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Fate of Thoracic Curves in Adolescent Idiopathic Scoliosis after Selective Thoracic Fusion: Systematic Review of Literature and Meta-Analysis

Mohamed F Khattab, MD., Ahmed S Younes, MD., Nabil A Ghaly, MD.
Orthopaedic Surgery Department, Ain Shams University, Cairo, Egypt.

ABSTRACT

Background Data: In adolescent idiopathic scoliosis (AIS), the upper thoracic spine (T1–T5) may represent an additional curve called the proximal thoracic curve (PTC), which is nearly equal and opposite to the main thoracic curve (MTC); this is a classic example of a ‘‘double thoracic curve pattern.” So, after selective thoracic fusion (STF) for MTC by either anterior or posterior instrumentation and fusion, what happens to the noninstrumented PTC and instrumented MTC?

Study Design: Systematic review of literature and meta-analysis.

Purpose: To evaluate the fate of the noninstrumented PTC and instrumented MTC after STF for the MTC by either anterior or posterior instrumentation and fusion.

Methods: This study was conducted by searching the PubMed and Cochrane databases and included patients with AIS treated by STF between 1999 and 2020. The type of approach, degree of correction achieved in MTC, PTC, and apical vertebral rotation (AVR), and complications rate were reported independently by two authors.

Results: Our systematic review yielded 1686 patients, with 18 studies meeting the required criteria. MTC has been corrected by 24.89 ± 8.45 degrees, while PTC has been corrected by 14.94 ± 7.18 degrees. Cobb’s angle was reported in seven studies for MTC angle and four studies for lumbar and thoracolumbar curves angle and has been corrected by 19.68 ± 6.55 degrees. Moreover, shoulder tilt has been corrected by 0.83 ± 0.83. Data for correction of AVR was reported in two studies and has been corrected by 15.95 ± 4.65 degrees.

Conclusion: Anterior and posterior spinal fusion had no statistical significance difference regarding MTC, shoulder tilt, and AVR correction. However, PTC corrections was more significant after anterior spinal fusion (ASF) than posterior spinal fusion (PSF). (2021ESJ228)

Keywords: Proximal thoracic curve, Main thoracic curve, Adolescent idiopathic scoliosis, Selective thoracic fusion, Spinal fusion.

Address correspondence and reprint requests: Ahmed Soliman Younes, MD.,
Orthopaedic Surgery Department, Ain Shams University, Cairo, Egypt
E-mails: ahmed.soliman687@gmail.com

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INTRODUCTION

Scoliosis is a three-dimensional spinal deformity characterized by a Cobb's angle of 10° or more with vertebral rotation and is commonly combined with hypokyphosis.[36] In adolescent idiopathic scoliosis (AIS), the upper thoracic spine (T1–T5) may incorporate an additional curve called the proximal thoracic curve (PTC), which is nearly equal and opposite to the main thoracic curve (MTC). This is known as the ''double thoracic curve pattern,'' which was first identified by the scientist Moe.[34]

Some scholars also suggested fusing PTC with MTC to avoid shoulder asymmetry and truncal decompensation during surgery. In addition, the conditions for fusing big PTCs are purely theoretical.[6,42] some scholars have reported spontaneous PTC correction after selective thoracic fusion (STF) for MTC, while others have reported the contrary.[39]

STFs were introduced by Moe to treat the structural thoracic curve when a more flexible lumbar component existed.[25] Factors to decide whether to perform STF or not are patient lifestyle and clinical status, including activity level, age, and preference to sports. Dancers or athletes require more lumbar flexibility for their activity; thus, STF is required.[4,10] Meanwhile, the patient and family must understand the potential for lumbar curve progression, junctional problems, and revision surgery to extend the fusion after STF.[4,10]

The purpose of this systematic review and meta-analysis is to study the fate of the noninstrumented PTC and instrumented MTC after STF of MTC by either anterior or posterior instrumentation and fusion.

PATIENTS AND METHODS

We conducted a systematic review and meta-analysis using PubMed, Embase, and Cochrane databases updated to fit the epidemiological scope of our review purpose and available evidence and to be in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. This systematic review was approved by our IRB.

Criteria for considering studies for this review: randomized controlled trials, nonrandomized controlled trials, prospective and retrospective comparative cohort studies, and case-control studies were the types of studies we reported. Cross-sectional trials, case series, and case reports were excluded.

Included participants: only human subjects were included in the studies.

Types of interventions: treatment of AIS by STF for MTC using either anterior or posterior instrumentation and fusion was included.

Types of postoperative outcome measures: MTC, PTC, correction of Cobb's angle (thoracic, lumbar, and thoracolumbar), correction of shoulder tilt, correction of AVR and complications were reported.

Search strategy for identification of studies: the search was conducted using Cochrane Library, Embase, and PubMed databases searching for the following keywords: adolescent idiopathic scoliosis, proximal thoracic curve, main thoracic curve, selective thoracic fusion, anterior spinal fusion, and posterior spinal fusion for the studies published between 1999 and 2020.

Inclusion criteria: type of scoliosis (adolescent idiopathic scoliosis), patients aged 10–18 years, English language, literature from 1999 to 2020, treatment of AIS by STF, and both sexes were the inclusion criteria.

Exclusion criteria: other types of scoliosis (neuromuscular, syndromic, or congenital), incomplete outcome results, and animal studies were all excluded.

Data extraction: two investigators extracted the data independently, and differences and disagreements were resolved by the research meeting. A third author checked the accuracy of the extracted data. The data were recorded using a standard data extraction form, including the basic information of studies (the last author's name, year of the publication, and size of the sample), the basic participants' information (age, sex, and type of the surgery), clinical data (STF either anterior or posterior instrumentation and fusion, correction of Cobb's angle of PTC and MTC, AVR correction, and complications rate).

Statistical Analysis

The results of the included studies were combined using the Review Manager program and manually screened for inclusion eligibility. Based on the search results and the inclusion/exclusion parameters, a PRISMA flowchart of the searched data was generated.

RESULTS

The search retrieved 712 records. Then, 629 studies were excluded after titles and abstracts screening and removing the duplications, while 83 were considered potentially eligible records for full-text screening. Finally, 18 studies were included after the exclusion of 65 studies as follows: 4 studies with different languages, 10 with different interventions, 46 with different outcomes, 4 review articles, and 1 study where the full text was not available (Figure 1).

