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Surgical and Functional Implications of Lenke Type 3 Idiopathic Scoliosis in Children and Adolescents: A Comparative Study

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Rezumat

Implicații chirurgicale ale scoliozei idiopatice Lenke tip 3 la copii și adolescenți: corelații funcționale și relevanță pentru planificarea intervenției

Introducere: Scolioza idiopatică Lenke tip 3, caracterizată prin două curburi structurale opuse, reprezintă una dintre cele mai complexe forme de deformare spinală pediatrică, cu evoluție rapidă în perioada de creştere cu evoluție rapidă în perioada de creştere şi care impune frecvent evaluarea precoce a indicației chirurgicale. Prezentul studiu îşi propune să compare parametrii clinici, radiografici şi ai calității vieții la copiii şi adolescenții cu scolioză Lenke tip 3 şi să identifice factorii dependenți de vârstă care pot influența momentul optim al intervenției chirurgicale.
Metode: Studiul a inclus pacienți pediatrici diagnosticați cu scolioză idiopatică Lenke tip 3, caracterizată prin două curburi structurale opuse, împărțiți în două loturi: copii (<12 ani) şi adolescenți (12–16 ani). Au fost înregistrate date demografice, clinice şi radiografice, incluzând valorile unghiului Cobb pentru curbura toracică şi lombară, rotația axială şi punctele de inflexiune. Calitatea vieții a fost evaluată utilizând chestionarul SRS-22r.
Rezultate: La adolescenți s-au înregistrat unghiuri Cobb toracice semnificativ mai mari ($p < 0,01$) şi scoruri mai scăzute ale calității vieții, în special în domeniile Durere ($p = 0,008$) şi Aspect ($p = 0,001$). S-a identificat o corelație inversă moderată între severitatea curburii toracice şi scorurile Funcție ($r = –0,45$, $p = 0,011$) şi Aspect ($r = –0,52$, $p = 0,004$). Curbura lombară nu a fost asociată semnificativ cu calitatea vieții. Copiii au prezentat scoruri superioare în toate domeniile, diferențele în domeniul sănătății mintale neatingând semnificație statistică.
Concluzii: Adolescenții cu scolioză Lenke tip 3 prezintă deformări mai avansate şi o afectare crescută a calității vieții comparativ cu copiii. Declinul psihosocial legat de vârstă şi progresia curburii toracice pot reprezenta indicatori precoce relevanți pentru planificarea chirurgicală şi momentul intervenției.

Cuvinte cheie: Lenke tip 3, SRS-22r, calitatea vieții, planificare chirurgicală

Abstract

Background: Lenke type 3 double major curves represent a complex deformity that may progress rapidly during pediatric development and often raise early surgical considerations. This study aimed to compare clinical, radiographic, and quality-of-life (QoL) characteristics between children and adolescents with Lenke type 3 scoliosis and to explore age-related factors that may influence future surgical decision-making.

Methods: A cross-sectional analysis was conducted on pediatric patients diagnosed with Lenke type 3 double major curves, divided into two groups: children (<12 years) and adolescents (12-16 years). Demographic, clinical, and radiographic parameters were recorded, including thoracic and lumbar major coronal curves, axial rotation, and inflection points. QoL was assessed using the SRS-22r questionnaire.

Results: Adolescents presented with significantly greater thoracic major coronal curve ($p<0.01$) and reported lower quality of life scores, particularly in the Pain ($p=0.008$) and Appearance ($p=0.001$) domains of the SRS-22r questionnaire. A moderate inverse correlation was observed between thoracic major coronal curve and both Function ($r=–0.45$, $p=0.011$) and Appearance ($r=–0.52$, $p=0.004$) scores. Lumbar major coronal curve did not show significant associations with quality of life domains. Children reported overall higher quality of life scores across all domains, although Mental Health differences were not statistically significant between groups.

Conclusions: Adolescents with Lenke type 3 scoliosis demonstrate more advanced deformity and greater QoL impairment than younger children, even before reaching classical surgical thresholds. Age-related psychosocial decline and thoracic curve progression may represent early indicators relevant for surgical planning and timing of intervention.

Keywords: Lenke type 3, double major curve, SRS-22r, quality of life, surgical planning

Introduction

The surgical management of idiopathic scoliosis – particularly Lenke type 3 double major curves – remains a major challenge due to the complex three-dimensional deformity and its impact on thoracic balance, pulmonary function, and post-operative quality of life (1,2). Understanding the evolution of these deformities during childhood and adolescence is critical for optimal timing of surgical intervention and patient selection (3). Idiopathic scoliosis is a complex three-dimensional spinal deformity characterized by a lateral curvature of ≥10° on the Cobb method, accompanied by vertebral rotation (4,5). It affects approximately 1-3% of adolescents worldwide, with prevalence increasing to 4-5% in females, peaking during the pubertal growth spurt [10-15 years] (6).

