INTRAOPERATIVE TRACTION IN SURGERY FOR ADOLESCENT IDIOPATHIC SCOLIOSIS

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Objective. To analyze the effectiveness of intraoperative traction in the treatment of adolescent idiopathic scoliosis, including in relation to the initial magnitude of scoliotic curve.
Material and Methods. Data on patients meeting the following criteria were selected from the electronic database and analyzed: idiopathic scoliosis (Lenke types I, III, V); age 10 to 20 years; surgery performed through posterior approach; hook or hybrid (using of pedicle screws only in the lumbar spine, at 2–4 levels) fixation; no previous history of spine surgery; and follow-up period at least two years.
Results. Flattening of thoracic kyphosis and alignment of lumbar lordosis during surgical correction were significantly more pronounced in the traction group. Postoperative changes in the sagittal contour of the thoracic and lumbar spine did not differ significantly between the traction and no-traction groups. Intraoperative traction was associated with significantly reduced blood loss, though operation time decreased statistically insignificantly. Normalization of the frontal imbalance in the immediate and long-term postoperative periods was different in the two groups, but these differences were insignificant. Intraoperative traction was most effective in the group with deformities of 50° to 75°, although it also increased the achieved correction in patients with scoliosis of a smaller and greater magnitude.
Conclusion. The operation performed with intraoperative traction allows achieving greater correction during an intervention and smaller loss of correction during a long follow-up period than that without a distraction influence. This applies equally to both primary and secondary curvatures.
Key Words: intraoperative traction, idiopathic scoliosis, adolescent scoliosis.

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The use of axial traction to correct spinal deformities has a long history. The oldest reference available is the Srimad Bhagwat Mahapuranam (written between 3500 BC and 1800 BC) that contains Hindu mythological epics where it is mentioned how Lord Krishna corrected a severe spinal deformity (at three locations) in one of his devotees by stepping with his leg on the devotee's feet, took by the chin with his two fingers and pulled upwards. This caused a full correction of the deformity. Hippocrates, Galen, and Ibn Sina also used axial traction for the same purpose but used different means. This treatment often produced paraplegia [11].

At present, axial traction is used both during surgery [3] and pre- and postoperatively [5, 13]. Traction is based on the viscoelastic behavior of vertebral and paravertebral soft tissues allowing one to achieve a large extent of correction [2]. In theory, skeletal traction can decrease an apical vertebral rotation [8] and minimize the force applied on vertebral instrumentation.

There are few papers devoted to study the effectiveness of intraoperative skeletal traction and the results are contradictory. Mac-Thiong et al. [15] suppose that traction is not a required procedure. LaMothe et al. [12] concluded on the potential benefits of using skeletal traction. In all the references, the effectiveness of intraoperative traction (IOT) is considered regardless of the scoliotic curve magnitude.

We have used intraoperative axial tractive force acting on the spine for the correction of scoliotic deformities since 1996 and suppose that it facilitates the correction of a scoliotic curve and reestablishes the frontal balance of the trunk.

The aim of this study is to analyze the effectiveness of IOT, including in relation to the initial magnitude of a scoliotic curve in patients with idiopathic adolescent scoliosis.

Material and Methods

The patients meeting the following criteria were selected from an electronic database:
– idiopathic scoliosis (Lenke types I, III, V);
– age 11 to 20 years;
– operation performed through posterior approach;
– hook or hybrid fixation (using of pedicle screws only in the lumbar spine, at 2–4 levels);
– no previous history of spine surgery;
– follow-up period at least two years.

A total of 548 patients met these criteria. Of these, 373 were operated using IOT and 175 – without. The mean age of the patients was 15.6 years in the IOT group and 15.9 years in the group with no intraoperative traction (NIOT). The ratio of females and males was 335 to 38 in the IOT group and it was 161 to 14 in the NIOT group. Lenke type I thoracic deformities dominated in both groups (266 and 130) over type III thoracolumbar (66 and 28) and type V lumbar deformities (41 and 17).

Following the induction of anesthesia and before prone positioning of the patient, the CITO type clamp was fixed to skullcap (parietal region of the skull), Kirshner-wires were inserted in the frontal plane through both thigh bones in the supramalleolar region and fixed with clamps for skeletal traction. The first traction did not exceed 3–5 kg, and it was increased to 50 % of body weight before rods insertion and decreased to the initial value after instrumentation assembly. Immediately after the surgery, clamps and wires were removed.

