal plane is important, but it should not be the main value at the time the results are measured. We know that certain residual deformities are well tolerated. It should be considered as an element within the overall outcome. Curve progression in operated patients is multifactorial, being one of the main causes of the crankshaft effect. This effect, known as the crankshaft phenomenon, causes vertebral rotation through growth of the vertebral body with posterior fixation, clinically causing an increase in the hump. The rate of correction in the coronal plane is variable and the percentage of correction has been shown to be higher with pedicle screws than that achieved with hooks or hybrid assemblies.<sup>6-8</sup> We believe that this variability is due to the peculiarities of each curve that make it more or less flexible, among other characteristics. In our series of consecutive cases, mean correction was 60%, for which we believe it to be similar to larger published series. In recent studies the correction rates reach values as high as 80%.<sup>9</sup> We believe that our results are somewhat lower because they are the first cases of AIS to be treated with 3rd generation material. In 2009, our center pioneered the introduction of this material in adolescent idiopathic scoliosis in Uruguay. Currently,

thanks to advances in instrumentation, surgical techniques and the experience of the surgical team, the results in the coronal plane are significantly better.

As we have previously seen, in the short- and medium-term pedicle screws have shown little correction loss. The loss of correction is obviously more significant in the first year, and the values observed in years 2 to 5 are progressive but not significant.<sup>10</sup> It has been clearly demonstrated that loss of correction with third generation material is significantly less (1.9% vs. 11.2%) than that documented for hybrid material.<sup>11</sup> Few studies quantify the angle value lost in the long term with third generation material. In their study of scoliosis treated with third generation material, Suk et al., reported a 3% loss of correction at 5 years. We did not find any studies that contemplate this parameter over longer periods. In our series, 5% had been lost by the end of follow-up, which was not a significant loss in the coronal plane. We found no relationship between the degree of correction lost and the type of curve or the preoperative angle value.

Sagittal balance has already been established as one of the most significant parameters for evaluating the radiological and functional results in any spinal intervention. There is a clear relationship between sagittal balance changes and negative clinical outcomes, especially with a positive balance. Long-term studies of AIS treated with systems such as Harrington rods have reported changes in sagittal balance, especially a high incidence of lumbar lordosis loss. Long-term studies of these systems have shown a high incidence of lumbar pain at 10 years, reaching as high as 75% in some series.<sup>12,13</sup> At the end of follow-up, our series had only 1 case that reported lumbar pain within the last 6 months. The use of thoracic pedicle screws and correction of the deformity in three planes permits the use of more stable and rigid assemblies achieving correction of deformity in the sagittal plane.<sup>14</sup> We believe that this is one of the main reasons why the incidence of residual pain is lower with modern instrumentations. In our series, no significant postoperative changes in sagittal balance were reported.

Regarding the patient's perception of the cosmetic result, we believe that the results in our series are very good. The psychological changes in cosmetic perception of adolescents with AIS are well documented.<sup>15,16</sup> On the other hand, each individual's self-perception varies throughout life.<sup>17,18</sup> Our questionnaire was administered at the end of follow-up when the mean age of the patients was 23 years. We noticed that 90% of the cases were "not at all" bothered by the cosmetic result. Although the degree of correction in the radiographic controls was acceptable, in many cases a certain deformity remained that did not seem to have had a negative impact on the patient at that point in their life.

The overall satisfaction of patients who were operated for spinal deformity is good.<sup>19,20</sup> These results are comparable to those obtained in our series. Of the 19 cases, 17 would "yes, definitely" accept the same treatment and 18 were "completely satisfied" with the procedure. As for functional level, the results were very good: 18 patients reported that they "never" were limited in sports or daily activities. (Figure 4 and 5)

One of the limitations of our study is the sample size, which did not allow us to draw statistically significant conclusions.

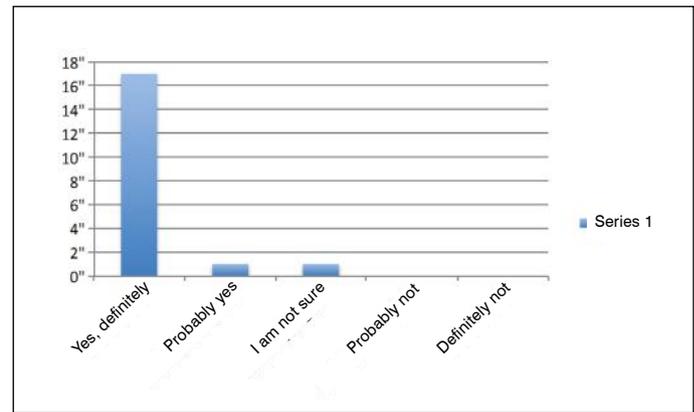


Figure 4. Would you accept the same treatment another time if you were in the same situation?

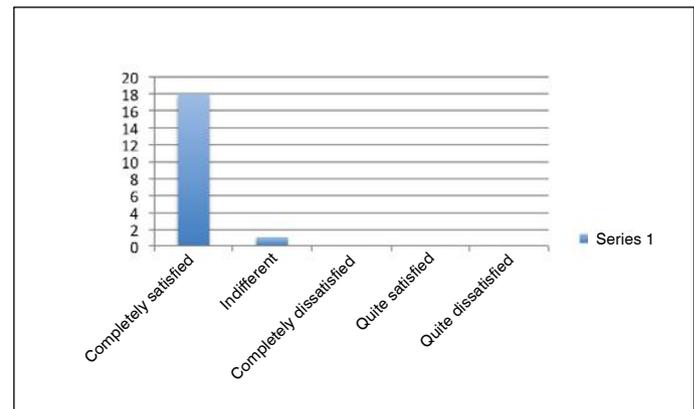


Figure 5. Are you satisfied with the results of the treatment?

## CONCLUSION

The short- and long-term radiographic evolution in patients treated with third generation material yielded good radiographic clinical results. We did not find significant progression of the angular value in the coronal plane at the end of follow-up. In 3 cases (16%) there was loss of correction greater than 10%. Despite the low correction rate (60%) in the coronal plane, the overall satisfaction and the cosmetic results were very good at the end of follow-up. Ninety percent were "not at all" concerned with the cosmetic result. We believe that this reinforces the concept that the coronal plane is just one of the components that impact the functional and psychological prognoses. No major complications were found, the functional results were very good, and there was minimal incidence of residual pain.

All authors declare no potential conflict of interest related to this article.

**CONTRIBUTION OF THE AUTHORS:** Each author made significant individual contributions to this manuscript. FG, AR, JMV: review, performance of surgeries and data analysis. SS: writing, review, intellectual concept and preparation of the entire research project; LP, NG: writing, statistical analysis, intellectual concept.

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