From a surgical perspective, Lenke type 3 double major curves are considered among the most demanding deformities requiring posterior spinal fusion because both structural curves must be simultaneously corrected and balanced (7). Surgical planning relies on radiographic parameters such as major curve magnitude, apical rotation, and inflection points, which guide decisions on timing, fusion level selection, and correction strategy (8). Understanding how these parameters evolve from childhood to adolescence is clinically relevant for determining when surgical intervention may become necessary.

Lenke double major curves, defined radiographically as having two structural curves in opposite directions (thoracic + lumbar), represents a clinically significant subtype associated with higher biomechanical imbalance, rapid progression, and increased esthetic and functional impact compared to single-curve presentations (9). According to the Lenke classification, these cases correspond to type 3 double major curves, characterized by structural deformities in both the thoracic and lumbar regions. This subtype is recognized as having greater biomechanical and psychosocial impact compared with single-curve deformities (10,11). Quality of life (QoL) in idiopathic scoliosis has been extensively studied using tools such as the Scoliosis Research Society-22 revised (SRS-22r) questionnaire, assessing Function, Pain, Appearance, and Mental Health domains (12-14). The SRS-22r questionnaire is

one of the most widely employed patient-reported outcome measures for adolescent idiopathic scoliosis, assessing quality of life across domains of Function, Pain, Appearance, and Mental Health (15,16).

Given these gaps, this study aimed to compare clinical, radiographic, and QoL characteristics between children and adolescents diagnosed with Lenke type 3 double major curves. Our working hypothesis was that adolescents would exhibit more severe deformity and a greater decline in QoL – even prior to meeting classical surgical criteria – suggesting that developmental stage may be a relevant factor in anticipating surgical need.

Material and Methods

Study Design

Between January 2021 and 2024, a prospective observational study was conducted on pediatric patients admitted to the Pediatric Surgery and Orthopedics Department in South-Eastern Romania with a diagnosis of Lenke type 3 double major curves.

Rationale for Selecting Lenke Type 3 Curves

Lenke type 3 double major curves were intentionally selected because they represent one of the most biomechanically complex and surgically demanding scoliosis patterns, requiring the correction of two structural curves. Unlike single-curve patterns, Lenke type 3 deformities show reduced compensatory capacity, more rapid progression during adolescence, and greater impact on trunk symmetry and cosmetic appearance. These particularities make this subtype clinically relevant for exploring age-related differences that may influence future surgical planning. Including heterogeneous Lenke patterns would have introduced substantial variability, reducing comparability across age groups.

Study Population and Group Allocation

The inclusion criteria were as follows: (1) newly diagnosed cases of Lenke type 3 double major curves; (2) no prior history of scoliosis-specific treatment; (3) patients who completed the Scoliosis Research Society-22 revised (SRS-22r) questionnaire; and (4) patients under the age of 18. The exclusion criteria included: (1) previous treatment for scoliosis (surgical, orthotic, or physiotherapy interventions); (2) history of debilitating or oncologic comorbidities; (3) infantile idiopathic scoliosis; and (4) refusal to participate or incomplete questionnaire data. Inclusion required the availability of standardized standing postero-anterior spinal radiographs to ensure accurate measurement of major coronal curves.

To facilitate comparative analysis, patients were stratified into two age-based groups: children, defined as individuals younger than 12 years (n = 14), and adolescents, defined as those aged 12 to 16 years (n = 29). A Flow chart is available (*Fig. 1*). Idiopathic scoliosis is conventionally divided into three subtypes: infantile (onset <4 years), juvenile (4-10 years), and adolescent (>10 years until skeletal maturity), with distinct clinical and radiographic characteristics reported in the literature. In the present study, however, patients were stratified pragmatically into <12 years (children) and 12-16 years (adolescents) to explore potential differences in quality of life according to developmental stage rather than onset definition.

