

CRANKSHAFT PHENOMENON IN ADOLESCENT IDIOPATHIC SCOLIOSIS

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Introduction: Crankshaft Phenomenon refers to the loss of three-dimensional correction of the scoliotic curve which occurs after the back spine fusion is done to children who have not completely reached the skeletal maturity. Patients with infantile and juvenile idiopathic scoliosis are at the highest risk; however, this phenomenon also occurs in adolescents who are immature at the time of surgery.

The aim of this study was to determine the relationship between the age of operated patients and the possible postoperative progression of scoliotic incurvation (The Crankshaft's Phenomenon) after surgical correction of adolescent idiopathic scoliosis.

Subjects and Methods: The retrospective-prospective study was performed among 48 patients with adolescent idiopathic scoliosis, randomised selected, with both sexes included. All analyzed patients underwent a surgical correction of scoliosis through rear access, using the Isola's or the SSE (Spine System Evolution) implants. Correlation between presurgical and postsurgical values (at the end of the physiological growth) of spine scoliosis part Cobb's Angle is investigated.

Results and Conclusion: The increase of the scoliotic part curvature (an average of 16.22%) in patients operated in the period of the intensive growth of the spine can be expected due to the ratio of the measured quantities of Cobb's Angle, and the postoperative control examination in this group showed highly positive statistical correlation with $r=0.97$ correlation factor. The less increase of the curvature of the spine (an average of 7.52 %) can be expected in patients operated in the period of stagnating growth of the spine and the relationship between measured values of Cobb's Angle and the postoperative control examination in this group showed a highly positive statistical correlation (correlation factor $r=0.98$) as well. Individual size of the postoperative spinal curvature do not condition the size of the possible progression of the curvature.

Key words: Crankshaft Phenomenon - Adolescent Idiopathic Scoliosis

INTRODUCTION

Crankshaft Phenomenon refers to the loss of three-dimensional correction of the scoliotic curve and it occurs after a posterior spine fusion is done to children who have not completely reached the skeletal maturity. The physiological skeletal maturity can be identified/established using the so-called Risser's Sign. Most people with adolescent idiopathic scoliosis are skeletally mature during the surgical intervention and due to this - the correction of the scoliotic curve after the instrumentation and spine fusion usually takes place over time and does not detrimentally affect the remaining growth of the frontal part of the spine. In an immature child, however, the rear fusion can cause continued growth of the anterior spinal column which can cause the progression of the scoliotic deformity over time. This event is known as the Crankshaft Phenomenon. Dubousset named this phenomenon when he noticed that the entire spine and torso gradually

turn and deform like the front of the spine, which continues to grow and rake around the axis of the fusion mass (in a manner similar to the automotive crankshaft) [1]. Patients with infantile and juvenile idiopathic scoliosis are at the highest risk, however, this Phenomenon also occurs in adolescents who are skeletally immature at the time of the spine fusion [2].

The aim of this study was to determine the relationship between the age of the patient at the time of surgery and the possible postoperative progression of scoliotic incurvation (The Crankshaft's Phenomenon) after surgical correction of adolescent idiopathic scoliosis.

PATIENTS AND METHODS

This retrospective – prospective study was performed among 48 patients of random selection, with both sexes included, who suffered of adolescent idiopathic scoliosis.

110 patients were operated at the Orthopedic and Trauma Clinic of Tuzla University Clinical Center in period 1996 - 2011. This research did not include patients who had had the infantile, the juvenile, the congenital or the neuromuscular scoliosis operated, nor does it include the patients who had had any operative and postoperative complications. The patients who were analyzed were divided into two groups. Some belong to the group of patients with intensive growth, the age that corresponds to the first half of the adolescent age (up to 12 years for girls and 14 years for boys), while the others belong to the group of patients at the stagnation of skeletal growth, the age that corresponds to the second half of the adolescent age (up to 14 years for girls and up to 16 years for boys). All patients underwent the surgical correction of scoliosis through the rear access and the applicable instruments of Isola's and SSE (Spine System Evolution) have been used. Both - the instruments and the surgical technique were identical. We analyzed the patients at the immediate postoperative condition, as well as at the end of their physiological spine growth (what means at the time of skeletal maturity). Patients in this period were only subjected to a surgical procedure. The immediate postoperative scoliotic part Cobb's Angle values on X-ray were compared to those at the end of the spine physiological growth. The Cobb's method was used to measure the size of the spine distortions as well. The X-rays of all patients were recorded from equal distances. The statistical analysis of the collected

data was performed using the basic tests and using the descriptive statistics (determination of the means of measured values, standard deviation and standard error), but using the correlation matrix which refers to the test of correlation between the measured values as well.

