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Original Research

Evaluation of age-related surgery in congenital scoliosis

Congenital scoliosis

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Abstract
Aim: In deformity surgeries performed on pediatric, adolescent and adult patients with congenital scoliosis, age-related goals, techniques and results change. In this study, we aimed to guide patient management and surgical planning and avoid possible complications in 5 pediatric (0-12 years), 5 adolescent (13-19 years) and 5 adult (>20 years) patients operated for congenital scoliosis.
Material and Methods: A retrospective review of patients operated for congenital scoliosis between 2017 and 2022 in a single center was performed. The characteristics and measurement values of 15 congenital scoliosis patients who were operated using bilateral pedicle screw system were compared in relation to age. Scoliosis Research Society 22-question questionnaire was applied.
Results: The length of hospital stay of the pediatric group was statistically higher than of the adult group (p=0.021). There was no significant difference in the SRS-22 questionnaire of the groups. According to intragroup comparisons, the final postoperative values of the pediatric and adolescent groups were statistically lower than the preoperative values (p=0.001; p=0.042). The amount of decrease in thoracic kyphosis values in the pediatric group was statistically higher than in the adult group (p=0.038).
Discussion: Congenital scoliosis is a complex spinal problem associated with many abnormal findings. When a surgeon decides to perform congenital scoliosis surgery, the more important criterion than the patient's age is the severity of the segmentation defect present in the patient. In proportion to the damage caused by the deformity to the patient's quality of life, it should be decided whether to perform the surgery or to delay surgery.

Keywords
Adult Congenital Scoliosis, Adolescent Congenital Scoliosis, Pediatric Congenital Scoliosis, Congenital Scoliosis, Surgical Technique

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Introduction

Scoliosis is defined as a lateral curvature of the spine of at least 10° measured by the Cobb angle. It is divided into neuromuscular, congenital and idiopathic [1]. There is not much literature information about adult congenital scoliosis [2]. Congenital scoliosis was first classified in 1968 by Winter et al. based on x-ray images [3-4]. In principle, congenital scoliosis has two possible forms of malformation. Failures of formation or failures of segmentation, or a combination of both, lead to a mixed deformity. Congenital scoliosis is associated with a high frequency of anomalies inside and outside the spine [5].

Lumbar hemivertebrae progress more slowly than thoracic vertebrae [5,6]. Segmentation defects involve multiple blocks of vertebrae [3]. Scoliosis curves are complex three-dimensional deformities involving the coronal, sagittal and rotational planes. In adolescents, if the Cobb angle cannot be reduced below 25° on side bending radiographs, it is defined as structural and usually progresses by 1 degree per year as the patient matures. Non-structural curves usually do not progress as the patient matures [1].

Since congenital scoliosis varies greatly from patient to patient, the indications, patterns and complications of surgery also vary greatly, and there are no clear guidelines that could be used [7,8]. Scoliosis surgery may also be preferred for cosmetic and psychological reasons [9].

Material and Methods

Data Collection

Ethics committee approval for the study was obtained from University of Health Sciences Izmir Tepecik Training and Research Hospital (Decision no: 2023/03-48). Patients who underwent surgery for congenital scoliosis between 2017 and 2020 in a single center were retrospectively analyzed. Three groups of congenital scoliosis patients: 5 pediatric (0-12 years), 5 adolescent (13-19 years) and 5 adult (>20 years) patients were included in the study. Patients with incomplete medical records and patients with irregular follow-up were excluded. Radiologic images taken before and after the operation, physical examination findings, pathways followed in the diagnosis and treatment of the cases, demographic data, age, gender, number of comorbidities, follow-up period, deformity level, SVA% (sagittal vertical axis), PI-LL mismatch % (pelvic incidence- lumbar lordosis), PT% (pelvic tilt), sagittal and coronal radiographic data, SVA(mm) (sagittal vertical axis), TK (°) (thoracic kyphosis), LL (°), PI-LL mismatch (°), PJA (proximal junctional angle), PT(°), PI (°), SS(°)(sacral slope), Thoracic Cobb angle (°)(TCA), Lumbar Cobb angle (°)(LCA), Coronal balance (mm)(CI), sagittal balance (mm)(SI) were measured. Operative and systemic complications were evaluated. The Scoliosis Research Society 22-question questionnaire [SRS-22r] was administered to each patient postoperatively.

