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RADIOGRAPHIC EVALUATION OF SURGICAL CORRECTION OF SCOLIOSIS DUE TO CEREBRAL PALSY USING INTRA-OPERATIVE TRACTION AND NEW CORRECTION TECHNIQUE WITH 3RD PROVISIONAL ROD

AVALIAÇÃO RADIOGRÁFICA DE CORREÇÃO CIRÚRGICA DE ESCOLIOSE DEVIDO A PARALISIA CEREBRAL USANDO TRAÇÃO INTRAOPERATIVA E NOVA TÉCNICA DE CORREÇÃO COM TERCEIRA HASTE PROVISÓRIA

EVALUACIÓN RADIOGRÁFICA DE CORRECCIÓN QUIRÚRGICA DE ESCOLIOSIS DEBIDO A PARALISIA CEREBRAL MEDIANTE TRACCIÓN INTRAOPERATIVA Y NUEVA TÉCNICA DE CORRECCIÓN CON TERCERA BARRA PROVISORIA

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ABSTRACT

Objective: Evaluate the radiographic results of patients with cerebral palsy and Lonstein and Akbarnia type II scoliosis who underwent intraoperative halofemoral traction (IFAT) and correction with a 3rd provisional nail. Methods: Retrospective case series study. Were evaluated preoperative (PRE), traction (TR), immediate (POI), and late (POT) total spine radiographs. Were verified the angular value of the main curve (COBB), pelvic obliquity (OP), trunk balance in the coronal plane (CSVA), vertical sagittal alignment (SVA), curve flexibility, and percentage of correction in the final PO. Friedam and Wilcoxon tests were performed ($p<0.05$). Results: Twenty-one patients were included in the study, with a mean age of 16 (±4.13). There was a statistical difference when comparing COBB PRE with TRACTION to POI and POT ($p=0.0001$), OP in PRE with TRACTION, and between PRE and POT ($p=0.0001$). There was a statistical difference in coronal (CSVA) and sagittal (SVA) balance concerning PRE and POT. The percentage of correction for the main curve was 55.75% (± 11.11), and for the OP, 64.86% (± 18.04). Conclusion: The correction technique using the 3rd provisional nail technique and intraoperative traction presents a correction power of 55.75% of the proximal curve and 64% of the pelvic obliquity. In addition, it is easy to assemble, has a short surgical time, and causes little loss of correction during follow-up. ***Level of Evidence III B; I study a series of retrospective cases.***

Keywords: Spinal Fractures; Kyphosis; Diagnostic Imaging.

RESUMO

Objetivo: Avaliar os resultados radiográficos de pacientes com paralisia cerebral e escoliose tipo II de Lonstein e Akbarnia submetidos à tração halo-femoral intra-operatória (THFI) e correção com 3ª haste provisória. Métodos: Estudo série de casos retrospectivo. Foram avaliadas radiografias de coluna total pré-operatórias (PRÉ), sob tração (TR), pós-operatória imediata (POI) e tardia (POT). Verificou-se valor angular da curva principal (COBB), obliquidade pélvica (OP), equilíbrio do tronco no plano coronal (CSVA), alinhamento sagital vertical (SVA), flexibilidade da curva e percentual de correção no PO final. Foram realizados os testes de Friedam e Wilcoxon ($p<0,05$). Resultados: Vinte e um pacientes foram incluídos no estudo, com idade média de 16 (±4,13) anos. Houve diferença estatística quando se comparou: COBB PRÉ com TRAÇÃO em relação ao POI e POT ($p=0,0001$), OP no PRÉ com TRAÇÃO e entre o PRÉ e POT ($p=0,0001$). Houve diferença estatística em relação ao equilíbrio coronal (CSVA) e sagital (SVA) em relação ao PRE e POT. O percentual de correção da curva principal foi de 55,75% (± 11,11) e da OP de 64,86% (± 18,04). Conclusão: A técnica de correção utilizando a técnica da 3° haste provisória e tração intra-operatória apresenta poder de correção de 55,75% da curva proximal e 64% da obliquidade pélvica. Além disso, apresenta facilidade de montagem, tempo cirúrgico pequeno e pouca perda de correção ao longo do seguimento. ***Nível de Evidência III B; Estudo de série de casos retrospectivos.***

