



Determination of Proximal Junctional Kyphosis in Adolescent Idiopathic Scoliosis Correction Fusion using Pedicle Screw Versus Hook Plus Screw Pedicle Instrumentation

**Mohamad Hossein Tabatabaei Nodushan^{1*}, Ali Andalib¹
and Mohammad Reza Etemadifar¹**

¹Department of Orthopedic Surgery, Isfahan University of Medical Sciences, Isfahan, Iran.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Spinal instrumentation in idiopathic adolescent scoliosis (AIS) aims to correct spinal deformity, and maintain spinal stability. Proximal junctional kyphosis (PJK) is a relatively common postoperative complication. Posterior-only fusion using diverse instruments such as pedicle screw and hybrid hook plus screw is favored to correct spinal deformity. The current study aims to compare PJK incidence between pedicle screw versus hybrid hook plus screw.

Methods: This non-randomized clinical trial has been conducted on 71 AIS patients undergone posterior-only spinal deformity fusion using pedicle screw only (n=42) or hook plus pedicle (n=29) implantation in 2015-20. The proximal thoracic (PT), main thoracic (MT), T5-T12 sagittal Cobb angles and proximal junctional angle (PJA) were evaluated through radiographies taken at baseline, immediately postoperative, within 6 and 18 months. PJK was defined as PJA >10 degrees.

Results: Using both pedicle screw only and hook plus pedicle have led to significant improvement in MT, PT, PJA and T5-T12 angles (P-value<0.05); however, the two groups were not statistically

different (P-value>0.05). Seventeen cases (23.9%) presented PJK among which 11 (26.2%) and 6 (20.7%) ones were in the pedicle screw versus hook plus screw implantation groups, respectively (P-value=0.54). The comparison of PJA and T5-T12 Cobb angles revealed significant difference between the PJK versus non-PJK cases (P-value<0.05).

Conclusion: AIS instrumentation was accompanied by satisfying outcomes using pedicle screw or hook plus screw. However, none of the applied instruments was superior over the other; PJK occurred in fewer cases undergone posterior-only approach of AIS correctional surgery using hook and screw.

Keywords: Follow-up studies; kyphosis; spinal fusion; adolescents.

1. INTRODUCTION

Spinal instrumentation in idiopathic adolescent scoliosis (AIS) aims to correct spinal deformity, maintain long-term spinal stability and enable the patients perform daily chores ultimately [1]. Traditionally, the correctional operations focused on coronal plane deviations, while nowadays; surgeons consider AIS as a more complex 3-dimensional deformity with notable sagittal and transverse deviations, as well. Recently, surgeons prefer more aggressive surgeries to achieve the most efficient correction in this complex deformity [2,3].

Posterior-only approach is the most favored treatment used to correct spinal deformity in three columns [4]. Nevertheless, proximal junctional kyphosis (PJK) is a relatively common postoperative complication that mostly occurs following a long instrumented posterior spinal fusion (IPSF); however, it may be detected at any level [5]. PJK can be presented with wide ranges of presentation from an incidental radiographic finding with no apparent symptoms to discomfort or pain, sagittal imbalance leading to difficulties while walking, and poor posture [6].

Hook and wire fixation has been routinely considered as a practical instrument for the appropriate correction of spinal deformity; however, recently the attentions have been turned to thoracic pedicle screws due to better perseverance of the correction and shorter fusion length. Increased rigidity of pedicle screws has decreased the incidence of thoracic kyphosis [7], whereas, screws have led to a higher PJK incidence when compared to hook constructs [1,8]. Nevertheless, paucity of knowledge is available about the incidence of PJK following each of the approaches. The current study is among the limited studies comparing efficacy, outcomes and incidence of PJK following correctional spinal deformity surgeries using pedicle screws versus hook plus screws.

2. METHODS

2.1 Study Population

The current census non-randomized clinical trial has been conducted on 71 patients with idiopathic adolescent scoliosis admitted at Alzahra or Kashani Hospitals affiliated at Isfahan University of Medical Sciences for correctional surgeries from June 2015 to August 2020.