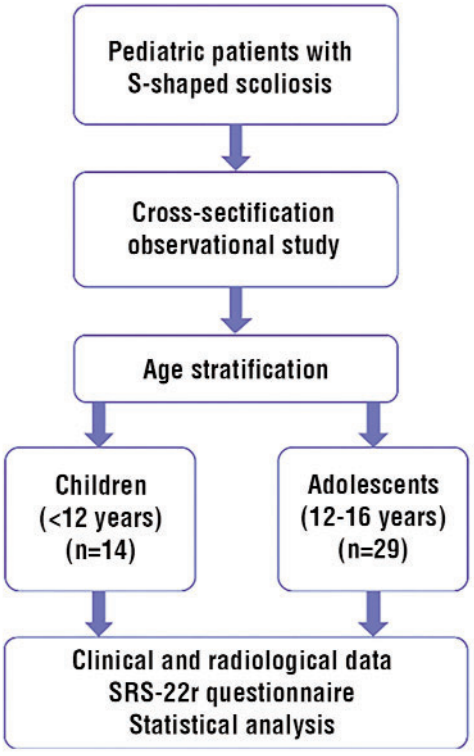

Figure 1. Flowchart of Patient Selection and Study Design in Children and Adolescents with Lenke type 3 double major curves

Quality-of-Life Evaluation

Although none of the patients in this cohort underwent surgical correction during the study periAlthough none of the patients in this cohort underwent surgical correction during the study period, the radiographic characterization (Lenke type 3 pattern, major coronal curve, and axial rotation) reflects parameters typically used in preoperative surgical planning. Thus, this analysis provides insight into the stage at which surgical indication might arise relative to psychosocial and functional deterioration. This classification allowed for the assessment of age-specific differences in clinical and radiological parameters, as well as in quality-of-life outcomes measured through the SRS-22r questionnaire. SRS-22r refers to the revised version of the SRS-22 questionnaire, validated in English and subsequently adapted in multiple languages. The Romanian version of the SRS-22r questionnaire was administered on diagnosis, prior to any therapeutic intervention. Patients completed the questionnaire individually, with a member of the research team available to clarify wording but without influencing responses.

Data Collection

Clinical and demographic data were collected for each patient, including sex, age, weight, height, and body mass index (BMI). The spinal deformity was described based on the type and direction of curvature (thoracic dextroconvex + lumbar levoconvex or thoracic levoconvex + lumbar dextroconvex), axial rotation, thoracic and lumbar inflection points, and major coronal curve for both thoracic and lumbar curves. BMI categories were classified according to WHO pediatric growth standards (underweight, normal weight, overweight, obesity).

Radiographically, all included cases corresponded to Lenke type 3 double major curves, defined by the presence of both structural thoracic and structural lumbar components. According to the general definition of the World Health Organization, scoliosis is diagnosed when there is a lateral spinal curvature of 10 degrees or more, measured by the Cobb method (15). In this study, Lenke type 3 double major curves was defined radiographically as the presence of two structural curves in opposite directions – typically one thoracic (dextroconvex or levoconvex) and one lumbar (in the opposite direction) – resulting in a characteristic double-curve pattern on the coronal plane. This classification aligns with international standards for complex scoliotic deformities, which are often associated with more significant postural and functional impairment than single-curve presentations.

The SRS-22r questionnaire was used to evaluate patient-reported outcomes in four domains: Function, Pain, Appearance, and Mental Health. For each domain, a mean score ranging from 1 (worst) to 5 (best) was calculated (16).

Study Endpoints

The primary endpoint of the study was to compare clinical and radiographic characteristics between children and adolescents with Lenke type 3 double major curves, with the aim of identifying developmental differences relevant for future surgical planning.

The secondary endpoints were:

- to evaluate differences in SRS-22r quality-of-life scores between children and adolescents, with emphasis on domains that may influence the timing of surgical referral;
- to assess the correlation between major coronal curve magnitude and QoL domains, as a potential early indicator of surgical need;
- to examine the radiographic behavior of thoracic versus lumbar curves in relation to future surgical planning in Lenke type 3 deformities.

Ethical Considerations

In compliance with the Declaration of Helsinki on human testing, the study was approved by the Ethics Committee of the Constanța County Clinical Emergency Hospital for the Approval of Clinical and Research Developmental Studies (approval no. 21/01.12.2020). For all participants informed consent to participate was obtained from their parents or legal guardians at the time of hospital admission.

Statistical Analysis

Statistical analysis was performed using SPSS (V28) and GraphPad Prism 10. Continuous variables were reported as mean ± standard deviation and categorical variables were expressed as frequencies with percentages. Group comparisons were performed using the Mann-Whitney U test or Kruskal-Wallis test. Correlations between major coronal curve and quality of life

Table 1. Comparative Overview of Clinical-Demographic and Vertebral Characteristics in Children and Adolescents with Lenke type 3 double major curves

