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The Frequency and Risk Factors for Cranial Facet Joint Violation during Pedicle Screw Instrumentation in Lumbar Spine Disorders

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ABSTRACT

Background Data: Cranial facet joint violation (FJV) by pedicle screws may increase stress to the level adjacent to the instrumentation and may contribute to adjacent segment disease (ASD).

Purpose: This study determines the frequency and risk factors for cranial FJV during pedicle screw instrumentation in various lumbar spine disorders.

Study Design: A retrospective study.

Patients and Methods: The data and imaging of adult patients with pedicle screw instrumentation for lumbar disorders from June 2018 to June 2021 were retrospectively reviewed for cranial FJV rate and evaluated for the role of the technique of instrumentation (conventional open or percutaneous), the facet angle (FA), the lumbar level, and the type of the disorder as risk factors for this violation. Preoperative Magnetic Resonance Imaging (MRI) was reviewed to measure the FA using T2 axial images. Postoperative Computed Tomography (CT) scans were examined to determine and grade cranial FJV.

Results: The study included 360 patients. The overall FJV rate was 17.6%. The FJV rate significantly increased among the percutaneous fixation group compared to that of the open one (29.2% vs. 15.9%, respectively, $p = 0.001$). Patients with FJV had significantly larger FAs ($p < 0.001$). Moreover, patients with significantly larger FAs had higher grades of FJV (p value < 0.001). The FJV rate significantly increased with FAs > 40.12° ($p < 0.001$). L5 level and degenerative disease were more prone to FJV and higher grades of violation.

Conclusion: The method of fixation, FA, lumbar level, and the type of lumbar disorder were the independent predictors of cranial FJV. This study reported a higher rate of FJV among patients with percutaneous fixation. The larger the FA, the higher the FJV rate and grade, especially with FAs > 40.12°, L5 level, and degenerative disease. (2021ESJ242)

Keywords: Facet angle, facet violation, lumbar spine, fixation

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INTRODUCTION

Pedicle screws have been increasingly used in lumbar spine fusions. [18-20,23] Complications have been reported in terms of pedicle violation rates, neurologic injuries, instrumentation failures, durotomies, and other parameters; however, few studies have investigated the cranial (i.e., superior-level) facet joint violation (FJV) rates and their risk factors. [3-5,9,12,19,20]

A better understanding of these facet violations could shed light on the prevalence of facet joint arthropathy [14] and junctional syndrome, which is the accelerated degenerative process that occurs in the unfused segments of the spine adjacent to the fused ones (i.e., adjacent segment disease, ASD).[19]

Individual variations exist in the change of facet angles (FAs) in the human body. FAs of different segments are different; moreover, FAs on the same segment are different. Thoracic FAs are distributed coronally, whereas lumbar FAs are distributed sagittally (average 25–56°).[10,11] To achieve the best surgical outcome, spine surgeons should be oriented with the facet joint morphometry and its possible variations among different ethnic groups.[8]

In terms of the pedicle screw technique in lumbar fixation, there is no relevant study about the effects of differences in lumbar segments and FAs on the FJV rate.[24]

Many authors have reported a superior FJV rate with percutaneous pedicle screws to that of the open technique.[24] Overall, there is no agreement on which approach has a greater incidence of FJV.[1]

This study determines the frequency and risk factors for cranial FJV during pedicle screw instrumentation in various lumbar spine disorders.

PATIENTS AND METHODS

This retrospective study was conducted at the Neurosurgery and Orthopedic Departments, Zagazig University Hospitals, Egypt. The standing data and imaging of patients with pedicle screw instrumentation for lumbar disorders from June 2018 to June 2021 were reviewed.

The study included adult patients (>18 years) of both sexes that have undergone bilateral pedicle screw instrumentation for any lumbar disorder (e.g., degenerative, traumatic, inflammatory, or neoplastic) using either the conventional open or percutaneous technique with the available preoperative MRI and postoperative CT scan obtained before hospital discharge. Patients with marked spinal deformity, unilateral instrumentation, and cranial instrumentation level extending to the thoracic spine were excluded.

Institutional Review Board (IRB) approval was obtained for this study (no. 6539-30-11-2020). The patients' consent to be enrolled in this retrospective study is not required as the patient's identity is not disclosed or compromised.

Patients were evaluated for cranial FJV rate and the role of the instrumentation technique (conventional open or percutaneous), FA, lumbar level, and the type of disorder as risk factors for this violation.