Inclusion criteria were adolescent idiopathic scoliosis (AIS) diagnosis undergone instrumented segmental posterior spinal fusion and complete radiographic follow-up for the least period of 18 months with distinct radiographic landmarks and an age range of 10 to 25 at the time of surgery. Over 20% defect in the study checklist, rejecting to participate in the study, making decision to change the surgical plan, not fulfilling the follow-up schedule and extraction of the instruments due to any reason were determined as the exclusion criteria.

The population of this census study was selected among all patients admitted at university hospitals for treatment of AIS using posterior-only approach. The included patients were non-randomly allocated into two groups of superior thoracic fusion using either pedicle screw or hook plus pedicle screw.

2.2 Interventions

All patients had posterior procedures positioned prone. Intraoperative multimodal neurological monitoring was used in all patients with a standardized total intravenous anesthetic technique.

2.2.1 Screw implantation

Posterior constructs in the screw group included segmental pedicle instrumentation at every level on the concave side and interrupted levels on the

convex side. Routinely, some screws were left out on the convex side, with screws placed proximally and distally for anchorage and apical derotation screws placed at the apex of the curve. A pedicle screw on the concave side was absent if an attempt to place a screw in the dysmorphic pedicle on the concave side was unsuccessful. All pedicle screws were inserted with a free hand pedicle screw placement technique as described by Kim et al. [2]. An image intensifier was used to confirm placement of the pedicle screws before rod reduction. A 5.5-mm-rod-based segmental instrumentation system was used in all the cases, and 2 cross links were used in 16 of the pedicle screw constructs.

2.2.2 Hook plus screw implantation

In this group, only the supra transverse hook was used in the upper part of the construct and the rest of the fixation points are screws.

2.3 Outcomes

The demographic information (age, gender, body mass index (BMI)) and the proximal and distal fused segments were recorded in the study checklist.

The primary outcome of the interventions was to measure the alterations in diverse spinal angles following each of the interventions and compare the two approaches. Therefore, upright anterior-posterior, and lateral radiographies, supine anterior-posterior radiographies, forward-bent and lateral-bent radiographies were taken. These radiological studies were done at baseline, immediately postoperatively, within 6 and 18 months after the interventions.

According to the radiographic manifestations, the patients were primarily classified into one of the six categories of AIS using Lenke classification [9]. The radiographic assessments in both coronal and sagittal planes were measured.

The calculated angles in coronal plane included, coronal proximal thoracic (PT) Cobb angle, and main thoracic Cobb angle (MT). The measured angles in sagittal plane included proximal junctional angle (PJA) and T5-T12 sagittal Cobb angle.

Accordingly proximal junctional kyphosis (PJK) was defined as over 10 degrees of the angle between the superior edge of the last instrumented vertebrae with the inferior edge of the below vertebrae [10].

2.4 Statistical Analysis

The obtained data were entered into the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 23. Descriptive data were presented in mean, standard deviation, percentages, and absolute numbers. For analytic data, Chi-square, T-test, and repeated measure ANOVA were utilized. P-value of less than 0.05 was considered as a significant level.

3. RESULTS

The current study has been conducted on 71 AIS patients, including 42 ones undergone posterior-only approach using pedicle screw and 29 ones using hook and screw. The studied population was similar in terms of age (P-value=0.83), gender distribution (P-value=0.72), BMI (P-value=0.79) and Lenke type of the deformity (P-value=0.18) (Table 1).

Table 1. Demographic characteristics of the studied population

Variables	Pedicle screw implantation (n=42)	Hook plus screw implantation (n=29)	P-value
Age (years), mean± standard deviation	13.78±3.70	14.06±5.11	0.83*
Gender, n (%)			
Female	32 (76.2)	21 (72.4)	0.72**
Male	10 (23.8)	8 (27.6)	
BMI (kg/m ²), mean± standard deviation	23.45±2.81	25.63±2.90	0.79*
Lenkeh type, n (%)			
A	6 (14.28)	9 (31.03)	0.18
B	11 (26.19)	8 (27.58)	
C	25 (59.52)	12 (41.37)	

*independent t-test, ** chi-square test

Table 2. The comparison of different angular alterations in the pedicle screw implantation versus hook plus screw implantation