Variables	Children (n=14)	Adolescents (n=29)	p-value
Age (years)*	11.71±0.21	15.10±0.93	-
Environment			0.445
Urban	12 (85.7)	22 (75.9)	
Rural	2 (14.3)	7 (24.1)	
Gender			0.697
Male	4 (28.6)	10 (34.1)	
Female	10 (71.4)	19 (65.5)	
Body Mass Index (kg/m^2)*			0.039
Normal weight	6 (42.9)	3 (10.3)	
Overweight	1 (7.1)	11 (37.9)	
Obesity	7 (50)	15 (51.7)	
Physical activity	10 (71.4)	18 (62.1)	0.044
Types of curvatures			
Thoracic dextroconvex, lumbar levoconvex	11 (78.6)	25 (86.2)	0.532
Thoracic levoconvex, lumbar dextroconvex	3 (21.4)	4 (13.8)	0.067
Axial vertebral rotation	11 (78.6)	29 (100)	0.029
Thoracic major coronal curve			0.047
Mild	13 (92.9)	19 (65.5)	
Moderate	1 (7.1)	5 (17.2)	
Severe	0	5 (17.2)	
Lumbar major coronal curve			0.037
Mild	13 (92.9)	19 (65.5)	
Moderate	1 (7.1)	10 (34.5)	
Severe	0	0	

Percentages in parentheses unless indicated otherwise; *Values are mean (standard deviation).
Values in italics indicate statistical significance (p <0.005).

scores were assessed using Spearman's rank correlation coefficient. A p-value <0.05 was considered statistically significant.

Results

The analysis of the clinical and demographic characteristics of patients with Lenke type 3 double major curves, grouped by age category (children vs. adolescents), is presented in *Table 1.* No statistically significant differences were observed in terms of gender distribution (p=0.697) or environment of origin (urban vs. rural, p=0.445). When adjusted for age, BMI categories demonstrated notable differences between the two groups. BMI category distribution differed between groups. In the children group, 50% were classified as obese, 7.1% as overweight, and 42.9% as normal weight. Among adolescents, obesity was present in 10.3% of cases, overweight status in 37.9%, and normal weight in 51.7%.

Radiographic characteristics also differed between age groups. Adolescents had significantly higher thoracic major coronal curves (p=0.047) and lumbar major coronal curves (p=0.037). Curve direction patterns were similar across groups.

Table 2 presents the results of the multivariate analysis assessing the association between age category and each of the four domains of the SRS-22r questionnaire. Statistically significant differences were observed for the Pain and Appearance domains. Adolescents reported lower scores compared to children in the pain domain (p=0.042), indicating increased pain perception.

Table 2. Multivariable analysis SRS-22r Scores in Children and Adolescents with Lenke type 3 double major curves

Variable	Function		Pain		Appearance		Mental Health	
	OR [95% CI]	*p-value	OR [95% CI]	*p-value	OR [95% CI]	*p-value	OR [95% CI]	*p-value
Children	3.036 [2.842-3.229]	0.513	3.236 [2.98-3.490]	0.042	3.550 [3.177-3.923]	0.260	3.907 [3.743-4.071]	0.125
Adolescents	2.959 [2.824-3.093]	0.011	3.169 [2.992-3.346]	0.005	3.293 [3.034-3.552]	0.031	4.062 [3.948-4.176]	0.056

OR = odds ratio; CI = confidence interval; *MVA = multivariate analysis;
Values in italics indicate statistical significance (p <0.005).

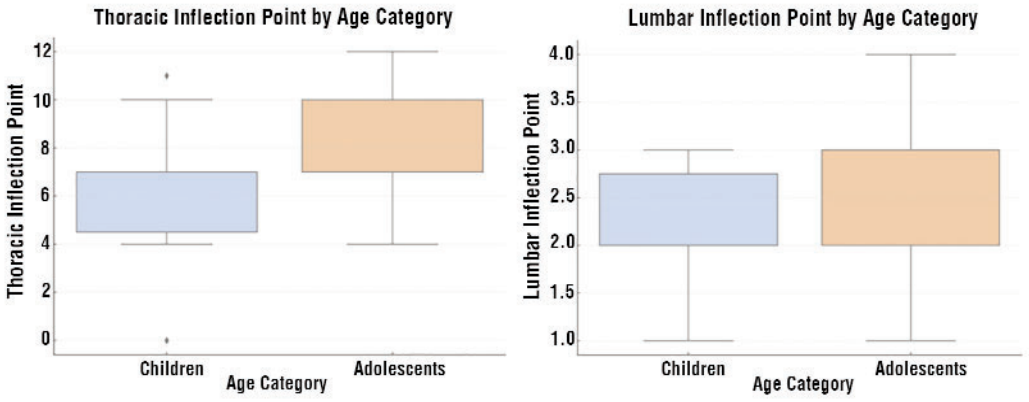

Figure 2. Inflection point of thoracic and lumbar level by age category

Similarly, appearance scores were significantly lower among adolescents (p=0.031). No significant differences were found in the function (p=0.513) and Mental Health (p=0.125) domains.

