ORIGINAL ARTICLE
DEFORMITIES

THE USE OF CRANIAL HALO TRACTION VERSUS TEMPORARY INTERNAL DISTRACTION IN STAGED SURGERY FOR SEVERE SCOLIOSIS: A COMPARATIVE STUDY

USO DE TRAÇÃO COM HALO CRANIANO VERSUS DISTRAÇÃO INTERNA TEMPORÁRIA EM CIRURGIAS ESCALONADAS EM ESCOLIOSE GRAVE: UM ESTUDO COMPARATIVO

USO DE LA TRACCIÓN CON HALO CRANEAL VERSUS DISTRACCIÓN INTERNA TEMPORAL EN CIRUGÍAS ESCALONADAS EN ESCOLIOSIS GRAVE: UN ESTUDIO COMPARATIVO

José Alberto Alves Oliveira[1], Antônio Cardoso Paiva[2], Pedro Paschoal Cassapis Cardoso Afonso[2], Paulo Cesar Almeida[3], Rogério dos Reis Visconti[2], Ricardo de Souza Portes Meireles[2]

1. Universidade Federal do Ceará, Management of Teaching and Research. Fortaleza, CE, Brazil.
2. Instituto Nacional de Traumatologia e Ortopedia Jamil Haddad, Spine Surgery Service, Rio de Janeiro, RJ, Brazil.
3. Universidade Estadual do Ceará, Center for Health Sciences, Fortaleza, CE, Brazil.

ABSTRACT

Objective: To determine which method is more effective – cranial halo traction or temporary internal distraction – in staged surgeries for patients with severe (≥ 100º) and stiff (<25% flexibility) scoliosis. Methods: A sample of 12 patients with traction and 7 patients without traction, operated on between January 2013 and December 2017. The patients' demographic data, the type of surgery performed, complications, and coronal and sagittal alignment parameters were recorded before surgery and in the final follow-up. The data were processed in SPSS 20.0. Comparisons were made between the means (Student's t-test) and the clinical and procedure-related characteristics (likelihood ratio and Fisher's Exact tests), at a confidence level of 0.05. Results: There were no significant intergroup differences for clinical characteristics, complications or degree of correction. However, more patients in the group submitted to temporary internal distraction required vertebral resection osteotomies during definitive surgery ($p<0.05$). Conclusions: Based on the results, it was not possible to establish which is the most effective method, but it is suggested that staged traction may be more effective, and safer, particularly when the surgeon is less experienced, during surgery on patients with severe and stiff scoliosis. ***Level of evidence IV; Vase series.***

Keywords: Scoliosis; Traction; Spinal Fusion.

RESUMO

Objetivo: Determinar qual método é mais eficaz, tração com halo craniano ou distração interna temporária em cirurgias escalonadas para pacientes com escoliose grave (≥ 100º) e rígida (< 25% de flexibilidade). Métodos: Amostra com 12 pacientes com tração e 7 sem tração, operados entre janeiro de 2013 e dezembro de 2017. Os dados demográficos dos pacientes, o tipo de cirurgia realizada, as complicações e os parâmetros de alinhamento coronal e sagital foram registrados antes da cirurgia e no acompanhamento final. Os dados foram processados no SPSS 20.0. Foram feiras comparações entre as médias (teste t *de Student) e as características clínicas e relacionadas com o procedimento (teste de razão de verossimilhança e de teste exato de Fisher), com n*ível de confiança de 0,05. Resultados: *Não houve diferenças significativas entre os grupos quanto a características clínicas, complicações e grau de correção. No entanto, mais pacientes do grupo submetido à distração interna temporária necessitaram de osteotomias de ressecção vertebral durante a cirurgia definitiva (p < 0,05). Conclusões: Não se pôde estabelecer com base nos resultados qual o método mais eficaz, porém se sugere que a tração escalonada pode ser mais eficaz e mais segura, principalmente para cirurgiões com menos experiência em cirurgia de pacientes com escoliose grave e rígida.* ***Nível de evidência: IV; S*érie de Casos.**

Descritores: *Escoliose; Tração; Fusão Vertebral.*

RESUMEN

Objetivo: Determinar qué método es más efectivo, tracción con halo craneal o distracción interna temporal, en cirugía escalonadas para pacientes con escoliosis severa (≥ 100º) y rígida (<25% de flexibilidad). Métodos: Muestra con 12 pacientes en el grupo de tracción y 7 en el grupo sin tracción, intervenidas entre enero de 2013 y diciembre de 2017. Los datos demográficos de los pacientes, los tipos de cirugía, las complicaciones, los parámetros de alineación coronal y sagital se registraron antes de la cirugía y en el último acompañamiento. Los datos se procesaron en SPSS 20.0. Se realizaron comparaciones entre las medias (prueba t de Student) y las características clínicas y relacionadas con el procedimiento (razón de verosimilitud y prueba exacta de Fisher), con un nivel de confianza de 0,05. Resultados: No hubo diferencias significativas entre los grupos en cuanto a características clínicas, complicaciones y grado de corrección. Sin embargo,

