International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

The Surgical Outcomes of Hemivertebra Excision Using Egg - Shell Osteotomy: A Case Series

Asrul Fahmi Azizan[1], Fazir Mohamad[2], Dzulkarnain Amir[3], Faizal Manan[4], Hanna Safii[5]

Spine Unit, Orthopaedic Department Hospital Kuala Lumpur, Malaysia

Abstract: ***This study evaluates the surgical outcomes of hemivertebra excision using the eggshell osteotomy technique in patients with congenital scoliosis. A retrospective case series of seven patients was analyzed, measuring segmental and compensatory curves preoperatively, postoperatively, and at final follow - up. The results demonstrated significant initial corrections in segmental coronal curvature and kyphosis; however, long - term outcomes varied, with some patients showing progression. Continuous monitoring is crucial for managing deformity progression and optimizing treatment plans. The eggshell osteotomy technique is effective for immediate correction, but variability in outcomes highlights the need for personalized management.***

Keywords: Congenital scoliosis, hemivertebrae, hemivertebra excision, eggshell osteotomy, hemivertebrae outcome

1. Introduction

The incidence of congenital spine deformity is estimated to be between 0.1 to 1.0 per 1, 000 births, with a higher prevalence in females (Ghandi et al., 2022). These deformities are often associated with a spectrum of abnormalities seen in VACTERL association (Pariza et al., 2021). Hemivertebra (HV) occurs when only one side of a vertebra develops, leading to spinal deformity (Liu et al., 2021).

Congenital spinal deformities present unique and challenging management issues, especially in the context of a growing spine (Haapala et al., 2023). Hemivertebrae, a common cause of congenital scoliosis, requires appropriate surgical intervention to prevent the progression of the spinal curve and to preserve spinal growth and lung function (Yang et al., 2020). Multiple surgical techniques have been described, with hemivertebra excision using the "eggshell" technique being one of them. The average age for hemivertebra excision ranges from 1.5 to 17 years (Zhang et al., 2011).

Hemivertebra excision is a safe and effective procedure that provides correction and stability to the spine. It can be performed via a posterior - only approach, often in combination with short - segment fusion. The "eggshell" procedure involves decancellation of the hemivertebra body, allowing for intraoperative correction through osteotomy of the hemivertebra.

This retrospective case series includes seven patients who underwent hemivertebra excision with eggshell osteotomy at our centre. Segmental and compensatory curves were measured preoperatively, immediately postoperatively, and at the final follow - up. The compensatory curve was assessed as proximal and distal secondary curves, measured only in the coronal plane. The patients presented with varying degrees of segmental coronal and kyphotic deformities. The study evaluates preoperative segmental measurements, as well as proximal and distal deformities, to assess the efficacy of the eggshell technique.

2. Results

Table 1: Case series of patients with hemivertebra underwent hemivertebra excision

Patient ID	Age (Date) at Surgery	Fused Segments	Segmental Curve, Kyphosis, Proximal and Distal Secondary Curve (Pre - OP)	Segmental Curve, Kyphosis, Proximal and Distal Secondary Curve (Intra - OP)	Segmental Curve, Kyphosis, Proximal and Distal Secondary Curve. Last Follow Review Age (Date)
Patient 1 L1 hemivertebrae	9 Y (24.9.2020)	2	40^0, 15^0, 20^0, 20^0	11^0, 5^0, 8^0, 5^0	25^0, 4^0, 13^0, 2^0 13Y (10.11.2023)
Patient 2 T10 hemivertebrae CVM at other thoracic vertebrae	2.5 Y (2.2.2016)	2	27^0, 13^0, 35^0, 17^0	5^0, 0^0, 23^0, 8^0	12^0, 4^0, 54^0, 17^0 8Y (20.6.2021)
Patient 3 L2 hemivertebrae	13Y (22.6.2020)	4	34^0, 6^0, 17^0, 10^0 lumbar lordosis	14^0, 3^0, 8^0, 40^0 lumbar l0rd0sis	16^0, 3^0, 2^0, 39^0 lumbar lordosis 17Y (12.5.2023)
Patient 4 L1 hemivertebra	19Y (11.11.2020)	7	57^0, 43^0, 20^0, 45^0	35^0, 25^0, 12^0, 17^0	39^0, 23^0, 13^0, 25^0 23Y (14.7.2023)
Patient 5 L2 hemivertebrae	11Y (29.12.2023)	2	380, 90, 100, 320	200, 90, 5^0, 16^0	27^0, 10^0, 12^0, 17^0 12Y (29.3.2024)
Patient 6 T10 hemivertebra	3Y (26.2.2021)	2	390, 160, 110, 240	190, 100, 40, 320	26^0, 3^0, 4^0, 34^0 5.5Y (25.8.2023)
Patient 7 T11 hemivertebrae	2.5Y (22.12.2017)	2	440, 280, 20, 220	40, 90, 30, 310	27^0, 5^0, 12^0, 43^0 7.5 Y (10.6.2022)