Descritores: *Fraturas da Coluna Vertebral; Cifose; Diagnóstico por Imagem.*

RESUMEN

*Objetivo: Evaluar los resultados radiográficos de pacientes con parálisis cerebral y escoliosis tipo II de Lonstein y Akbarnia a quienes se les realizó tracción halofemoral intraoperatoria (*THFI*) y corrección con una tercera barra provisoria. Métodos: Estudio retrospectivo de*

Study conducted by the Spine Group of the Dr. Henrique Santillo Rehabilitation and Readaptation Center (CRER - Goiânia/GO).
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serie de casos. Se evaluaron radiografías totales de columna preoperatorias (PRE), de tracción (TR), post-operatorias inmediatas (POI) y tardías (POT). Se verificó el valor angular de la curva principal (COBB), la oblicuidad pélvica (OP), el equilibrio del tronco en el plano coronal (CSVA), la alineación sagital vertical (SVA), la flexibilidad de la curva y el porcentaje de corrección en el PO final. Se realizaron las pruebas de Friedam y Wilcoxon (p<0,05). Resultados: Se incluyeron en el estudio 21 pacientes, con una edad media de 16 (±4,13) años. Hubo diferencia estadística al comparar: COBB PRE con TRACCIÓN en relación a POI y POT (p=0,0001), OP en PRE con TRACCIÓN y entre PRE y POT (p=0,0001). Hubo diferencia estadística en relación al equilibrio coronal (CSVA) y sagital (SVA) en relación a PRE y POT. El porcentaje de corrección para la curva principal fue del 55,75% (± 11,11) y para la OP del 64,86% (± 18,04). Conclusión: La técnica de corrección mediante la técnica de la tercera barra provisoria y tracción intraoperatoria presenta un poder de corrección del 55,75% de la curva proximal y del 64% de la oblicuidad pélvica. Además, es de fácil montaje, tiene un tiempo quirúrgico corto y poca pérdida de corrección durante el seguimiento. ***Nivel de evidencia III B; Estudio una serie de casos retrospectivos.***

Descriptores: *Fracturas Vertebrales; Cifosis; Diagnóstico por Imagen.*

INTRODUCTION

Patients with Cerebral Palsy (CP) have a high incidence of neuromuscular scoliosis. The prevalence varies according to the degree of functional impairment of the patient, being more frequent in patients with a lower walking ability (gross motor function classification (GMFCS) type IV and V).[1-3] The type of curve also varies according to the patient's function, with compensated trunk curves being more frequent in ambulatory patients (Lonstein and Akbarnia Group I), whereas non-ambulatory patients predominantly present with decompensated trunk curves and pelvic obliquity (PO) (Lonstein and Akbarnia Group II).[4] (Figure 1)

The surgical treatment of these deformities is usually long arthrodeses extending to the ilia. For many years, the gold standard for correcting these deformities was sublaminar fixation systems using the Luque-Galveston technique. There is a preference for pedicle screws, which promote greater correction, stability, and lower pseudoarthrosis rate.[5,6] Furthermore, the use of intraoperative halo-femoral traction (THFI) has been described as safe and with better power to correct OP.[7]

Correction of the deformity and placement of the rods can be quite difficult from a technical point of view in rigid curves with OP, especially in cases with lumbar hyperlordosis. Because these deformities do not follow the pattern of idiopathic scoliosis, it is usually impossible to perform the rod defeaturing maneuver, which would allow the coronal plane deformities to be transformed into the physiological curves of the sagittal plane. In these cases, pre-molding the stem with large deformity in the coronal plane and subsequent correction with *in situ* molding and cantilever are usually needed in these cases.[8]

From this need, a technique called correction through the 3rd provisional stem was developed, in which the main lumbar or thoracolumbar curve is corrected through a provisional stem, by the isolated defeat of this curve by the convexity. This allows easier placement of the contralateral definitive stem and final correction and the entire curve, with subsequent replacement of the temporary stem with the second definitive stem.

The present study aims to evaluate the radiographic results of cerebral palsy patients with Lonstein and Akbarnia type II scoliosis who underwent surgical treatment with intraoperative halo-femoral traction (THFI) and correction technique with 3rd provisional rod.