Description of the studies: all over the 18 studies reported, 1686 patients were diagnosed with AIS. Patients underwent STF by either anterior or posterior instrumentation and fusion. In this review, the total number of reported patients was 1686 patients, including 746 in the ASF group and 940 in the PSF group. The mean age of patients in the ASF group was 14.6 years, while that in the PSF group was 14.5 years. The male ratio (i.e., number of males per 100 females) was 14% in the ASF group and 8% in the PSF group. According to Lenke's classification, the curve types (1C, 2C, 3C, 4C, 5C, and 6C) which meet the criteria for STF were reported. More descriptive data were included in reported articles and complications, as shown in Table 1.

Main Thoracic Curve:

Data for MTC have been reported in 15 studies. Table 1 shows and compares the difference between anterior and posterior instrumentation. Follow-up periods were two years in eight studies, two to four years in five studies, and more than four years in two studies. MTC has been corrected by 24.89 ± 8.45 degrees and there was no statistical significance difference (p value = 0.50) between anterior and posterior instrumentation with no clinical significance, mean difference (MD) = 1.36 [CI = −2.60, 5.32] (Figure 2).

Proximal Thoracic Curve:

Data for PTC correction have been reported in three studies. Table 1 shows and compares the difference between anterior and posterior instrumentation for MTC. The mean correction of the MTC was 14.94 ± 7.18 degrees in all studies and there were a statistical significance and clinical significance difference between anterior and posterior correction, favouring the anterior fusion (p value < 0.01, MD = −3.1 [CI = −4.37, −1.82]) (Figure 3).

Cobb's Angle (Thoracic, Lumbar, and Thoracolumbar):

Data for correction of Cobb's angle have been reported in 11 studies, 7 studies for MTC angle, and 4 studies for lumbar and thoracolumbar curves angle. Table 1 shows and compares the difference between anterior and posterior instrumentation; Cobb's angle has been corrected 19.68 ± 6.55 degrees and there was no statistical or clinical significance difference between anterior and posterior instrumentation (p value = 0.08, MD = −3.76 [CI = −7.96, 0.44]) (Figure 4).

Shoulder Tilt:

Data for correction of shoulder tilt have been reported in two studies. Table 1 shows and compares the difference between anterior and posterior instrumentation; shoulder tilt has been corrected by 0.83 ± 0.83 degrees and there was no statistical significance or clinical significance difference between anterior and posterior instrumentation (p value =0.34, MD = 0.18 [CI = −0.19, 0.56]) (Figure 5).

Apical Vertebral Rotation:

Data for correction of AVR reported in two studies. Table 1 shows and compares the difference between anterior and posterior instrumentation; AVR has been corrected by 15.95 ± 4.65 degrees and there was no statistical significance or clinical significance difference between anterior and posterior instrumentation (p value = 0.99, MD = 0.07 [CI = −8.11, 7.96]) (Figure 6).

Table 1. Summary of the included studies.

Study ID	Group	Number	Age/year	Sex/ (females %)	Risser sign	Follow-up/year	MTC	PTC	Cobb angle	Shoulder tilt	AVR	Complications
Betz et al., 1999[3]	ASF	78	14	NR	NR	2.6	58 ± 10.6	NA	NA	NA	NA	Repeat thoracotomy, skin burn from an axillary, suture abscess
	PSF	100	14	NR	NR	2.5	59 ± 9.6	NA	NA	NA	NA	Pneumothorax, acute respiratory distress syndrome, suture abscess, pleural effusion, shoulder pain
Dobbs et al., 2004[8]	ASF	56	NR	80%	NR	2	28 ± 7.6	NA	28 ± 7.6	NA	NA	NR
	PSF	44	NR	93%	NR	2	31.7 ± 9	NA	31.7 ± 9	NA	NA	NR
Dong et al., 2015[9]	ASF	17	14.8	82.3%	NR	4	16.2 ± 8.5	NA	5.2 ± 4.6	NA	NA	Thigh pain, urethral injury
	PSF	36	14.5	91.7%	NR	4	10.8 ± 6.8	NA	5.1 ± 4.7	NA	NA	Implant failures, pseudarthrosis
Edwards et al., 2004[10]	ASF	15	14.78	NR	2.2	2.7	32.3 ± 8.8	NA	27.4 ± 9.1	NA	NA	NR
	PSF	26	13.7	NR	2.9	6	41.08 ± 8.7	NA	32.46 ± 9	NA	NA	NR
Fu et al., 2009[12]	ASF	27	14.7	94.3%	NR	2	26.3 ± 7.7	NA	20.2 ± 7.2	NA	21.8 ± 4.7	NR
	PSF	79	14.7		NR	2	18.47 ± 6.1	NA	12.1 ± 6.1	NA	26 ± 6.9	NR
Geck et al., 2009[13]	ASF	31	15.6	NR	NR	2	NA	NA	15 ± 6.6	NA	NA	Proximal junctional
	PSF	31	15.5	NR	NR	2	NA	NA	6.95 ± 2.75	NA	NA	
Hee & Wong, 2007[14]	ASF	25	14.2	100%	5	2	18 ± 11	NA	NA	NA	NA	Instrumentation failure, broken implants, pull-out, pseudarthrosis
	PSF	11	14.5	100%	5	2	17 ± 5	NA	NA	NA	NA	
Kuklo et al., 2001[18]	ASF	41	15.4	NR	NR	2.8	31 ± 10	16.27±7.5	NA	0.8 ± 0.8	NA	NR
	PSF	44	14.7	NR	NR	3.6	44.5 ± 9.6	20.86±8.2	NA	0.3 ± 0.5	NA	NR
Lenke et al., 1999[20]	ASF	70	14.5	NR	NR	2	NA	NA	19 ± 9.1	NA	NA	NR
	PSF	53	14.5	NR	NR	2	NA	NA	32 ± 11.4	NA	NA	NR
Li et al., 2009[23]	ASF	22	13.7	NR	3	2	16 ± 12.2	NA	2.16 ± 0.54	NA	NA	No complications
	PSF	24	13.5	NR	2	2	16 ± 14.2	NA	2.39 ± 0.66	NA	NA	
Miyanji et al., 2018[28]	ASF	69	15.5	78.2%	3.7	2	17.2 ± 8.2	NA	18.6 ± 7.6	NA	NA	NA
	PSF	92	15.3	82.6%	3.5	2	17.3 ± 8.7	NA	17.9 ± 6.3	NA	NA	
Newton et al., 2020[29]	ASF	23	12	69.6%	0	2	34 ± 8	NA	36 ± 11	1±1	10±3	Atelectasis, pulmonary oedema, Horner syndrome
	PSF	26	13	88.5%	0	2	12 ± 4	NA	78 ± 8	1.2±1	6±4	No complications
Nohara et al. 2015[30]	ASF	30	15.5	100%	NR	10	19.1 ± 5.5	15.7±6.6	12.7 ± 7.3	NA	NA	NR
	PSF	30	15.7	100%	NR	10	24.6 ± 8.3	17.8±6.4	12.9 ± 7.3	NA	NA	NR
Rhee et al. 2002[33]	ASF	50	14	NR	NR	2.6	NA	NA	NA	NA	NA	NR
	PSF	60		NR	NR	2.6	NA	NA	NA	NA	NA	NR
Rushton & Sell, 2015[35]	ASF	18	15.4	85.7%	NR	3.2	30.3 ± 9	NA	NA	NA	NA	Four implant failures and/or revision for progression
	PSF	24	15.8		NR	2.7	18.5 ± 10.1	NA	NA	NA	NA	3 pleural effusions, 2 atelectasis, 2 pneumothoraces, 3 cases of pneumonia, 4 wound complications
Sucato et al., 2008[37]	ASF	135	14.4	NR	2.8	2	25.1 ± 14.9	8±6.8	NA	NA	NA	NR
	PSF	218	15.3	NR	3	2	18.75 ± 9.2	11 ± 7.5	NA	NA	NA	NR
Tao et al., 2012[38]	ASF	23	13.9	95.6%	3	3.12	12.96 ± 2.8	NA	NA	NA	NA	NR
	PSF	26	13.6	96.1%	3	2.93	10.88 ± 4.5	NA	NA	NA	NA	NR
Wang et al., 2008[41]	ASF	16	15.38	93.7%	3.5	2	20 ± 7.2	NA	9.75 ± 4.1	NA	NA	No complications
	PSF	16	14.88	93.7%	3.5	2	21.57 ± 7.5	NA	7.56 ± 4.2	NA	NA	