Patient 1 initial assessment revealed a segmental coronal curvature of 40° and kyphosis of 15°. Postoperative measurements indicated a reduction to a coronal curvature of 11° and kyphosis to 5°, achieving a 72.5% correction. At the 3 - year follow - up, the segmental coronal curvature had increased to 25°, a 127.3% progression, while kyphosis remained unchanged. The compensatory curves, both proximal and distal, were effectively corrected to below 10°.

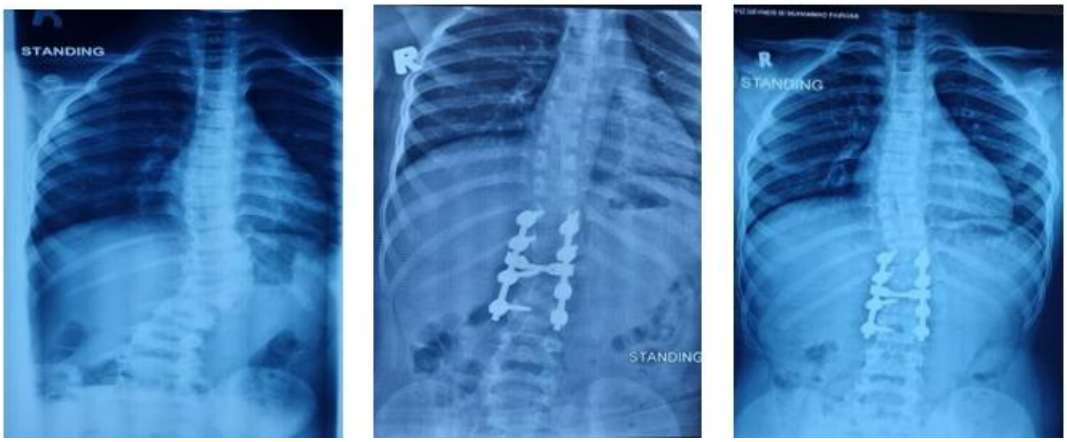


Figure 1: Pre - operative, post - operative and latest x - ray of **Patient 1**

Patient 2 presented with a segmental coronal curvature of 27° and kyphosis of 13°. Following the surgical procedure, the coronal deformity was reduced to 5° and kyphosis was completely corrected, resulting in an 81.5% correction. However, at the 6 - year follow - up, the segmental coronal curvature had increased to 12°, a 140% progression, and kyphosis to 4°. The proximal curve showed significant progression to 54°, and the distal curve increased to 17°. The proximal curve progression mainly due complex vertebral malformation at the multiple level at thoracic vertebra proximal to excised hemivertebra. Patient 2 underwent a second surgery involving the implantation of a magnetic growing rod.

