J Orthop Spine Trauma. 2026 August; 12(4): 174-8. DOI: 10.18502/jost.v12i4.22581

Research Article

Posterior Surgery in Scheuermann's Kyphosis: A Retrospective Review of 210 Cases

Saeid Safaei[1], Taravat Yazdanian[2], Parisa Azimi[3,*]

[1] Knee and Sport Medicine Research Center, Milad Hospital, Tehran, Iran
[2] Sean M Healey and AMG Center for ALS, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA
[3] Neurosurgeon, Department of Neurosurgery, Clinical Research Development Unit of Shahid Madani Hospital, School of Medicine, Alborz University of Medical Sciences, Karaj, Iran; Neuroscience Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[*]Corresponding author: Parisa Azimi; Department of Neurosurgery, Clinical Research Development Unit of Shahid Madani Hospital, School of Medicine, Alborz University of Medical Sciences, Karaj, Iran. Tel: +98-26-34427001; Email: parisa.azimi@gmail.com

Received: 24 March 2026; **Revised:** 26 May 2026; **Accepted:** 01 July 2026

Abstract

Background: Scheuermann's kyphosis (SK), also known as juvenile kyphosis, is one of the most common causes of spinal deformity in adolescents. The objective of this study was to review the outcomes of posterior-only surgical correction for SK over 25 years.
Methods: We retrospectively reviewed patients diagnosed with SK who underwent posterior spinal surgery. Health-related quality of life (HRQoL) was assessed using the Oswestry Disability Index (ODI) and the Scoliosis Research Society-30 questionnaire (SRS-30). Additionally, radiographic parameters were evaluated preoperatively and at follow-up.
Results: A total of 210 patients with SK underwent posterior-only surgical correction. The mean age at surgery was 17.5 years (range: 12-38 years), with a mean follow-up of 17.5 years. Significant improvements were observed in sagittal Cobb angle (85.9° to 43.2°, $P < 0.001$), coronal Cobb angle (32.5° to 11.5°, $P < 0.001$), L1-S1 lordosis ($P = 0.001$), and sagittal balance ($P = 0.043$). Clinical outcomes assessed at the 6-month postoperative follow-up also improved significantly, with the ODI decreasing from 23.2 to 5.8 ($P = 0.003$) and the SRS-30 score increasing from 64.0 to 133.5 ($P < 0.001$). The mean pelvic incidence (PI) was 46°, with no significant correlation between PI and either the preoperative sagittal Cobb angle ($P = 0.46$) or kyphosis correction ($P = 0.70$). However, based on our clinical observations, postoperative kyphosis correction approximating the patient's PI appeared to be associated with more favorable outcomes. This observation should be considered exploratory and requires prospective validation. The overall complication rate was 4%, and the mean loss of correction at the final follow-up was 1.6°.
Conclusion: A posterior-only approach is an effective and safe treatment for SK; however, whether correction approximating PI can optimize individualized outcomes remains a hypothesis requiring prospective evaluation.

Keywords: Scheuermann Disease; Spine; Surgery

Citation: Safaei S, Yazdanian T, Azimi P. **Posterior Surgery in Scheuermann's Kyphosis: A Retrospective Review of 210 Cases.** *J Orthop Spine Trauma* 2026; 12(4): 174-8.

Background

Scheuermann's kyphosis (SK), also known as juvenile kyphosis, is one of the most common causes of structural thoracic hyperkyphosis and back pain in adolescents and young adults. First described by Scheuermann in 1920, the disorder is characterized by a rigid kyphotic deformity of the growing spine (1). The classic radiographic criteria proposed by Sørensen define SK as anterior wedging of more than 5° in at least three consecutive vertebral bodies (2). SK is classified into typical and atypical forms. The typical form primarily affects the thoracic spine and fulfills Sørensen criteria, whereas the atypical form usually involves the thoracolumbar or lumbar spine and may not always satisfy these radiographic criteria despite being clinically significant (3).