Operative procedure: All operations were performed by senior surgeons. The lowest transpedicular screw vertebra was selected according to the last vertebra intersected by the central sacral vertical line. The selection of the upper instrumented vertebra (UIV) was performed according to the laterally tilted radiographs [10]. Three or four pedicle screws were placed on the proximal and distal foundation. Pedicle screws were placed wherever necessary to obtain additional correction. Ponte osteotomies were performed when kyphosis correction was required. Rods were corrected by applying reduction and extension.

Measurement Method

Segment angles kyphosis/lordosis: measured from the upper endplate to the lower endplate of the hemivertebra. SVA (°): the distance of the vertical line tangent to the anterior C7 vertebra in the sagittal plane from the posterior superior edge of the sacrum.TK (°): Sagittal cobb angle measured from the superior endplate of T5 to the inferior plate of T12. LL (°): Sagittal cobb angle measured from the upper plate of T12 to the end plate of the sacrum.

PI-LL mismatch (°):PI°-LL° PJA: proximal junction angle (sagittal Cobb angle between UIV and UIV+2 level (UIV+2)),PT (°): angle between the vertical line passing through the axis of the femoral head and the line joining the femoral head to the sacral endplate midpoint PI (°): The angle between a line perpendicular to the upper endplate of S-1 and the line joining the upper endplate SS (°): The angle between the upper endplate of S1 and the horizontal line TCA (°): The angle of lateral deviation of the curve on a standing spine x-ray in the frontal plane; parallel lines are drawn on the superior surface of the uppermost vertebra forming the curve and on the posterior surface of the lowest vertebra forming the curve, the angle between the uprights lowered to these lines is measured as the Cobb angle [11]. LCA (°): TCA (°) measurement method was applied. CI (mm): Deviation of the standing C7 plumb line from the mid-sacral vertical line was considered significant if it exceeded 20 mm. SI(mm): Measured as the distance from the C7 plumb line to a plumb line. Vertical line drawn and determined from the posterosuperior corner of the sacrum. Positive (+) sagittal balance was considered when the C7 plumb line was anterior to the posterosuperior corner of the sacrum and negative (-) when the C7 plumb line was posterior to the posterosuperior corner. Deviation greater than 20 mm in the sacrum was considered decompensation. Junctional kyphosis was defined as an angle of more than 10° between the lower endplate of the uppermost instrumented vertebra and the upper endplate of the vertebra two levels higher. Coronal imbalance: The distance between the C7 plumb line and the central sacral vertical line is more than 2 cm [1]. Transfusion threshold: A hemoglobin level <8 g/dL was considered the transfusion threshold.

Statistical Method

Data were analyzed using the statistical package program IBM SPSS Statistics Standard Concurrent User V 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics were expressed as number of units (n), percentage (%), mean ± standard deviation (x̄ ±ss), median (M), minimum (min), maximum (max) and intercartillary distance (IQR) values. The normal distribution of the numerical variables was evaluated by the Shapiro- Wilk normality test. The hHomogeneity of variances was evaluated by Levene's test. Fisher's exact test was used to compare the groups with categorical variables. Comparisons of the groups with numerical variables were made by One-way analysis of variance if the data were normally distributed and by Kruskal-Wallis analysis if the data were not normally distributed. If the result of one-way analysis of variance was found to be significant, the Tukey test was used as a multiple comparison (post hoc) test. In the Kruskal-Wallis analysis, the Dunn-Bonferroni test was used as a multiple comparison test. In the comparison of preop and final postop sagittal and coronal radiographic values according to the measurement times, two-way analysis of variance in repeated measures was used if the data were normally distributed. The Bonferroni correction was applied for all pairwise comparisons in two-way repeated measures analysis of variance. For Sacral slope (°) and Lumbar Cobb angle (°) where assumptions were not met, intergroup comparisons were made by the Kruskal-Wallis analysis and intragroup comparisons were made by the Wilcoxon test. $p<0.05$ was considered statistically significant.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