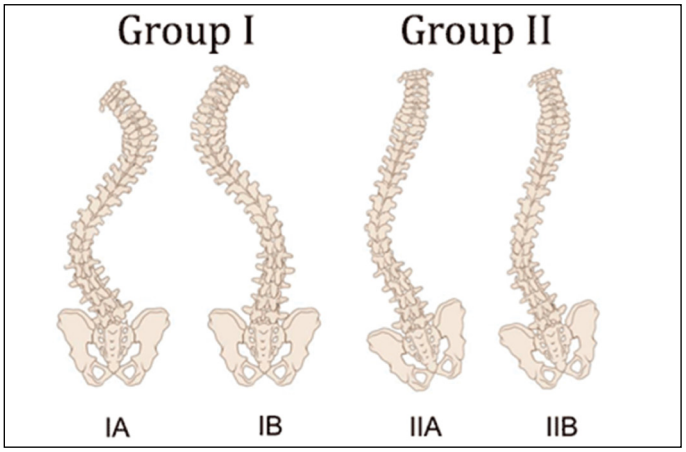

Figure 1. Lonstein and Akbarnia's classification. Group, I is characterized by compensated trunks (IA double curve and IB thoracic) and Group II by decompensated trunks with pelvic obliquity (IIA presence of lumbosacral fractional curve and IIB with the sacrum being part of the main curve).

METHODS

Retrospective case series study. After CEP approval (28283020.4.0000.0023), imaging examinations and medical records of patients with cerebral palsy (CP) who underwent surgical treatment for scoliosis from January 2012 to July 2019 were evaluated, with a minimum follow-up of six months. Because this was a retrospective study of medical records, with no contact, intervention, or identification of patients, the Research Ethics Committee allowed the waiver of the informed consent form. The same surgeon performed all procedures.

We included all cases with Lonstein and Akbarnia type II scoliosis[4] (Figure 1) and underwent surgical treatment with THFI and a 3rd provisional rod correction technique. Cases of neuromuscular scoliosis of other etiologies and Lonstein and Akbarnia type I curves were excluded, since the correction technique in these cases is different from that used in this study, following the patterns of idiopathic scoliosis. In addition, patients who underwent bridge osteotomies or any 3-column osteotomy were excluded.[9] Cases with incomplete exams or poor-quality radiographs that made radiographic measurements impossible were also excluded.

The surgical technique consisted of general anesthesia, prophylactic antibiotics, installation of Gardner Wells clamp on the skull, and unilateral transfemoral (on the higher side of the OP) skeletal traction. The halo-femoral traction system was assembled using 5 to 10 kg of weight at the cephalic pole and 1/3 to 1/2 of the value corresponding to the body weight at the distal end. (Figure 2)

Schwab type I osteotomies[9] were performed at all levels, followed by instrumentation with polyaxial pedicle screws, based on vertebral anatomy, using the Free-Hand technique[10] at all levels from the upper thoracic region (T2, T3, or T4) to the sacrum. It is important to point out that although no Bridge type osteotomy was performed, Schwab's type I osteotomies[9] are very wide in the lumbar and thoracolumbar region, removing the entire inferior facet, in an attempt to make the curve as flexible as possible. Pelvic fixation was performed using the iliac screw technique or S2 alar iliac screws (S2AI)[11] according to case-by-case preference.

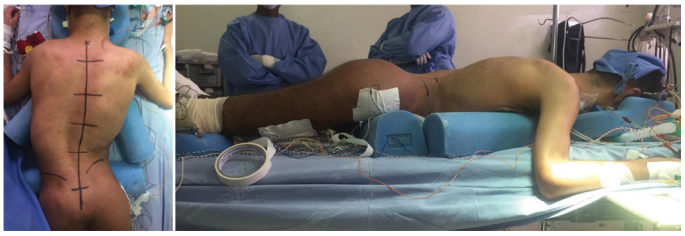

Figure 2. Positioning the patient with intraoperative hallofemoral traction (THFI).

After instrumentation, the correction was started with the so-called 3rd temporary rod technique. The technique consists of placing a short rod in the convexity of the lumbar/thoracolumbar curve and defeating it by the Cotrel-Dubousset technique[12] so that the deformity in the coronal plane becomes lumbar lordosis. This maneuver is performed by convexity; because compression can be performed between the fixation points to increase lumbar lordosis if necessary. Except in cases of hyperlordosis, where the intention is to reduce lumbar hyperlordosis by performing the concavity correction with a hypomolded rod for posterior distraction.