In all the cases, osteoplasty was performed using only local autografts (spinous, transverse, and articular processes, semi-arches), which were harvested from the entire length of instrumented fusion area. The number of motion segments included in this area was almost similar in both groups involving 12–13 levels.

Spondylograms of the thoracic and lumbar spine in the upright position were obtained preoperatively, before discharge, and at the end of follow-up. At these periods, the Cobb angle for primary and secondary curves, thoracic kyphosis and lumbar lordosis magnitudes, frontal balance (the offset angle from the T1 vertebral centroid from the mean sacral line), as well as intraoperative blood loss and operative time for both groups were evaluated.

Statistics. All paired comparisons were performed using the Mann–Whitney test. It is a nonparametric test not requiring normal dataset distribution, in contrast to, for example, Student's t-test. The Kruskal–Wallis test was used for several groups – an extension of the Mann–Whitney test for several samples. All manipulations with data were performed using the R package.

Results

All the results are given in Table.

Primary curve. The initial curve magnitude in the IOT group was 60.5°, correction was 32.7°, and correction loss was 3.1°; in the NIOT group – 54.1°, 26.2°, 5.9°, respectively. The differences were statistically significant.

We tried to explain the influence of the initial primary curve magnitude on the outcome in three groups: lower than 50°, from 50° to 75°, and more than 75°. IOT was found to increase the achieved correction in all groups but the greatest effect was observed in the patients with deformities from 50° to 75°. Correction for the NIOT group was 27.9° and it was 34.9° when using IOT. This difference was statistically significant (Mann – Whitney test – 1.244e-0.9).

Secondary curve. The initial curve magnitude was 44.2°, correction was 20.6°, and loss of correction was 1.4° in the IOT group; these magnitudes were 37.7°, 14.2°, 2.3°, respectively, in the NIOT group. The differences were statistically significant.

Thoracic kyphosis. The initial curve magnitude was 30.8° in the IOT group, it decreased by 7.3° postoperatively, and later there was an increase in kyphosis by 0.9°; the NIOT group – 23.4°, by 2.4°, by 2.6°, respectively. The intraoperative flattening of kyphosis in both groups was statistically significant, and an increase in kyphosis in the long-term postoperative period was statistically insignificant.

Lumbar lordosis. The initial curve magnitude was 58.2° in the IOT group, it decreased by 6.7° postoperatively, and later there was an increase in lordosis by 1.0°; the NIOT group – 54.8°, by 3.2°, by 1.8°, respectively. The intraoperative flattening of lordosis in both groups was statistically significant; an increase in the long-term postoperative period was statistically insignificant.

Frontal imbalance. In the IOT group, it decreased approximately by 3 mm and by 5.7 mm in the NIOT group. In the long-term postoperative period, frontal imbalance continued to decrease: by 4.1 mm in the IOT group and by 4.4 mm in the NIOT group. All the changes were statistically insignificant.

The operative time in the NIOT group was 183.7 min and 165.9 min – in the IOT group. The difference was statistically insignificant (Mann–Whitney test – 0.01166).

Blood loss. In the NIOT group patients, the mean blood loss was 1005.1 ml and it was 867.7 ml in the IOT group, i.e., using IOT decreases blood loss approximately by 137.4 ml. The difference was statistically significant according to the Mann–Whitney test (1.215e-07).

Discussion

We have not found any papers exploring the effect of IOT when using the Harrington distractor. The authors of the CD instrumentation in one of the first publications devoted to its application recommended the regular use of IOT in surgery of adolescent idiopathic scoliosis due to a variety of potential advantages: spine stabilization during surgery and facilitated hook and screw insertion as well as curve improvement prior to surgical curve correction with instrumentation. The authors employed IOT, which was decreased during the insertion of the first wire, during operating a series of 250 patients and did not reveal any neurological complication [13].