The mean follow-up period was 41.2 months (8-60 months). The mean patient age was 10.2±2.2 years in the pediatric group, 16.0±1.4 years in the adolescent group and 26.0±6.9 years in the adult group. The mean age of the adult group was statistically higher than of the pediatric and adolescent groups ($p<0.001$). The number of male patients was 2 (40.0%) in the pediatric group, 1 (20.0%) in the adolescent group and 3 (60.0%) in the adult group (p=0.800) (Table 1).

The reasons for surgery were mostly lower back and leg pain and curvature in the lower back in lumbar scoliosis, back pain and pressure sores at the level of kyphosis in thoracolumbar scoliosis. In one patient with advanced deformity, operation was decided due to shortness of breath and development of clubfoot. The number of patients with increased curvature was one in the pediatric group (20.0%) and 2 in the adolescent group (40.0%). The number of patients with low back pain was 2 in the adolescent and adult groups (40.0%) (p=0.145), (Table-1).

The number of patients with SVA≤5cm was 3 in all three groups (60.0%). The number of patients with PI-LL mismatch ≥20° was one (20.0%) in the pediatric group, 2 (40.0%) in the adolescent group and 3 (60.0%) in the adult group. The number of patients with PT≤20° was 2 (40.0%) in the pediatric group, 5 (100.0%) in the adolescent group and 3 (60.0%) in the adult group (p=0.765, p=0.251), (Table 1).

According to intergroup comparisons, there was no statistical difference between preoperative and postoperative SVA values of the groups (p=0.474, p=0.750). Thoracic kyphosis (°) final postop values of the pediatric and adolescent groups were statistically lower than the preop values (p=0.001; p=0.042). The decrease in the values of the adult group was not statistically significant (p=0,999), and the amount of decrease in the Thoracic kyphosis (°) values in the pediatric group was statistically higher than in the adult group according to the difference comparisons (p=0,038). According to intra-group comparisons, the final postop LL (°) values of the three groups were statistically lower than the preop values (p=0.007; p=0.009; p=0.049). According to within-group comparisons, the final postop PI-LL mismatch (°) values of the pediatric and adult groups were statistically higher than the preop values (p=0.010; p=0.010). According to within-group comparisons, final postop PJA (UIV-UIV+2) (°) values in the pediatric group were statistically lower than preop values (p=0.021). According

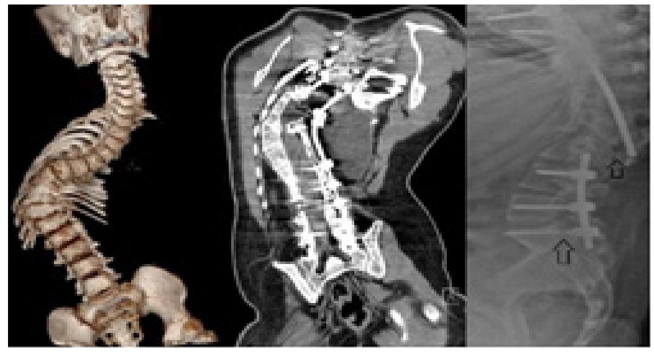

Figure 1. A 12-year-old male patient who had undergone neonatal surgery for meningomyelocele was paraplegic. He had back pain. Spur excision for T11-T12 diastomyelia, transpedicular screws in T3-T6 vertebrae, column osteotomy in T6-T7-T8-T9 vertebrae, T8-T9-T10 costal resection and posterior fixation with L4-L5-S1 transpedicular screws were performed. One year later, he was re-operated due to fracture of the S1 pedicular screw (lower arrow) and rod (upper arrow) on the control radiograph.