Study conducted at Instituto Nacional de Traumatologia e Ortopedia Jamil Haddad, Rio de Janeiro, RJ, Brazil.
Correspondence: José Alberto Alves Oliveira. Rua Bruno Porto, 600, apto 2201-A, Parque Iracema, Fortaleza, CE, Brazil. 60824010. bertoalvesoliveira@gmail.com

http://dx.doi.org/10.1590/S1808-185120212004250449

Received on 03/29/2021 accepted on 08/03/2021

Reviewed by: Dr. Karen Weissman/Dr. Ratko Yurac/Dr. Helton Delfino

más pacientes del grupo sometido a distracción interna temporal requirieron osteotomías de resección vertebral durante la cirugía definitiva (p < 0,05). Conclusiones: Con base en los resultados, no fue posible establecer el método más efectivo, pero se sugiere que la tracción escalonada puede ser más eficaz y más segura, especialmente para cirujanos con menos experiencia en cirugía de pacientes con escoliosis severa y rígida. ***Nivel de evidencia: IV; Serie de Casos***

Descriptores: Escoliosis; Tracción; Fusión Vertebral.

INTRODUCTION

Despite the various surgical techniques and modern instrumentation systems available, surgery involving severe and stiff scoliosis with ≥100° remains challenging due to the magnitude of the deformity, and the potential for pseudoarthrosis and neurological complications.[1,2] Single-stage surgery for this type of deformity may pose a greater risk to the patient, due to implant failure caused by the high corrective forces on the fixation systems.[3]

To reduce these complications, procedures are sometimes performed in more than one stage. These include methods such as temporary internal distraction, anterior release, cranial halo traction, halo-femoral traction, and halo-gravity traction (HGT), aimed at achieving a partial reduction of the stiff curves before surgery. Traction has the advantage that it allows for gradual correction over time, which may prevent the need for aggressive osteotomies and reduce neurological injury during surgery.[4-7]

However, complications can occur during cranial halo traction, including surgical site infection, pin loosening, brachial plexus injury, and cranial nerve palsy, most commonly of the 6th nerve, followed by a combination of the 9th, 10th and 12th nerves.[3,8]

The aim of this study was to determine which method is more effective – cranial halo traction or temporary internal distraction – in staged surgeries for patients with severe (≤.100°) and stiff (< 25% flexibility) scoliosis.

METHODS

Type of study

A case series study of 19 patients submitted to surgery for severe scoliosis at a national referral center for spinal deformities, between January 2013 (first computerized register of this pathology in the hospital's database) and December 2017 (the last patient with a minimum of two years postoperative at the time of data collection).

Study participants

The inclusion criteria were as follows: individuals of both sexes who had undergone severe (Cobb ≥ 100º) and stiff (< 25% major curve flexibility) scoliosis surgery between T1 and the ilium; availability of panoramic x-rays in the anterior-posterior (AP) and profile views in the orthostatic position, as well as inclination in dorsal decubitus, preoperative and in the final follow-up, and AP serial x-rays in bed between the surgical stages. The exclusion criteria were: patients with severe cranial deformities that precluded the use of the halo; osteogenesis imperfecta due to osteoporosis; the presence of intra- or extradural (tumor, syringe) or severe localized canal stenosis with or without pre-existing neurological impairment; previous spinal surgery; patients submitted to surgery at other facilities, and postoperative follow-up of less than 2 years.

The patients' demographic data, details of the surgery, and any complications were taken from the doctor's medical records. The following scoliosis etiologies were observed: idiopathic, using the Lenke et al classification;[9] congenital, using Winter's[10] classification, syndromic and neuromuscular. Retrospective measures of the radiological parameters were conducted in all the patients and independently reviewed by an orthopedist in the final year of a fellowship in spinal surgery who did not participate in the procedures and follow-up of patients. All the radiographic measures were calculated using the free software program Surgimap version 2.2.15.5 CE 0129.

