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Evaluation of the Factors Affecting the Loss of Lumbar Lordosis in Surgical Treatment of Patients with Adolescent Idiopathic Scoliosis Using Segmental Instrumentation

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Abstract

Background: The identification of independent factors affecting the loss of lumbar lordosis can facilitate programmed surgery in adolescent idiopathic scoliosis (AIS) patients especially with considering the importance of sagittal characteristics.
Objectives: This study aimed to investigate the factors affecting the amount of the loss of lumbar lordosis in surgical treatment of the patients with AIS using segmental instrumentation.
Methods: In this study which was conducted in three years, 91 AIS patients who underwent segmental instrumentation were studied and 63 patients remained in the study according to the inclusion criteria. All patients' information was recorded on admission in separate forms and radiography results were coded and archived before the surgery for more evaluation. All patients were subject to standing whole spine radiograph again 12 months after the surgery. Ultimately, the information was put into predetermined forms and was used for a statistical analysis after the completion of forms.
Results: The mean age of the patients was 15.62 $\pm$ 3.09 years. The mean preoperative lumbar lordosis was 45.25 $\pm$ 12.17 degrees and the mean preoperative thoracic kyphosis was 41.54 $\pm$ 16.31 degrees. The mean postoperative lumbar lordosis was 34.37 $\pm$ 10.26 degrees. The mean postoperative thoracic kyphosis was obtained 26.56 $\pm$ 9.17. The mean surgical correction of thoracic kyphotic deformity and lumbar lordosis were correlated with each other with the correlation coefficient of 0.71 ($P < 0.001$). Men have more (16.62 $\pm$ 8.74) loss of lumbar lordosis than women (10.05 $\pm$ 8.53) ($P < 0.001$). There was not any significant correlation between the type (hook/hybrid) of the instrumentation with the loss of lumbar lordosis ($P = 0.07$, $P = 0.41$).
Conclusions: Considering the findings of this study, the most important factor affecting the amount of post-operative loss of lumbar lordosis in segmental instrumentation in AIS patients is the amount of the correction of thoracic kyphosis. So that, the greater the amount of the correction of thoracic kyphosis, the more the loss of lumbar lordosis. Men, also, have a more loss of lumbar lordosis.

Keywords: Lumbar Lordosis, Thoracic Kyphosis, Segmental Instrumentation

1. Background

Lateral curvature more than 10 degrees of the spine usually associated with rotation and without specific cause is called idiopathic scoliosis (1, 2).

Adolescent idiopathic scoliosis (AIS) is the most common type of idiopathic scoliosis including about 80-85% of the cases (2, 3). Therapeutic target in AIS patients with skeletal maturity is to bring Cobb angle to 40 degrees or less. The choice of treatment depends on the curvature and the patient's growth potential in the future (4). The primary objective in the surgical management of the patients with AIS is the prevention of curvature progression through the Spinal Fusion. Moreover, the correction of the partial curvatures if possible is the secondary objective (5). The most common surgical procedure for patients with AIS is Posterior Spinal Fusion with instrumentation (PSFI) that includes a variety of hooks, screws, and wires that can be used for connecting rod to the spinal column in different segments. Using segmental instrumentation causes more stability for the patients and helps them to move without the aid of external devices such as cast or brace a few days after the surgery (6, 7). In recent years, segmental instrumentation has been considered as a more stable structure in the surgical treatment of AIS compared to Harrington system, so that the use of this method makes 3-D curvature correction especially kyphosis correction of the thoracic spines and lumbar lordosis (2, 8). In the past, it was proven that using this method is directly related to improving the health and quality of life in patients with AIS. Identifying

independent risk factors in the loss of lumbar lordosis can facilitate surgical planning in patients with AIS, in particular, with regard to the importance of sagittal characteristics.

2. Objectives

The aim of this study was to investigate the factors affecting the amount of the loss of lumbar lordosis correction in the surgical treatment of the patients with AIS using segmental instrumentation.

3. Methods

This was a retrospective study conducted as a descriptive analytical cross-sectional research. After the ethical board's approval, all patients with AIS subject to PSFI surgery since April 2011 to April 2014 for the correction of scoliosis, were enrolled in the study. In the present study, 91 patients with AIS who underwent segmental instrumentation were studied. According to complete follow-up, 63 patients participated in the study. At the beginning of this study, a form was designed to individually record the information about each patient. The form included information such as age, sex, preoperative lumbar lordosis, postoperative lumbar lordosis, the amount of preoperative thoracic kyphosis, the amount of postoperative thoracic kyphosis, the date of the surgery, and the device used for surgery. All patients' information was recorded on admission in a separate form and preoperative coded radiographies were archived. All patients were subject to standing whole spine radiograph again 12 months after the surgery. After coding the information, radiography images were examined by an orthopedic resident and revised by a spinal surgery fellow for measuring pre- and postoperative lumbar lordosis and thoracic kyphosis.