Fig. 2 presents the distribution of thoracic and lumbar inflection points. In children, thoracic inflection points were more proximal and lumbar inflection points showed limited variation. Adolescents displayed greater variability in both thoracic and lumbar inflection points.

Fig. 3 shows the correlations between major coronal curve magnitudes and SRS-22r domain scores. In adolescents, Spearman analysis indicated moderate inverse correlations between thoracic major coronal curve and both Function ($r = -0.45$, $p = 0.011$) and Appearance scores ($r = -0.52$, $p = 0.004$). No significant correlations were found between lumbar major coronal curve and any SRS-22r domain in either age group. Correlation coefficients in the children group were low and did not reach statistical significance.

Fig. 4 illustrates the relationship between physical activity levels and major coronal curve severity. In children, physical activity scores remained relatively uniform across Cobb angle values. In adolescents, lower physical activity scores were observed in association with higher thoracic major coronal curves.

Discussions

The present study shows that adolescents with Lenke type 3 double major curves report significantly lower SRS-22r scores in the Pain, Function, and particularly Appearance domains compared with children (<12 years). These findings are consistent with previous literature reporting that greater curve magnitude is associated with poorer HRQoL, especially in relation to pain and self-image (8,17).

Several reports have shown that adolescents with major coronal curves exceeding 30°-45° exhibit significantly reduced SRS-22r scores (18,19). Our results correspond with these findings, as adolescents demonstrated lower Appearance and Pain scores and moderate inverse correlations with thoracic curve magnitude. These outcomes align with those of Toren et al. who reported marked deterioration in self-image and pain among adolescents with idiopathic scoliosis (20), as well as with Soliman et al. who noted higher QoL scores in patients with curves <40° (21).

Although we detected moderate negative correlations between thoracic Cobb angle and Function scores, the association with Mental Health was weaker – consistent with existing literature stating that curve severity has less impact on mental health unless accompanied by significant functional or cosmetic concerns (22). In addition, a registry study of 149 patients reported that self-image was more strongly associated with pain and physical function than any radiographic measure, supporting our finding that subjective perception moderates the impact of physical deformity (23).

Interestingly, no strong correlation between lumbar major coronal curve and any domain emerged in our analysis, reflecting findings from Uehara et al. who identified that thoracic curvature exerts a more profound influence on HRQoL than lumbar deformity (24). This could reflect the thoracic spine's greater role in body image and respiratory function, further affecting adolescents'