The patients were divided into two groups; those in whom cranial halo traction was used between surgical stages, and those in whom it was not. In the first surgical stage, posterior release was performed with dissection of the paravertebral tissues to give the stiff spinal column more flexibility, and corrective grade 1, 2 or 3 posterior column osteotomies were carried out (Schwab et al. classification).[11] Depending on the case, pedicular screws were placed, and in the second stage, grade 4 to 6 posterior column osteotomies were conducted, if necessary, and definitive posterior fusion.

Radiographic assessment

Radiographs were taken of the entire spinal column in the anteroposterior (AP) and lateral positions, with the patient in orthostatic and dorsal decubitus, to assess the Lenke et al classification[9] in cases of idiopathic scoliosis, as well as the preoperative flexibility of the major curve and without inclinations during the postoperative follow-up. The patients who underwent cranial traction had weekly AP radiographs taken, in bed, with the final radiograph being considered the last one before the definitive fusion. These were compared with preoperative decubitus radiographs.

To calculate the Cobb angle of the major and compensatory curves in the anteroposterior and lateral views (T5- T12 for thoracic kyphosis; L1-S1 for lumbar lordosis) preoperatively, between the surgical stages, and postoperatively, the same terminal vertebrae were used. Positive and negative values were used to denote kyphosis and lordosis, respectively. Major curve flexibility was calculated as follows: (preoperative Cobb in the orthostatic position – Cobb in lateral inclination/preoperative Cobb in orthostasis x 100%). The final coronal and sagittal correction rates of the major curve were calculated as preoperative Cobb – postoperative Cobb / preoperative Cobb x 100%). The apex of the major curve was considered the center of the vertebral body farthest from the perpendicular line, traced from the central sacral vertical line (CSVL). Pelvic obliquity was calculated using the angle obtained between the line tangential to the apex of the iliac crest and a horizontal line. The coronal and sagittal deformity angular ratios (DAR) were calculated according to Lewis et al.,[12] Implant density was calculated as the ratio between the number of screws used and the number of possible fixation points on each vertebra that was part of the curve. The number of fused segments were those included within the fusion area.

The spinopelvic alignment parameters included the coronal vertical axis (CVA), calculated as the deviation from the C7 plumb line in relation to the central sacral vertical line (CSVL), the C7 sagittal vertical axis (SVA), pelvic incidence (PI), pelvic tilt (PT) and sacral slope (SS).

Cranial halo traction and temporary internal distraction

The decision to use cranial halo traction between surgical stages is made by the surgeon, based on previous planning of the case. The following were performed in the first stage: posterior release with resection of the interspinous and yellow ligaments; facetectomies at all levels; Ponte osteotomies (if necessary) and instrumentation with pedicular screws, followed by internal distraction or cranial halo traction to make the stiff spinal column more flexible. In the second stage, the following were carried out: posterior three-column osteotomies (PSO or VCR) if necessary; posterior arthrodesis with autologous bone graft, definitive titanium rod placement and locking of the system.

The group of patients not submitted to cranial halo traction was managed with posterior temporary internal distraction until definitive fusion surgery. Instrumentation of segments planned in the preoperative period was carried out with pedicular screws, and a long rod was connected to the concave side of the curve, followed by the

distraction maneuver with the help of pliers and distractors. During internal distraction, somatosensory and motor evoked potentials were assessed, and the wake-up test was conducted at the end of the procedure. These patients remained restricted to bed until the second surgical stage, which was performed at around 15 days after the first procedure. In the last stage, the temporary internal distraction rod was replaced with permanent rods on the convex and concave sides of the curve. The previous pedicular screws were maintained or partially removed, depending on the surgical plan. After the posterior osteotomies and correction maneuvers, decortication was performed at all levels, followed by autologous bone graft staining for posterior fusion.

In the group of patients with cranial halo traction, the patient was returned to the surgery center after the first stage, under general anesthesia. Asepsis was carried out with povidone-iodine before insertion of the pins. The anterior pins were placed 1 cm above the lateral portion of the eyebrow, given that medial insertion could damage the supraorbital and the supratrochlear nerves, while lateral insertion could damage the masticatory muscles. The posterior pins were placed 1 cm above and posteriorly to the auricular pavilion. The halo ring orifices above the ear were left open for posterior traction fixation. Local hair removal is not absolutely necessary, but can facilitate insertion of the pins, decreasing the risk of infecting the pin with hair wrapped around it. An experienced assistant was always present to help with inserting and tightening the pins. Typically, pins were inserted on both sides of the frontal bone, and posteriorly on either side, making a total of four pins.