ASF: anterior spinal fusion; PSF: posterior spinal fusion; MTC: main thoracic curve; PTC: proximal thoracic curve; AVR: apical vertebral rotation; NA: not applicable; NR: not reported.

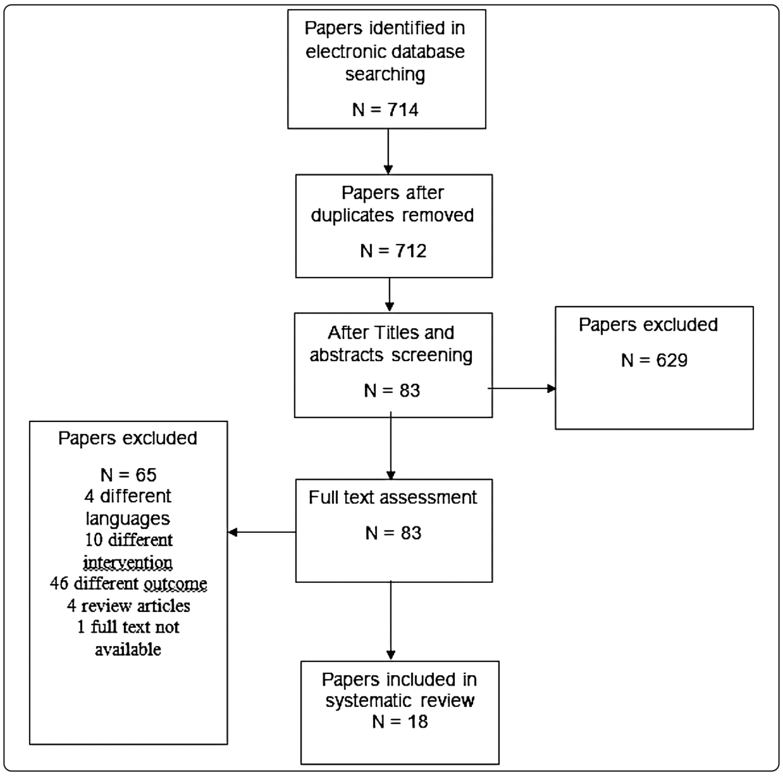

Figure 1. PRISMA flowchart for study selection.