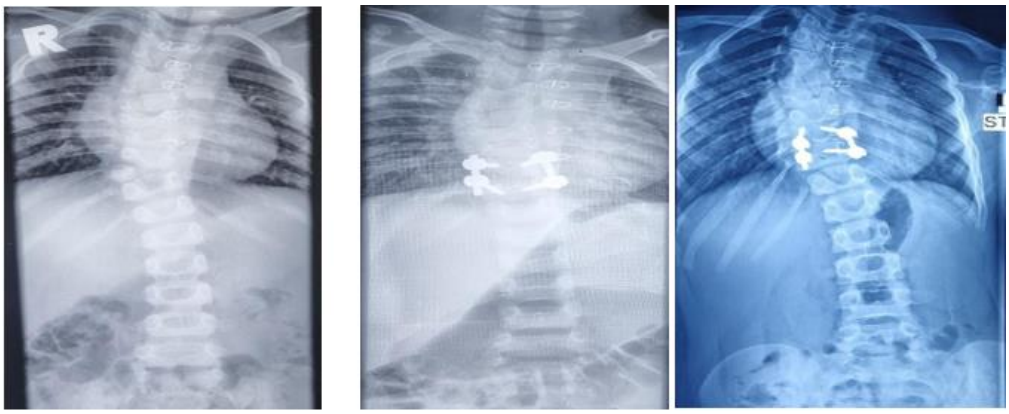


Figure 2: Pre - operative, post - operative and latest x - ray of **Patient 2**

Patient 3 was noted for a preoperative segmental coronal curvature of 34° and segmental kyphosis of 6°. The surgical intervention corrected the coronal curvature to 14° and improved lumbar lordosis to 40°, a 58.8% correction. At a 3 - year follow - up, the segmental coronal curvature had slightly increased to 16°, a 14.3% progression, with lumbar lordosis remaining nearly unchanged at 39°. The proximal compensatory curvature returned to normal.

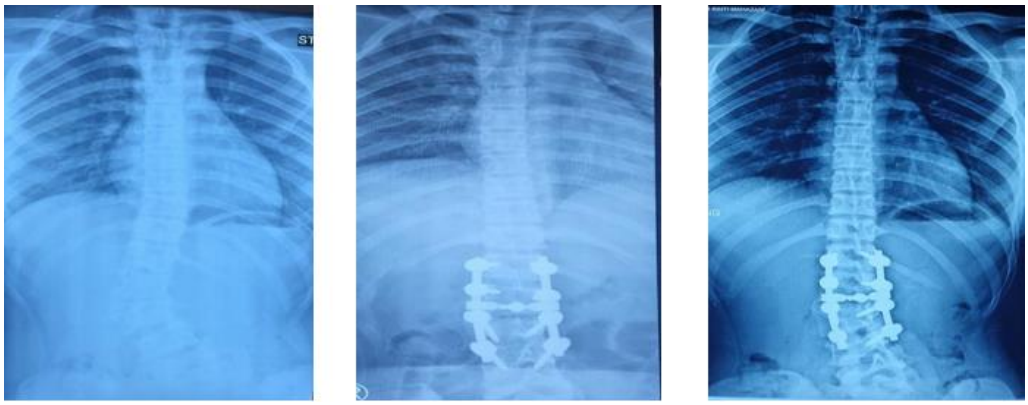


Figure 3: Pre - operative, post - operative and latest x - ray of **Patient 3**

Patient 4 late presentation at 18 years showed a segmental coronal curvature of 57° and kyphosis of 43°. There is a significant truncal shift, requiring additional fusion segments to bring the plump line back to the center. Postoperative results demonstrated a correction to a coronal curvature of 35° and kyphosis to 25°, a 38.5% correction. Three years later, the segmental coronal curvature had progressed to 39°, a 12.7% progression, with kyphosis maintaining postoperative values. The proximal and distal curvatures were slightly increase to 13° and 25°, respectively.