Preoperative MRI of the lumbar spine of the patients was reviewed to measure the lumbar FA based on Noren et al.'s method,[15] which is also adopted by Kong et al.[7] T2 axial images were used. FA is the angle between the reference plane and the facet line (Figure 1).[7]

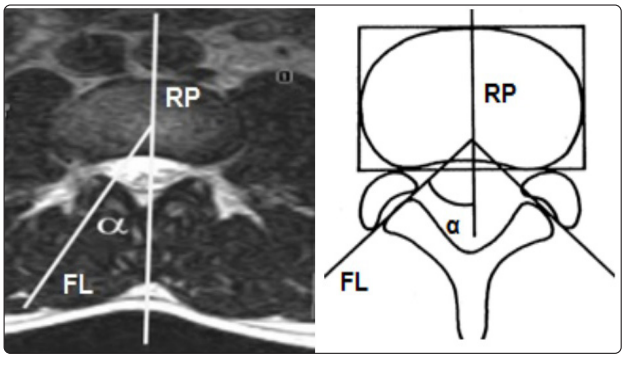

Figure 1. Reference plan (RP) is the line that passes in the mid axis of the intervertebral disc and spinous process basis, while facet line (FL) is the line that passes between the anteromedial and posteromedial border of the bilateral superior articular facet. The facet angle (α) is the angle between RP and FL.

Operative Technique:

During the study period, the patients underwent conventional open or percutaneous pedicle screw fixation techniques by the same group of consultant neurosurgeons. The procedure began with the induction of general anesthesia, followed by the patient being placed prone, prepared, and draped in a sterile manner on a Jackson table.

The Open (Conventional) Technique. A midline skin incision was made, and the thoracolumbar fascia was incised with a cautery knife. The paraspinal musculature was subperiosteally detached from the spinous processes and the laminae. The multifidus muscle was detached from the laminae, facet joints, and transverse processes. The entry point was identified and decorticated. An awl was introduced, followed by a pedicle finder with the appropriate mediolateral and craniocaudal angulation. The trajectory was palpated with a sound probe. Then, an appropriate tap was introduced, followed by an appropriately sized screw. Intraoperative fluoroscopy was used to monitor appropriateness. The rest of the screws were placed in the same manner and connected with the rod system.[2]

The Minimally Invasive (Percutaneous) Technique. This technique used intraoperative radiography (image intensifier; the fluoroscope). Adequate anteroposterior radiographs with parallel endplates and centered spinous processes were obtained. A 2 cm longitudinal incision was marked laterally to the lateral border of the pedicle. The incision was made, and monopolar fasciotomy was performed. Then, dilators were applied. The Jamshidi needle was docked onto the lateral aspect of the pedicle at the ''3 o'clock'' position and then advanced 20 mm to 25 mm into the pedicle, ensuring that the needle remains lateral to the medial pedicle wall. A K-wire was placed down the Jamshidi needle; then, a pedicle tap was placed down the trajectory of the K-wire. A final pedicle screw was placed down the K-wire. At other levels, the same steps were repeated, and the rod was inserted and secured to the screw heads.[13]

Postoperative Evaluation. Postoperative CT scans obtained before hospital discharge were examined to determine the instrumented lumbar levels, the presence and grading of the cranial FJV according to the diagnostic, and grading criteria of Babu et al.[1] (Table 1).[24]

Table 1. Classification criteria of FJV.[24]

Grade	Relationship between screws and facet joints
Grade 0	Screws not in facet
Grade 1	Screw in lateral facet but not in facet articulation
Grade 2	Penetration of facet articulation by screw, with entry distance less than 1 mm
Grade 3	Screw travels within facet articulation, with entry distance larger than 1 mm

Statistical Analysis:

Continuous variables were expressed as mean ± SD and median (range). The categorical variables were expressed as a number (percentage). Continuous variables were checked for normality using the Shapiro–Wilk test. The paired *t*-test was used to compare two dependent variables of normally distributed data, whereas the Kruskal–Wallis H test compared more than two groups of nonnormally distributed variables. On the other hand, the percentage of categorical variables was compared using Pearson's Chi-square test or Fisher's exact test. Receiver operating characteristic (ROC) curve analysis was employed to identify the optimal cutoff values of FAs with maximum sensitivity and specificity to predict FJV. Moreover, the area under curve (AUC) was calculated. The criteria to qualify for AUC were as follows: 0.90–1 = excellent; 0.80–0.90 = good; 0.70–0.80 = fair; 0.60–0.70 = poor; 0.50–0.6 = fail. The optimal cutoff point was established at the point of maximum accuracy. We used univariate and multivariate binary logistic regression to enter covariates to determine predictors for FJV. A p value <0.05 was considered significant. All tests were two-sided. SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) and MedCalc windows (MedCalc Software bvba 13, Ostend, Belgium) were used for all statistics.