Traction was generally initiated immediately, with a low weight of 2.0–5.0 kg, gradually increasing to a rate of 0.5-1.5 kg per day, as tolerated. The objective was to reach a maximum traction of 30-50% of the patient's weight, depending on how well it was tolerated. Traction was applied throughout the day, with the patient restricted to the bed and the headboard raised to 45° to avoid proximal migration of the patient. Neurological examinations of the cranial nerves and upper/lower limbs were conducted daily by the orthopedist in fellowship spinal training. The pin fixation points were cleaned every day by the nursing team. Staged traction generally lasted between 2 and 4 weeks, depending on the patient's overall medical condition, before subsequent definitive fusion. The final traction period was determined based on multiple factors, and was decided on a case-by-case basis.

Patients of both groups were operated on with intraoperative neuromonitoring in all stages. During the definitive fusion procedure, traction was decreased to 50% that of preoperative levels and maintained throughout the procedure. None of the patients was submitted to an anterior approach.

We assessed traction-related complications such as infection and loosening of the halo-pins, as well as surgical complications in the two groups, including neurological deficit for Medical Research Council scale, dural tear, pneumothorax, broken/loose implant, infection and recurrence of the deformity.

Statistical analysis

The data were processed in the software program SPSS 20.0 (Chicago, IL, USA, license number 10101131007). The population was characterized using descriptive and comparative analysis. The comparison between clinical and procedure-related characteristics was conducted by applying the likelihood ratio test, and complications using Fisher's Exact test. Intergroup differences, as means and standard deviations, were calculated using the paired Student's t-test. For inferential analysis, those with $p < 0.05$ were considered statistically significant.

Ethical aspects

The study was approved by the institutional Research Ethics Committee, under protocol number 4.372.245, in line with National Health Council Resolutions 466/2012 and 580/2018. As this is a retrospective study, no informed consent was required.

RESULTS

Nineteen of the 39 patients that met the inclusion criteria were selected and divided into a traction group (12 patients) and a no traction group (7 patients). Two patients with syndromic cases of scoliosis (Marfan syndrome and skeletal dysplasia) were selected, and three with neuromuscular etiology – one with myelomeningocele, who was submitted to traction, and two with sequelae of cerebral palsy, who were submitted to temporary internal distraction. In the traction group, the average initial and final weights of the device were 4.27±1.73 kg and 10.27±3.13 kg, respectively, and the equipment was used for 17.41±9.02 days.

Comparison between the clinical and surgery-related characteristics showed no significant intergroup difference (p= 0.05). It is important to emphasize that the follow-up time was more than two years in both groups. (Table 1)

The degree of osteotomy used in the definitive surgical procedure demonstrated that the patients not submitted to staged traction exhibited a larger number of vertebral resection osteotomies ($p<0.05$). In addition, the group with no traction exhibited lower implant density ($p<0.05$). (Table 2)

Analysis of the different magnitudes of the major and compensatory curves in the traction and no traction groups, conducted in the final postoperative follow-up, showed a reduction in the proximal thoracic curve (43% in the traction group vs 59% in the no -traction group), major thoracic curve (53% vs 60 %), and thoracic-lumbar/lumbar curve (55% vs 48%), but with no significant intergroup difference ($p>0.05$). When traction was used, the magnitude of the major curve was decreased by 18% before the definitive fusion procedure, while in the other group, it was decreased by 5%. (Table 2)

Intergroup comparison of the pre- and postoperative spinopelvic alignment variables, conducted in the last postoperative assessment, showed no significant differences in most of the variables. It is important to highlight the higher pelvic incidence in the traction group, as well as the steeper sacral slope when compared to the other group ($p<0.05$). (Table 2)

Table 1. Clinical and surgical characteristics of patients with severe scoliosis (≥ 100º), who underwent surgery in two stages with and without Halo-Gravity Traction.

CHARACTERISTICS	Traction (12/63,2%)	No traction (7/36.8%)	p
Sex			0,890[1]
Female	10 (62.5%)	6 (37.5%)	
Male	2 (66.7%)	1(33.3%)	
Age at surgery (years)	21.37±3.49	19.36±6.01	0.380[2]
BMI (KG/M2)	18.90±4.04	22.92±3.68	0.127[2]
ASA			0.279[1]
1	(6/75%)	(2/25%)	
2	(6/60%)	(4/40%)	
3	-	(1/100%)	
Scoliosis Etiology			0.057[1]
Idiopathic	(7/87.5%)	(1/12.5%)	
Congenital	(2/33.3%)	(4/66.7%)	
Neuromuscular	(1/33.3%)	(2/66.7%)	
Syndromic	(2/100.0%)	-	
Scoliosis classification			0.190[1]
Lenke 2	(2/100%)	-	
Lenke 3	(3/100%)	-	
Lenke 4	(2/66.7%)	(1/33.3%)	
Winter 1	(1/25%)	(3/75%)	
Winter 2	(1/100%)	(1/100%)	
operative time (minutes)	800.00±247.73	801.85±202.62	0.987[2]
Estimated blood loss (ml)	1642.22±1058.79	1400.00±718.33	0.634[2]
Hospitalization time (days)	53.09±39.14	52.14±20.54	0.954[2]
FOLLOW-UP TIME (YEARS)	3.52±4.55	2.20±1.93	0.480[2]