The data were put into SPSS software 21 (statistical package for social sciences) and analysis. To investigate the descriptive statistics of the study, frequency table and t-test were used and Independent Sample T-test was applied to analyze them. Using Excel software, the difference between pre- and postoperative lumbar lordosis and thoracic kyphosis was calculated by SPSS statistical software and T-test Independent sample and their changes were studied in age, gender, and the device applied in the surgery. In this study, $P < 0.05$ was considered significant in the obtained results. Also, the mean variations were evaluated as $\pm$ 2 SD.

4. Results

91 patients were assessed at the beginning of study. Due to the incomplete records or the lack of cooperation, 28 patients were excluded from the study. 55 out of the 63 patients (87.3%) were female and 8 patients (12.7%) were male. Hybrid instrument for 31 patients (49.2%) and hook instrument for 32 patients (50.8%) were used in the surgery. The mean age of the patients was 15.62 $\pm$ 3.09 years. Mean preoperative lumbar lordosis in the patients under the study was 45.25 $\pm$ 12.17 degrees and the mean preoperative thoracic kyphosis was 41.54 $\pm$ 12.17 degrees. The mean preoperative lumbar lordosis and thoracic kyphosis of both sexes can be observed in (1).

The mean postoperative lumbar lordosis was 34.37 $\pm$ 10.26 degrees and the mean postoperative thoracic kyphosis in the patients of both sexes was 26.56 $\pm$ 9.17. The mean postoperative lumbar lordosis and thoracic kyphosis in the patients of both sexes is observed in Table 2.

According to the conducted statistical analysis, the correlation coefficient between preoperative/postoperative lumbar lordosis was 0.70 ($P < 0.001$). Moreover, the correlation coefficient between the preoperative/postoperative thoracic kyphosis was 0.68 ($P < 0.001$). Based on the conducted statistical analysis, lumbar lordosis decreased significantly in the patients. Moreover, the thoracic kyphosis also had a significant reduction after the instrumentation. The average loss of the thoracic kyphosis and lumbar lordosis of the patients was significantly correlated with a correlation coefficient of 0.71 ($P < 0.001$).

The average loss of lumbar lordosis among females was 10.05 $\pm$ 8.53 degrees and among males it was 16.62 $\pm$ 8.74 degrees ($P < 0.001$). The mean loss of thoracic kyphosis of the female and male patients studied were 13.98 $\pm$ 12.02 and 21.87 $\pm$ 13.92, respectively. The statistical analysis of the above findings shows that the amount of the loss of lumbar lordosis and thoracic kyphosis of the patients under the study is significantly correlated with sex ($P < 0.001$) (Table 3). The average loss of lumbar lordosis in the patients for whom hybrid had been applied was 9.71 $\pm$ 9.89 degrees and in the patients for whom hook had been used, it was equal to 12.03 $\pm$ 7.49 degrees. The average correction of the thoracic kyphosis in the patients for whom hybrid had been used was 15.58 $\pm$ 11.60 degrees, and in the patients for whom hook had been applied was equal to 14.40 $\pm$ 13.36 degrees, respectively (Table 3). The data analysis of this study showed that the used device (hybrid and hook) is not significantly related to the loss of lumbar lordosis and thoracic kyphosis in the patients ($P = 0.07$, $P = 0.12$).

5. Discussion

In recent years, segmental instrumentation has been known as a more stable structure in the surgical treatment of AIS compared to Harrington rodding, so that the use

Table 1. Preoperative Lumbar Lordosis and Thoracic Kyphosis in the Patients of Both Sexes Under the Study

Gender	Frequency	Mean	Variation Range
Female			
Lumbar Lordosis	55	44.42	11.54
Thoracic Kyphosis	55	40.09	15.59
Male			
Lumbar Lordosis	8	51.00	15.53
Thoracic Kyphosis	8	51.50	18.76

Table 2. Postoperative Lumbar Lordosis and Thoracic Kyphosis in Patients of Both Sexes Under Segmental Instrumentation