RESULTS

Basic Characteristics. The study included 360 patients. Males constituted 51.5% of patients, and the mean age was 45.15 years. In total, 48 patients (13.3%) underwent percutaneous fixation; 192 patients (53.3%) had a degenerative disease. L4 (27.2%) was the most frequent lumbar level, followed by L5 (21.9%) (Table 2).

Table 2. Basic characteristics among the studied patients (N=360).

Parameters		Results
Sex	Male	186 (51.7%)
	Female	174 (48.3%)
Age	Mean±SD	45.15±13.17
	Median (Range)	46 (18 – 73)
	≤45 years	173 (48.1%)
	>45 years	187 (51.9%)
Method of fixation	Percutaneous	48 (13.3%)
	Open	312 (86.7%)
Type of lumbar disorder	Trauma	144 (40%)
	Degenerative	192 (53.3%)
	Inflammatory	6 (1.7%)
	Neoplastic	18 (5%)
Lumbar Level	L1	66 (18.3%)
	L2	61 (16.9%)
	L3	56 (15.6%)
	L4	98 (27.2%)
	L5	79 (21.9%)
FJV (720 facet joints)	Absent	593 (82.4%)
	Present	127 (17.6%)
FJV grade	Grade 0	593 (82.4%)
	Grade I	74 (10.3%)
	Grade II	37 (5.1%)
	Grade III	16 (2.2%)

FJV: facet joint violation.

Frequency of FJV. Overall, FJV occurred in 127 facets out of 720 (17.6%). Grade I violation occurred in 10.3% of facet joints (Table 2). FJV rate in the percutaneous group was 29.2% vs. 15.9% in the open group (Table 5).

Facet Angle. Patients with FJV had significantly larger FAs than those without FJV (mean: 39.43 vs. 34.65, respectively, $p < 0.001$). There was a significant difference between FAs among different grades of FJV where patients with grade III violation had the largest FAs, while patients without FJV had the smallest FAs (mean: 41.39 vs. 34.65, respectively, $p < 0.001$). Post hoc analysis between different pairs of violation grades revealed a significant difference between grade 0 and grade I, grade I and grade II, and grade II and grade III (Table 3).

Facet Angle Value as a Predictor of FJV and Its Grade. ROC curve analysis was conducted to get the cutoff of FA to predict FJV, revealing that the optimal cutoff was >40.12° with the corresponding sensitivity, specificity, and AUC being 53.5%, 97.81%, and 0.856, respectively. We used the same approach to obtain the cutoff value between grade 0 and grade I and found that the cutoff was >34.88° with corresponding sensitivity, specificity, and AUC of 94.5%, 51.1%, and 0.818, respectively. Moreover, the cutoff between grade I and grade II was >41.07° with corresponding sensitivity, specificity, and AUC of 56.7%, 83.8%, and 0.692, respectively. Lastly, the cutoff between grade II and grade III was >41.89° with corresponding sensitivity, specificity, and AUC of 68.7%, 81%, and 0.731, respectively. According to the AUC, the cutoff between violation and no violation had the largest AUC, so this cutoff had the priority. Other cutoffs were still valid but had inferior predictive values (Table 4 and Figure 2).

FJV and Its Grade among All Studied Patients in terms of Other Parameters. There was a significant association between the occurrence of FJV and method of fixation (p value = 0.001), lumbar level (p value < 0.001), type of disorder (p value < 0.001), and FA (p value < 0.001). Moreover, there was a significant association between the degree of FJV and method of fixation (p value = 0.001), lumbar level (p value < 0.001), type of disorder (p value < 0.001), and FA (p value < 0.001) (Table 5 and Figure 3).

Table 3. Facet angles among all studied patients (N = 360) (720 facet joints).

Parameters		No	Facet angles		*p* value
			Mean±SD (range)	Median	
All		720	35.49±3.86 (25.18–43.83)	35.73	--------
Side	Left side	360	35.54±3.97 (25.18–43.71)	35.79	0.323[a]
	Right side	360	35.45±3.75 (26.05–43.83)	35.63	
Lumbar Level	L1	132	38.51±2.74 (30.40–43.83)	38.70	<0.001[c]
	L2	122	31.26±3.26 (25.18–37.35)	31.47	
	L3	112	32.12±2.18 (27.70–36.10)	31.87	
	L4	196	35.16±1.87 (31.03–38.93)	35.24	
	L5	158	39.05±1.86 (35.18–42.98)	39.06	
FJV	Absent	593	34.65±3.54 (25.18–41.39)	34.83	<0.001[b]
	Present	127	39.43±2.64 (33.62–43.83)	40.43	
FJV grade	Grade 0	593	34.65±3.54 (25.18–41.39)	34.83	<0.001[c]
	Grade I	74	38.69±2.56 (33.62–43.07)	39.32	
	Grade II	37	40.06±2.41 (35.89–43.55)	41.13	
	Grade III	16	41.39±2.25 (37.27–43.83)	42.62	

FJV: facet joint violation; a: paired *t*-test; b: Mann–Whitney *U* test; c: Kruskal–Wallis H test; *p* value<0.05 is significant.