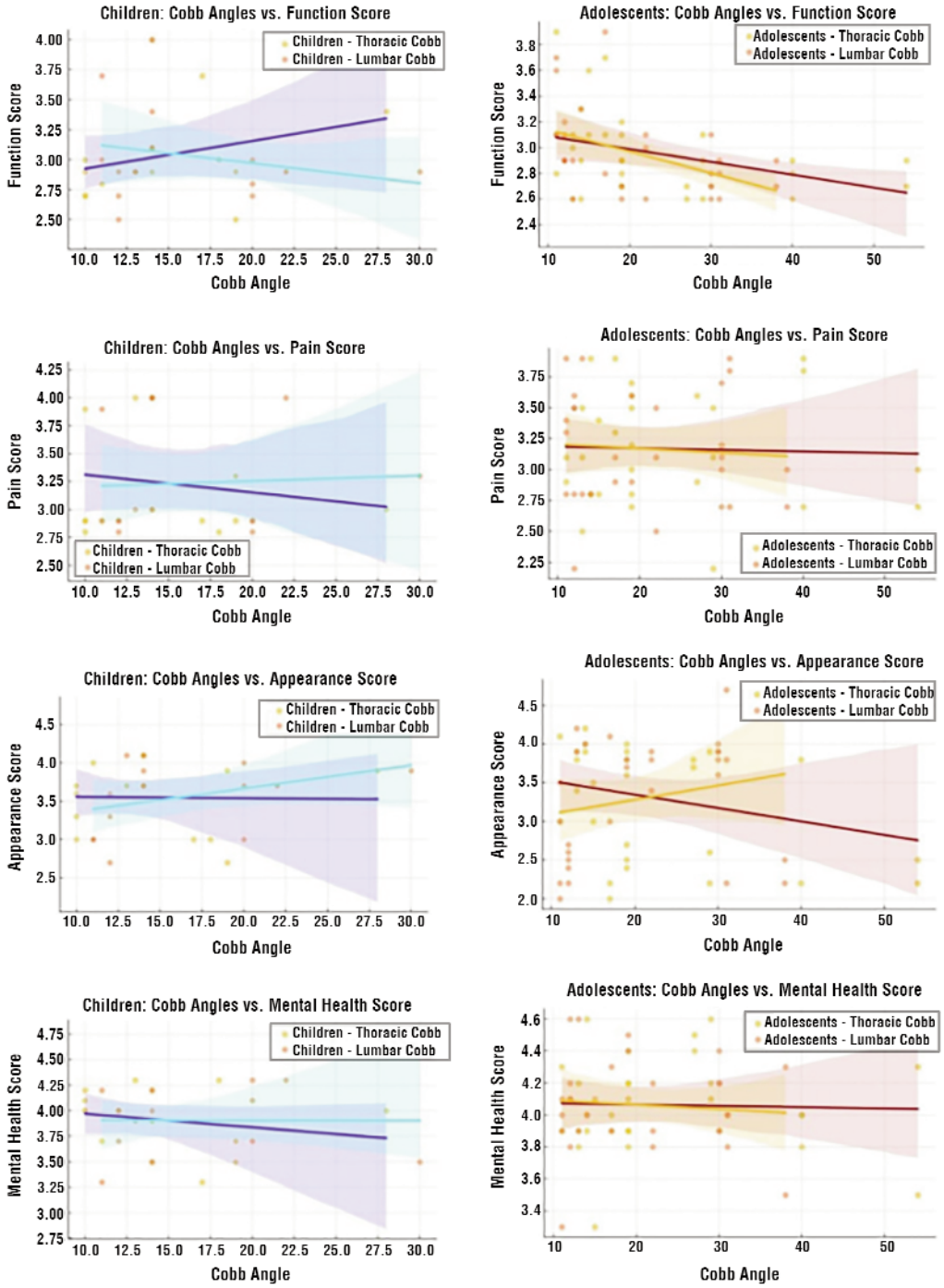

Figure 3. Major coronal curve Correlations with SRS-22r domains.

QoL. In light of these results, interventions targeting the thoracic curve – such as earlier bracing or targeted physiotherapy (e.g., Schroth exercises) – may be especially effective in preserving functional capacity and self-image during adolescence (20). These clinical approaches align with evidence supporting non-operative strategies for managing moderate curves (<40°) and preventing progression (25).

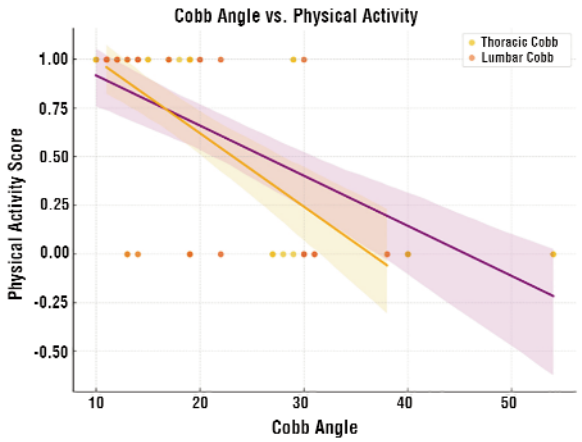

Figure 4. Correlation between major coronal curve and physical activity

Implications for Surgical Planning

Lenke type 3 double major curves require complex surgical correction due to the need to restore coronal and sagittal balance across two structural deformities. Although no patients in this cohort underwent surgery, the radiographic parameters we analyzed – major coronal curve severity, apical rotation, and inflection point distribution – are fundamental components of preoperative decision-making. Our results show that adolescents experience a marked decline in Pain and Appearance scores despite not meeting conventional surgical thresholds (>45°).

This suggests that psychosocial burden may precede radiographic severity and could justify earlier surgical consideration in selected cases. Furthermore, progression of thoracic deformity in adolescence directly affects surgical strategy, including the selection of upper and lower instrumented vertebrae and the anticipated need for extended fusion. The higher biomechanical imbalance characteristic of Lenke type 3 curves makes timely referral for surgical evaluation essential, particularly when QoL deterioration becomes evident. Integrating patient-reported outcomes with radiographic criteria may therefore optimize the timing and scope of operative correction in this challenging curve subtype.

Strengths and Limitations

One of the key strengths of this study is its focused analysis on a specific and clinically relevant subgroup of idiopathic scoliosis – Lenke type 3 double major curves – which are often underrepresented in literature despite their higher biomechanical and psychosocial burden.