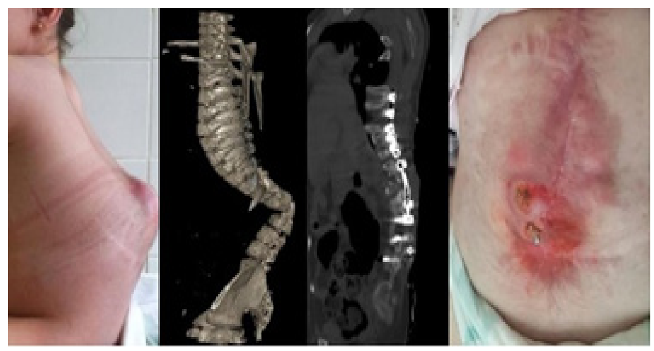

Figure 2. A 7-year-old girl was operated for meningomyelocele in the neonatal period and a ventriculo-peritoneal shunt was inserted. The patient had L1 hemivertebra and thoracolumbar kyphorotoscoliosis. Bilateral lower extremities had proximal 2-3/5 muscle strength. The patient could not lie supine and could not lean back when sitting. Transpedicular screws were applied to the vertebrae between T4-L5. Partial osteotomies were performed on the vertebrae T11-T12-L1 and the kyphotic segment was corrected. One year after surgery, he was operated again because of the appearance of screws through the skin.

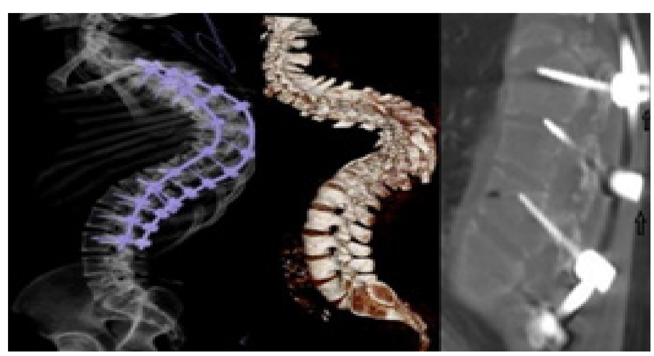

Figure 3. Twenty-two-year-old male patient presented with back pain and scoliosis. T7 corpectomy and T7-T8-T9 costatransvertebrectomy were performed. Bilateral pedicular screws were inserted into the vertebrae in the T2-L3 range and posterior stabilisation was performed with appropriate distraction and reductions. The patient was re-operated 1 year later due to the appearance of screws through the skin (arrows on the right).

Table 1. Comparison of the descriptive characteristics of the groups.

	Groups			Test statistics†	
	Pediatric n=5	Adolescent n=5	Adult n=5	test value	p value
Age, (years)					
±ss	10,2±2,2[a]	16,0±1,4[a]	26,0±6,9[b]	17,359	<0,001†
min-max	(7-12)	(14-17)	(18-35)		
Gender n (%)					
F	3 (60,0)	4 (80,0)	2 (40,0)	1,665	0,800&
M	2 (40,0)	1 (20,0)	3 (60,0)		
Operation time (min)					
M (IQR)	510,0 (135,0)	525,0 (137,5)	400,0 (400,0)	1,239	0,538‡
Hospitalization (days)					
M (IQR)	19,0 (12,5)[a]	13,0 (37,0)[ab]	9,0 (5,5)[b]	7,716	0,021‡
SVA, n (%)					
≤5cm	3 (60,0)	3 (60,0)	3 (60,0)	-	-
>5cm	2 (40,0)	2 (40,0)	2 (40,0)		
PI-LL mismatch, n (%)					
≤10°	2 (40,0)	2 (40,0)	2 (40,0)		
10-20°	2 (40,0)	1 (20,0)	0 (0,0)	2,98	0,765&
≥20°	1 (20,0)	2 (40,0)	3 (60,0)		
PT, n (%)					
≤20°	2 (40,0)	5 (100,0)	3 (60,0)	4,017	0,251&
20°-30°	3 (60,0)	0 (0,0)	2 (40,0)		
Complaint, n (%)					
Pain in the legs, curvature in the waist	1 (20,0)	0 (0,0)	0 (0,0)		
Back pain	0 (0,0)	2 (40,0)	2 (40,0)		
waist leg pain	2 (40,0)	0 (0,0)	0 (0,0)		
Dropped feet and shortness of breath	0 (0,0)	0 (0,0)	1 (20,0)	13,679	0,145&
Curvature increase	1 (20,0)	2 (40,0)	0 (0,0)		
Back pain	0 (0,0)	1 (20,0)	2 (40,0)		
Wound on the back	1 (20,0)	0 (0,0)	0 (0,0)		