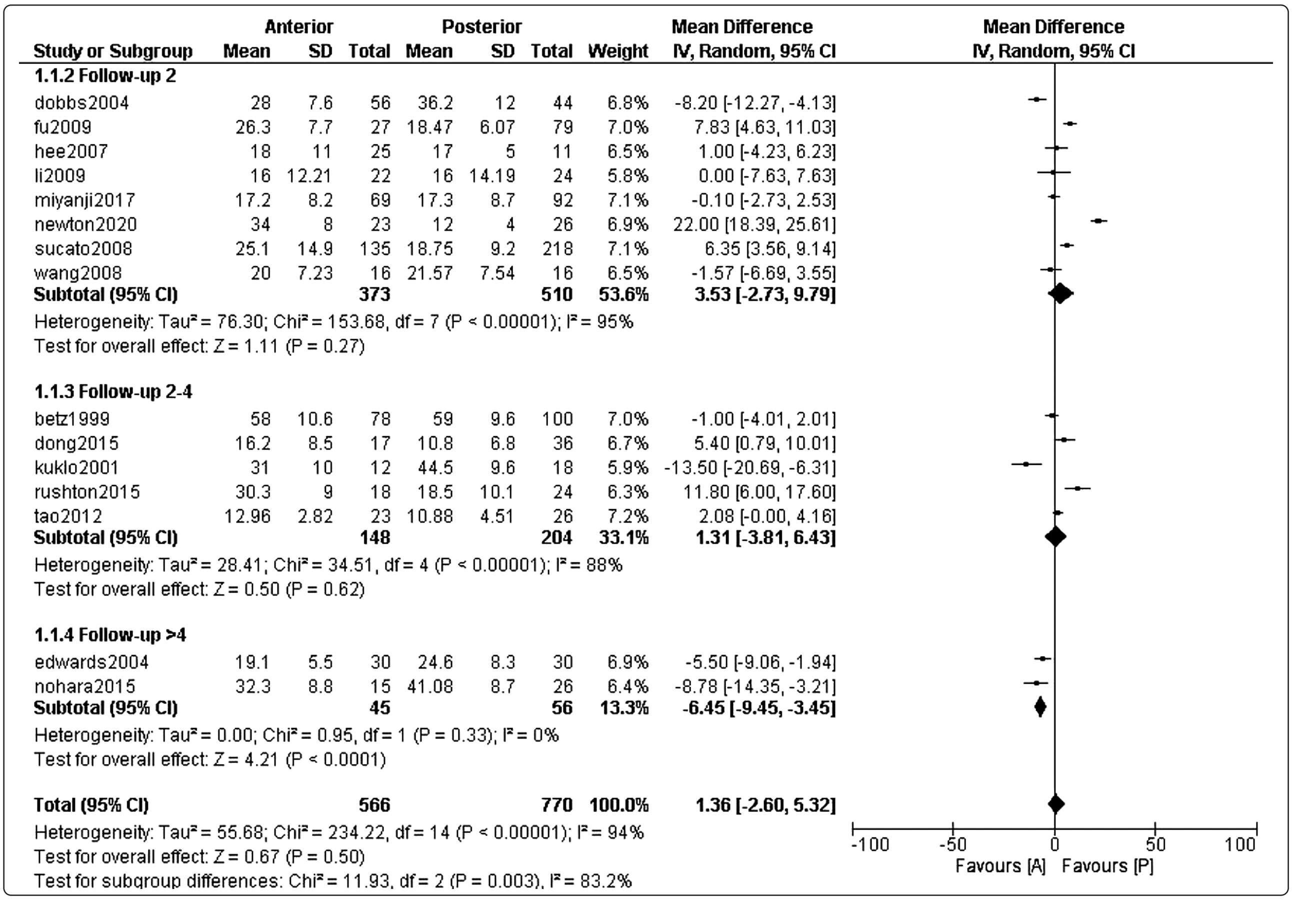

Figure 2. Forest plot for main thoracic curve.

Study or Subgroup	Anterior Mean	Anterior SD	Anterior Total	Posterior Mean	Posterior SD	Posterior Total	Weight	Mean Difference IV, Fixed, 95% CI
kuklo2001	16.27	7.54	41	20.86	8.21	44	14.5%	-4.59 [-7.94, -1.24]
nohara2015	15.7	6.6	30	17.8	6.4	30	15.0%	-2.10 [-5.39, 1.19]
sucato2008	8	6.8	135	11	7.5	218	70.5%	-3.00 [-4.52, -1.48]
Total (95% CI)			**206**			**292**	**100.0%**	**-3.10 [-4.37, -1.82]**

Heterogeneity: Chi² = 1.13, df = 2 (P = 0.57); I² = 0%
Test for overall effect: Z = 4.76 (P < 0.00001)

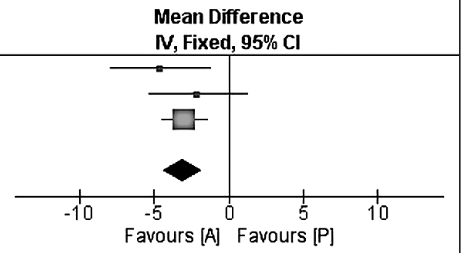

Figure 3. Forest plot for proximal thoracic curve.

Study or Subgroup	Anterior Mean	Anterior SD	Anterior Total	Posterior Mean	Posterior SD	Posterior Total	Weight	Mean Difference IV, Random, 95% CI
1.3.1 New Subgroup								
dobbs2004	26.6	6.2	56	31.1	7.9	44	9.3%	-4.50 [-7.34, -1.66]
dong2015	5.2	4.6	17	5.1	4.7	36	9.3%	0.10 [-2.57, 2.77]
edwards2004	27.4	9.1	15	32.46	9	26	8.2%	-5.06 [-10.82, 0.70]
fu2009	20.2	7.2	27	12.1	6.1	79	9.2%	8.10 [5.07, 11.13]
geck2009	15	6.6	31	6.95	2.75	31	9.4%	8.05 [5.53, 10.57]
lenke1999	19	9.1	70	32	11.4	53	9.0%	-13.00 [-16.74, -9.26]
li2009	2.16	0.54	22	2.39	0.66	24	9.7%	-0.23 [-0.58, 0.12]
miyanji2017	18.6	7.6	57	17.9	6.3	57	9.3%	0.70 [-1.86, 3.26]
newton2020	36	11	23	78	8	26	8.3%	-42.00 [-47.45, -36.55]
nohara2015	12.7	7.3	30	12.9	7.3	30	9.0%	-0.20 [-3.89, 3.49]
wang2008	9.75	4.12	16	7.56	4.21	16	9.3%	2.19 [-0.70, 5.08]
Subtotal (95% CI)			**364**			**422**	**100.0%**	**-3.76 [-7.96, 0.44]**

Heterogeneity: Tau² = 47.40; Chi² = 355.98, df = 10 (P < 0.00001); I² = 97%
Test for overall effect: Z = 1.76 (P = 0.08)

Study or Subgroup	Anterior Total	Posterior Total	Weight	Mean Difference IV, Random, 95% CI
Total (95% CI)	**364**	**422**	**100.0%**	**-3.76 [-7.96, 0.44]**

Heterogeneity: Tau² = 47.40; Chi² = 355.98, df = 10 (P < 0.00001); I² = 97%
Test for overall effect: Z = 1.76 (P = 0.08)
Test for subgroup differences: Not applicable

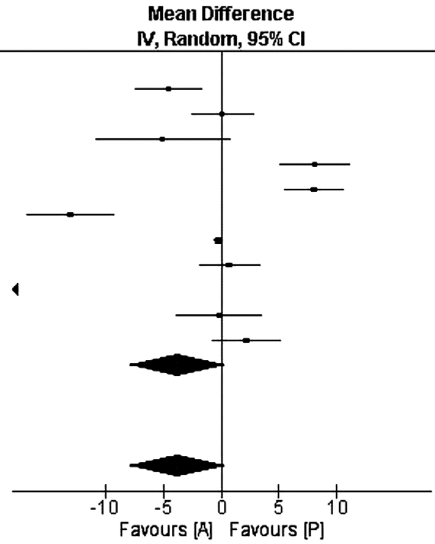

Figure 4. Forest plot for correction of Cobb's angle.