RESULTS

The increase of the spinal curvature (meaning the increase of the Cobb's Angle value) during the period from operation done in adolescence (in other words - during the growth of the spine) and until the check-up (at the time of skeletal maturity) is recorded in 53% of the studied patients.

In the group of patients who underwent surgery during the period of rapid growth of the spine, there were 69.56% of examined patients with an increased Cobb's Angle, while this number was much smaller in the group of patients who underwent the surgery at the time near skeletal maturity and was 36% of the examined.

The average Cobb's Angle in all patients who underwent surgery during adolescence and physiological spine growth had a postoperative value of 19.60, while at the control exam (conducted at the time of skeletal maturity) it had a value of 220, which means that it increased by 12.2% (Figure 1 and 2).



Figure 1. Postoperative condition of the scoliotic spinal curvature during physiological growth spine (example)



Figure 2. The increase of the scoliotic curve noted of the at the control examination - at the time of complete growth of the spine (same patient after 0.98 (Figure 3))

The ratio of measured values of Cobb's Angle showed (both postoperatively and at the control examination)

a highly positive statistical correlation with the correlation factor $r = 0.98$ (Figure 3).

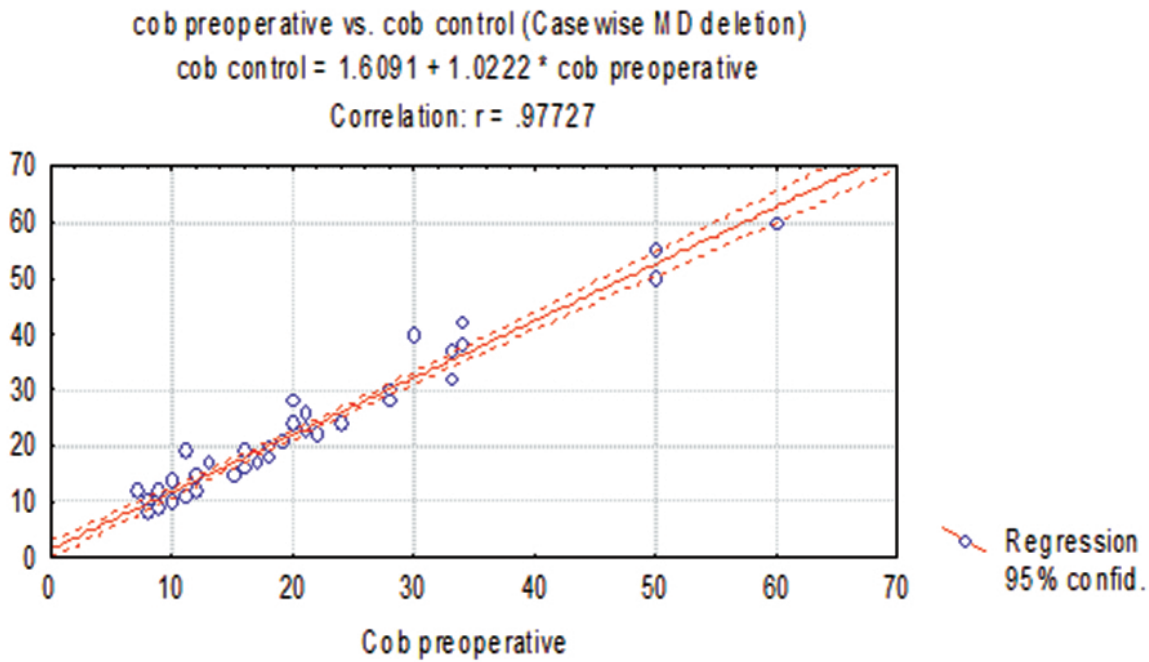


Figure 3. The ratio of measured values of Cobb’s Angle postoperatively and at the control examination

The average Cobb’s Angle in the group of patients in the age of intensive growth of the spine had a postoperative value of 20.650, while at medical follow-up done at the time of skeletal maturity – at the time of completion of the physiological growth of the spine – it had the value of 240,

showing that it increased by 16.22 %. The ratio of measured values of Cobb’s Angle showed, both postoperatively and at the control examination, the highly positive statistical correlation with the correlation factor $r = 0.97$ (Figure 4).