The indications for surgical treatment remain controversial. In general, surgery is considered for patients with a kyphotic deformity greater than 75° accompanied by persistent pain (4). Other accepted indications include progressive deformity, neurological complications (5, 6), and failure of appropriate conservative treatment. Surgical correction may be achieved using posterior-only, anterior-only, or combined anterior–posterior approaches. Bradford et al. recommended preoperative traction followed by anterior release and fusion combined with posterior Harrington rod instrumentation for curves exceeding 70° (7). Subsequently, Ponte introduced a posterior shortening osteotomy for the correction of hyperkyphosis without anterior column lengthening (8). Subsequent studies have demonstrated that posterior-only correction using Ponte osteotomy provides radiographic and clinical outcomes comparable to those of combined approaches while avoiding the morbidity associated with anterior surgery (9-11). Overall, the reported correction of kyphosis ranges from 40° to 50°, and correction should generally not exceed 50% of the preoperative deformity to minimize postoperative junctional complications (12). More recently, spinopelvic parameters, particularly pelvic incidence (PI), have become increasingly important in surgical planning and restoration of sagittal alignment in patients with SK (13).

Despite advances in surgical techniques and spinal instrumentation, the optimal surgical strategy for maximizing deformity correction while minimizing complications remains a matter of debate. Therefore, evidence regarding surgical outcomes continues to play an important role in guiding clinical decision-making. The present study aimed to evaluate the radiographic and clinical outcomes of posterior-only surgical treatment in patients with SK.

Methods

Study Design: A retrospective review was conducted on

260 patients with SK. Patients who underwent combined anterior–posterior surgery were excluded. Consequently, 210 patients treated with a posterior-only approach were included in the study. All procedures were performed by the senior author, who had more than 25 years of experience in spinal deformity surgery, between 1992 and 2017. A wake-up test was performed in all patients. During the final decade of the study, intraoperative neuromonitoring (IONM) was routinely used in addition to the wake-up test.

Radiographic Evaluation: All radiographic measurements were independently reviewed by another spine surgeon. Standing full-length radiographs extending from the cervical spine to the sacrum were obtained for all patients. In earlier cases, radiographs were acquired using separate but fixed radiographic cassettes to obtain full-length images. Preoperative, immediate postoperative, and final follow-up radiographs were analyzed. Radiographic parameters included sagittal Cobb angle, coronal Cobb angle, and lumbar lordosis (L1-S1) (14). Kyphosis correction was defined as the difference between the preoperative and postoperative sagittal Cobb angles. Curve flexibility was assessed using supine hyperextension radiographs obtained with a bolster placed beneath the apex of the deformity. The flexibility index was calculated as the difference between the standing preoperative sagittal Cobb angle and the hyperextension Cobb angle, divided by the preoperative sagittal Cobb angle and expressed as a percentage. Sagittal balance was evaluated by measuring the horizontal distance between the C7 plumb line and the S1 sacral promontory (15).

Clinical Evaluation: Clinical outcomes were assessed using the Scoliosis Research Society-30 questionnaire (SRS-30) and the Oswestry Disability Index (ODI). All patients completed both questionnaires preoperatively and again at the 6-month postoperative follow-up (16, 17).

Surgical Technique: All patients underwent posterior-only surgical correction. The decision to perform a Ponte osteotomy was based on curve flexibility. In patients whose kyphotic deformity was corrected by more than 50% on supine hyperextension radiographs, posterior spinal fusion without osteotomy was performed. In patients with less flexible deformities, posterior spinal fusion combined with Ponte osteotomy was undertaken. Ponte osteotomies were performed across the apex of the deformity, typically extending two to three levels above and two to three levels below the apex, depending on curve rigidity and the degree of correction required. Pedicle screws were used as the primary fixation method, while laminar or transverse process hooks were selectively placed at the proximal end of the construct. The upper instrumented vertebra (UIV) was selected as the proximal end vertebra of the kyphotic curve, whereas the lower instrumented vertebra (LIV) was selected according to the distal sagittal alignment. Before 2009, the vertebra immediately distal to the first lordotic disc was selected as the LIV. Since 2009, the sagittal stable vertebra has been selected as the LIV to reduce the risk of distal junctional kyphosis (DJK). Associated scoliosis was classified into two patterns: Type I, in which the apices of the scoliosis and kyphosis coincided, and Type II, in which the apex of the scoliosis was located either cephalad or caudal to the apex of the kyphosis (10).