Table 4. Facet angles as a predictor of facet joint violation, ROC curve analysis.

Cutoff values	SN (95%CI)	SP (95%CI)	PPV (95%CI)	NPV (95%CI)	Accuracy (95%CI)	AUROC (95%CI)	*p* value
Violation versus no violation							
Facet angle >40.12	53.54% (44.5–62.4)	97.81 (96.3–98.8)	84% (74.9–90.2)	90.8% (89.1–92.2)	90% (87.2–92.4)	0.856 (0.828–0.881)	<0.001
Grade I versus grade 0							
Facet angle >34.88	94.59% (86.7–98.5)	51.10% (47–55.2)	19.4% (17.9–21)	98.7% (96.7–99.5)	55.9% (51.4–60)	0.818 (0.787–0.847)	<0.001
Grade II versus grade I							
Facet angle >41.07	56.76% (39.5–72.9)	83.78% (73.4–91.3)	63.6% (49.3–75.9)	79.5% (72.6–85%)	74.8% (62.1–85.2)	0.692 (0.597–0.776)	<0.001
Grade III versus grade II							
Facet angle >41.89	68.75% (41.3–89)	81.08% (64.8–92)	61.1% (42.7–76.8)	85.7% (74–92.7)	77.4% (57.7–91.1)	0.731 (0.592–0.844)	<0.001
Cutoff							
Violation	Absent	Present	Grade 0	Grade I	Grade II	Grade III	
Facet angle	≤40.12	>40.12	≤34.88	>34.88 - 41.07	>41.07 - 41.89	>41.89	

ROC curve: receiver operating characteristic curve; SN: sensitivity; SP: specificity; PPV: positive predictive value; NPV: negative predictive value; AUROC: area under receiver operating characteristic curve; 95%CI: 95% confidence interval; *p* value<0.05 is significant.

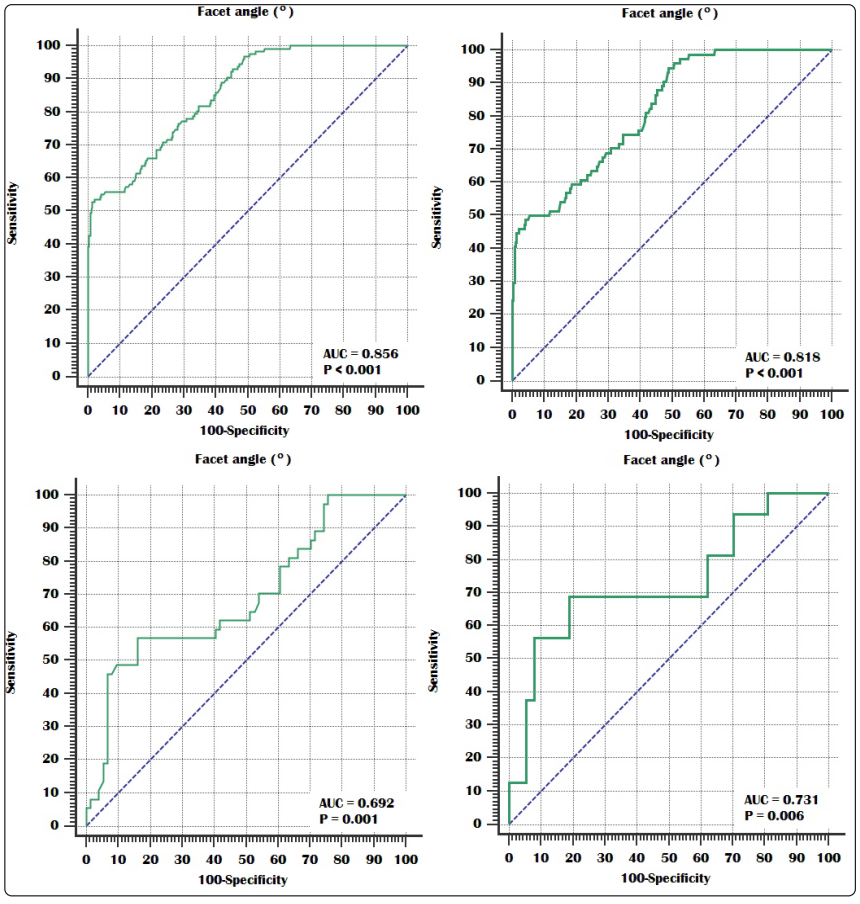

Figure 2. ROC curve analysis of facet angle as a predictor of facet joint violation: upper left, violation versus no violation; upper right, grade I versus grade 0; lower left, grade II versus grade I; lower right, grade III versus grade II.