1-p by the likelihood ratio test; 2- p by Student's t-test. BMI (Body Mass Index).

A total of 22 surgical complications were observed; 12 in the traction group, but with no significant intergroup differences. (Table 3) The patients of this group exhibited no cranial halo-related complications, such as infection or pin loosening at the insertion site.

DISCUSSION

There is no consensus on how to manage stiff and severe scoliosis. The options include anterior release by thoracotomy or thoracoscopy, followed by posterior instrumentation in one or two stages; anterior release with instrumentation associated with posterior fusion and instrumentation; use of the halo with preoperative traction or between staged surgery; or posterior-only vertebral column resection.[6,13]

Table 2. Comparison between pre- and postoperative radiographic parameters of patients with severe scoliosis (≥ 100º) who underwent two-stage surgery with and without Halo-Gravity Traction.

Characteristics	Traction (12/63.2%)	No traction (7/36.8%)	p
Apical vertebral			0.443[1]
T6	-	(1/100%)	
T7	(3/75%)	(1/25%)	
T8	(3/75%)	(1/25%)	
T9	(3/60%)	(2/40%)	
T10	(3/75%)	(1/25%)	
T12	-	(1/100%)	
Osteotomy degree			**0.021**[1]
1	(4/80%)	(1/20%)	
2	(7/77.8%)	(2/22.2%)	
5	(1/20%)	(4/80%)	
Proximal thoracic preop. (º)	41.97±14.14	39.00±16.00	0.72[2]
Proximal thoracic postop. (o)	23.93±11.21	16.10±8.73	0.17[2]
Main thoracic preop. (o)	104.65±17.75	100.00±24.59	0.61[2]
Main curve on the last traction or distraction (o)	85.67 ± 17.41	94.7±13.2	0.30[2]
Main thoracic postop. (o)	49.50±14.04	39.57±19.93	0.21[2]
Thoracolumbar/lumbar preop. (o)	60.40±32.21	42.01±23.31	0.18[2]
Thoracolumbar/lumbar postop.(o)	26.60±22.28	21.61±7.52	0.49[2]
Coronal flexibility (%)	11.83±6.28	8.49±2.80	0.13[2]
Coronal correction postop. (%)	50.62±9.44	61.20±13.19	0.05[2]
Thoracic kyphosis preop. (o)	43.49±12.93	40.72±9.05	0.59[2]
Thoracic kyphosis postop. (o)	30.30±5.09	30.50±7.20	0.94[2]
Sagital correction (%)	27.29±14.36	24.97±7.99	0.70[2]
Pelvic obliquity preop. (o)	5.87±5.78	6.11±2.41	0.90[2]
Pelvic obliquity postop. (o)	5.40±7.04	6.31±5.86	0.79[2]
CVA preop.(Cm)	3.25±2.00	3.77±1.99	0.59[2]
CVA postop .(Cm)	1.54±1.78	1.62±1.51	0.91[2]
Coronal dar preop.	22.82 ±4.49	25.22±7.88	0.66[2]
Coronal dar postop.	9.91±0.48	10.28±5.88	0.90[2]
SVA preop. (Cm)	3.35±4.11	3.50±6.23	0.95[2]
SVA postop. (Cm)	3.10±3.02	3.68±2.93	0.69[2]
Sagital dar preop.	12.26±2.17	9.63±2.52	0.28[2]
Sagital dar postop.	8.50±0.56	6.97±2.61	0.33[2]
Lordosis (l1-s1) preop. (o)	57.72±9.76	48.81±15.34	0.13[2]
Lordosis (l1-s1) postop. (o)	52.64±9.86	45.35±12.20	0.17[2]
Pi	42.01±15.05	22.00±14.32	0.01[2]
PT preop. (o)	15.41±9.10	20.20±17.00	0.43[2]
PT postop. (o)	16.98±9.94	24.31±18.66	0.27[2]
SS preop. (o)	37.87±8.31	29.30±7.70	0.04[2]
SS postop. (o)	37.55±8.25	29.68±6.24	0.03[2]
Fused levels	12.41±1.31	13.42±1.61	0.15[2]
Implant density	0.84±0.11	0.69±0.11	0.01[2]

1-p by the likelihood ratio test; 2- p by the student's t-test. CVA (Coronal Vertical Axis), DAR (Deformity Angular ratio), SVA (Sagittal Vertical Axis), PI (Pelvic Incidence), SS (Sacral Slope), PT (Pelvic Tilt).