n: Number of patients, %: Percentage of column, x-: Mean, ss: Standard deviation, M: Median, IQR: Interquartile range, †: One-way analysis of variance, ‡: Kruskal-Wallis analysis, &: Fisher's exact test, a and b superscripts indicate the difference between groups in the same row. There is no statistical difference between groups with the same superscript. Hospitalisation (days):Duration of hospitalisation.

to intra-group comparisons, the final postop PT (°) values of the pediatric group were statistically higher than the preop values (p=0,017) (Table 2).

According to intra-group comparisons, the final postop Thoracic Cobb angle (°) values of the adult group were statistically lower than the preop values (p=0,048). According to intra-group comparisons, the final postop Lumbar Cobb angle (°) values of the three groups were statistically lower than the preop values (p=0,049; p=0,038; p=0,033) (Table 3).

The mean blood loss during the operation was between 277-2000ml. Five patients received allogeneic blood transfusion. The mean operation time was 510 min in the pediatric group, 525 min in the adolescent group and 400 min in the adult group (p=0.538). The mean hospital stay was 19 days in the pediatric group, 13 days in the adolescent group and 9 days in the adult group. The length of hospital stay in the pediatric group was statistically higher than that in the adult group (p=0.021) (Table 1).

Patients were evaluated postoperatively with the Scoliosis Research Society 22-question questionnaire [SRS-22r]. There was no statistically significant difference between the groups in pain, self-image, function activity, mental health, satisfaction with treatment and total scores.

Thoracolumbar rotoscoliosis was present in 2 patients in the pediatric group, 3 in the adolescent group and 2 in the adult group. 2 adolescent patients had thoracic butterfly vertebrae. One adult patient had cervicothoracolumbar scoliosis. Hemivertebrae were observed at T2, T3, T9, L1, L2, L3, L4 vertebral levels. One pediatric patient had diastomyelia at the T11-T12 level. None of the patients had a syrinx.

Postoperative revision was performed in 2 pediatric patients, 1 adult patient due to pedicular screw malposition and 1 pediatric patient due to rod fracture (Figure-1). One pediatric patient with second degree mitral regurgitation developed postoperative hemopneumothorax. An adolescent with restrictive lung disease and limited cervical extension developed pneumothorax, pulmonary atelectasis and external iliac vein thrombosis. One hepatitis B carrier adult patient developed postoperative hyperbilirubinemia. Two pediatric patients developed postoperative systemic infection. In 1 pediatric and 1 adult patient, it was observed that the screw came out of the skin of the kyphosis region (Figures –2 and 3), approximately one year after the operation and they were operated again for this reason. The complication rate was 3/5 in pediatric patients, 1/5 in adolescents and 3/5 in adults. No operation-related deficit was observed in any patient.

Table 2. Comparison of sagittal and coronal radiographic values of the groups according to age and time of measurement.