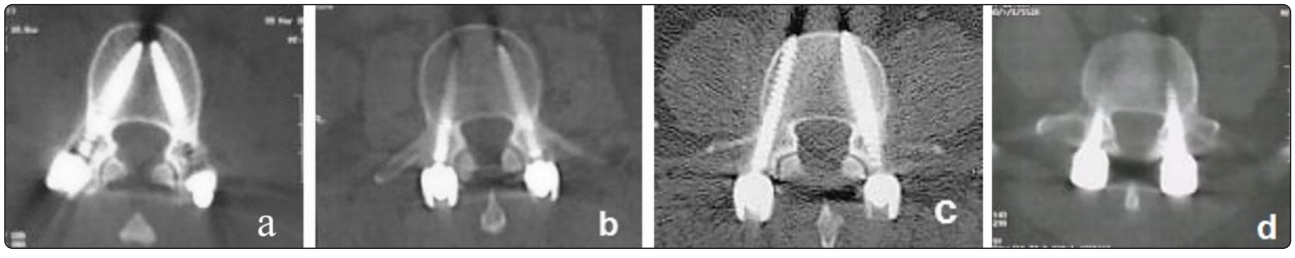

Figure 3. (A) Bilateral grade 0 FJV. (B) Bilateral grade 1 FJV. (C) Right grade 0 and left grade 1 FJV. (D) Right grade 2 and left grade 3 FJV.

FJV and Its Grade among Patients with FAs ≤40.12° (639 joints). We compared the FAs according to different parameters and an insignificant difference was found between patients who underwent percutaneous fixation and open fixation regarding FAs (mean ± SD: 34.06 ± 3.56 vs. 34.85 ± 3.37, respectively, p value = 0.058), indicating that patients who underwent percutaneous fixation were more prone to violation even if they had small FAs (Table 6).

Predictors of FJV among All Patients. Age, fixation method, type of disorder, lumbar level, and FA were unadjusted independent predictors for FJV in the univariate model. We adjusted the multivariate model by adjusting for all parameters. Before adjusting, the odds ratio (95% CI) for FA was 51.42 (26.82–98.59) and after adjusting for all variables—either significant or insignificant—in the univariate model, the adjusted odds ratio (95% CI) for facet angle became 313.479 (95.630–1027.600). When comparing the odds ratio and adjusted odds ratio for each variable, we realized large inflation of the odds ratio of FA, so we can say that FA had the upper hand (Table 7).

Table 5. Facet joint violation and its grades among all studied patients (N = 360) (720 joints).

Parameters	N	FJV		p value[d]	FJV grade				p value[d]
		Absent	Present		Grade 0	Grade I	Grade II	Grade III	
All	720	593 (82.4%)	127 (17.6%)		593 (82.4%)	74 (10.3%)	37 (5.1%)	16 (2.2%)	
Method									
Percutaneous	96	68 (70.8%)	28 (29.2%)	0.001	68 (70.8%)	16 (16.7%)	9 (9.4%)	3 (3.1%)	0.015
Open	624	525 (84.1%)	99 (15.9%)		525 (84.1%)	58 (9.3%)	28 (4.5%)	13 (2.1%)	
Side									
Left side	360	295 (81.9%)	65 (18.1%)	0.769	295 (81.9%)	38 (10.6%)	20 (5.6%)	7 (1.9%)	0.905
Right side	360	298 (82.8%)	62 (17.2%)		298 (82.8%)	36 (10%)	17 (4.7%)	9 (2.5%)	
Lumbar level									
L1	132	101 (76.5%)	31 (23.5%)	<0.001	101 (76.5%)	19 (14.4%)	9 (6.8%)	3 (2.3%)	0.002
L2	122	111 (91%)	11 (9%)		111 (91%)	8 (6.6%)	3 (2.5%)	0 (0%)	
L3	112	94 (83.9%)	18 (16.1%)		94 (83.9%)	14 (12.5%)	4 (3.6%)	0 (0%)	
L4	196	171 (87.2%)	25 (12.8%)		171 (87.2%)	13 (6.6%)	7 (3.6%)	5 (2.6%)	
L5	158	116 (73.4%)	42 (26.6%)		116 (73.4%)	20 (12.7%)	14 (8.9%)	8 (5.1%)	
Lumbar disorder									
Trauma	288	260 (90.3%)	28 (9.7%)	<0.001	260 (90.3%)	17 (5.9%)	9 (3.1%)	2 (0.7%)	0.001
Degenerative	384	291 (75.8%)	93 (24.2%)		291 (75.8%)	53 (13.8%)	26 (6.8%)	14 (3.6%)	
Inflammatory	12	11 (91.7%)	1 (8.3%)		11 (91.7%)	0 (0%)	1 (8.3%)	0 (0%)	
Neoplastic	36	31 (86.1%)	5 (13.9%)		31 (86.1%)	4 (11.1%)	1 (2.8%)	0 (0%)	
Facet angles									
≤40.12	639	580 (90.8%)	59 (9.2%)	<0.001	580 (90.8%)	40 (6.3%)	14 (2.2%)	5 (0.8%)	<0.001
>40.12	81	13 (16%)	68 (84%)		13 (16%)	34 (42%)	23(28.4%)	11(13.6%)	