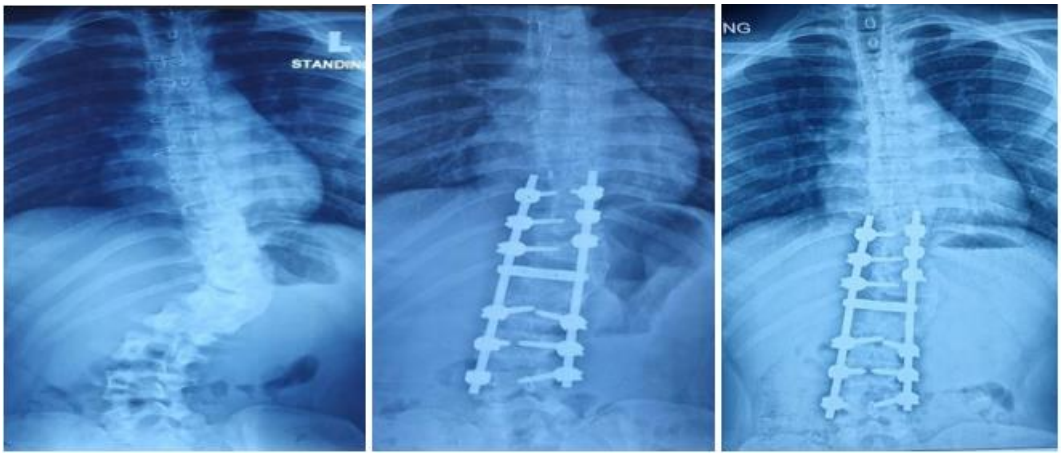


Figure 4: Pre - operative, post - operative and latest x - ray of **Patient 4**

Patient 5 underwent surgery at 11 years with a segmental coronal curvature of 38° and kyphosis of 9°. The operation achieved a corrected coronal curvature of 20° and maintained kyphosis at 9°, a 47.4% correction. In the 2024 follow - up, the segmental coronal curvature had risen to 27°, a 35% progression, and segmental kyphosis reduced to 3°. The proximal and distal curvatures were observed at 12° and 17°, respectively. Unfortunately, Patient 5 experienced implant breakage and awaiting the results of a CT scan to assess fusion at the hemivertebra segment excision. Implant removal remains a main consideration.

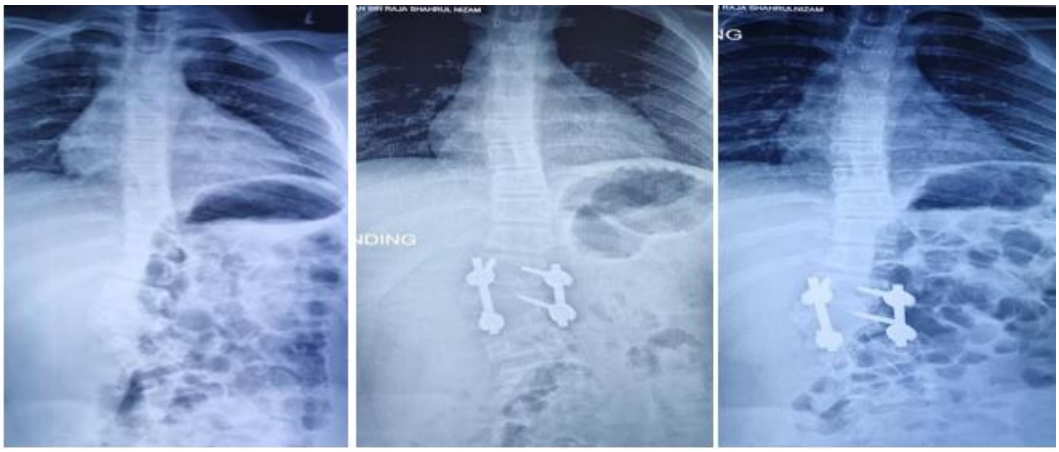


Figure 5: Pre - operative, post - operative and latest x - ray of **Patient 5**

Patient 6 at 1.5 years, displayed a segmental coronal deformity of 39° and kyphosis of 16°. The surgical outcome showed a reduction in the coronal curvature to 19° and kyphosis to 10°, a 51.3% correction. At a 2.5 - year follow - up, the segmental coronal curvature was 26°, a 36.8% progression, and kyphosis had maintained below 10°. The proximal deformity remained unchanged, while the distal deformity exhibited a slight increase to 34°. Patient 6 still under follow - up and was put on brace.