Variables	Group	Baseline	Postoperative	Within 6 months	Within 18 months	P1	P2
		Mean±standard deviation					
Main thoracic Cobb angle	Pedicle screw implantation (n=42)	60.05±5.00	27.65±2.49	30.28±4.60	33.09±2.43	<0.001	0.34
	Hook plus screw implantation (n=29)	60.68±2.51	26.48±1.45	28.58±2.86	31.80±1.50	<0.001	
P4 Proximal thoracic Cobb angle	Pedicle screw implantation (n=42)	0.58	0.08	0.02	0.01	<0.001	0.26
	Hook plus screw implantation (n=29)	26.41±1.74	20.15±1.74	20.21±1.57	18.51±1.60	<0.001	
P4 Proximal junctional angle	Pedicle screw implantation (n=42)	0.53	0.09	0.02	0.001	<0.001	0.77
	Hook plus screw implantation (n=29)	5.35±0.71	6.29±0.89	8.33±2.49	10.23±3.81	<0.001	
P4 T5-T12 sagittal Cobb angle	Pedicle screw implantation (n=42)	0.40	0.72	0.57	0.66	0.01	0.09
	Hook plus screw implantation (n=29)	26.25±3.85	20.25±3.99	22.54±3.95	22.89±3.50	0.04	
P4		0.50	0.08	0.005	0.56		

P1 and P2: Repeated measure ANOVA, P4: independent t-test

Table 2 shows the alterations in different angle measurements following each of the utilized instruments for AIS spinal deformity correction. Based on this table, using pedicle screw as well as hook plus pedicle have led to significant changes in diverse measured angles (P-value<0.05). In addition, both instrumentations were similar in the correction of deformities, in general (P-value>0.05).

Among the studied patients, 17 cases (23.9%) referred with PJK among which 16 cases (22.5%) had proximal junctional angle of 10-20

degrees and one (1.4%) patient >20 degrees. The PJK cases included, 11 (26.2%) and 6 (20.7%) ones in the pedicle screw implantation and hook plus screw implantation groups, respectively (P-value=0.54).

Table 3 compares diverse angle measurements between the patients with and without PJK regardless of the implanted devices. Accordingly, proximal junctional angles and T5-T12 Cobb angles were significantly different between the PJK versus non-PJK cases (P-value<0.05).

Table 3. The comparison of thoracic angles between PJK and non-PJK patients

Variable	PJK group (n=17)	Non-PJK group (n=54)	P-value*
Main thoracic Cobb angle			
Baseline	60.96±4.76	60.11±3.97	0.46
Post operation	30.13±4.69	29.41±3.85	0.53
Within 6 months	27.50±2.47	27.06±2.10	0.47
Within 18 months	32.93±2.46	32.45±2.10	0.43
Proximal thoracic Cobb angle			
Baseline	26.72±1.66	26.43±1.38	0.51
Post operation	20.17±1.60	19.92±1.31	0.58
Within 6 months	20.05±1.73	19.74±1.47	0.47
Within 18 months	18.36±1.55	18.09±1.39	0.50
Proximal junctional angle			
Baseline	5.14±0.82	5.51±0.75	0.09
Post operation	6.81±0.90	6.17±0.84	0.009
Within 6 months	11.63±1.91	7.13±0.81	<0.001
Within 18 months	15.57±2.81	8.36±0.89	<0.001
T5-T12 sagittal Cobb angle			
Baseline	29.00±3.30	25.08±2.95	0.001
Post operation	24.83±3.60	21.49±2.80	0.02
Within 6 months	25.62±3.63	20.35±2.87	0.003
Within 18 months	23.22±3.63	18.51±2.77	0.03

*Independent samples T-test

4. DISCUSSION

The current census study aimed to evaluate the eighteen-month follow-up outcomes of posterior-only instrumentation for AIS deformity correctional surgery and the incidence of PJK as one of the notifying complications of AIS correctional interventions. The two evaluated groups were similar in terms of age, gender distribution, BMI, Lenke type of deformity and all baseline measured spinal angles. Therefore, the probable confounding role of these factors in the final outcomes has been eliminated and the achievements can be attributed to the type of applied instruments only. Our eighteen-month follow-up investigation revealed that spinal instrumentation using pedicle screw as well as hook plus screw were accompanied by a significant improvement in all measured angles. Besides, the comparison of two instruments generally revealed similar outcomes. However, insignificantly but PJA was higher among pedicle screw implanted patients and PJK incidence was more in these cases.