FJV: facet joint violation; d: chi-square test; *p* value <0.05 is significant.

Table 6. Facet joint violation and its grade among joints with facet angle ≤40.12 (639 joints).

Parameters	N	FJV		p value[d]	FJV grade				p value[d]
		Absent	Present		Grade 0	Grade I	Grade II	Grade III	
All	639	580 (90.8%)	59 (9.2%)	-----	580 (90.8%)	40 (6.3%)	14 (2.2%)	5 (0.8%)	-----
Method									
Percutaneous	86	68 (79.1%)	18 (20.9%)	<0.001	68 (79.1%)	13 (15.1%)	4 (4.7%)	1 (1.2%)	0.001
Open	553	512 (92.6%)	41 (7.4%)		512 (92.6%)	27 (4.9%)	10 (1.8%)	4 (0.7%)	

FJV: facet joint violation; d: chi-square test; *p* value <0.05 is significant.

Table 7. Predictors of facet joint violation among all studied patients (N = 360) (720 facet joints).

Parameters	Univariate analysis				Multivariate analysis			
	β	OR (95%CI)		*p* value	β	AOR (95%CI)		*p* value
Age								
≤45 years		1.000				1.000		
>45 years	-0.075	0.927	(0.632–1.361)	0.700	-0.907	0.404	(0.216–0.756)	0.005
Constant	-1.502			<0.001				
Sex								
Male		1.000				1.000		
Female	-0.207	0.813	(0.553–1.195)	0.293	-0.321	0.726	(0.425–1.239)	0.240
Constant	-1.444			<0.001				
Method of fixation								
Open		1.000				1.000		
Percutaneous	0.781	2.184	(1.338–3.563)	0.002	1.609	4.995	(2.509–9.946)	<0.001
Constant	-1.668			<0.001				
Type of disorder								
Trauma		1.000				1.000		
Degenerative	1.088	2.968	(1.884–4.675)	<0.001	2.323	10.202	(4.266–24.398)	<0.001
Inflammatory	-0.169	0.844	(0.105–6.783)	0.873	-0.501	0.606	(0.040–9.264)	0.719
Neoplastic	0.404	1.498	(0.539–4.161)	0.438	1.535	4.644	(1.356–15.899)	0.014
Constant	-2.228			<0.001				
Lumbar level								
L1	1.131	3.097	(1.480–6.484)	0.003	-1.380	0.252	(0.061–1.040)	0.057
L2		1.000				1.000		
L3	0.659	1.932	(0.869–4.295)	0.106	0.692	1.998	(0.811–4.920)	0.132
L4	0.389	1.475	(0.698–3.118)	0.308	-0.151	0.860	(0.371–1.994)	0.725
L5	1.296	3.654	(1.791–7.454)	<0.001	-2.067	0.127	(0.037–0.434)	0.001
Constant	-2.312			<0.001				
Side								
Left		1.000				1.000		
Right	-0.057	0.944	(0.644–1.385)	0.769	0.108	1.115	(0.659–1.886)	0.686
Constant	-1.513			<0.001				
Facet angle								
≤40.12		1.000				1.000		
>40.12	3.940	51.421	(26.819–98.592)	<0.001	5.748	313.479	(95.630–1027.600)	<0.001
Constant	-2.285			<0.001				
Model constant					-3.315			<0.001

β: regression coefficient; OR: odds ratio; AOR: adjusted odds ratio; CI: confidence interval; *p* value < 0.05 is significant.

DISCUSSION

In the present study, 360 Egyptian patients with pedicle screw instrumentation were retrospectively evaluated for the frequency of cranial FJV and the role of the technique of pedicle screw instrumentation (conventional open or percutaneous), the FA, the lumbar level, and the type of the lumbar disorder as risk factors for this violation.