The screw heads are locked after rod placement to correct the main curve. A definitive long stem already shaped in the sagittal plane is more easily positioned contralaterally (concavity of the main curve) because THFI practically corrects the curve for correction of the lumbar/thoracolumbar curve. After fixing the blockers, the short temporary rod is removed and replaced by the definitive long rod, already molded in the sagittal plane. At that point, weights are removed from the THFI and decortication, and arthrodesis is performed using only local bone grafting.

Preoperative anteroposterior (AP) and lateral (P) total spine radiographs (PRE) with the patient seated with as little support as possible and total spine radiographs with traction (TR) with the patient in the supine position with upper and lower limb traction were evaluated. Postoperative evaluation was performed with full spine radiographs in AP and P. The patient was seated with as little support as possible at the patient's first outpatient evaluation (POI) and last available evaluation (POT). All cases were classified according to Lonstein and Akbarnia.[4]

The radiographic parameters analyzed in the AP X-rays were: the angular value of the main curve in the preoperative (COBB PRE), traction (COBB TR), early postoperative (COBB POI), and late postoperative (COBB POT) X-rays. Pelvic obliquity was also assessed on preoperative (OP PRE), traction (OP TR), and late postoperative (OP OP OPT) radiographs. Finally, trunk balance in the coronal plane was assessed by the distance to the plumb line from C7 to the median vertical sacral line on the preoperative (CSVA PRE) and late postoperative (CSVA POT) radiographs (mm). In the P radiographs, the sagittal alignment was evaluated through the vertical sagittal axis in the preoperative (PRE VAS) and last postoperative (POT VAS) (mm).[13] (Figure 3)

The curve flexibility was calculated (Flexibility = COBB PRE - COBB TR / COBB PRE x 100), and the correction percentage in the final postoperative period (Correction=COBB PRE - COBB POT / COBB PRE x 100).

The parameters obtained by the radiographs were submitted to the Shapiro-Wilk normality test, verifying a non-parametric distribution. Comparing the Cobb angle (COBB PRE, COBB TR, COBB POI, and COBB POT) and pelvic obliquity (OP PRE, OP TR, and OP POT) variables, Friedman's test was applied with *post hoc* Wilcoxon's test. The Wilcoxon test was used to compare VAS (VAS PRE and VAS POST) and CSVA (CSVA PRE and CSVA POST). A statistically significant difference was considered to be $p < 0.05$. IBM SPSS 23.0 software was used.

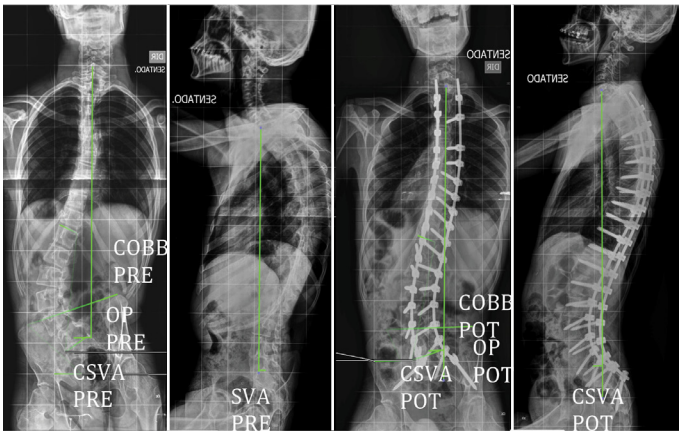

Figure 3. Radiographic parameters analyzed in AP and P Rx. COBB PRE (°), OP PRE (°), CSVA PRE (mm), SVA PRE (mm), COBB POT (°), OP POT (°), SVA POT (mm).

RESULTS

Twenty-one patients were evaluated, 11 (52%) females and 10 (48%) males. The average age was 16 years (11 to 27). The average weight at the time of surgery was 41 kg (34 to 52), and the vast majority were classified as GMFCS 5 (18 cases, 86%), while the rest were classified as type 3 (14%). According to Lonstein and Akbarnia's classification[4], 14 (66%) were classified as type IIB and 7 (34%) as type IIA. The average follow-up time was 14.05 months. As for the intraoperative data. the mean duration of the surgeries was 259 minutes (± 23.07), and the mean estimated bleeding was 462.5 ml (± 101.66).