Complication Assessment: Complications were assessed throughout the follow-up period and were recorded on a per-patient basis. Proximal junctional kyphosis (PJK) was defined as a proximal junctional sagittal Cobb angle ≥10° and at least 10° greater than the corresponding preoperative angle. DJK was defined as the development of a kyphotic deformity at the distal junction adjacent to the LIV, demonstrated by an increase in the distal junctional angle of ≥ 10° compared with the immediate postoperative radiograph. Surgical site infection (SSI) was defined as any superficial or deep postoperative wound infection that required antibiotic therapy and/or surgical debridement. Implant failure was defined as the breakage or loosening of the instrumentation, including hook or screw failure. Pseudarthrosis was defined as radiographic or intraoperative evidence of nonunion that necessitated revision surgery. Neurological complications were defined as any new postoperative motor or sensory deficit. Reoperation was defined as any unplanned secondary surgical procedure related to the index operation.

Statistical Analysis: Statistical analyses were performed using Microsoft Excel 2016 and IBM SPSS Statistics (version 22, IBM Corporation, Armonk, NY, USA). The Wilcoxon signed-rank test was used to compare preoperative and postoperative sagittal Cobb angle, coronal Cobb angle, SRS-30, and ODI scores. The Spearman's rank correlation test was applied to evaluate the relationships between PI, preoperative sagittal Cobb angle, and the kyphosis correction rate.

Results

Of the 260 patients initially identified, 37 underwent combined anterior–posterior surgery, 8 had incomplete radiographic or clinical data, and 5 had inadequate follow-up. Consequently, 210 patients who underwent posterior-only surgery and met the inclusion criteria were included in the final analysis. The mean age at surgery was 17.5 years (range: 12–38 years), and the mean follow-up duration was 17.5 years. The study population comprised 168 male (80%) and 42 (20%) female patients. The apex of the kyphotic deformity was located in the thoracic (n = 168, 80%), thoracolumbar (n = 30, 14%), and lumbar (n = 12, 6%) spine. Demographic characteristics, radiographic parameters, and clinical outcomes are summarized in table 1.

Table 1. Radiographic and clinical results

Parameters	Preoperative	Postoperative	6-month postoperative follow-up	Final follow-up	P-value*
Sagittal Cobb angle	85.9 ± 9.4 (70, 110)	40.1 ± 9.9 (35, 60)	-	43.2 ± 9.8 (35, 65)	< 0.001
Coronal Cobb angle	32.5 ± 10.0 (15, 44)	10.0 ± 6.5 (0, 27)	-	11.5 ± 6.1 (5, 25)	< 0.001
Flexibility index (%)	50.0 ± 13.0 (10, 74)	-	-	-	-
L1-S1 lordosis angle	-60.3 ± 20.0 (-80, -35)	-49.6 ± 16.0 (-54, -35)	-	-50.8 ± 14.0 (-52, -30)	0.001
Sagittal balance (mm)	-22.1 ± 16.0 (-48, 0)	-	-	-3.4 ± 27.0 (-55, 34)	0.043
ODI	23.2 ± 20.0 (0, 64)	-	5.8 ± 8.9 (0, 28)	-	0.003
SRS-30	64.0 ± 10.0 (52, 88)	-	133.5 ± 11.0 (114, 150)	-	< 0.001

Values are presented as mean ± standard deviation (range).
ODI: Oswestry Disability Index; SRS-30: Scoliosis Research Society-30 questionnaire
Radiographic parameters were assessed preoperatively, immediately postoperatively, and at the final follow-up, whereas ODI and SRS-30 were assessed preoperatively and at the 6-month follow-up. *P-values represent comparisons between preoperative and final follow-up measurements for radiographic parameters, and between preoperative and 6-month follow-up measurements for ODI and SRS-30.

Posterior-only surgery resulted in significant improvements in sagittal and coronal alignment. Both sagittal and coronal Cobb angles were significantly corrected after surgery and remained stable at the final follow-up. Lumbar lordosis also improved significantly, while sagittal balance showed a significant restoration toward normal alignment. Clinical outcomes assessed at the 6-month postoperative follow-up improved significantly following surgery. Both the ODI and SRS-30 scores demonstrated significant improvement compared with the preoperative values (Table 1).