Table 3. Intra- and postoperative surgical complications in patients with severe scoliosis (≥ 100º) who underwent surgery in two stages with and without Halo-Gravity Traction.

Complications	Traction	No traction	P*
Neurologic deficit			0.51
Intraoperative 1st time	(1/25%)	(3/75%)	
Intraoperative 2nd time	(2/66.6%)	(1/33.4%)	
Dural tear			1.00
Intraoperative 1st time	(1/100%)	-	
Pneumothorax			0.43
Intraoperative 1st time	(1/50%)	(1/50%)	
Intraoperative 2nd time	(5/71.4%)	(2/28.6%)	
Implant failure			0.52
Postoperative 2nd time	(1/33.4%)	(2/66.6%)	
Wound infection			1.00
Postoperative 2nd time	(1/50%)	(1/50%)	

*p by Fisher's Exact Test.

In a multicenter study that assessed the effect of traction on severe spinal deformities, no difference in percentage of correction was found between the major curve in the halo and no halo groups after two years of follow-up. Those authors also observed that patients submitted to preoperative traction exhibited less need for vertebral column resection to correct deformities than the group that did not use this procedure.[14]

Corroborating the findings of the abovementioned research, the present study found no difference between the final value of the major curve in patients submitted to, or not submitted to staged traction (49.50±14.04; 39.57±19.93, p>0.05) after two years of follow-up.

A number of authors[2] who assessed the efficacy of cranial halo traction after anterior release surgery, followed by definitive posterior fusion for severe scoliosis (≥100º), reported that on average, staged traction reduced the Cobb angle of the major curve from 100° immediately before anterior release surgery to 75° before final fusion. The patients weighed an average of 35.1 kg, the maximum weight of 12.7 kg was used for traction, i.e., 36% of body weight, with an average use of 53.5 days.

In our study, none of the patients underwent anterior release surgery in the first stage, exhibiting an average decline in the Cobb angle of the major curve, from 104° before surgery to 85° before final posterior fusion with the use of staged traction. However, in our research, the patients weighed an average of 45 kg, with the maximum weight of 10kg for traction, i.e., 22% of body weight, for an average use of 17 days.

In another study, which assessed the effect of preoperative traction in pediatric patients with severe scoliosis, the preoperative Cobb angle of the major curve was decreased to 44º (37.4% correction), using average traction of 35.8% of body weight for an average period of 70 days.[15]

In our research in the final postoperative follow-up, the major curve was decreased to 49.5º, with a 55% correction in relation to the preoperative value in the group submitted to cranial halo traction. However, it is important to emphasize that there were no significant intergroup differences in these variables.

During assessment of the effect of preoperative cranial halo traction on severe scoliosis and kyphosis in adults, Shimizu et al.,[5] observed that pelvic tilt (PT) decreased after traction. This may indicate that the thoracic kyphosis/thoracolumbar correction improved compensatory pelvic retroversion and hip extension.[5]

In the present study, coronal imbalance improved considerably in both groups, albeit with no significant difference between them. There was no significant improvement in sagittal alignment parameters in either group. The authors believe this was because the patients had no kyphotic deformities or significant sagittal imbalance.

The prevalence of complications inherent to cranial halo traction is 22%, the most common complication being related to the pins

(16%), such as pin loosening requiring replacement, infection at the insertion site, the need for oral antibiotic therapy, debridement or local asepsis. The following complications may also occur: cervicalgia, nystagmus, dizziness and nausea, which can be relieved by reducing the traction weight.[13] These complications were not observed in the present study.