Regarding the radiographic parameters, the results are presented in Table 1. There was a statistical difference when comparing the value of COBB PRE and COBB TRACTION versus COBB POI and COBB POT. There was no statistical difference when comparing COBB POI and COBB POT. (Figure 4)

OP showed a statistical difference when comparing PRE OP and TR OP and PRE OP with POT OP. There was no statistical difference when comparing OP TR and OP POT. There was a statistical difference when comparing coronal and sagittal trunk balance

Table 1. Comparison between pelvic obliquity (OP), COBB, vertical sagittal axis (SVA), trunk balance in the coronal plane (CSVA) preoperatively (PRE), under traction (TR), immediate postoperative (POI) and late postoperative (POT).

	Average (standard deviation)	Minimum - Maximum	p-value [a]	Simple effect [c] (p value)
COBB PRE	96,37° (±21,07)	55,60° - 135°	0,0001 [a]	PRE ≠ TR (0.0001) PRE ≠ POI (0.0001) PRE ≠ POT (0.0001) TR ≠ POI (0.0001) TR ≠ POT (0.001) POI = POT (0.102)
COBB TR	65,94° (±17,09)	31,32° – 107°		
COBB POI	41,31° (±16,09)	21,10° - 76°		
COBB POST	42,83° (±15,61)	22,6° - 76,5°		
OP PRE	30,08° (±18,08)	8,3° - 84,80°	0,0001 [a]	PRE ≠ TR (0.0001) PRE ≠ POST (0.0001) TR = POST (0.297)
OP TR	14,23° (±7,96)	4,0°- 38,80°		
OP POST	9,47° (±6,58)	4° - 38,8°		
SVA PRE	72,87 (±38,55)	29,30 - 176,00	0,013b	NA
SVA POST	50,88 (±34,84)	11,80 - 134,00		
CSVA PRE	57,87 (±39,33)	5,90 - 161,00	0,013b	NA
CSVA POST	40,07 (±37,36)	5,30 - 132,00		

TR = Under Traction; POI = early postoperative period; POT = late postoperative period; OP = Pelvic Obliquity; VAS = Vertical Sagittal Axis; CSVA = trunk balance in the coronal plane (distance from the plumb line of C7 to the mid-sacral line); [a] = Friedman test was applied; [b] = Wilcoxon test was applied; [c] = Simple significant effect1: Wilcoxon *post hoc*; NA = Not applicable. SVA and CSVA values in mm.

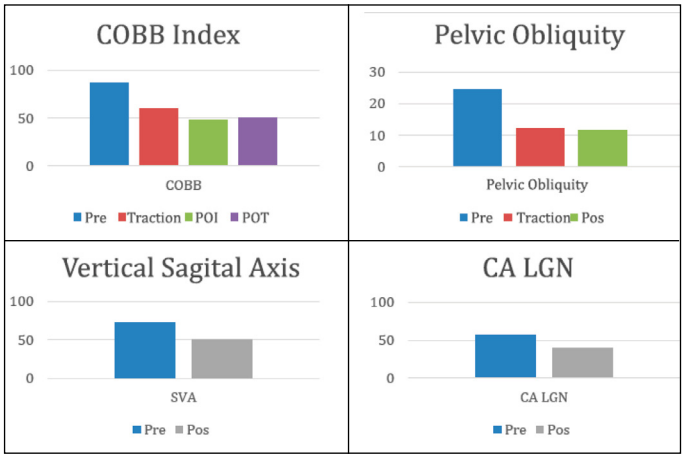

Figure 4. COBB values in degrees of the main curve, pelvic obliquity, vertical sagittal axis (VAS), and trunk balance in the coronal plane (CSVA) in the preoperative (PRE), under traction (TR), early postoperative (POI), and late postoperative (POT) evaluations.

between the preoperative and the last postoperative period (CSVA and SVA). (Table 1)

Regarding flexibility, the main curve had a mean flexibility of 31.19% (4.28 to 58.46, with ± of 14.95) and the OP 64% (27.71 to 68.86, with ± of 18.08). The correction power of the technique was 55.75% (minimum 37.5 and maximum 79.26, with ± 11.11) for the main curve and 64.86% (minimum 27.71 and maximum 96, with ± 18.04) for the OP (Figure 5). There were no technique-related complications, such as the loosening of the implants.