The mean PI was 46° (range: 22°–70°). No significant correlation was found between PI and kyphosis correction ($P = 0.70$), or between PI and the preoperative sagittal Cobb angle ($P = 0.46$). However, based on our long-term clinical observations, patients whose postoperative kyphosis correction approximated their PI appeared to have more favorable radiographic and clinical outcomes.

This observation was not formally tested in the present study and should be regarded as exploratory until validated in prospective studies. Ponte osteotomies were performed in 21 patients, with the number of fused vertebrae ranging from 10 to 16. The UIV was T1 in 74 patients (35.2%), T2 in 92 (43.8%), and T3 or lower in the remaining 44 patients (21.0%). The LIV was T12 in 8 patients (3.8%), L1 in 36 (17.1%), L2 in 63 (30.0%), L3 in 79 (37.6%), and below L3 in the remaining 24 patients (11.4%). Pedicle screws were used as the primary fixation method in all patients, whereas laminar or transverse process hooks were used at the proximal end of the construct in 201 patients (95.7%). In patients undergoing Ponte osteotomy, the osteotomies were performed over 4–7 motion segments, most commonly centered at the apex of the kyphotic deformity. Associated scoliosis was identified in 52 patients (25%), including 20 with Type I and 32 with Type II.

Complications were recorded per patient. The overall complication rate was 4% (8/210 patients). Three patients developed postoperative SSI, one patient experienced proximal hook failure, two patients developed PJK, and two patients developed DJK. No cases of permanent neurological deficit, implant failure other than proximal hook failure, pseudarthrosis, or revision surgery were observed during the follow-up period. The mean loss of correction at the final follow-up was 1.6°.

Discussion

To the best of our knowledge, this study represents the largest single-surgeon series reported to date evaluating posterior-only surgical correction for SK. All 210 patients were treated by the same senior surgeon over 25 years. The findings demonstrate that posterior-only correction, with or without Ponte osteotomy, depending on curve flexibility, is a safe, effective, and reliable treatment option for patients with SK in whom conservative management has failed. It should be noted that, based on our observations over 25 years of clinical experience, patients whose kyphosis correction approximated their PI appeared to achieve more favorable postoperative outcomes than those treated according to the traditionally recommended 50% correction. Although this observation was not formally evaluated in the present study, it raises the possibility that PI may serve as a practical guide for individualizing the degree of correction in SK. Further prospective studies are warranted to validate this hypothesis.

The surgical management of SK has evolved considerably since the condition was first described. Bradford et al. initially reported the results of posterior surgery with a relatively high complication rate and recommended surgical intervention only for patients with disabling pain or spinal cord compression (7). They subsequently demonstrated satisfactory outcomes using combined anterior and posterior spinal fusion with minimal loss of correction (10). Likewise, Taylor et al. reported favorable results using Harrington compression instrumentation through a posterior approach (18). Advances in segmental pedicle screw instrumentation have further improved the surgical management of SK, and several studies have shown comparable outcomes between posterior-only and combined anterior–posterior procedures (12, 19-22). Similarly, Sardar et al. concluded that most patients could be successfully treated using a posterior-only approach (23). Our findings are consistent with these previous reports and further support the effectiveness of posterior-only correction.

DJK remains one of the major concerns following surgical correction of SK. Traditionally, the distal fusion level was selected as the vertebra immediately caudal to the first lordotic disc. However, Cho et al. recommended extending the instrumentation to the sagittal stable vertebra to reduce the risk of DJK (19). In the present study, DJK occurred in only two patients, supporting the use of the sagittal stable vertebra as a safe and appropriate distal fusion level. A retrospective review of 693 surgically treated patients with SK from the Scoliosis Research Society (SRS) Morbidity and Mortality Database reported an overall complication rate of approximately 14% (24). Other published series have reported similar complication rates (23, 24). In contrast, the overall complication rate in the present study was 4%, suggesting that posterior-only correction can be performed with a low incidence of complications in appropriately selected patients.