Study or Subgroup	Anterior Mean	Anterior SD	Anterior Total	Posterior Mean	Posterior SD	Posterior Total	Weight	Mean Difference IV, Fixed, 95% CI
newton2020	1	1	23	1.2	1	26	45.1%	-0.20 [-0.76, 0.36]
kuklo2001	0.8	0.8	12	0.3	0.5	18	54.9%	0.50 [-0.01, 1.01]
Total (95% CI)			**35**			**44**	**100.0%**	**0.18 [-0.19, 0.56]**

Heterogeneity: Chi² = 3.29, df = 1 (P = 0.07); I² = 70%
Test for overall effect: Z = 0.96 (P = 0.34)

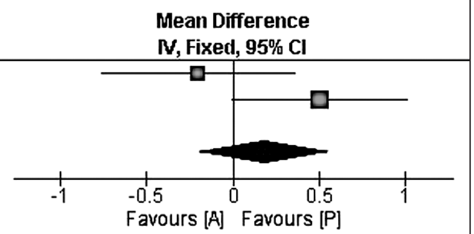

Figure 5. Forest plot for correction of shoulder tilt.

Study or Subgroup	Anterior Mean	Anterior SD	Anterior Total	Posterior Mean	Posterior SD	Posterior Total	Weight	Mean Difference IV, Random, 95% CI
fu2009	21.8	4.7	27	26	6.9	79	49.7%	-4.20 [-6.54, -1.86]
newton2020	10	3	23	6	4	26	50.3%	4.00 [2.03, 5.97]
Total (95% CI)			**50**			**105**	**100.0%**	**-0.07 [-8.11, 7.96]**

Heterogeneity: Tau² = 32.41; Chi² = 27.70, df = 1 (P < 0.00001); I² = 96%
Test for overall effect: Z = 0.02 (P = 0.99)

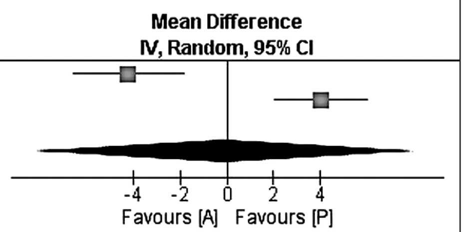

Figure 6. Forest plot for correction of apical vertebral rotation.

DISCUSSION

This systematic review and meta-analysis reported 18 studies with 1686 patients with AIS who underwent STF using either anterior spinal fusion (ASF) or posterior spinal fusion (PSF). The following outcome indicators were considered: MTC, PTC, Cobb's angle (thoracic, lumbar, and thoracolumbar) correction, shoulder tilt correction, AVR correction, and associated complications.

Main Thoracic Curve:

According to 15 studies in our review, MTC findings were similar in either the ASF or the PSF and there was no statistical significance difference between anterior and posterior instrumentation with no clinical significance. However, according to the findings of Kovac et al.[16] study, ASF can achieve greater correction of the MTC than PSF. In their study, the PSF had hybrid constructs made of hooks and pedicle screws.

Sucato et al.[37] reported that ASF restored thoracic kyphosis from T5 to T12 better than posterior techniques using hybrid or hooks-only constructs. ASF patients had significantly more thoracic kyphosis than PSF through follow-up after surgery. Potter et al.[31] compared ASF patients with PSF for Lenke 1C curves demonstrating that the anterior group had a significantly greater increase in thoracic kyphosis than the posterior group (5.7 vs. 4.4°) ($p < 0.004$). Luljenqvist et al.[21] found a similar increase in thoracic kyphosis from 29.2° to 33.6° at follow-up in 23 patients using an anterior dual-rod instrumentation system for thoracic scoliosis. Moreover, Rhee et al.[33] results showed that ASF is more kyphogenic to the thoracic spine than posterior techniques. They explained their findings by the PSF's lack of actual use of sublaminar wires, distraction forces, or rod rotation (each of which encourages thoracic kyphosis).

Geck et al.[13] compared anterior dual-rod instrumentation to posterior pedicle screws and fusion and reported that adolescents with Lenke 5C curves had significantly better corrections and less loss of correction and reduced hospital stay when treated with posterior pedicle screws and fusion compared to anterior instrumentation. More recently, PSF techniques used pedicle screw fixation constructs where PSF can achieve greater correction than ASF, which is in part due to the spontaneous correction and derotation of the thoracolumbar/lumbar curves during this technique.[24]

Nohara et al.[30] reported a significant loss in correction in ASF compared to PSF at longer follow-up periods. Even though no significant difference was observed, the 10-year postoperative correction rate of ASF was lower than that of PSF. One contributing reason for the significant loss in correction in ASF compared to PSF is the distal adding-on effect.

Proximal Thoracic Curve:

In our review, data for PTC were reported in three studies. PTC outcome demonstrated statistical significance difference between ASF and PSF, favouring ASF over PSF. Few studies have reported the PTC outcome after isolated correction of the MTC, whether by ASF or PSF. Nohara et al.[30] reported a highly significant correction of PTC in the ASF group and a significant correction in the PSF group in a 10-year follow-up period.

Identifying and potentially treating the PTC in AIS surgery are still an important part of the preoperative planning. Furthermore, it is still somewhat debatable when the PTC would become structural. Winter and Denis[43] reported that the MTC may be overcorrected beyond the flexibility of the PTC, resulting in spinal asymmetry, left proximal rib cage elevation, and shoulder imbalance. Lee et al.[19] stated that the PTC was frequently more rigid than the MTC and concluded the trouble determining whether the PTC should be included in the fusion. They also found that most patients had a spontaneous adjustment of the unfused PTC after instrumentation and fusion of the MTC.