DISCUSSION

Surgery to treat neuromuscular deformities are large, highly complex procedure, generally associated with high rates of complications, reinterventions, higher rates of hemoconcentrate transfusion, longer hospital stays, and higher infection rates.[14] Because they are extensive arthrodesis, extending from the proximal thoracic region to the pelvis, and are usually rigid curves, the usual correction maneuvers used in the surgical treatment of idiopathic scoliosis are not possible to use, making this surgical step a major technical challenge and increasing the time of the procedure.

Therefore, in our service, we have developed a technique to correct this type of deformity that uses a provisional 3rd rod in the convexity of the lumbar/thoracolumbar curve, allowing an easier correction of the main curve, and subsequent definitive fixation with the long rod on the contralateral side. This technique is indicated only in Lonstein and Akbarnia type II curves, with the lumbar/thoracolumbar curve as the main deformity.[4]

An important point in this technique is the use of intraoperative traction. This modality has been widely used in neuromuscular scoliosis, especially in non-ambulatory patients with OP. Takeshita et al., in a retrospective case series, presented the results of 40 patients treated surgically (Luque-Galveston and Iliac screws) with or without intraoperative traction. In the 20 patients with traction, the correction of the PO was 78% (26° to 6°), while in the group without traction, it was 52% (17° to 7°).[7] Also, Vialle et al. presented results of 51 patients using THFI compared to a historical series of 59 patients without traction. They observed better correction of the curve in the coronal plane (63% vs 44%) and the PO (81% vs 56%). This study used a proximal fixation with hooks and distal fixation with screws in the sacrum and ilium.[15] The use of THFI allows correction without relying on implants, which in CP patients is a great advantage due to the presence of osteoporosis, which is common in these patients.

Luque-Galveston-type sublaminar fixation was the treatment of choice in these patients for many years. However, despite few studies in the literature, a shift to pedicle screws has been observed.[5,8] Modi et al. presented a case series of 26 patients operated on with posterior fixation with pedicle screws. The average correction was 57.9%, similar to our series (55%). However, in this series, patients with CP were not only operated on; some underwent three-column osteotomies.[16]

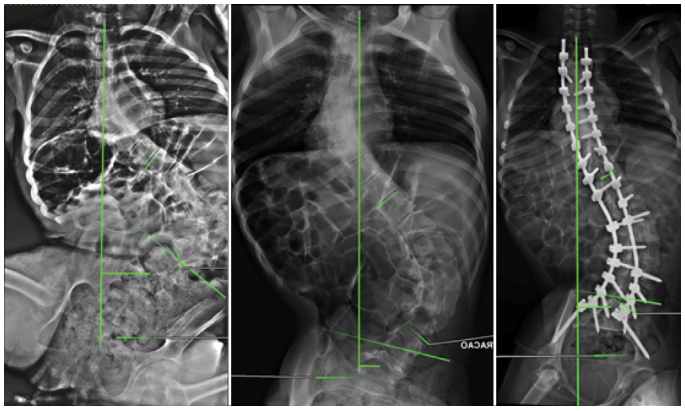

Figure 5. An 18-year-old female patient presented with the main curve of 126°, which on traction corrected to 97°, and a late postoperative of 58°.

Daher et al. compared the results of patients operated on with pedicle screws and Luque-Galveston fixation. When only the screw-fixed patients were evaluated, the percentage of correction was 59.80% of the main curve and 72.11% of the OP. The flexibility of the curve was 39.47%, and the OP was 56.54%. These results are similar to the present study's, with an average main curve correction of 55% and OP correction of 64.86%. Our casuistic shows more rigid curves, with the flexibility of 31.19% of the curve and 64% of the OP. This can be explained because patients with pathologies other than CP, who have flaccid deformities, were included in the previous study.

The study has the following limitations: being retrospective, having a small number of patients, and clinical aspects with quality-of-life questionnaires have not yet been performed. However, it presents a fairly homogeneous population of only patients with CP and a Group II curve of the Lonstein and Akbarnia classification. In addition, it presents a very reproducible technique, which allows good correction power.

CONCLUSION

The correction technique using 3rd provisional rod and intraoperative traction showed significant Cobb corrections of the proximal curve, OP, and trunk balance in the sagittal and coronal plane. The correction rate of the main curve was 55.75%, and the OP was 64.86%. Compared to other known techniques, this approach has advantages in patients with cerebral palsy, since it reduces the risk of breakage of the definitive rods, especially in places of greater tension, such as the apexes of kyphosis or lordosis.

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

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