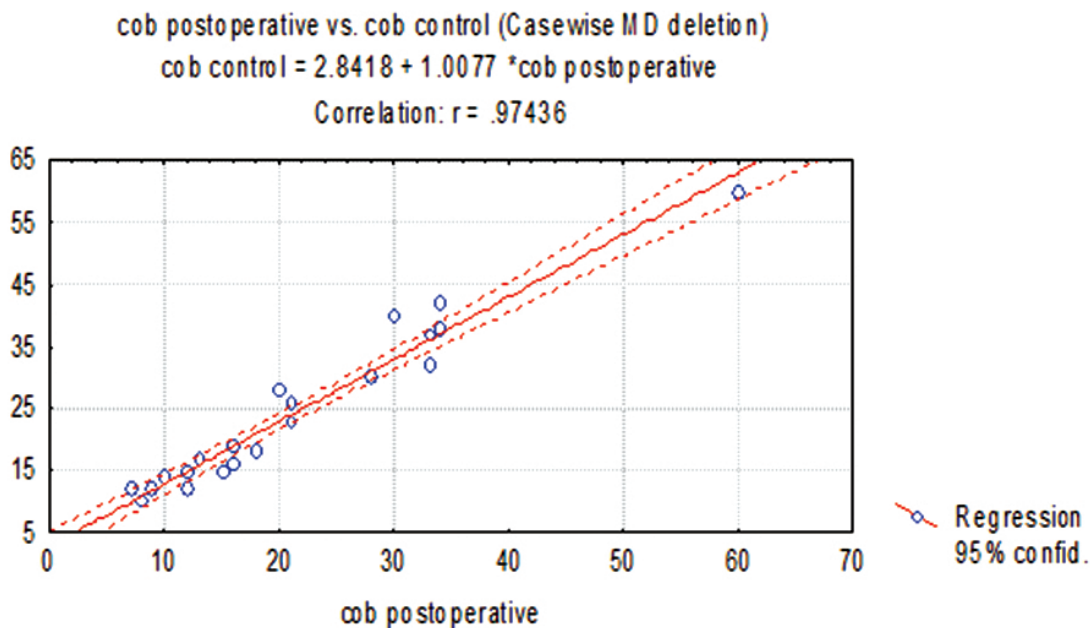


Figure 4. The ratio of measured values of Cobb’s Angle in the age group of patients with postoperative intensive growth of spine and at control examination

The average Cobb’s Angle in the second half of the studied group of patients (operated at the age of stagnating growth of the spine) had a postoperative value of 18.600, while at the control examination (at skeletal maturity) it had the value of 200, showing that it increased by 7.52 %.

The ratio of measured values of Cobb’s Angle showed (both postoperatively and at the control examination) once again the highly positive statistical correlation with the correlation factor $r = 0.98$ (Figure 5).

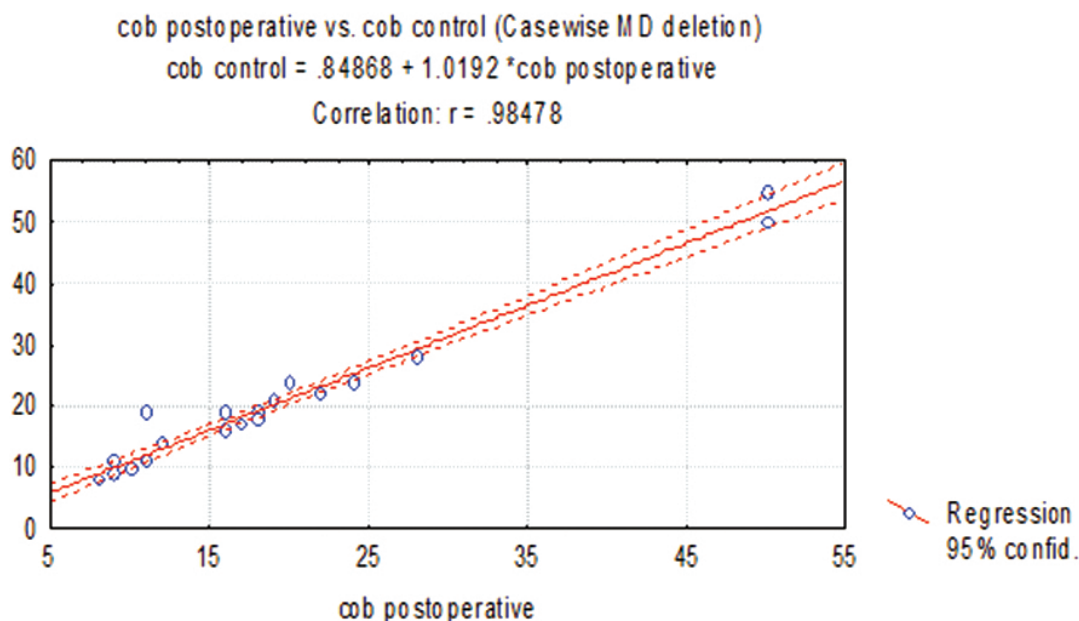


Figure 4. The ratio of measured values of Cobb's Angle in the age group of patients with postoperative stagnating growth of the spine and at control examination

The individual size of the postoperative spinal curvature does not condition the size of the possible progression of the curvature during the postoperative period to the age of the complete growth of the spine (Table 1).

