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Original Article

A comparison of the effects of two different techniques on shoulder balance in the treatment of congenital scoliosis: Vertical expandable prosthetic titanium rib and dual growing rod

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Abstract

Purpose: The purpose of this study is to compare the effects of two different growth guidance techniques (dual growing rod and vertical expandable prosthetic titanium rib [VEPTR]) on shoulder balance, in the surgical treatment of congenital scoliosis. **Materials and Methods:** Thirteen patients who were operated due to congenital scoliosis are divided into two groups. The coracoid height difference and clavicular tilt angle difference were measured on standing anteroposterior X-ray images in the preoperative, early postoperative periods, and during the last follow-up. **Results:** Clinical improvement in shoulder balance was obtained in VEPTR during the last follow-up, but there was no significance in the comparison among the two groups during the last follow-up. **Conclusion:** The effect of the growth guidance techniques on shoulder balance positively contributes in the surgical treatment of congenital scoliosis.

Key words: Congenital scoliosis, dual growing rod, shoulder balance, vertical expandable prosthetic titanium rib

INTRODUCTION

Growth guidance techniques encourage spinal growth via routine lengthening procedures of the spinal instrumentation.[1]

Theoretically, as it distracts the ribs and expands thorax, expansion thoracoplasty, and stabilization with a vertical expandable prosthetic titanium rib (VEPTR) on the curve's concave side, indirectly correct the curve.[2-5] Dual growing rods are placed on both sides of the curved spine, and the single rod is placed on the concave side of the curve. Performing distraction on the tandem connectors results in a direct correction of the curve.[6-8]

While making surgical decisions regarding cosmesis for the treatment of scoliosis, in addition to the spine's coronal balance

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also shoulder balance is one of the most important criteria to be estimated.[9] The effect of growth guidance techniques on shoulder balance is temporary, and these techniques may play a role in establishing shoulder balance in the final fusion stage. Some surgeons may prefer to leave the patients with the implants that are used to perform growth guidance techniques, without performing the final fusion surgery.[10] Thus, with the use of growth guidance techniques, when the final fusion is not performed at the end of the lengthening period, the shoulder balance attained following the lengthening period gains greater importance.

The aim of this study is to evaluate how the two different growth guidance techniques radiologically effect on shoulder balance in the treatment of congenital scoliosis.

MATERIALS AND METHODS

Thirteen patients with congenital scoliosis were operated on between the years 2004 and 2011. Two different nonfusion techniques (dual growing rod and VEPTR) were performed [Figures 1 and 2]. For two groups, rod extensions were applied periodically. In Group 1, the dual rod technique was performed in 7 patients, where the side-to-side submuscular connectors were placed on both sides of the major curve. Finally, Group 2 consisted of 6 patients who were treated with VEPTR technique (including in 4 patients original VEPTR and 2 patients like VEPTR) in which the implant was applied on the concave side of the major spinal curve.

In Group 1, there were 6 female patients and 1 male patient, and the average age at the beginning of the treatment was 7.5 (range: 4.6-10) years. Group 2 consisted of 5 female patients and 1 male patient, and the average age at the beginning of the treatment was 4 (range: 1.6-6.6) years. Final fusion surgery was performed in 6 of the 7 patients in Group 1, and in 2 of the 6 patients in Group 2. Demographic characteristics can be seen in Table 1.

The lengthening procedures were performed in 6-10 months intervals. The numbers of distractions were noted for two groups.

The radiological evaluation was performed on standardized lateral and posteroanterior X-ray images obtained in the preoperative, in the early postoperative periods and during the last follow-up. Cobb's angle of the main curve, shoulder balance coracoid height difference and clavicular tilt angle difference (CHD and CTAD), and coronal balance, were measured on the radiographies.[11]

The patient was classified as shoulder imbalanced if CHD was more than 9 mm and/or CTAD was more than 4.5° [Figure 3].[12] The measurements that are expressed in millimeters were calibrated according to the scale on the digital X-ray images.

The complications were investigated.

Demographic and radiographical data of the groups were analyzed statistically using computer software (PASW version 15.0, SPSS, IBM Corporation, NY, US). Mann-Whitney U-test were used ($P < 0.05$ was significance set value) to analyze the parameters of age, lengthening numbers, follow-up time, and lengthening intervals. To analyze sex and other categorical data, Pearson Chi-square test was performed. CHD, CTAD, main curve, and coronal balance values for each group were analyzed using Mann-Whitney U-test ($P < 0.05$ was significance set value). Wilcoxon Signed-Ranks Test was used for the comparison of parameters among the two groups ($P < 0.05$ was significance set value).