The prevalence of surgery-related complications was 32%. These were related to implant failure, loss of curve correction and surgical wound infection had the same prevalence of around 4%. Pulmonary complications such as atelectasis with the need for mechanical ventilation, pneumonia and hemopneumothorax represented 5%, while neurological deficit had a combined prevalence of 1%.[16]

Halo traction is not indicated in certain situations, such as fixed cervical kyphosis and cervical instability. Excessive distraction may, in some cases, result in cervical deformity.[17] An alternative to the contraindications and limitations of cranial halo traction is temporary internal distraction.[6]

In a study[18] that assessed the effect of internal distraction with a minimally invasive technique, performed according to Buchowski et al.,[19] with no posterior or anterior release in staged surgery for the treatment of stiff and severe scoliosis, a 49% correction was observed in the primary curve after this procedure, with T5-T12 sagittal imbalance correction of 26%. At 12 to 15 weeks after the initial surgery, patients were submitted to posterior fusion, without the need for three-column osteotomy, achieving final average correction of 64% without death or neurological and pulmonary complications.[18]

In our research, the patients submitted to temporary internal distraction (the no traction group) without a minimally invasive technique and only one distraction showed a reduction in the primary curve after this procedure of around 5% and after the final procedure, with a larger number of VCR, around 60%, and a final sagittal Cobb angle correction of 25%.

Another study that assessed the result of staged surgery with temporary internal distraction for patients with severe and stiff scoliosis found that the preoperative primary coronal thoracic curve was corrected by 46% after the first operation (129.8º to 70.5º) and 60.4% (129.8º to 51.8º) after the second procedure, while preoperative kyphosis was corrected by 50.9% (94.7º to 46.2º) after the first operation and 64.8% (94.7º to 32.9º) after the second. The average hospitalization time was 28.5 days for the first operation and 24.6 days for the second, with 6 months between them.[20]

In the present study, the average hospitalization time was 52.14 days in the group that underwent internal distraction, with no significant difference in relation to the cranial traction group (53.09 days). However, it is important to emphasize that patients submitted to temporary internal distraction exhibited lower implant density when compared to the cranial traction group (0.69 x 0.84, $p < 0.05$).

In this study, 22 complications related to surgical procedures were observed, albeit without significant differences between them. The traction group included one patient with a decline in motor evoked potential during the first and second surgery. Neuroprotective measures were performed (increased average blood pressure, use of saline solution and methylprednisolone) with the patient evolving to GIII paresis of the lower left limb in the immediate postoperative after posterior fusion (Medical Research Council Scale). Motor rehabilitation was prescribed, with complete recovery by the final follow-up. Another patient exhibited a decline in somatosensory evoked potential, for which neuroprotective measures were also conducted, evolving to Grade II strength immediately after surgery. The patient was referred to motor rehabilitation, returning to Grade IV strength in the final follow-up.

It is important to highlight one case of dural tear in a patient with myelomeningocele in the traction group, during the first stage of surgery. The wound was sutured with complete resolution immediately after surgery. The same patient underwent thoracic drainage during the procedure, and the chest drain was removed after 3 to 5 days due to resolution of the pneumothorax. The patient developed a pressure ulcer in an infected sacrum, and after the infection was resolved, underwent microsurgery with flap rotation, resulting in total resolution. Only one patient exhibited broken implants in the postoperative follow-up, and underwent two revision surgeries to replace the material, resolving the case.

Despite the lack of significant differences between complications in the two groups, possibly due to the surgeons' experience in performing posterior vertebral column resection, staged cranial traction reduced the need for more aggressive corrective procedures in the last surgical stage, suggesting that this is the more preferable method in these cases.

Although this is a comparative study on the treatment of severe scoliosis, it has the following limitations: it is a case series study with a small sample conducted at a single facility, and it does not address important issues such as the pulmonary and nutritional function of these patients.

CONCLUSION

Although the results showed no difference in effectiveness between the two methods, the authors of the present study believe that staged cranial traction may be a more effective and safer method for less experienced surgeons, for the correction of severe and stiff scoliosis, as it decreases the need for more morbid osteotomies such as posterior vertebral column resection, by correcting the deformity in a more gradual and controlled manner. It is believed that lower weight associated with a shorter cranial traction period (average of two weeks) helps to lower the risk of complications when using this method.

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

CONTRIBUTIONS OF THE AUTHORS: Each author made significant individual contributions to this manuscript. JAAO: writing, statistical analysis, intellectual concept and preparation of the entire research project; ACP: writing, review and intellectual concept; PPCCA: writing, review and intellectual concept; PCA: statistical analysis, writing and review; RRV: writing, review and intellectual concept; RSPM: writing, review and performing the surgeries.