After instrumentation, there was infrequently a slight progression (5°) of the PTC. If side-bending radiographs show that the PTC is flexible (20°

on side-bending radiographs), selective MTC instrumentation and fusion will elevate the left shoulder via convex compressive correction. As a result, the uninstrumented PTC will correct spontaneously in an attempt to balance the head and shoulders. Since ASF frequently saves one to two proximal fusion levels (fusing end vertebrae to end vertebrae), the additional motion segment(s) may contribute to better PTC correction. This may also prevent the fusion from being extended to T2 or T3, which could result in upper thoracic extensor muscle dissection, denervation, and instrumentation prominence.[19]

In contrast to the posterior approach, which can be extended proximally intraoperatively, the anterior approach may not be technically possible for fusing into the PTC. Consequently, the preoperative radiographic and clinical characteristics of the PTC are critical in determining the capacity to perform a selective ASF of the MTC, denoting potential spontaneous curve correction. Whenever there is a definite positive T1 tilt (5°) on the clinical examination, with the left shoulder elevated, a selective ASF is contraindicated because the compressive correction of the MTC would work to further elevate the left shoulder.[18]

Spontaneous PTC correction occurs upon instrumented MTC correction after both PSF and ASF. Furthermore, this spontaneous correction was slightly greater after the ASF of the MTC versus a PSF of the MTC. The postoperative PTC correction correlates positively with the preoperative PTC and the preoperative PTC flexibility.[7,15,18]

Cobb's Angle (Thoracic, Lumbar, and Thoracolumbar):

Cobb's angle measurement is a classical method for assessing AIS spine deformity in the coronal plane using a standard posteroanterior radiograph.[5] Data for correction of Cobb's angle in our review showed no statistical or clinical significance difference between the ASF and PSF groups.

In a study conducted by Lenke et al.[20], ASF outperformed PSF, where ASF corrected the thoracic Cobb's angle better than PSF. On the other hand, the PSF group reported very low corrections (38%) with PSF using segmental hooks and describes deliberately decreasing posterior correction to limit postoperative decompensation. Kovac et al.[16] used sublaminar wiring and hooks to treat a group with larger deformities (the mean thoracic Cobb's angle >70). They observed greater thoracic curve correction and chest volume increase with ASF versus PSF. Other studies focused on the coronal plane correction between anterior and posterior surgery and reported different outcomes. Moreover, Luo et al.[26] reported that the PSF can yield a better correction of Cobb's angle from preoperation to final follow-up.

Furthermore, Franic et al.[11] found that both ASF and PSF procedures offered a similar degree of frontal Cobb angle reduction, while the long-term impacts of surgical correction on the sagittal Cobb angle appeared to be more stable in the PSF group.

Shoulder Tilt:

Data for correction of shoulder tilt were reported in two studies in our review and showed no statistical significance or clinical significance difference between ASF and PSF procedures.

According to Kuklo et al.'s[18] study, when there is a real positive T1 tilt (>5°) with the left shoulder elevated on the clinical assessment, a selective ASF is contraindicated because compressive adjustment of the MTC would work to further elevate the left shoulder. When the T1 tilt is neutral and the shoulders are clinically equal level, an ASF of the MTC can be conducted, based on the PTC's side-bending flexibility. If the side-bending flexibility is greater than 25°, indicating that spontaneous correction is possible, then an ASF of the MTC can be performed. However, the partially "structural" PTC must be accommodated by leaving residual tilt to the proximal end instrumented vertebra of the MTC to avoid PTC and shoulder imbalance. In the final situation, if the T1 tilt is negative and the right shoulder is clearly higher on physical examination, an ASF of the MTC can usually be performed safely irrespective of the PTC's side-bending flexibility. These criteria are based on the surgeon's experience and are difficult to validate through data analysis.[18]

Li M et al.[22] believed that fusing MTC while leaving a structural PTC unfused may lead to a shoulder imbalance. Meanwhile, Kuklo TR et al.[17] and Qiu XS et al.[32] have proposed correcting the PTC according to clavicular angle, T1 tilt, or the patient's preoperative shoulder level. However, a very weak negative correlation was found between the PTC percentage of correction and postoperative shoulder balance (r = −0.027, $p = 0.910$).

Apical Vertebral Rotation:

Data for correction of AVR were reported in two studies, and there was no statistical significance or clinical significance difference between anterior and posterior instrumentation. Many factors can influence rotation correction, including curve type, magnitude, curve flexibility, spinal instrumentation, rotation evaluating method, and surgeon factor. Fu et al.'s[12] study compared rotation correction by different periapical anchors along a rod placed on the concave side in the posterior approach with the same derotation manoeuvre by different surgical interventions (anterior and posterior). AVR in AIS was effectively corrected by either the anterior approach or posterior derotation manoeuvre using pedicle screw fixation on the periapical segments of the concave side and compared with the use of hooks and the wires, which was more prominent in patients whose scoliosis was flexible.

Postoperative Complications:

Despite the advanced instrumentation, new surgical techniques, and new technology that resulted in good surgical outcomes, complication rates have remained relatively constant. Surgical complications affect from 5% to 23% of all AIS patients. According to these studies, the anterior and posterior complication rates were 5.2% and 5.1%, respectively.[2,27,40]

Complications of ASF such as vascular and urethral injury and weakness of the psoas major were reported by Dong et al.[9], while implant failure (such as broken rods or distal hook pull-out) and/or required revision for progression were reported in another study.[35] Meanwhile, complications of the PSF may include implant failures, pseudarthrosis misalignment of pedicle screws resulting in neurological complications, and, very rarely, pneumothorax.[7] Rushton et al.[35] in their anterior and posterior groups reported many chest-related complications, including pleural effusions, atelectasis, pneumothoraces, and pneumonia; however, all these issues were resolved through conservative management. The incidence of postoperative complications after either ASF and PSF might be related to several factors, including patient and surgeon factors, making risk stratification somewhat burdensome.[1]

Limitations

This review reliably includes a relatively large number AIS patients with long-term follow-up periods up to 10 years in some studies; however, it was limited by its small number of RCTs.

CONCLUSION

Anterior and posterior spinal fusion had no statistical significance difference regarding MTC, shoulder tilt, and AVR correction. However, regarding PTC correction, anterior spinal fusion (ASF) showed greater significant correction than posterior spinal fusion (PSF).