The primary concern of this study was to

investigate the FA from the surgical point of view as a risk factor for FJV during lumbar fixation; moreover, a morphometric analysis of the facet joints among the Egyptian population was also conducted. To the best of our knowledge, data are scarce about facet morphometry among different ethnicities, especially Egyptians, and most studies were in western countries.[8]

The overall FJV rate was 17.6%. The FJV rate significantly increased among the percutaneous fixation group than the open one (29.2% vs. 15.9%, respectively). Patients with FJV had significantly larger FAs. Furthermore, patients with significantly larger FAs had higher grades of FJV. We noticed that patients who underwent percutaneous fixation were more prone to FJV even if they had small FAs. According to our data, the FJV rate significantly increased with FAs >40.12°. The lumbar level significantly affected the FJV rate and grade: the L5 level was more prone to FJV and higher grades of violation. Also, patients with the degenerative disease were more subject to FJV than patients with other disorders. The fixation method, facet angle, lumbar level, and type of lumbar disorder were the independent predictors of FJV in the univariate analysis with a pivotal role of the FA, especially when >40.12°.

Regardless of the insertion technique, whether open or percutaneous, pedicle screw instrumentation has allowed for more stable constructs, earlier mobilization, and better deformity correction through the use of three columns of spinal fixation.[16] Cranial (i.e., superior-level) FJV by pedicle screws may contribute to ASD. There are limited relevant studies on the effects of differences in segments, type of lumbar disorder, and FAs on the FJV rate. Moreover, few studies have compared FJV in open or percutaneous fixation cases.[1,14]

As FJV may be a factor for the development of ASD, Babu et al.[1] evaluated the FJV and its grades in those who underwent further lumbar surgery as a result of symptomatic ASD. They found that high FJV rates and the incidence of grade II violations were significantly higher in those patients and grade III violations were 8-fold higher than those who did not develop ASD. However, many other factors, such as the length of the fusion construct, may also contribute to the development of ASD. They concluded that the exact impact of FJV on this outcome is unclear, and the lack of long-term follow-up is inadequate to make conclusive statements regarding the development of ASD in patients with FJV. They recommended that further studies are warranted to identify the independent predictive factors for ASD.[1] The rate of symptomatic ASD ranges from 12.2 to 18.5% in patients with pedicle screw instrumentation and from 5.2 to 5.6% in patients with other forms of instrumentation.[21]

A study on 91 patients with lumbar degenerative diseases treated with percutaneous pedicle screw fixation has found an overall superior FJV rate of 34.07% and a high-grade violation rate of 16.06% that was significantly higher with FA ≥40°.[25]

In a retrospective study, Teles et al.[22] have reviewed 131 patients who underwent posterior lumbar instrumented fusions and found a FJV rate of 28% in the percutaneous technique group and 12.3% in the open surgery group and concluded that coronal orientation of the facet joint (FA 45°>) is a significant risk factor for facet violation independent of the surgical technique.

Another retrospective study [24] has evaluated 115 patients who underwent percutaneous pedicle screw fixation and found a total FJV rate of 30.46%. When FA was >35 degrees, the FJV rate increased dramatically. The authors attributed their results to the overlapping between the oval-shaped pedicle ring and the projection of the facet joint in the intraoperative fluoroscopy during percutaneous fixation, which becomes more significant with larger FAs. [24] Similarly, Jones-Quaidoo et al. [6] conducted a retrospective comparative cohort of 132 patients. The FJV rate was 13.6% in the percutaneous and 6% in the open group. They concluded that using a percutaneous method to insert pedicle screws results in a statistically significantly higher incidence of FJV, even if only proximal screws are considered. [6]

Regarding the fixation method, Babu et al.[1] have retrospectively reviewed 126 open and 153 percutaneous cases. They found that percutaneous procedures had a higher overall FJV rate and a greater incidence of high-grade violations than open procedures.[1] In a research on the incidence and factors related to FJV by percutaneous pedicle screws, Park et al.[17] have found a 50% overall incidence of patient violations and a 31.5% incidence of screw violations, which were significantly higher in the percutaneous screw procedures. The violations were three times more frequent at the most cranial pedicle screws of L5.[17] Moshirfar et al.[14] have retrospectively evaluated 204 patients who underwent pedicle screw instrumentation of the lumbar spine via a posterior midline surgical approach for superior FJV. Superior FJV occurred in 15% of screws and 24% of patients, more frequently in single-level than in multiple-level procedures and most frequently with the most cephalad screws at L5.[14]