REFERENCES

1. Mehrpour S, Sorbi R, Rezaei R, Mazda K. Posterior-only surgery with preoperative skeletal traction for management of severe scoliosis. Arch Orthop Trauma Surg. 2017;137(4):457–63.
2. Watanabe K, Lenke LG, Bridwell KH, Kim YJ, Hensley M, Koester L. Efficacy of perioperative halo–gravity traction for treatment of severe scoliosis (≥100°). J Orthop Sci. 2010;15(6):720–30.
3. Park DK, Braaksma B, Hammerberg KW, Sturm P. The Efficacy of Preoperative Halo-Gravity Traction in Pediatric Spinal Deformity The Effect of Traction Duration. J Spinal Disord Tech. 2013;26(3):146-54.
4. Nemani VM, Kim HJ, Bjerke-Kroll BT, Yagi M, Sacramento-Dominguez C, Akoto H, et al. Preoperative Halo-Gravity Traction for Severe Spinal Deformities at an SRS-GOP Site in West Africa. SPINE. 2015;40(3):153-61.
5. Shimizu T, Lenke LG, Cerpa M, Lehman Jr RA, Pongmanee S, Sielatycki JA. Preoperative halo-gravity traction for treatment of severe adult kyphosis and scoliosis. Spine Deform. 2020;8(1):85–95.
6. Silva LECT, Barros AGC, Azevedo GBL. Management of severe and rigid idiopathic scoliosis. Eur J Orthop Surg Traumatol. 2015;25(Suppl 1):S7–S12.
7. Bettany-Saltikov J, Weiss HR, Chockalingam N, Kandasamy G, Arnell T. A Comparison of Patient-Reported Outcome Measures Following Different Treatment Approaches for Adolescents with Severe Idiopathic Scoliosis: A Systematic Review. Asian Spine J. 2016;10(6):1170-94.
8. Rinella A, Lenke LG, Whitaker C, Kim Y, Park S, Peelle M, et al. Perioperative Halo-Gravity Traction in the Treatment of Severe Scoliosis and Kyphosis. Spine. 2005;30(4):475-82.
9. 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(8):1169-81.

10. Lonstein J, Winter R, Bradford D, Ogilvie J. Moe's Textbook of Scoliosis and Other Spinal Deformities. Philadelphia: Saunders. 1987.
11. Schwab F, Blondel B, Chay E, Demakakos J, Lenke L, Tropiano P, et al. The Comprehensive Anatomical Spinal Osteotomy Classification. Neurosurgery. 2014;74(1):112–12.
12. Lewis NDH, Keshen SGN, Lenke LG, Zywiel MG, Skaggs DL, Dear TE, et al. The Deformity Angular Ratio Does It Correlate With High-Risk Cases for Potential Spinal Cord Monitoring Alerts in Pediatric 3-Column Thoracic Spinal Deformity Corrective Surgery? Spine. 2015;40(15):E879-E885.
13. Kandwal P, Vijayaraghavan GP, Nagaraja UB, Jayaswal A. Severe Rigid Scoliosis: Review of Management Strategies and Role of Spinal Osteotomies. Asian Spine J. 2017;11(3):494-503.
14. Sponseller PD, Takenaga RK, Newton P, Boachie O, Flynn J, Letko L, et al. The Use of Traction in the Treatment of Severe Spinal Deformity. Spine. 2008;33(21):2305-9.
15. Bogunovic L, Lenke LG, Bridwell KH, Luhmann SJ. Preoperative Halo-Gravity Traction for Severe Pediatric Spinal Deformity: Complications, Radiographic Correction and Changes in Pulmonary Function. Spine Deform. 2013;1(1):33-9.
16. Yang C, Wang H, Zheng Z, Zhang Z, Wang J, Liu H, et al. Halo-gravity traction in the treatment of severe spinal deformity: a systematic review and meta-analysis. Eur Spine J. 2016;26(7):1810-6. DOI: 10.1007/s00586-016-4848-y.
17. Buchowski JM, Bhatnagar R, Skaggs DL, Sponseller PD. Temporary Internal Distraction as an Aid to Correction of Severe Scoliosis. J Bone Joint Surg. 2006;88(9):2035-41.
18. Hu H-M, Hui H, Zhang H-P, Huang D-G, Liu Z-K, Zhao Y-T, et al. The impact of posterior temporary internal distraction on stepwise corrective surgery for extremely severe and rigid scoliosis greater than 130°. Eur Spine J. 2015;25(2):557-68. DOI 10.1007/s00586-015-4013-z.
19. Buchowski JM, Skaggs DL, Sponseller PD. Temporary Internal Distraction as an Aid to Correction of Severe Scoliosis Surgical Technique. J Bone Joint Surg Am. 2007;89 Suppl 2(Part 2):297-309.
20. Cheng X, Ma H, Tan R, Wu J, Zhou J, Zou D. Two-stage posterior-only procedures for correction of severe spinal deformities. Arch Orthop Trauma Surg. 2012;132(2):193–201.