Figure 6: Pre - operative, post - operative and latest x - ray of **Patient 6**

Patient 7 presented at 1.5 years with a segmental coronal curvature of 44° and kyphosis of 28°. Postoperative results indicated a correction to 4° in the coronal plane and 9° in kyphosis, a 90.9% correction. The proximal deformity remained at 3°, and the distal deformity increased to 31°, At the end of 5 years follow up, the coronal segmental deformity progress to 27 o a 675% progression. Patient 7 was plan for second surgery which was growing rod.

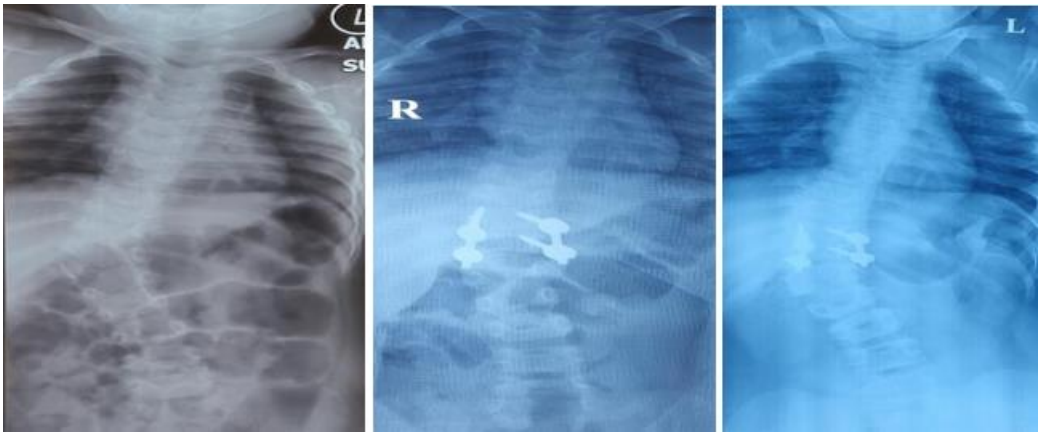
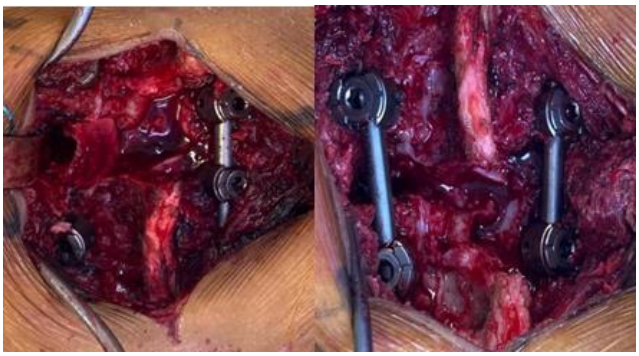


Figure 7: Pre - operative, post - operative and latest x - ray of **Patient 7**



Picture 1 **Picture 2**

Figure 8: Intra operative eggshell osteotomy

"**Picture 1** show laminectomy and decancellation of the hemivertebra. **Picture 2** show medial wall osteotomy and collapsing the "eggshell to get surgical correction.

3. Discussion

This case series evaluates the surgical outcomes of hemivertebra excision using the eggshell osteotomy technique. Initial postoperative assessments revealed substantial reductions in segmental coronal and kyphotic deformities, with correction rates ranging from 39.3% to 90.9%. These outcomes align with the objectives of spinal deformity surgery, including halting deformity progression. However, the study also identified considerable variability in long - term outcomes, particularly in the coronal plane, with progression ranging from 12.7% to 675%. This variability highlighted the significant challenges in managing pediatric spinal deformities, where ongoing spinal growth can significantly influence surgical results.