REFERENCES

1. Al-Mohrej OA, Aldakhil SS, Al-Rabiah MA, Al-Rabiah AM: Surgical treatment of adolescent idiopathic scoliosis: Complications. Annals of Medicine and Surgery 52:19–23, 2020
2. Bartley CE, Yaszay B, Bastrom TP, Shah SA, Lonner BS, Asghar J, et al: Perioperative and delayed major complications following surgical treatment of adolescent idiopathic scoliosis. The Journal of bone and joint surgery American 99:1206–1212, 2017

3. Betz R, Harms J, Clements D, Lenke LG, Lowe TG, Shufflebarger HL, et al: Comparison of anterior and posterior instrumentation for correction of adolescent thoracic idiopathic scoliosis. Spine 24:225–239, 1999
4. Bridwell KH: Selection of instrumentation and fusion levels for scoliosis: where to start and where to stop. Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2004. J Neurosurg Spine 1:1–8, 2004
5. Cheng JC, Castelein RM, Chu WC, Danielsson AJ, Dobbs MB, Grivas TB, et al: Adolescent idiopathic scoliosis. Nature Reviews Disease Primers 1:15030, 2015
6. Cho RH, Yaszay B, Bartley CE, Bastrom TP, Newton PO: Which Lenke 1A curves are at the greatest risk for adding-on... and why? Spine 37(16):1384–1390, 2012
7. Choudhry MN, Ahmad Z, Verma R: Adolescent Idiopathic Scoliosis. The Open Orthopaedics Journal 10:143–154, 2016
8. Dobbs M, Lenke L, Walton T, Peelle M, Rocca GD, Steger-May K, et al: Can we predict the ultimate lumbar curve in adolescent idiopathic scoliosis patients undergoing a selective fusion with undercorrection of the thoracic curve? Spine 29:277–285, 2004
9. Dong Y, Weng X, Zhao H, Zhang J, Shen J, Qiu G: Lenke 5C curves in adolescent idiopathic scoliosis: anterior vs posterior selective fusion. Neurosurgery 78:324–331, 2015
10. Edwards C, Lenke L, Peelle M, Sides B, Rinella A, Bridwell KH: Selective thoracic fusion for adolescent idiopathic scoliosis with C modifier lumbar curves: 2- to 16-year radiographic and clinical results. Spine 29:536–546, 2004
11. Franic M, Kujundzic Tiljak M, Pozar M, Romic D, Mimica M, Petrak J, Ivankovic D, et al: Anterior versus posterior approach in 3D correction of adolescent idiopathic thoracic scoliosis: a meta-analysis. Orthopaedics & Traumatology, Surgery & Research: OTSR 98:795–802, 2012
12. Fu G, Kawakami N, Goto M, Tsuji T, Ohara T, Imagama S: Comparison of vertebral rotation corrected by different techniques and anchors in surgical treatment of adolescent thoracic idiopathic scoliosis. Clinical Spine Surgery 22:182–189, 2009
13. Geck MJ, Rinella A, Hawthorne D, Macagno A, Koester L, Sides B: Comparison of surgical treatment in Lenke 5C adolescent idiopathic scoliosis: anterior dual rod versus posterior pedicle fixation surgery: a comparison of two practices. Spine 34:1942–1951, 2009
14. Hee H, Yu Z, Wong H: Comparison of segmental pedicle screw instrumentation versus anterior instrumentation in adolescent idiopathic thoracolumbar and lumbar scoliosis. Spine 32:1533–1542, 2007
15. Konieczny MR, Senyurt H, Krauspe R: Epidemiology of adolescent idiopathic scoliosis. J Child Orthop 7:3–9, 2013
16. Kovač V, Puljiz A, Smerdelj M, Pecina M: Scoliosis curve correction, thoracic volume changes, and thoracic diameters in scoliotic patients after anterior and after posterior instrumentation. International orthopaedics 25:66–69, 2001
17. Kuklo TR, Lenke LG, Graham EJ, Won DS, Sweet FA, Blanke KM, et al: Correlation of radiographic, clinical, and patient assessment of shoulder balance following fusion versus nonfusion of the proximal thoracic curve in adolescent idiopathic scoliosis. Spine 27:2013–2020, 2002
18. Kuklo TR, Lenke LG, Won DS, Graham EJ, Sweet FA, Betz RR, et al: Spontaneous proximal thoracic curve correction after isolated fusion of the main thoracic curve in adolescent idiopathic scoliosis. Spine 26:1966–1975, 2001

19. Lee GA, Betz RR, Clements III DH, Huss GK: Proximal kyphosis after posterior spinal fusion in patients with idiopathic scoliosis. Spine 24:795–809, 1999
20. Lenke LG, Betz RR, Bridwell KH, Harms J, Clements DH, Lowe TG: Spontaneous lumbar curve coronal correction after selective anterior or posterior thoracic fusion in adolescent idiopathic scoliosis. Spine 24:1663, 1999
21. Liljenqvist UR, Bullmann V, Schulte TL, Hackenberg L, Halm HF: Anterior dual rod instrumentation in idiopathic thoracic scoliosis. European Spine Journal 15:1118–1127, 2006
22. Li M, Gu S, Ni J, Fang X, Zhu X, Zhang Z: Shoulder balance after surgery in patients with Lenke Type 2 scoliosis corrected with the segmental pedicle screw technique. Journal of Neurosurgery: Spine 10:214–219, 2009
23. Li M, Ni J, Fang X, Liu H, Zhu X, He S, et al. Comparison of selective anterior versus posterior screw instrumentation in Lenke5c adolescent idiopathic scoliosis. Spine 34:1162–1166, 2009
24. Lonner BS, Auerbach JD, Estreicher M, Milby AH, Kean KE: Video-assisted thoracoscopic spinal fusion compared with posterior spinal fusion with thoracic pedicle screws for thoracic adolescent idiopathic scoliosis. JBJS 91:398–408, 2009
25. Lonstein JE: Selective thoracic fusion for adolescent idiopathic scoliosis: long-term radiographic and functional outcomes. Spine Deform 6:669–675, 2018
26. Luo M, Wang W, Shen M, Xia L: Anterior versus posterior approach in Lenke 5C adolescent idiopathic scoliosis: a meta-analysis of fusion segments and radiological outcomes. Journal of orthopaedic surgery and research 11:1-8, 2016
27. Lykissas MG, Jain VV, Nathan ST, Pawar V, Eismann EA, Sturm PF, et al: Mid- to long-term outcomes in adolescent idiopathic scoliosis after instrumented posterior spinal fusion: a meta-analysis. Spine 38:113–119, 2013
28. Miyanji F, Nasto L, Bastrom T, Samdani AF, Yaszay B, Clements D, et al: A detailed comparative analysis of anterior versus posterior approach to Lenke 5C curves. Spine 43:285–291, 2018
29. Newton P, Bartley C, Bastrom T, Kluck DG, Saito W, Yaszay B: Anterior spinal growth modulation in skeletally immature patients with idiopathic scoliosis. Journal of Bone and Joint Surgery 102:769–777, 2020
30. Nohara A, Kawakami N, Saito T, Tsuji T, Ohara T, Suzuki Y, et al: Comparison of surgical outcomes between anterior fusion and posterior fusion in patients with AIS Lenke Type 1 or 2 that underwent selective thoracic fusion-long-term follow-up study longer than 10 postoperative years. Spine 40:1681–1689, 2015
31. Potter BK, Kuklo TR. Lenke LG: Radiographic outcomes of anterior spinal fusion versus posterior spinal fusion with thoracic pedicle screws for treatment of Lenke Type I adolescent idiopathic scoliosis curves. Spine 30:1859–1866, 2005
32. Qiu X-s, Ma W-w, Li W-g, Wang B, Yu Y, Zhu Z-z, et al: Discrepancy between radiographic shoulder balance and cosmetic shoulder balance in adolescent idiopathic scoliosis patients with double thoracic curve. European Spine Journal 18:45–51, 2009
33. Rhee J, Bridwell K, Won D, Lenke LG, Chotigavanichaya C, Hanson DS: Sagittal plane analysis of adolescent idiopathic scoliosis. Spine 27:2350–2356, 2002
34. Rose PS, Lenke LG: Classification of operative adolescent idiopathic scoliosis: treatment guidelines. Orthopedic Clinics of North America 38:521–529, 2007