The first study devoted to the effectiveness of IOT in treating adolescent idiopathic scoliosis was published in 2004 by Mac-Thiong et al [15]. The authors compared traction (40 patients) and no-traction (100 patients) groups. Skin traction was initiated after the induction of anesthesia and weight application to the patient from 25 to 30 pounds up to one third of the patient's body weight (as chosen by the operating surgeon). The outcomes were somewhat disappointing: although the lower baseline curve magnitudes but with a greater mobility of deformities, a larger fusion length, and a higher number of pedicle screws were observed in the study group compared to control group, the differ-

Table

Main parameters of scoliotic deformity when using intraoperative traction (IOT) and without

Analyzed parameters	The mean parameter in the NOIT group	The mean parameter in the IOT group	Mann — Whitney test
Primary curve correction, degrees	26.2	32.7	9.477e-13
Loss of primary curve correction, degrees	6.0	3.1	5.004e-11
Countercurve correction, degrees	14.4	20.6	2.2e-16
Loss of countercurve correction, degrees	2.3	1.4	0.0007357
A decrease in thoracic kyphosis, degrees	-1.3	7.8	2.2e-16
A postoperative increase in thoracic kyphosis, degrees	1.8	0.9	0.06501
The flattening of lumbar lordosis, degrees	3.1	7.0	6.211e-12
A postoperative increase in lumbar lordosis, degrees	1.8	0.9	0.06501
A decrease in frontal imbalance, mm	5.7	3.0	0.2364
A postoperative decrease in frontal imbalance, mm	-4.1	-4.4	0.8711

ence in the achieved correction of primary curve was insignificant. Significant differences were noted in the region of lumbar countercurve where IOT showed a greater effectiveness. Regarding the sagittal contour of the vertebral column, IOT flattens the lumbar lordosis and slightly influences the dynamics of thoracic kyphosis. Operative time and blood loss in the study group were significantly higher than in control (2447 ml, 351 min and 1742 ml, 301 min, respectively), but the authors do not provide a convincing explanation to this difference. The authors did not note any serious complications associated with IOT. Based on these findings, Mac-Thiong et al. [15] do not recommend the routine use of IOT in surgery of idiopathic scoliosis.

Hamzaoglu et al. [6] presented the outcomes of intraoperative halo-femoral traction in treating severe scoliosis (more than 100°). In 15 patients, primary curve was corrected from 112° to 60°, compensatory curve – from 69° to 40° and kyphosis decreased from 102° to 48°. Traction was started with 12 kg (6 kg on the head, 3 kg on each leg). Weights were added with 1 kg per hour to a total of 12 kg on the head and 12 kg on the legs (the total weight did not exceed 30–50 % of body weight). Surgical technique involved the resection of articular processes and posterior release (removal of supraspinous, interspinous ligaments, and ligamentum flavum). The authors highly appreciate intraoperative halo-traction since it provides a good correction, minimization of complications, and elongates the thoracic cavity improving the pulmonary function. The loss of correction was 4° for primary curve and 2° for thoracic kyphosis at more than two years postoperatively. Unfortunately, there is no opportunity to evaluate the contribution of IOT to the achieved correction because of an absence of the comparison group.

Jhaveri et al. demonstrated the effect of IOT (skull-femoral traction with weight applied with approximately 50 % of body weight) on correction of severe scoliosis, primarily, on apical vertebral derotation [8]. They operated on 22 patients with idiopathic and neuromuscular scoliosis using IOT and observed a significant apical derotation (assessed using the Nash–Moe grading system) from 3.1° to 2.4°. Apical vertebral rotation decreased in 14 (64 %) of 22 patients. The Cobb angle was corrected from 88° to 49° (44.3 % correction). In addition, this derotation achieved with IOT facilitates manipulations on the deformed spine (decortication and other procedures).

Lewis et al. [14] supposed that IOT can cause spinal cord stretching and ischemia. The authors studied motor evoked potentials in patients with adolescent idiopathic scoliosis. It was found that IOT is associated with frequent changes in evoked potentials: an initial onset of changes in the potentials occurred at a mean of 94 min from the onset of surgery; the changes were unilateral or bilateral and improved at a mean of 5.5 min after decreasing or removing traction. At wound closure, the changes recovered to baseline completely or partially and there were no neurological deficits. According to the authors, the thoracic location of the primary curve, an increase in the Cobb angle, and rigid curve are risk factors for changes in evoked potentials.

Kulkami and Shah [10] presented the outcomes of using IOT in 10 adult patients with severe neglected scoliosis. Traction weight at 50 % of body weight was suspended on legs and one-third of body weight was suspended on the skull. Posterior-only correction was employed. The Cobb angle improved from 89° to 40° (55 % correction). Apical vertebral rotation assessed with Nash–Moe improved from III to II grade. There were no complications associated with using traction, including neurological complications. According to authors, IOT obviates the need of an anterior approach, facilitates screw implantation, and is an effective and safe method.