Restoration of sagittal alignment is one of the primary objectives of surgical correction, because sagittal balance has been shown to be an important predictor of functional outcome in patients with spinal deformity (25-27). The SRS defines normal thoracic kyphosis as 20°–40°, whereas Bernhardt and Bridwell suggested that thoracic kyphosis of up to 50° might still be considered within the normal range (14). Nevertheless, the relationship between PI and the optimal degree of kyphosis correction remains controversial. Tyrakowski et al. proposed that PI was not a reliable predictor of lumbar lordosis in patients with SK (28). They hypothesized that increased thoracic kyphosis, together with compensatory lumbar lordosis and decreased sacral slope during growth, might result in a lower PI. Jiang et al. reported lower PI in patients with thoracic SK (29), whereas Cahill et al. found no significant difference in PI compared with controls (30). The findings of the present study are consistent with those reported by Cahill et al., as no significant correlation was observed between PI and either preoperative thoracic kyphosis or the degree of surgical correction.

Combined scoliosis and kyphosis were observed in a considerable proportion of patients and should be carefully considered when determining the extent of spinal instrumentation. Careful preoperative planning is essential to avoid postoperative coronal decompensation following correction of the kyphotic deformity.

Surgical techniques evolved over the 25-year study period, including changes in distal fusion-level selection after 2009 and the routine use of IONM during the final decade. Before the adoption of IONM, neurological monitoring relied on the wake-up test. Despite these changes, the surgical indications and overall operative philosophy remained consistent throughout the study.

The present study focused exclusively on patients treated with a posterior-only approach. Although combined anterior–posterior procedures were performed during the early years of our experience, these patients were excluded to avoid potential selection bias. Based on our 25-year experience and the favorable outcomes observed in this series (Table 1), we recommend posterior-only correction for the surgical management of SK, without the routine need for an anterior approach.

This study has several limitations. First, IONM was not available for all patients, because it was introduced during the latter part of the study period. Second, no direct comparison was made between the posterior-only approach and other surgical techniques. Third, the 25-year study period encompassed substantial advances in surgical instrumentation and perioperative management, which may have introduced some degree of heterogeneity despite consistent surgical indications and treatment philosophy. Finally, the observation that correction approximating PI may be associated with better postoperative outcomes was not prospectively evaluated. Future prospective matched-cohort studies are needed to validate this observation.

Conclusion

Our 25-year review demonstrates that posterior-only surgical correction of SK is both feasible and safe. Significant correction of kyphosis was achieved and maintained, with low complication rates and improved patient outcomes. This approach can be recommended for patients with SK who require surgical intervention after failed conservative treatment. Our long-term clinical observations suggest that PI may be a useful consideration when planning the degree of kyphosis correction; however, this hypothesis was not formally evaluated in the present study and requires prospective validation.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgments

The authors thank the staff of Milad Hospital, Tehran, Iran, for their assistance and cooperation.

This retrospective study was conducted at Milad Hospital, using clinical data from patients who underwent surgery over a 25-year period. As the study involved a retrospective analysis of previously collected clinical data and no additional interventions were performed for research purposes, no formal ethics approval number or approval date was assigned. The study was conducted in accordance with the principles of the Declaration of Helsinki and relevant institutional guidelines.