Regarding the rate of top-level FJV after pedicle-instrumented lumbar fusions with a Wiltse muscle-splitting approach, Shah et al.[19] have conducted a study on 106 patients and found that despite necessary intraoperative precautions regarding the pedicle entry point and use of lateral fluoroscopy, top-level FJV was common: 33% to 35% of patients and 20% to 23% of the most cephalad pedicle screws. [19]

As a retrospective study, our study has the limitation of any retrospective one, including a heterogeneous group of patients, incomplete follow-up data, and lack of some outcome parameters specifications. Moreover, the patients included in this study are of a single population and there are anatomical differences in FAs; consequently, FJV rates exist among different populations; further comparative multiethnic studies should be conducted. Prospective studies should be undertaken to avoid FJV intraoperatively by adjusting the checkpoints on the C-arm fluoroscopy and using assisting technologies such as 3D fluoroscopy and navigational and robotic technologies. The actual contribution to the development of ASD, together with other independent predictive factors, should be addressed in further large-scale, long-term follow-up studies.

CONCLUSION

The fixation method, FA, lumbar level, and type of lumbar disorder were the independent predictors of cranial FJV. This study reported a higher rate of FJV among patients with percutaneous pedicle screw instrumentation than their counterparts with the conventional open technique. The larger the FA, the higher the FJV rate and the higher the grade of the violation. FJV rate significantly increased with FAs >40.12°. The lumbar level (especially L5) and degenerative disease (rather than other lumbar disorders) significantly increased the FJV rate. Spine surgeons should consider these risk factors to limit their role in developing ASD.

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ABBREVIATION'S LIST

ASD: Adjacent Segment Disease
AUC: Area Under Curve
CT: Computed Tomography
FA: Facet Angle
FJV: Facet Joint Violation
FL: Facet line
IRB: Institutional Review Board
MRI: Magnetic Resonance Imaging
ROC: Receiver Operating Characteristic
RP: Reference plan

الملخص العربي

معدل الحدوث وعوامل الخطورة لانتهاك مفصل الوجيه القحفي أثناء تركيب مسامير عنق الفقرات في اضطرابات الفقرات القطنية

البيانات الخلفيه: قد يزيد انتهاك مفصل الوجيه القحفي بواسطة مسامير عنق الفقرات من الضغط على المستوى المجاور للتثبيت وبالتالي يساهم في الاعتلال الفقاري المجاور.

الغرض: تهدف هذه الدراسة لتحديد معدل حدوث وعوامل الخطورة لانتهاك مفصل الوجيه القحفي أثناء تركيب مسامير عنق الفقرات في اضطرابات الفقرات القطنية.

تصميم الدراسة: دراسة مرجعية.

المرضي و الطرق: تم مراجعة بيانات وأشعات المرضى البالغين الذين خضعوا لتركيب مسامير عنق الفقرات بسبب اضطرابات الفقرات القطنية بأثر رجعي في الفترة من يونيو 2018 وحتى يونيو 2021 وذلك من حيث معدل حدوث انتهاك مفصل الوجيه القحفي ، ودور التقنية المستخدمة في تركيب المسامير ما إذا كانت الطريقة التقليدية المفتوحة أو عن طريق الجلد، وزاوية الوجيه، والمستوى القطني ، ونوع المرض كعوامل خطورة للانتهاك. كما تم مراجعة أشعة الرنين المغناطيسي قبل الجراحة لقياس زاوية الوجيه والأشعة المقطعية بعد الجراحة لتحديد وقياس درجة انتهاك مفصل الوجيه القحفي.

النتائج: اشتملت الدراسة على 360 مريض وبلغ معدل انتهاك مفصل الوجيه القحفي الكلي 17.6% والذي زاد بشكل ملحوظ في مجموعة التثبيت عن طريق الجلد. وقد كانت زاوية الوجيه كبيرة في المرضى الذين حدث لديهم انتهاك لمفصل الوجيه القحفي والعكس صحيح حيث زاد معدل الانتهاك في الزوايا أكبر من 40.12°. كما كان المستوى القطني الخامس والأمراض التنكسية عرضة أكثر من غيرهم لحدوث الانتهاك وزيادة درجته.

الخلاصة: تعد طريقة التثبيت وزاوية الوجيه والمستوى القطني ونوع الاضطراب القطني هي العوامل التي تنبئ بحدوث انتهاك مفصل الوجيه القحفي. وقد سجلت هذه الدراسة معدلات حدوث عالية لانتهاك مفصل الوجيه القحفي في مرضى التثبيت عن طريق الجلد، وكلما زادت زاوية الوجيه زاد معدل انتهاكه بخاصة الزوايا أعلى من 40.12° وكذلك المستوى القطني و الامراض التنكسية.