Da Cunha et al. [4] operated on 72 patients with idiopathic scoliosis (45 – with IOT, 27 – without traction). Skeletal traction was used. Traction weight was applied a maximum of 50 % of body weight. All operations using hybrid constructs were performed through posterior approach. Operative time was 375 min and blood loss was 1485 ml in the IOT group and the corresponding values were 447 min and 2083 ml in the NIOT group. Correction of the primary curve was 62.5 % (baseline 62°) in the IOT group; NIOT – 58.0 % (baseline 63°). Complications associated with IOT were not observed.

Alsayegh et al. [1] compared two groups of patients with adolescent idiopathic scoliosis operated on using skull-femoral traction and without (28 and 45 patients, respectively). The IOT group experienced significant decreases in blood loss (1485 versus 2083 ml) and operative time (375 versus 447 min). The percentage of curve correction was almost similar in two groups (62.5 versus 58.1 %). Complications associated with IOT, including neurological complications, were not observed.

LaMothe et al. [12] presented a literature review in order to answer the following questions: does intraoperative traction have any advantages and whether this method is associated with risk for patients? A total of nine papers included in the review report the outcomes of surgical treatment of 150 patients with idiopathic scoliosis and 106 – with neuromuscular scoliosis.

The complications associated with IOT are not numerous. There was one case of traction-related pressure sore per 150 surgeries for idiopathic scoliosis and 19 cases of reversible spinal cord intraoperative monitoring changes without clinical consequences. An analysis of the literature data has shown that in the case of adequate assessment of curve characteristics and spinal cord monitoring, IOT can be used to improve correction of idiopathic scoliosis, thereby forgoing the need for an anterior approach. A straightening of the physiological curves, thoracic kyphosis and lumbar lordosis, can be associated with the effect of IOT.

A variety of papers have been devoted to using IOT in the surgery of neuromuscular scolioses [7, 9, 16, 17]. The authors report the effectiveness of IOT. However, since asymmetric traction is used for correcting pelvic obliquity in consequences of infantile cerebral palsy, we do not discuss these papers but mention them for completeness.

We have examined the largest cohort of patients among the published cohorts and the findings are not fully consistent with previous data. Thus, it was found that surgery performed using IOT provides a greater intraoperative correction and a lower loss of correction in the long-term postoperative follow-up than without a distraction influence. This equally refers to both the primary and secondary curves. The flattening of thoracic kyphosis and the alignment of lumbar lordosis during surgical correction were significantly more pronounced in the IOT group. Postoperative changes in the sagittal contour of the thoracic and lumbar spine did not differ significantly between the traction and no-traction groups. Using IOT decreases significantly blood loss, the operative time reduces but these differences are statistically insignificant. The normalization of the frontal imbalance both in the immediate and long-term postoperative periods was different in the two groups but these differences are also statistically insignificant. The greatest effectiveness of IOT was observed for the group of patients with deformities from 50° to 75°, although IOT increased the achieved correction in scolioses with lower and greater curve magnitudes.

White and Panjabi [18] proved that according to biomechanics, axial traction provides a better correction in deformities of greater than 57° compared to translation maneuver. Our data support this conclusion since IOT is most effective exactly in the group of patients with deformities from 50° to 75°. We did not observe complications associated with using IOT.

Conclusion

Intraoperative skeletal traction can significantly improve the degree of correction of both primary and secondary curves, particularly with curve magnitudes from 50° to 75°. IOT also provides a lower postoperative loss of correction and intraoperative blood loss but has no effect on the dynamics of frontal balance restoration. We are not inclined to directly associate the lower loss of correction and reduced blood loss with using IOT, since there no enough basis. More research is needed in order to support or discard this association.