References

1. Bezalel T, Carmeli E, Been E, Kalichman L. Scheuermann's disease: current diagnosis and treatment approach. *J Back Musculoskelet Rehabil.* 2014;27(4):383-90. doi: 10.3233/bmr-140483. [PubMed: 24898440].
2. James J. Scheuermann's Juvenile Kyphosis. Clinical Appearances, Radiography, Aetiology, and Prognosis. *J Bone Joint Surg Br.* 1965;47-B(1):203. doi: 10.1302/0301-620X.47B1.203-a.
3. Blumenthal SL, Roach J, Herring JA. Lumbar Scheuermann's. A clinical series and classification. *Spine (Phila Pa 1976).* 1987;12(9):929-32. [PubMed: 3441839].
4. Azar FM, Canale ST, Beaty JH. Campbell's Operative Orthopaedics E-Book. Amsterdam, Netherlands: Elsevier Health Sciences; 2016.
5. Stambough JL, VanLoveren HR, Cheeks ML. Spinal cord compression in Scheuermann's kyphosis: case report. *Neurosurgery.* 1992;30(1):127-30. doi: 10.1227/00006123-199201000-00025. [PubMed: 1738443].
6. Kapetanos GA, Hantzidis PT, Anagnostidis KS, Kirkos JM. Thoracic cord compression caused by disk herniation in Scheuermann's disease: a case report and review of the literature. *Eur Spine J.* 2006;15 Suppl 5(Suppl 5):553-8. doi: 10.1007/s00586-005-0053-0. [PubMed: 16421745]. [PubMed Central: PMC1602190].
7. Bradford DS, Moe JH, Montalvo FJ, Winter RB. Scheuermann's kyphosis. Results of surgical treatment by posterior spine arthrodesis in twenty-two patients. *J Bone Joint Surg Am.* 1975;57(4):439-48. [PubMed: 1141252].
8. Ponte A. Surgical treatment of Scheuermann's hyperkyphosis. *Orthop Trans.* 1985;9:127.
9. Lee SS, Lenke LG, Kuklo TR, Valenté L, Bridwell KH, Sides B, et al. Comparison of Scheuermann kyphosis correction by posterior-only thoracic pedicle screw fixation versus combined anterior/posterior fusion. *Spine (Phila Pa 1976).* 2006;31(20): 2316-21. doi: 10.1097/01.brs.0000238977.36165.b8. [PubMed: 16985459].
10. Bradford DS, Ahmed KB, Moe JH, Winter RB, Lonstein JE. The surgical management of patients with Scheuermann's disease: a review of twenty-four cases managed by combined anterior and posterior spine fusion. *J Bone Joint Surg Am.* 1980;62(5):705-12. [PubMed: 7391093].
11. Geck MJ, Macagno A, Ponte A, Shufflebarger HL. The Ponte procedure: posterior only treatment of Scheuermann's kyphosis using segmental posterior shortening and pedicle screw instrumentation. *J Spinal Disord Tech.* 2007;20(8): 586-93. doi: 10.1097/BSD.0b013e31803d3b16. [PubMed: 18046172].
12. Hosman AJ, Langeloo DD, de Kleuver M, Anderson PG, Veth RP, Slot GH. Analysis of the sagittal plane after surgical management for Scheuermann's disease: a view on overcorrection and the use of an anterior release. *Spine (Phila Pa 1976).* 2002;27(2):167-75. doi: 10.1097/00007632-200201150-00009. [PubMed: 11805663].
13. Legaye J, Duval-Beaupère G, Hecquet J, Marty C. Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J.* 1998;7(2):99-103. doi: 10.1007/s005860050038. [PubMed: 9629932]. [PubMed Central: PMC3611230].
14. Bernhardt M, Bridwell KH. Segmental analysis of the sagittal plane alignment of the normal thoracic and lumbar spines and thoracolumbar junction. *Spine (Phila Pa 1976).* 1989;14(7):717-21. doi: 10.1097/00007632-198907000-00012. [PubMed: 2772721].
15. Lowe TG, Kasten MD. An analysis of sagittal curves and balance after Cotrel-Dubousset instrumentation for kyphosis secondary to Scheuermann's disease. A review of 32 patients. *Spine (Phila Pa 1976).* 1994;19(15):1680-5. doi: 10.1097/00007632-199408000-00005. [PubMed: 7973960].
16. Mousavi SJ, Parnianpour M, Mehdian H, Montazeri A, Mobini B. The Oswestry Disability Index, the Roland-Morris Disability Questionnaire, and the Quebec Back Pain Disability Scale: translation and validation studies of the Iranian versions. *Spine (Phila Pa 1976).* 2006;31(14):E454-9. doi: 10.1097/01.brs.0000222141.61424.f7. [PubMed: 16778675].
17. Ghandehari H, Mahabadi MA, Mahdavi SM, Shahsavaripour A, Seyed Tari HV, Safdari F. Evaluation of Patient Outcome and Satisfaction after Surgical Treatment of Adolescent Idiopathic Scoliosis Using Scoliosis Research Society-30. *Arch Bone Jt Surg.* 2015;3(2):109-13. [PubMed: 26110177]. [PubMed Central: PMC4468625].
18. Taylor TC, Wenger DR, Stephen J, Gillespie R, Bobechko WP. Surgical management of thoracic kyphosis in adolescents. *J Bone Joint Surg Am.* 1979;61(4):496-503. [PubMed: 438235].
19. Cho KJ, Lenke LG, Bridwell KH, Kamiya M, Sides B. Selection of the optimal distal fusion level in posterior instrumentation and fusion for thoracic hyperkyphosis: the sagittal stable vertebra concept. *Spine (Phila Pa 1976).* 2009;34(8):765-70. doi:

10.1097/BRS.0b013e31819e28ed. [PubMed: 19365243].
20. Papagelopoulos PJ, Klassen RA, Peterson HA, Dekutoski MB. Surgical treatment of Scheuermann's disease with segmental compression instrumentation. *Clin Orthop Relat Res*. 2001(386):139-49. doi: 10.1097/00003086-200105000-00018. [PubMed: 11347827].
21. Johnston CE, Elerson E, Dagher G. Correction of adolescent hyperkyphosis with posterior-only threaded rod compression instrumentation: is anterior spinal fusion still necessary? *Spine (Phila Pa 1976)*. 2005;30(13):1528-34. doi: 10.1097/01.brs.0000167672.06216.73. [PubMed: 15990668].
22. Etemadifar M, Ebrahimzadeh A, Hadi A, Feizi M. Comparison of Scheuermann's kyphosis correction by combined anterior-posterior fusion versus posterior-only procedure. *Eur Spine J*. 2016;25(8):2580-6. doi: 10.1007/s00586-015-4234-1. [PubMed: 26365711].
23. Sardar ZM, Ames RJ, Lenke L. Scheuermann's Kyphosis: Diagnosis, Management, and Selecting Fusion Levels. *J Am Acad Orthop Surg*. 2019;27(10):e462-e72. doi: 10.5435/jaaos-d-17-00748. [PubMed: 30407981].
24. Coe JD, Smith JS, Berven S, Arlet V, Donaldson W, Hanson D, et al. Complications of spinal fusion for scheuermann kyphosis: a report of the scoliosis research society morbidity and mortality committee. *Spine (Phila Pa 1976)*. 2010;35(1):99-103. doi: 10.1097/BRS.0b013e3181c47f0f. [PubMed: 20042960].
25. Mac-Thiong JM, Transfeldt EE, Mehbod AA, Perra JH, Denis F, Garvey TA, et al. Can c7 plumbline and gravity line predict health related quality of life in adult scoliosis? *Spine (Phila Pa 1976)*. 2009;34(15):E519-27. doi: 10.1097/BRS.0b013e3181a9c7ad. [PubMed: 19564757].
26. Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. *Spine (Phila Pa 1976)*. 2005;30(6):682-8. doi: 10.1097/01.brs.0000155425.04536.f7. [PubMed: 15770185].
27. Smith JS, Shaffrey CI, Glassman SD, Berven SH, Schwab FJ, Hamill CL, et al. Risk-benefit assessment of surgery for adult scoliosis: an analysis based on patient age. *Spine (Phila Pa 1976)*. 2011;36(10):817-24. doi: 10.1097/BRS.0b013e3181e21783. [PubMed: 20683385].
28. Tyrakowski M, Mardjetko S, Siemionow K. Radiographic spinopelvic parameters in skeletally mature patients with Scheuermann disease. *Spine (Phila Pa 1976)*. 2014;39(18):E1080-5. doi: 10.1097/brs.0000000000000460. [PubMed: 24921842].
29. Jiang L, Qiu Y, Xu L, Liu Z, Wang Z, Sha S, et al. Sagittal spinopelvic alignment in adolescents associated with Scheuermann's kyphosis: a comparison with normal population. *Eur Spine J*. 2014;23(7):1420-6. doi: 10.1007/s00586-014-3266-2. [PubMed: 24639080].
30. Cahill PJ, Steiner CD, Dakwar E, Trobisch PD, Lonner BS, Newton PO, et al. Sagittal Spinopelvic Parameters in Scheuermann's Kyphosis: A Preliminary Study. *Spine Deform*. 2015;3(3):267-71. doi: 10.1016/j.jspd.2014.11.001. [PubMed: 27927469].