The surgical intervention generally succeeded in maintaining the segmental curve below 50° and control secondary curve progression. However, Patient 2 experienced an increase in the proximal curve from 23o to 54°, indicating notable progression and requiring discussion about potential additional surgical correction. Preoperative counseling is critical to inform the possibility of proximal curve progression, particularly in patients with complex vertebral malformations

The timing of surgical intervention is a key consideration. Early surgery may reduce the risk of deformity progression, whereas delaying surgery can allow for more spinal growth but might result in a more complex and severe deformity. Progression of secondary curves into structural curves is challenging to address with hemivertebra excision alone and may require additional procedures, such as sliding rods or

growing rods, as seen in Patient 7. Decisions regarding surgery should consider the patient's age, deformity characteristics, the number of hemivertebra, the presence of other vertebral abnormalities, and the severity of compensatory curves. Early surgical intervention can help prevent rapid deformity progression (He et al., 2022). Wang et al. (2023) emphasized the importance of surgical timing in achieving successful outcomes with fewer long - term complications. Proper selection of fusion levels, complete resection of the hemivertebra, and effective reduction of scoliosis and kyphosis are critical for preventing the progression of both main and compensatory curves post - surgery (Chang et al., 2017).

Postoperative immobilization is crucial for maintaining surgical correction. A singlet - body cast was used for durations of four to six months post - surgery. Physical therapy, bracing, and regular follow - up are the key to multidisciplinary management and essential for optimizing long - term outcomes.

The eggshell osteotomy technique has proven to be a valuable addition to the surgical management of congenital spinal deformities. This technique is reliable and can be effectively combined with other osteotomy procedures (Wang et al., 2020). Integrating various osteotomies with appropriate instrumentation provides a comprehensive approach to address deformities, enhancing outcomes, and improving the quality of life for pediatric patients (Guo et al., 2016; Yang et al., 2020).

Nevertheless, potential complications requiring close postoperative monitoring to manage issues such as deformity progression (Zhang et al., 2011). The progression of secondary curves following hemivertebra excision remains a significant concern, potentially due to incomplete resection of the hemivertebra (Yang et al., 2020). Despite a low risk of neurological complications post - surgery (Zhang et al., 2011), monitoring for other potential issues, such as implant - related complications or internal fixation failure, remains essential (Shi et al., 2015), (Guo et al., 2016). Revision surgery may be necessary in cases of deformity progression after hemivertebra excision (Crostelli et al., 2022). Complications, such as severe postoperative curve progression, implant failure, and trunk imbalance, may require comprehensive revision strategies (Shi et al., 2021).

Managing the late presentation of hemivertebra and congenital scoliosis presents unique challenges. The use of pedicle screws offers an alternative approach to addressing spinal deformities (Sarwahi et al., 2013). It has effectively maintained deformity correction in long - term follow - up when combined with vertebral column resection (VCR) (Chang et al., 2016). A thorough evaluation of every case is essential to tailor individualized treatment plans (Mohanty & Kumar, 2000). In our series, we have successfully managed late presentation hemivertebra in patient 4 with long fusion with the combination of the eggshell osteotomy.

This case series has limitations, including a small sample size, absence of a control group, and a retrospective design. Future research should aim to provide more conclusive data on the long - term outcomes of the eggshell osteotomy procedure. Studies with longer follow - up periods and larger patient cohorts across multiple centers are needed. Incorporating patient - reported outcomes will be valuable for assessing post - surgery functional status and quality of life.

4. Conclusion

The eggshell osteotomy technique demonstrated significant corrections in segmental coronal curvature and kyphosis. However, variability in long - term outcomes was observed, with some patients experiencing notable progression in segmental and compensatory curves. The follow - up periods varied among patients, which may influence observed outcomes. Continuous postoperative monitoring is crucial, and the potential need for further surgical intervention should be clearly explained to patients and their families.

To optimize the benefits of this surgical approach, future research should focus on refining surgical techniques, enhancing postoperative care protocols, and establishing guidelines for intervention timing. Sharing insights from this case series can deepen the understanding of managing congenital scoliosis and provide valuable guidance for surgeons handling these complex conditions.