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References

1. **Alsayegh S, LaMothe J, Letal M, Parsons D, Ferri-de-Barros F.** Intraoperative skull femoral traction (ISFT) in posterior instrumentation for adolescent idiopathic scoliosis: safety and effect on perioperative care. Can J Surg. 2013;56(4 Suppl 2):S55.
2. **Clark JA, Hsu LC, Yau AC.** Viscoelastic behaviour of deformed spines under correction with halo pelvic distraction. Clin Orthop Relat Res. 1975;(110):90–111.
3. **Cotrel Y, Dubousset J, Guillaumat M.** New universal instrumentation in spinal surgery. Clin Orthop Relat Res. 1988;227:10–23.
4. **Da Cunha RJ, Al Sayegh S, LaMothe JM, Letal M, Johal H, Parsons DL, Ferri-de-Barros F.** Intraoperative skull-femoral traction in posterior spinal arthrodesis for adolescent idiopathic scoliosis: the impact on perioperative outcomes and health resource utilization. Spine. 2015;40:E154–E160. DOI: 10.1097/BRS.0000000000000711.
5. **Ferguson RL, Allen BL Jr.** Staged correction of neuromuscular scoliosis. J Pediatr Orthop. 1983;3:555–562. DOI: 10.1097/01241398-198311000-00001.
6. **Hamzaoglu A, Ozturk C, Aydogan M, Tezer M, Aksu N, Bruno MB.** Posterior only pedicle screw instrumentation with intraoperative halo-femoral traction in the surgical treatment of severe scoliosis (>100 degrees). Spine. 2008;33:979–983. DOI: 10.1097/BRS.0b013e31816c8b17.
7. **Huang MJ, Lenke LG.** Scoliosis and severe pelvic obliquity in a patient with cerebral palsy: surgical treatment utilizing halo-femoral traction. Spine. 2001;26:2168–2170.
8. **Jhaveri SN, Zeller R, Miller S, Lewis SJ**. The effect of intra-operative skeletal (skull femoral) traction on apical vertebral rotation. Eur Spine J. 2009;18:352–356.
9. **Keeler KA, Lenke LG, Good CR, Bridwell KH, Sides B, Luhmann SJ.** Spinal fusion for spastic neuromuscular scoliosis: is anterior releasing necessary when intraoperative halo-femoral traction is used? Spine. 2010;35:E427–E433. DOI: 10.1097/BRS.0b013e3181d9527e.
10. **Kulkami AG, Shah SP.** Intraoperative skull-femoral (skeletal) traction in surgical correction of severe scoliosis (>80°) in adult neglected scoliosis. Spine. 2013;38:659–664. DOI: 10.1097/BRS.0b013e318277c874.
11. **Kumar K.** Spinal deformity and axial traction. Spine. 1996;21:653–655.
12. **LaMothe JM, Al Sayegh S, Parsons DL, Ferri-de-Barros F.** The use of intraoperative traction in pediatric scoliosis surgery: a systematic review. Spine Deformity. 2015;3:45–51. DOI: 10.1016/j.jspd.2014.06.007.
13. **Letts RM, Palakar G, Bobecko WP.** Preoperative skeletal traction in scoliosis. J Bone Joint Surg Am. 1975;57:616–619.
14. **Lewis SJ, Gray R, Holmes LM, Strantzas S, Jhaveri S, Zaarour C, Magana S.** Neurophysiological changes in deformity correction of adolescent idiopathic scoliosis with intraoperative skull-femoral traction. Spine. 2011;36:1627–1638. DOI: 10.1097/BRS.0b013e318216124e.
15. **Mac-Thiong JM, Labelle H, Poitras B, Rivard CH, Joncas J.** The effect of intraoperative traction during posterior spinal instrumentation and fusion for adolescent idiopathic scoliosis. Spine. 2004;29:1549–1554. DOI: 10.1097/01.BRS.0000131421.66635.AF.
16. **Takeshita K, Lenke LG, Bridwell KH, Kim YJ, Sides B, Hensley M.** Analysis of patients with nonambulatory neuromuscular scoliosis surgically treated to the pelvis with intraoperative halo-femoral traction. Spine. 2006;31:2381–2385. DOI: 10.1097/01.brs.0000238964.73390.b6.
17. **Vialle R, Delecourt C, Morin C.** Surgical treatment of scoliosis with pelvic obliquity in cerebral palsy: the influence of intraoperative traction. Spine. 2006;31:1461–1466. DOI: 10.1097/01.brs.0000219874.46680.87.
18. **White AA, Panjabi MM, eds.** Practical Biomechanics of Scoliosis and Kyphosis. Clinical Biomechanics of the Spine, 2nd ed. Philadelphia: J.B. Lippincott, 1990.

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