Table 1: Demographic characteristics

	Group 1 Dual growing rod	Group 2 VEPTR
Number of patients	7	6
Age	7.5 (4.6-10)	4 (1.6-6.6)
Follow-up period	4.2 (2-7)	4.7 (2-6)
Average number of distractions	4.9 (4-8)	5.8 (4-7)
Diagnosis	Congenital	Congenital

VEPTR = Vertical expandable prosthetic titanium rib

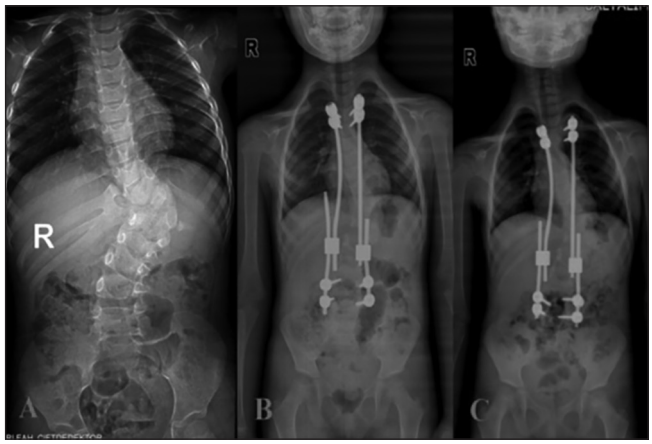

Figure 1: Posteroanterior X-ray images of a patient from Group 1 obtained in the preoperative, early postoperative periods, and during the last follow-up

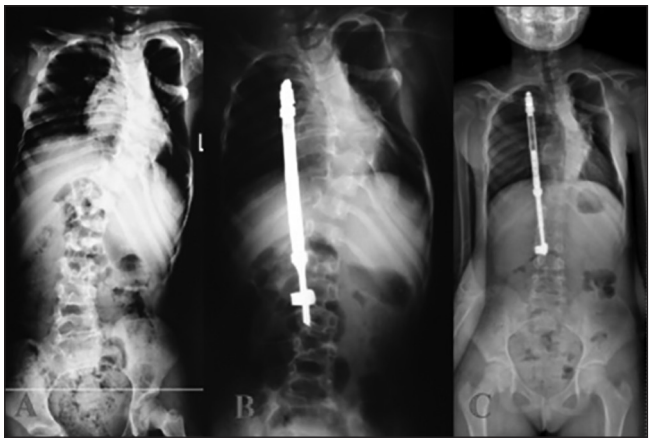

Figure 2: Posteroanterior X-ray images of a patient from Group 2 obtained in the preoperative, early postoperative periods, and during the last follow-up

RESULTS

The average follow-up periods for Group 1 and Group 2 were 4.2 (range: 2-7) years and 4.7 (range: 2-6) years, respectively. The average numbers of distractions for Group 1 and Group 2 were 4.9 (range: 4-8) and 5.8 (range: 4-7), respectively [Table 1].

For Group 1, the average preoperative CHD was 16.3 (range: 4-34) mm, the average early postoperative CHD was 14 (range: 3-33) mm ($P < 0.05$), and the average last follow-up period CHD was 16.1 (range: 7-39) mm ($P > 0.05$). For Group 2, the average preoperative CHD was 16.8 (range: 6-36) mm, the average early postoperative CHD was 13.5 (range: 4-30) mm ($P > 0.05$), and the average last follow-up period CHD was 8.8 (range: 1-22) mm ($P > 0.05$) [Table 2].

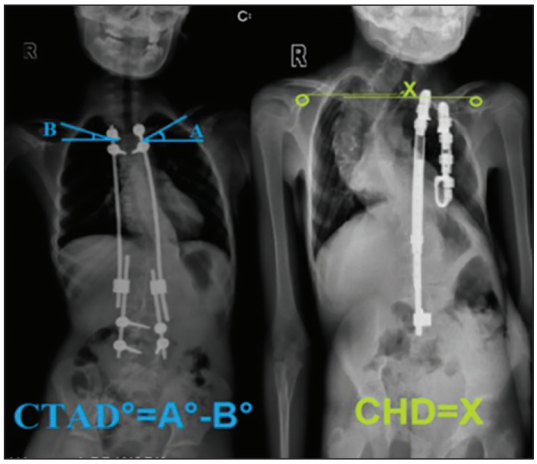

Figure 3: Measurement of radiographic shoulder balance parameters. Clavicular tilt angle difference indicates clavicular tilt angle difference and coracoid height difference indicates coracoid height difference

For Group 1, the average preoperative CTAD was 10.7° (range: 2-20°), the average early postoperative CTAD was 10.3° (range, 0-21°) ($P > 0.05$), and the average last follow-up period CTAD was 9° (range: 1-23°) ($P > 0.05$). For Group 2, the average preoperative CTAD was 9° (range: 3-23°), the average early postoperative CTAD was 7.3° (range: 1-25°) ($P > 0.05$), and the average last follow-up period CTAD was a 5° (range: 2-8°) ($P > 0.05$) [Table 2].

The average preoperative Cobb's angle of the main curve in Group 1 was 69.3° (range: 54-93°), while the average early postoperative Cobb's angle was 50.7° (range: 45-60°) ($P < 0.05$), and the average Cobb's angle during the last follow-up period was 45.1° (range: 34-60°) ($P < 0.05$). In Group 2, the average preoperative Cobb's angle of the main curve was 65.8° (range: 48-98°), the average early postoperative Cobb's angle was 57.3° (range: 44-85°) ($P < 0.05$), and the average Cobb's angle measured during the last follow-up period was 48.8° (range: 32-90°) ($P < 0.05$) [Table 2].