	Groups			Test statistics†	
	Pediatric n=5	Adolescent n=5	Adult n=5	test value	p value
SVA					
Preop	25,40±47,05	52,20±43,95	16,20±49,54	F=0,795	0,474
Final Postop	46,00±93,41	17,20±45,60	17,80±54,34	F=0,295	0,75
Difference	-20,60±65,84	35,00±49,12	-1,60±19,97	F=1,676	0,228
TI‡: F; p	0,891; 0,364	2,571; 0,135	0,005; 0,943		
Thoracic kyphosis (°)					
Preop	49,80±11,08	46,40±6,99	50,00±16,97	F=0,134	0,876
Final Postop	25,60±8,96	33,20±9,15	49,99±24,46	F=3,067	0,084
Difference	24,20±17,91[a]	13,20±10,87[ab]	0,01±8,22[b]	F=4,349	0,038
TI‡: F; p	17,347; 0,001	5,161; 0,042	0,001; 0,999		
LL (°)					
Preop	55,60±20,89	58,40±21,56	59,00±18,77	F=0,039	0,961
Final Postop	37,20±13,22	40,60±12,66	46,60±28,13	F=0,302	0,745
Difference	18,40±12,03	17,80±13,14	12,40±13,11	F=0,335	0,722
TI‡: F; p	10,379; 0,007	9,713; 0,009	4,721; 0,049		
PI-LL mismatch (°)					
Preop	-15,40±24,99	-13,80±14,84	-18,80±14,02	F=0,094	0,911
Final Postop	5,60±19,44	-6,40±14,88	2,00±31,88	F=0,352	0,71
Difference	-21,00±8,86	-7,40±10,67	-20,80±22,57	F=1,299	0,308
TI‡: F; p	9,430; 0,010	1,171; 0,300	9,251; 0,010		
PJA (UIV–UIV+2) (°)					
Preop	12,60±7,50	10,00±6,48	10,92±6,11	F=0,192	0,828
Final Postop	4,20±3,49	8,10±5,37	6,00±6,52	F=0,684	0,523
Difference	8,40±6,11	1,90±8,47	4,92±6,44	F=1,054	0,379
TI‡: F; p	7,026; 0,021	0,359; 0,560	2,410; 0,146		
PT (°)					
Preop	15,80±9,76	8,40±4,93	15,20±6,69	F=1,543	0,253
Final Postop	25,40±14,42	12,20±5,54	20,20±8,93	F=2,084	0,167
Difference	-9,60±11,67	-3,80±3,42	-5,00±5,52	F=0,788	0,477
TI‡: F; p	7,745; 0,017	1,213; 0,292	2,101; 0,173		

Data are summarised as mean±standard deviation. TI: Test Statistics, †: Comparisons between groups in each measurement, ‡: Comparisons between measurements in each group, F: Two-way analysis of variance for repeated measures, a and b superscripts indicate differences between groups in the same row. Groups with the same superscript are not statistically different.

Table 3. Comparison of sagittal and coronal radiographic values of the groups according to age and time of measurement.

	Groups			Test statistics†	
	Pediatric n=5	Adolescent n=5	Adult n=5	test value	p value
PI (°)					
Preop	39,60±5,37	42,20±14,17	40,20±9,01	F=0,089	0,915
Final Postop	42,80±8,41	43,20±16,75	48,60±7,50	F=0,386	0,688
Difference	-3,20±4,76	-1,00±12,81	-8,40±14,52	F=0,545	0,594
TI‡: F; p	0,386; 0,546	0,038; 0,849	2,663; 0,129		
Sacral slope (°)					
Preop	22,00 (16,50)	26,00 (26,00)	28,00 (18,50)	H=0,917	0,632
Final Postop	25,00 (27,00)	24,00 (19,00)	28,00 (8,00)	H=0,652	0,722
Difference	2,00 (22,00)	-2,00 (16,00)	0,00 (12,5)	H=0,467	0,792
TI‡: z; p	0,674; 0,500	0,001; 0,999	0,184; 0,854		
Thoracic Cobb angle (°)					
Preop	48,60±25,86	41,60±24,97	40,00±25,10	F=0,163	0,851
Final Postop	25,00±29,61	14,60±5,90	24,80±19,52	F=0,411	0,672
Difference	23,60±37,33	27,00±20,53	15,20±20,77	F=0,246	0,785
TI‡: F; p	3,720; 0,078	4,869; 0,048	1,543; 0,238		
Lumbar Cobb angle (°)					
Preop	32,00 (43,00)	35,00 (11,00)	20,00 (28,00)	H=1,463	0,481
Final Postop	12,00 (47,00)	14,00 (22,00)	9,00 (25,50)	H=0,612	0,737
Difference	27,00 (31,50)	28,00 (20,50)	9,00 (17,50)	H=1,827	0,401
TI‡: z; p	1,969; 0,049	2,211; 0,038	2,723; 0,033		
Coronal imbalance (mm)					
Preop	9,60±33,72	20,60±8,88	-14,40±34,36	F=2,005	0,177
Final Postop	-5,00±10,68	15,60±9,56	2,00±23,85	F=2,126	0,162
Difference	14,60±26,68	5,00±9,90	-16,40±23,03	F=2,819	0,099
TI‡: F; p	2,386; 0,148	0,280; 0,606	3,011; 0,108		