Surfing the literature has shown similar findings to ours as all posterior-only approaches have been accompanied by satisfying results

regardless of using pedicle screw or hook. However, most of the studies favored applying screw pedicle because of better coronal and rotational corrections achieved in comparison to hook [11,12]. Nevertheless, sagittal malalignment is the most significant concern using screw pedicles rather than hooks [13].

According to the findings of our study, 23.9% of the cases represented PJK among which 11 ones out of 42 patients (26.2%) were in the pedicle screw group and the latter 6 ones out of 29 patients (20.7%) in the hook plus screw group. Helgeson and colleagues conducted a study to compare posterior spinal correctional fusion using using hooks, hybrid constructs, pedicle screws, and pedicle screws with hooks only at the top level. Those operated using screw pedicles represented the highest rate of PJK (8.1%) in comparison to the others, but they eventually concluded that the clinical significance of this is phenomenon is unclear [1]. The latter study by Kim et al. represented PJK incidence in 27% of the patients. Similarly, they presented higher frequency of PJK among pedicle screw implanted only group than hook only and hook plus screw groups. Furthermore, factors including, male gender, larger

preoperative thoracic kyphosis angle, greater immediate postoperative thoracic kyphosis angle decrease, and thoracoplasty performance were the factors associated with PJK incidence [8]. Failure to assess the factors associated with PJK incidence is one of the limitations of the current study.

Clements and colleagues noted that increased screw pedicle density was accompanied by a significant decrease in postoperative thoracic kyphosis, while increase in hook density revealed an inverse correlation [14]. On the other hand, postoperative decrease in thoracic kyphosis is an underlying reason for development of PJK [15]. Therefore, most of the scientists have noted that optimal corrections by pedicle screw have led to worse PJK in the follow-up assessments.

Measurements of PJK angles revealed that despite the normal ranges of this angle at baseline and even postoperative assessments, the angles initiated to turn into pathological entities (>10 degrees) within six months after the intervention and this condition deteriorated by eighteen month regardless of the type of administered instruments. Nevertheless, almost all the studies have unanimously presented higher incidence rate of PJK by applying pedicle screw as compared to hooks. The reasons contributed to this event, include remarkable increase in curve correction and therefore, decreased kyphosis, increased posterior soft tissue disruption (capsular, ligamentous, and muscular) and the construct rigidity of this instrument as compared to the hooks [13,16].

The studies in the literature represented a direct correlation between preoperative thoracic hyperkyphosis and PJK in follow-up evaluations [17]. Furthermore, they declared that postoperative substantial correctional changes in thoracic kyphosis may lead to a higher incidence of PJK in the follow-up evaluations [8]. Despite the cut-off of more than 5 degrees postoperative T5-T12 angle correction represented by Kim et al. [8] as the risk factor for PJK development, the other more recent study increased the threshold alteration in thoracic kyphosis angle to 10 degrees for further PJK development [13]. This finding is in contrast with ours, as those patients undergone hook plus screw implantation experienced more significant changes in T5-T12 angles postoperatively, while the incidence rate of PJK was less in this group.

The limitations of this study included the mid-period of following the patients. Furthermore, a larger and equal sample population can help better generalization of the outcomes. Further studies with long-term follow-up design and on larger studied populations are recommended.

5. CONCLUSION

According to this study, AIS instrumentation was accompanied by satisfying outcomes using pedicle screw or hook plus screw. However, none of the applied instruments was superior over the other; PJK occurred in fewer cases undergone posterior-only approach of AIS correctional surgery using hook and screw.

CONSENT AND ETHICAL APPROVAL

The study proposal was approved by the Ethics Committee of Isfahan University based on code (Ir.mui.med.rec.1398.087). The patients were informed about the surgical methods, their advantages and disadvantages, randomization protocol and were reassured regarding their personal information. They were requested to sign written consent form for participation in the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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