Additionally, the study included age-stratified comparisons between children and adolescents, offering valuable insights into the progression of curve severity and the differential impact on quality of life across developmental stages. The use of the SRS-22r, a validated, scoliosis-specific quality of life instrument, provided robust subjective outcome data. Furthermore, multiple curve-related radiographic parameters (thoracic and lumbar major coronal curves, inflection points, and axial rotation) were statistically correlated with individual SRS-22r domains, enhancing the clinical interpretability of findings.

However, this study is not without limitations. The sample size was modest and may limit generalizability to larger populations or other scoliosis subtypes. The cross-sectional design precludes causal inference and does not allow for evaluation of long-term outcomes or curve progression. Additionally, while SRS-22r is widely used, its limitations – such as ceiling effects and cultural variability in perception – must be considered. Potential confounders such as brace compliance, physical activity levels, and socioeconomic status were not systematically assessed and may influence both spinal deformity and perceived quality of life.

Conclusions

Adolescents with Lenke type 3 double major curves show more severe thoracic deformity and greater impairment in pain and appearance than younger children. These findings indicate that QoL deterioration may occur before classical radiographic surgical thresholds are reached. Incorporating QoL assessment into routine evaluation may help identify patients who require earlier surgical referral. Early multidisciplinary review may improve timing of intervention and long-term outcomes.

Author's Contributions

Conceptualization: N.l., J.M. and F.D.E.; methodology: N.L., I.M. and F.D.E.; software: N.L.; validation: R.C.P., 0.0.C., M.P., T.V.S., M.S., 1.G.O., A.V.V. and S.P.; formal analysis: N.L., 1.M., R.C.P., 0.0.C., M.P. and F.O.E.; investigation: I.M., T.V.S., M.S., 1.G.O., A.V.V. and F.O.E.; resources: I.M., T.V.S., M.S., 1.G.O., A.V.V. and F.D.E.; data curation: J.M., N.l., R.C.P., D.O.C., M. P., F.A.M., S.P., F.D.E.; writing-original draft

preparation: N.L., J.M., and F.O.E.; writing-review and editing: N.L, I.M., N.L, and F.D.E.; visualization: T.V.S., M.S., 1.G.O., A.V.V. and S.P.; supervision: S.J., T.V.S., M.S., I.G.O., A.V.V. and S.P.; project administration: SJ., J.M., F.A.M, N.L, and F.0.E. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

None to declaire.

Ethical Statement

In compliance with the Declaration of Helsinki on human testing, the study was authorized by the Ethics Committee of the Constanta County Clinical Emergency Hospital for the Approval of Clinical and Research Developmental Studies (approval no. 21/01.12.2020). For all participants informed consent to participate was obtained from their parents or legal guardians at the time of hospital admission.