Data are summarised as mean±standard deviation. TI: Test Statistics, †: Comparisons between groups in each measurement, ‡: Comparisons between measurements in each group, F: Two-way analysis of variance for repeated measures, a and b superscripts indicate differences between groups in the same row. Groups with the same superscript are not statistically different.

Discussion

Various spinal deformities are classified into three categories: formation defects, segmentation defects or mixed spinal defects [12]. Surgical treatment for congenital scoliosis is complex [13]. Currently, in situ fusion, convex growth arrest and hemivertebra excision via a combined anterior and posterior approach in one or two stages are the surgical methods used [14]. Single-stage posterior hemivertebra resection combined with bilateral transpedicular screw instrumentation has become the widely adopted procedure for the correction of congenital scoliosis. The use of pedicle screws is a powerful method that allows excellent deformity correction in the coronal and sagittal planes and is safe even in very young children [15]. Pedicle screw instrumentation can effectively transmit the correction torque to the anterior and middle columns of the spine, increasing the pressure resistance of the anterior and middle columns, helping to retard the growth of the vertebrae and preventing the crankshaft phenomenon [16,17].

Posterior unilateral transpedicular screw fixation may be a recommended alternative in children to further minimize trauma and reduce growth arrest of the concave side. In addition, short-segment fusion can be performed to preserve more growing segments and motor units. This allows the non-fused concave side of the spine to grow [18]. The use of pedicle screws has a much better correction rate than other instrumental methods [19]. Pedicle screw instrumentation has no negative effect on the growth of vertebral bodies [20,21]. In one of the pediatric patients in our series, we performed osteotomy and unilateral instrumented fusion. In the 1st year of postoperative follow-up, we found that the rod and the lowest screw were fractured and we operated again.

Surgical options for congenital scoliosis in pediatric, adolescent and neglected and treated adult patients vary depending on several factors such as the type of anomaly, degree of deformity, vertebral type and age of the patient [13, 22-24]. An increase in the Cobb angle indicates an increased load on the spine, which may result in lower back and back pain. Surgical treatment options in pediatric and adolescent patients include growth-allowing systems or fusions. Typically, early surgical intervention before the age of three is the recommended treatment for young patients with congenital scoliosis. However, no evidence has been found in long-term studies to support this. Once a patient has reached skeletal maturity, surgical options such as in situ fusion, epiphysiodesis, vertical expandable prosthesis titanium rib implant and growth-guided devices may not be appropriate [12]. Procedures involving osteotomies such as pedicle removal osteotomy, hemivertebrectomy and vertebral column resection are technically more challenging and have higher complication rates than posterior spinal fusion [13]. In the correction of deformity in congenital scoliosis we preferred to perform hemivertebrectomy in our adult patients. There was no statistically significant difference in complication rates between the groups.

In pediatric and adolescent patients, long-term deformity correction is provided with posterior column resection and posterior fixation with pedicular screws. However, when we investigate the relevance of this information for adult patients, we can see that the literature is focused on the pediatric population and there is a lack of data and information about adult congenital deformity in the diagnosis and treatment process [2].

Limitations

In this group study, the small sample size limited the clarity of the statistical analysis. Larger sample sizes are needed.

Conclusions

Congenital scoliosis is a complex spinal problem associated with many abnormal findings. When a surgeon decides to perform surgery for congenital scoliosis, more important criterion than the patient's age is the severity of the segmentation defect present in the patient. Both for neglected adult patients and the adult population of treated pediatric patients, it is necessary to determine the decision and method of surgical treatment by defining the characteristics and complaints of adult congenital spinal deformity patients seeking medical attention.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of interest

The authors declare no conflict of interest.

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