Table 1. Cobb's Angle of patients with postoperative progression of the scoliosis bend at the control examination

Prva grupa intenzivnog rasta kralješnice		Druga grupa usporenog rasta kralješnice	
Postoperative	Controle	Postoperative	Controle
<i>Cob-angle</i>	<i>Cob-angle</i>	<i>Cob-angle</i>	<i>Cob-angle</i>
20	28	16	18
33	37	18	19
34	38	20	24
33	32	9	11
9	12	11	19
13	17	19	21
16	19	50	55
34	42	16	19
12	15	18	20
8	10		
28	30		
21	23		
21	26		
30	40		
10	14		
7	12		
9	12		

DISCUSSION

Lee and Nachemson assessed the progress of the postoperative deformity after the fusion in 63 patients with idiopathic scoliosis in a retrospective study. The average duration of monitoring was 5-16 years. The average progression of the deforming changes was three degrees of Cobb's Angle and three degrees of the Perdriolle rotation (from 9 to 17 degrees). The progression of Cobb's Angle of five degrees or more was recorded in 35% of cases, and more than 10 degrees was recorded in 11% of the examined patients. The chronological data from this study

showed that patients who were operated at the age of 11 or younger, have a high likelihood of progression of the postoperative deforming changes [3].

Christodoulou and associates recorded in their studies the average correction of Cobb's Angle on the examined patients with adolescent idiopathic scoliosis with 73% of the primary curve and with it, in average, 590 preoperatively to an average of only 130 postoperatively. At the end of the treatment, the average Cobb's Angle of the examined patients was 140 [4]. Yu with his associates operated 17 King type II patients. Cobb's Angle of the thoracic curve before surgery was

on average 56.90, after the surgery it was 21.60, and the average correction was 60.1%. At the final control examination, the Cobb's Angle was 23.50 [5].

Delorme and his associates analyzed 48 patients X-rays with adolescent idiopathic scoliosis who underwent rear instrumentation and spine fusion. They followed-up them preoperatively and postoperatively until they reached the skeletal maturity. In most patients (56%), there was no significant change in spinal length or in Cobb's Angle on average 2.4 years after the surgery. Cranckshaft's Phenomenon was detected in six patients (12%), where an increase in spinal length and Cobb's Angle was detected. Significant progression of the curvature of the scoliosis bend without any changes in spinal length was detected in nine patients (19%), while the increase in the length of the spine without evidence of progression of the curvature was present in six patients [6].

The results of our research also showed postoperative progression of the scoliosis curvature of the spine but in 53% of the investigated patients. Dubousset and his associates examined 39 patients with idiopathic scoliosis and found a higher resultant of postoperative progression of deforming changes in the angle and rotation of the spine in younger immature patients. The authors argue that this is an inevitable consequence of the continued growth of the anterior column of the spine in the presence of a rear fusion, and propose the anterior and posterior aspect of the compound in order to achieve stable correction in younger patients [1].

Our study also confirms bigger postoperative progression of deforming changes in younger patients. In the group of patients who underwent surgery during the period of rapid growth of the spine, there were 69.56% of the examined with an increase of Cobb's Angle at follow-ups, while this number was much lower in the group of patients who underwent surgery at the time of near skeletal maturity – during the period of stagnation of the growth the spine – and was 36% of the examined. The average Cobb's Angle in the age group of patients with intensive growth of the spine had a postoperative value of 20.650, while at the control examination (done at the time of complete physiological growth of the spine) it had the value of 240, which implicates that it increased by 16.22 %. The average Cobb's Angle in the second half of the studied group of patients operated at time near skeletal maturity – it had a postoperative value of 18.60, while during the control examination

which was conducted at the time of the completion of the physiological growth of the spine, it had the value of 200, implicating the increase by 7.52%.

CONCLUSION

The increase in the scoliosis curvature of the spine in patients operated in the age of intensive growth of the spine, an average of 16.22 %, can be expected because the ratio of measured values of Cobb's Angle showed, both postoperatively and in the control examination, a highly positive statistical correlation with the correlation factor $r = 0.97$. A much smaller increase in the scoliosis curvature of the spine, an average of 7.52 %, can be expected in patients operated at time near skeletal maturity – at the time of stagnating growth of the spine because the relationship between measured values of Cobb's Angle, both postoperatively and at the control examination in this group, again showed a highly positive statistical correlation with the correlation factor $r = 0.98$. The individual size of the postoperative curvature of the scoliosis part of the spine does not condition the size of the possible progression of the curvature.

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