References

[1] Ghandi, Y., Karimi, S., & Karimi, R. (2022). Congenital scoliosis and tetralogy of fallot with neurodevelopment delay: a case study and literature review. Journal of Pediatrics Review, 10 (3), 247 - 252. https: //doi. org/10.32598/jpr.10.3.913.2

[2] Pariza, P., Stavarache, I., Dumitru, V., Munteanu, O., Georgescu, T., Varlas, V., … & Bohiltea, R. (2021). Vacterl association in a fetus with multiple congenital malformations – case report. Journal of Medicine and Life, 14 (6), 862 - 867. https: //doi. org/10.25122/jml - 2021 - 0346

[3] Liu, J., Zhang, Y., Hai, Y., & Pan, A. (2021). A multi - dimensional online survey of experts, patients and the public on early detected scoliosis in fetus caused by spinal hemivertebra. . https: //doi. org/10.21203/rs.3. rs - 339554/v1

[4] Haapala, H., Heiskanen, S., Syvänen, J., Raitio, A., Helenius, L., Ahonen, M., … & Helenius, (2023). Surgical and health - related quality of life outcomes in children with congenital scoliosis during 5 - year follow - up. comparison to age and sex - matched healthy controls. Journal of Pediatric Orthopaedics, 43 (6), e451 - e457. https: //doi. org/10.1097/bpo.0000000000002408

[5] Yang, J., Chang, D., Suh, S., Kim, S., & Park, J. (2020). Clinical and radiological outcomes of hemivertebra resection for congenital scoliosis in children under age 10 years. Medicine, 99 (32), e21720. https: //doi. org/10.1097/md.0000000000021720

[6] Zhang, J., Wang, S., Qiu, G., Yu, B., Wang, Y., & Luk, K. (2011). The efficacy and complications of posterior hemivertebra resection. European Spine Journal, 20 (10), 1692 - 1702. https: //doi. org/10.1007/s00586 - 011 - 1710 - 0

[7] Ruf, M., Jensen, R., Letko, L., & Harms, J. (2009).

Hemivertebra resection and osteotomies in congenital spine deformity. Spine, 34 (17), 1791 - 1799. https: //doi. org/10.1097/brs.0b013e3181ab6290

[8] Guo, J., Zhang, J., Wang, S., Zhang, Y., Yang, Y., Yang, X., … & Zhao, L. (2016). Surgical outcomes and complications of posterior hemivertebra resection in children younger than 5 years old. Journal of Orthopaedic Surgery and Research, 11 (1). https: //doi. org/10.1186/s13018 - 016 - 0381 - 2

[9] Erturer, E., Kilinc, B., Gokcen, B., Erdogan, S., Kara, K., & Ozturk, C. (2017). The results of hemivertebra resection by the posterior approach in children with a mean follow - up of five years. Advances in Orthopedics, 2017, 1 - 6. https: //doi. org/10.1155/2017/4213413

[10] Xue, X. and Zhao, S. (2018). Posterior hemivertebra resection with unilateral instrumented fusion in children less than 10 years old: preliminary results at minimum 5 - year follow - up. Journal of Orthopaedic Surgery and Research, 13 (1). https: //doi. org/10.1186/s13018 - 018 - 0946 - 3

[11] Danisa, O., Turner, D., & Richardson, W. (2000). Surgical correction of lumbar kyphotic deformity: posterior reduction “eggshell” osteotomy. Journal of Neurosurgery Spine, 92 (1), 50 - 56. https: //doi. org/10.3171/spi.2000.92.1.0050

[12] Song, D., Zhang, Z., Wang, T., Qi, D., Wang, Y., & Zheng, G. (2021). Pedicle subtraction osteotomy in lateral position: a new strategy for correcting severe thoracolumbar kyphosis combined with hip flexion contracture in ankylosing spondylitis. Orthopaedic Surgery, 13 (8), 2396 - 2404. https: //doi. org/10.1111/os.13169

[13] Yin, X., Yan, L., He, B., Hao, D., & Liu, Z. (2020). Hemivertebra resection combined with wedge osteotomy for treatment of severe rigid congenital kyphoscoliosis in adolescence. . https: //doi. org/10.21203/rs.3. rs - 17556/v1

[14] Wang, C., Meng, Z., You, D., Zhu, H., Wang, F., Liu, J., … & Zhao, S. (2020). Individualized study of posterior hemivertebra excision and short-segment pedicle screw fixation for the treatment of congenital scoliosis. Orthopaedic Surgery, 13 (1), 98 - 108. https: //doi. org/10.1111/os.12838