References

1. Samaan MC, Missiuna P, Peterson D, Thabane L. Understanding the role of the immune system in adolescent idiopathic scoliosis: Immunometabolic CONnections to Scoliosis (ICONS) study protocol. BMJ Open. 2016; 6(7):e011812.
2. Thong W, Parent S, Wu J, Aubin CE, Labelle H, Kadoury S. Three-dimensional morphology study of surgical adolescent idiopathic scoliosis patient from encoded geometric models. Eur Spine J. 2016;25(10):3104-3113.
3. Komang-Agung IS, Dwi-Purnomo SB, Susilowati A. Prevalence Rate of Adolescent Idiopathic Scoliosis: Results of School-based Screening in Surabaya, Indonesia. Malays Orthop J. 2017;11(3):17-22.
4. Tavana P, Akraminia M, Koochari A, Bagherifard A. Classification of spinal curvature types using radiography images: deep learning versus classical methods. Artif Intell Rev. 2023;1-33. Online ahead of print.
5. Pasha S. How different the scoliotic curves are? Stud Health Technol Inform. 2021;280:53-57.
6. Janusz P, Stepniak Ł, Kotwicki T. Cervical spine sagittal alignment in patients with idiopathic scoliosis Lenke type 1 versus type 3. Stud Health Technol Inform. 2021;280:283.
7. Stone LE, Upasani VV, Pahys JM, Fletcher ND, George SG, Shah SA, et al. Harms Study Group. SRS-22r Self-Image After Surgery for Adolescent Idiopathic Scoliosis at 10-year Follow-up. Spine (Phila Pa 1976). 2023;48(10): 683-687.
8. Toombs C, Lonner B, Shah S, Samdani A, Cahill P, Shufflebarger H, et al. Quality of Life Improvement Following Surgery in Adolescent Spinal Deformity Patients: A Comparison Between Scheuermann Kyphosis and Adolescent Idiopathic Scoliosis. Spine Deform. 2018;6(6):676-683.
9. Ward WT, Friel NA, Kenkre TS, Brooks MM, Londino JA, Roach JW. SRS-22r Scores in Nonoperated Adolescent Idiopathic Scoliosis Patients With Curves Greater Than Forty Degrees. Spine (Phila Pa 1976). 2017;42(16):1233-1240.
10. Newton Ede MM, Jones SW. Adolescent idiopathic scoliosis: evidence for intrinsic factors driving aetiology and progression. Int Orthop. 2016;40(10): 2075-2080.
11. Schlösser TP, Stadhouder A, Schimmel JJ, Lehr AM, van der Heijden GJ, Castelein RM. Reliability and validity of the adapted Dutch version of the revised Scoliosis Research Society 22-item questionnaire. Spine J. 2014;14(8):1663-72.
12. Garg B, Mehta N, Swamy AM, Kumar S, Dixit V, Gupta V. Reliability and validity of a cross-culturally adapted Hindi version of the SRS-22r questionnaire in Indian patients. Spine Deform. 2020;8(5):885-891.
13. Pearson MJ, Philp AM, Haq H, Cooke ME, Nicholson T, Grover LM, et al. Evidence of Intrinsic Impairment of Osteoblast Phenotype at the Curve Apex in Girls With Adolescent Idiopathic Scoliosis. Spine Deform. 2019;7(4):533-542.
14. Yang KG, Goff E, Cheng KL, Kuhn GA, Wang Y, Cheng JC, et al. Abnormal morphological features of osteocyte lacunae in adolescent idiopathic scoliosis: A large-scale assessment by ultra-high-resolution micro-computed tomography. Bone. 2023;166:116594.
15. Trobisch P, Suess O, Schwab F. Idiopathic scoliosis. Dtsch Arztebl Int. 2010; 107(49):875-83; quiz 884.
16. Patient Outcome Questionnaires, Scoliosis Research Society, https://www.srs.org/Research/Patient-Outcome-Questionnaires.
17. Ceballos-Laita L, Carrasco-Uribarren A, Cabanillas-Barea S, Pérez-Guillén S, Pardos-Aguilella P, Jiménez Del Barrio S. The effectiveness of Schroth method in Cobb angle, quality of life and trunk rotation angle in adolescent idiopathic scoliosis: a systematic review and meta-analysis. Eur J Phys Rehabil Med. 2023; 59(2):228-236.
18. Oeffinger DJ, Iwinski H, Talwalkar V, Dueber DM. Psychometric analysis and the implications for the use of the scoliosis research society questionnaire (SRS-22r English) for individuals with adolescent idiopathic scoliosis. N Am Spine Soc J. 2024;19:100545.
19. Ng PTT, Claus A, Izatt MT, Pivonka P, Tucker K. Is spinal neuromuscular function asymmetrical in adolescents with idiopathic scoliosis compared to those without scoliosis?: A narrative review of surface EMG studies. J Electromyogr Kinesiol. 2022;63:102640.
20. Torén S, Diarbakerli E. Health-related quality of life in adolescents with idiopathic scoliosis: a cross-sectional study including healthy controls. Eur Spine J. 2022;31(12):3512-3518.
21. Soliman HAG. Health-related Quality of Life and Body Image Disturbance of Adolescents With Severe Untreated Idiopathic Early-onset Scoliosis in a Developing Country. Spine (Phila Pa 1976). 2018;43(22):1566-1571.
22. Erşen Ö, Yüzügüldü U, Başak AM, Güveli R, Ege T. Effect of clinical and radiological parameters on the quality of life in adult patients with untreated adolescent idiopathic scoliosis: a cross-sectional study. Eur Spine J. 2023; 32(4):1196-1203.
23. Cirrincione PM, Thakur A, Zucker CP, Wisch JL, Groisser BN, Nguyen J, et al. Exploring Correlations Between Pain and Deformity in Idiopathic Scoliosis With Validated Self-reported Pain Scores, Radiographic Measurements, and Trunk Surface Topographic Measurements. J Pediatr Orthop. 2023;43(10): 608-614.
24. Uehara M, Takahashi J, Kuraishi S, Shimizu M, Ikegami S, Futatsugi T, et al. Osteoid osteoma presenting as thoracic scoliosis. Spine J. 2015;15(12): e77-81.
25. Chen AF, Bi W, Singhabahu D, Londino J, Hohl J, Ward M, et al. Converting Scoliosis Research Society-24 to Scoliosis Research Society-22r in a Surgical-Range, Medical/Interventional Adolescent Idiopathic Scoliosis Patient Cohort. Spine Deform. 2013;1(2):108-114.