The average preoperative coronal balance in Group 1 was identified as 2.4 (range: 1-4.6) cm, while the average early postoperative coronal balance was 1.5 (range: 0.2-2.5) cm ($P < 0.05$), and the average coronal balance during the last follow-up period was 1.1 (range: 0.5-2.5) cm ($P < 0.05$). In Group 2, the average preoperative coronal balance was 3.3 (range: 0.4-8) cm, the average early postoperative coronal balance was 2.1 (range: 0.7-4.1) cm ($P > 0.05$), and the average coronal balance during the last follow-up period was 2.5 (range: 0.5-5.7) cm ($P > 0.05$) [Table 2].

In Group 1, 8 complications (2.6/year, 0.37/year/patient) occurred in 4 of the 7 patients (57.1%). The complications consisted of 2 hook dislocations, 2 screw pullouts, 1 rod fracture, 1 lamina fracture, 1 deep wound infection, and 1 proximal junctional kyphosis. In Group 2, 11 complications (3/year, 0.5/

Table 2: The mean values of the coronal plane parameters

	Group 1	The amount of correction (%)	Group 2	The amount of correction (%)
CHD (mm)				
Preoperative	16.3	—	16.8	—
Early postoperative	14	14.1	13.5	19.6
Last follow-up	16.1	1.2	8.8	47.6
CTAD (°)				
Preoperative	10.7	—	9	—
Early postoperative	10.3	3.7	7.3	18.9
Last follow-up	9	15.9	5	44.4
Cobb angle (°)				
Preoperative	69.3	—	65.8	—
Early postoperative	50.7	26.8	57.3	12.9
Last follow-up	45.1	34.9	48.8	25.8
Coronal balance (cm)				
Preoperative	2.4	—	3.3	—
Early postoperative	1.5	37.5	2.1	36.4
Last follow-up	1.1	54.2	2.5	24.2

CHD = Coracoid height difference; CTAD = Clavicular tilt angle difference

year/patient) occurred in 5 of the 6 patients (83.3%). These complications consisted of 3 proximal cradle migrations, 3 distal cradle migrations, deep wound infection in 2 cases, 2 hook displacements, and rod fracture in 1 case.

DISCUSSION

Management of shoulder balance as a part of cosmesis is one of the most significant criteria in scoliosis surgery, due to its impact on patient satisfaction.[13] However, as spine growth and the development of lung functions are the most essential factors to focus on, shoulder imbalance is not the main concern.[14]

In our study, we used the radiological parameters to evaluate shoulder balance, because in the relevant literature the radiological parameters that are used to evaluate shoulder balance are reported to be correlated with the clinical evaluation of the shoulder.[12,15,16] In a study carried out by Bagó *et al.*,[15] CHD was determined to be significantly linked with the real shoulder balance. Akel *et al.*,[12] evaluated shoulder balance of normal adolescent population that is evaluated both through a radiological and clinical perspective. They determined that CHD was highly correlated with the clinical evaluation parameters, while CTAD was correlated moderately. Uzümcügil *et al.*,[17] evaluated the shoulder balance in early onset scoliosis (EOS) scoliosis patients operated with a growing rod, due to various etiologies. They concluded that the CHD should be the primary parameter to be measured, as it proved to be the best method. We selected the above 2 radiological parameters for our own evaluations of shoulder balance regarding the relevant literature. Samy *et al.*,[14] reported that they have achieved improvement in Cobb's angle and modest intraoperative correction in shoulder balance in the patients with congenital scoliosis that were operated with VEPTR. They claimed that at the end of the follow-up period, CHD and CTAD parameters both improved significantly. Our analysis showed that as there was statistically significant correction only in CHD values in Group 1 in the early postoperative period. However, the correction of CHD was almost lost during the last follow-up period. Although CTAD was observed as it was corrected in the early postoperative period and during the last control, this correction was not statistically significant. In Group 2, there was a correction in both CHD and CTAD but it was not statistically significant.

In EOS patients treated with opening wedge thoracostomy by intercostal muscle lysis and VEPTR, Thompson *et al.*,[18] reported 1.19 complications per patient. Sankar *et al.*,[19] pointed out that while the complication rate of patients with a dual growing rod was 2.3/patient (average complications 0.52/year). In our study, dual growing rod led to the fewest number of complications (0.37/year/patient), while VEPTR had similarly high numbers of complications (0.5/year/patient).

In our study, two implants provided significant correction of the preoperative Cobb's angle, in the early postoperative period and follow-up period. However, the coronal balance significantly improved in Group 1, whereas it did not in Group 2.

This study's major conclusions are as follows: The VEPTR technique provided the highest rate of correction of CHD and CTAD, while the dual growing rod technique led to fewer complications, relatively better rate of correction of scoliosis and statistically better coronal balance. Both techniques provided correction in the shoulder imbalance or maintained the shoulder balance and the correction of the spinal deformity before the final fusion treatment, but the correction in the shoulder imbalance was not statistically significant. For a more accurate evaluation, a study including a larger number of patients is essential for a meaningful comparison.

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Conflicts of interest
There are no conflicts of interest.

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