35. Rushton PR, Grevitt MP, Sell PJ: Anterior or posterior surgery for right thoracic adolescent idiopathic scoliosis (AIS)? A prospective cohorts' comparison using radiologic and functional outcomes. Journal of Spinal Disorders & Techniques 28:80–88, 2015
36. Smyrnis PN, Sekouris N, Papadopoulos G: Surgical assessment of the proximal thoracic curve in adolescent idiopathic scoliosis. European Spine Journal 18:522–530, 2009
37. Sucato DJ, Agrawal S, O'Brien MF, Lowe TG, Richards SB, Lenke L: Restoration of thoracic kyphosis after operative treatment of adolescent idiopathic scoliosis: a multicenter comparison of three surgical approaches. Spine 33:2630–2636, 2008
38. Tao F, Wang Z, Li M, Pan F, Shi Z, Zhang Y, et al: A comparison of anterior and posterior instrumentation for restoring and retaining sagittal balance in patients with idiopathic adolescent scoliosis. Journal of Spinal Disorders & Techniques 25:303–308, 2012
39. Trobisch PD, Ducoffe AR, Lonner BS, Errico TJ: Choosing fusion levels in adolescent idiopathic scoliosis. JAAOS-Journal of the American Academy of Orthopaedic Surgeons 21:519–528, 2013
40. Vigneswaran HT, Grabel ZJ, Eberson CP, Palumbo MA, Daniels AH: Surgical treatment of adolescent idiopathic scoliosis in the United States from 1997 to 2012: an analysis of 20,346 patients. Journal of neurosurgery Pediatrics 16:322–328, 2015
41. Wang Y, Fei Q, Qiu G, Lee CI, Shen J, Zhang J, et al: Anterior spinal fusion versus posterior spinal fusion for moderate lumbar/thoracolumbar adolescent idiopathic scoliosis. Spine 33:2166–2172, 2008.
42. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA: Adolescent idiopathic scoliosis. The Lancet 371:1527–1537, 2008
43. Winter RB , Denis F: The King V curve pattern: its analysis and surgical treatment. Orthopedic Clinics of North America 25:353–362, 1994

الملخص العربي

دراسة منهجية لمصير المنحنيات الصدرية في مرضي الجنف مجهول السبب لدى المراهقين بعد الإلتحام الصدري الإنتقائي

البيانات الخلفية: قد يقدم العمود الفقري الصدري العلوي في الجنف مجهول السبب لدي المراهقين منحنا إضافيا وهو منحني الصدر القريب الذي يكون تقريبا مساويا ومعاكسا لمنحني الصدر الرئيسي. هذا هو «نمط المنحنى الصدري الأساسي المزدوج». إذن ما هو مصير منحني الصدر القريب غير الملتحم ومنحني الصدر الرئيسي الملتحم بعد التصحيح المعزول لمنحني الصدر الرئيسي إما عن طريق الإلتحام الإنتقائي الأمامي أو الخلفي؟.

تصميم الدراسة: دراسة منهجية.

الغرض: تقييم مصير منحني الصدر القريب غير الملتحم ومنحني الصدر الرئيسي الملتحم بعد التصحيح المعزول لمنحني الصدر الرئيسي إما عن طريق الإلتحام الإنتقائي الأمامي أو الخلفي.

المرضى و الطرق: تم إجراء هذه الدراسة بإستخدام قواعد بيانات PubMed و Cochrane ، وتشمل المرضى الذين تم تشخيصهم بالجنف مجهول السبب لدي المراهقين والمعالجين بواسطة الإلتحام الصدري الإنتقائي ونوع النهج ودرجة التصحيح الذي تم تحقيقه ومعدل المضاعفات التي تم الإبلاغ عنها.

النتائج: أسفرت مراجعتنا المنهجية عن 1686 مريضًا مع 18 دراسة تفي بالمعايير المطلوبة. وتم تصحيح منحني الصدر الرئيسي بمتوسط (24.89 ± 8.45) درجة. وتم تصحيح منحني الصدر القريب بمتوسط (14.94 ± 7.18) درجة. وتم تصحيح زاوية الكوب بمتوسط (19.68 ± 6.55) درجة. وتم تصحيح ميل الكتف بمتوسط (0.83 ± 0.83). تم تصحيح دوران العمود الفقري القمي بالمتوسط (15.95 ± 4.65).

الخلاصة: لم يكن للإلتحام الأمامي والخلفي للعمود الفقري فرق معنوي فيما يتعلق بمنحنى الصدر الرئيسي وإمالة الكتف وتصحيح دوران العمود الفقري القمي. ولكن فيما يتعلق بتصحيح المنحني الصدري القريب أظهر الإلتحام الأمامي تصحيحا معنويا اكبر من الخلفي.