Gender	Frequency	Mean	Variation Range
Female			
Lumbar Lordosis	55	34.36	9.72
Thoracic Kyphosis	55	26.11	7.96
Male			
Lumbar Lordosis	8	34.38	14.28
Thoracic Kyphosis	8	29.63	15.61

Table 3. Postoperative Loss of Lumbar Lordosis in Patients Under Segmental Fixation According to Sex and Type of Instrumentation

	Loss of Lordosis	P Value
By instrumentation type		0.12
Hook	12.03 ± 7.49	
Hybrid	9.71 ± 9.89	
Gender		< 0.001
Male	16.62 ± 8.74	
Female	10.05 ± 8.53	

of this method makes three-dimensional correction, especially, correcting kyphosis of the thoracic spine and lumbar lordosis (9, 10). Moreover, it has also been proven that applying this method is directly related to improving the health and quality of the life of the patients with AIS (11, 12). The patients who have significantly lost their lordosis often need to spend high energy and a compensatory and painful mechanism such as pelvic retroversion to maintain their gravity line and balance (13, 14). The concept of spinopelvic compensatory mechanism was explained by some French researchers over 20 years ago, but it was published in the English-language papers for the first time in the past decade (15). And from then on, an almost increasing process of research in the treatment of patients with spinal sagittal problems has been observed to prove the importance of this issue. Nowadays, it is proven that Harrington rodding in the lumbar spine, significantly, leads to the loss of lumbar lordosis and consequently Flat Back Syndrome (16). With this description, the most important risk factor in creating Flat Back in the surgical treatment of AIS is the Harrington rod. But, it seems that despite using segmental instrumentation, Flat Back risk still exists today. Some studies have discussed the fixed and free vertebrae, coronal gradient of terminal vertebrae, or other parameters that can be measured by direct or lateral radiography. There are some studies about how to return lumbar lordosis most of which have investigated sagittal thoracic changes using multi-segmental instrumentation regardless of demographic/spinopelvic parameters or the parameters that can be controlled by the surgeon (10, 17, 18). The findings of this study showed that the amount of the loss of lumbar lordosis is associated with the amount of the

correction of thoracic kyphosis in segmental instrumentation method, such that more correction of the thoracic kyphosis with the correlation coefficient of 0.71 is associated with the patients' lumbar lordosis being lost. Wang et al. (19) in 2015 investigated the efficacy of surgical lumbar curve correction on thoracic curves magnitude after selective lumbar PSFI in patients with type 5 lenke. They also showed that there is a significant correlation between thoracic kyphosis increase (in hypokyphotic patients) and lumbar lordosis increase after the surgery. In a study carried out by Clement et al. (20) in 2013 to investigate the relationship between thoracic kyphosis - lumbar lordosis and sagittal pelvic parameters in patients with AIS, it was found that proximal lumbar lordosis is significantly correlated with thoracic kyphosis.

Trobisch et al. (8) carried out a study in 2012 to investigate risk factors for the loss of lumbar lordosis as a result of surgical treatment using segmental instrumentation in patients with AIS. They investigated 470 patients with AIS who underwent surgical treatment by segmental instrumentation in two groups including a group with the loss of lumbar lordosis and a group without changing. The findings showed that three factors of postoperative thoracic kyphosis change, preoperative lordosis, and surgeon play the most important role in the loss of postoperative lordosis using segmental instrumentation. In another study, De Jonge et al. investigated the sagittal result of surgical treatment of AIS with multi-segmental hook system. In this study, they found that all patients with lumbar lordosis above 60 degrees were decreased postoperatively by about 20°. In other words, they demonstrated that high preoperative lordosis is a risk factor for more loss of postoperative lordosis (21).

Finally according to the findings of the present study, the most important factor affecting the amount of lumbar lordosis in segmental instrumentation in AIS patients is the amount of thoracic kyphosis correction. So that, the greater the amount of the correction of thoracic kyphosis, the more the loss of lumbar lordosis. Also, men have a more significant loss of lumbar lordosis, and the type (hybrid/hook) of instrumentation does not have any significant effect on the loss of lumbar lordosis.

Footnotes

Authors' Contribution: Ebrahim Ameri and Hassan Ghandhari: idea formation, design of the study, and revision of the final manuscript; Farshad Nikouei: design of the study, data interpretation, and revision of the final manuscript; Saeed Sabbaghan: data acquisition, drafting of the manuscript, final revision; Abdol Razzaqh Iri: data acquisition, drafting of the manuscript; Hossein Hamdollahzadeh: data acquisition, drafting of the manuscript.

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