[15] Crostelli, M., Mazza, O., Mariani, M., Mascello, D., Tundo, F., & Iorio, C. (2022). Hemivertebra resection and spinal arthrodesis by single - stage posterior approach in congenital scoliosis and kyphoscoliosis: results at 9.6 years mean follow - up. International Journal of Spine Surgery, 16 (1), 194 - 201. https: //doi. org/10.14444/8188

[16] Guo, J., Zhang, J., Wang, S., Wang, H., Zhang, Y., Yang, Y., … & Zhao, L. (2016). Risk factors for construct/implant related complications following primary posterior hemivertebra resection: study on 116 cases with more than 2 years’ follow - up in one medical center. BMC Musculoskeletal Disorders, 17 (1). https: //doi. org/10.1186/s12891 - 016 - 1229 – y

[17] Shi, Z., Li, Q., Cai, B., Yu, B., Feng, Y., Wu, J., … & Ran, B. (2015). Causes of the failure and the revision methods for congenital scoliosis due to hemivertebra. Congenital Anomalies, 55 (3), 150 - 154. https: //doi. org/10.1111/cga.12107

[18] Zhang, H., Du, Y., Liu, J., Deng, A., Wu, J., Wang, Y., … & Guo, C. (2022). Strategy and efficacy of surgery for congenital cervicothoracic scoliosis with or without hemivertebra osteotomy. Orthopaedic Surgery, 14 (9), 2050 - 2058. https: //doi. org/10.1111/os.13480

[19] Shi, B., Yang, L., Zhu, Z., Liu, W., Liu, Z., Sun, X., … & Qiu, Y. (2021). Failed primary surgery in congenital scoliosis caused by a single hemivertebra: reasons and revision strategies. Orthopaedic Surgery, 14 (2), 349 - 355. https: //doi. org/10.1111/os.13198

[20] He, J., Liu, F., Hu, W., Liu, J., Xia, B., Niu, X., … & Zhao, Y. (2022). Comparison of the curative efficacy of hemivertebra resection via the posterior approach assisted with unilateral and bilateral internal fixation in the treatment of congenital scoliosis. Frontiers in Surgery, 9. https: //doi. org/10.3389/fsurg.2022.821387

[21] Chang, D., Yang, J. H., Suk, S. I., Suh, S. W., Kim, J. H., Lee, S. J., … & Lee, J. Y. (2017). Fractional curve progression with maintenance of fusion mass in congenital scoliosis. Medicine, 96 (36), e7746. https: //doi. org/10.1097/md.0000000000007746

[22] Wang, Y., Sun, X., Li, W., Shi, B., Liu, Z., Wang, B., … & Zhu, Z. (2023). Hemivertebra resection after age three produces the similar results but with less complications compared to earlier surgery: a minimum of 5 - year follow - up. Journal of Orthopaedic Surgery and Research, 18 (1). https: //doi. org/10.1186/s13018 - 023 - 04096 – 7

[23] Sarwahi, V., Amaral, T., Dworkin, A., Pawar, A., & Wollowick, A. L. (2013). Pedicle screws can eliminate the need for hemivertebrae excision in late presenting congenital scoliosis or kyphosis. The Spine Journal, 13 (9), S143. https: //doi. org/10.1016/j. spinee.2013.07.366

[24] Chang, D., Yang, J. H., Lee, J. H., Kim, J. H., Suh, S. W., Ha, K., … & Suk, S. I. (2016). Congenital scoliosis treated with posterior vertebral column resection in patients younger than 18 years: longer than 10 - year follow - up. Journal of Neurosurgery: Spine, 25 (2), 225 - 233. https: //doi. org/10.3171/2015.11. spine151099

[25] Mohanty, S. P. and Kumar, N. (2000). Patterns of presentation of congenital scoliosis. Journal of Orthopaedic Surgery, 8 (2), 33 - 37. https: //doi. org/10.1177/230949900000800207