ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Spine

Editor
Nancy E. Epstein, MD
Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook

SNI
Open Access

Original Article

Confirmation of accuracy/inaccuracy of lumbar pedicle screw placement using postoperative computed tomography

Mohamed M. Arnaout[1], Magdy O. ElSheikh[1], Mansour A. Makia[1]

Department of Neurosurgery, Faculty of Medicine, Zagazig University, Zagazig, Egypt.

E-mail: *Mohamed M. Arnaout - mohamedarnaout@yahoo.com/mmarnaout@zu.edu.eg; Magdy O. ElSheikh - drmagdyelsheikh@gmail.com; Mansour A. Makia: doc_man201@yahoo.com

***Corresponding author:**
Mohamed M. Arnaout, Department of Neurosurgery, Faculty of Medicine, Zagazig University, Zagazig, Egypt.

mohamedarnaout@yahoo.com/mmarnaout@zu.edu.eg

Received : 19 March 2021
Accepted : 25 August 2021
Published : 11 October 2021

DOI
10.25259/SNI_290_2021

Quick Response Code:

ABSTRACT

Background: Transpedicular screws are extensively utilized in lumbar spine surgery. The placement of these screws is typically guided by anatomical landmarks and intraoperative fluoroscopy. Here, we utilized 2-week postoperative computed tomography (CT) studies to confirm the accuracy/inaccuracy of lumbar pedicle screw placement in 145 patients and correlated these findings with clinical outcomes.

Methods: Over 6 months, we prospectively evaluated the location of 612 pedicle screws placed in 145 patients undergoing instrumented lumbar fusions addressing diverse pathology with instability. Routine anteroposterior and lateral plain radiographs were obtained 48 h after the surgery, while CT scans were obtained at 2 postoperative weeks (i.e., ideally these should have been performed intraoperatively or within 24–48 h of surgery).

Results: Of the 612 screws, minor misplacement of screws (≤2 mm) was seen in 104 patients, moderate misplacement in 34 patients (2–4 mm), and severe misplacement in 7 patients (>4 mm). Notably, all the latter 7 (4.8% of the 145) patients required repeated operative intervention.

Conclusion: Transpedicular screw insertion in the lumbar spine carries the risks of pedicle medial/lateral violation that is best confirmed on CT rather than X-rays/fluoroscopy alone. Here, we additional found 7 patients (4.8%) who with severe medial/lateral pedicle breach who warranting repeated operative intervention. In the future, CT studies should be performed intraoperatively or within 24–48 h of surgery to confirm the location of pedicle screws and rule in our out medial or lateral pedicle breaches.

Keywords: Computed tomography, Fixation, Lumbar spine, Outcome, Pedicle screw

INTRODUCTION

Transpedicle screws are extensively utilized in the lumbar spine to address instability (i.e., degenerative lumbar spondylolisthesis/deformity, infection, tumors, and other).[2] Computed tomography (CT) scans best document adequate screw position, while also excluding other pathology (i.e., hematomas/seromas).

Routine intraoperative conventional fluoroscopy used for pedicle screw placement has been associated with up to a 40% rate of iatrogenic neural/vascular/other injury, in some cases warranting surgical revision.[1,3,9]

Here, we compared the utility of 24–48 h postoperative X-rays versus 2-week postoperative CT scans in confirming the adequacy of pedicle screw placement or the documentation of/extent of medial/lateral pedicle breaches.

MATERIALS AND METHODS

Over a period of 6 months, a consecutive series of 612 pedicle screws were primarily or secondarily placed from L1-L5 in 145 patients. Lumbar fusions were performed for degenerative lumbar disease, degenerative spondylolisthesis, spinal deformity, trauma, or neoplastic lesions [Tables 1 and 2]. The series included 93 males (64.1%) and 52 females (35.9%), averaging 39.3 years of age (range 21–60 years old). Notably, patients presented with varied clinical syndromes and neurological deficits [Table 1].

Surgery

Intraoperatively, pedicle screws were placed utilizing fluoroscopy alone. Routine anteroposterior and lateral plain radiographs were then obtained within 48 h postoperatively, while CT studies were performed at 2 postoperative weeks (i.e., the time of postoperative visits) CT grades for pedicle screw placement included: adequate screw location, or minor (<2 mm), moderate (>2 and <4 mm), or severe (>4 mm) misplacement. In addition, screw positions were correlated with outcomes (i.e., using visual analogue scale [VAS] scores) and with back/lower extremity pain lower limb (LL), both immediately, at 48 h, and 6 months postoperatively.

Table 1: Demographic data and presenting symptoms.

	n=145	%
Age (year)	39.9±11.902	
Gender		
Male	93	64.1
Female	52	35.9
Indication of operation		
Disc prolapse/instability	12	8.3
Lumbar canal stenosis (LCS)	20	13.8
Recurrent disc prolapse (LDP)/instability	21	14.5
Spondylolisthesis	68	46.9
Traumatic	24	16.5
Motor manifestations		
Full motor power	104	71.7
Unilateral 3–4/5 iliopsoas/quadriceps	8	5.5
Paraparesis 0-2/5	5	3.5
Unilateral 3–4/5 dorsiflexor/plantar flexor	28	19.3
Sensory manifestations		
Hypoesthesia	9	6.2
Paresthesia	3	2.1
Sciatica	133	91.7

Table 2: Level and inserted screws distribution.

Vertebral level	Number of inserted screws	Number of breaching screws (%)
L1	18	0 (0.0)
L2	42	3 (7.1)
L3	98	27 (27.5)
L4	244	69 (28.3)
L5	210	46 (21.9)

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA), and P <0.05 was considered statistically significant.

RESULTS

We found that 467 (76.3% of total) pedicle screws were adequately placed, while 104 (16.9%) had minor, 34 (5.6%) had moderate pedicle breaches; none required repeated surgery. The most common level for a breach was at the L4 level (i.e., 28.3% of L4 screws were misplaced) [Table 2]. The incidence of lateral wall penetration was more common than medial penetration (81 screws vs. 64 screws, respectively) [Figures 1 and 2, Table 3]. Postoperative neurological events after pedicle screw insertion were documented in 7 patients (1.1% of total screws).

Severe pedicle breaches were all requiring urgent/emergent surgical correction. At these latter reoperations, the entry points were rechecked with biplanar intraoperative fluoroscopy [Table 4].

Table 3: Comparison of VAS between patients with different degrees of breaching.

Mean of VAS	Degree of screw breaching by CT			Test	
	Minimal	Moderate	Severe	KW	*P*
VAS back	6 (4–8)	7 (2–8)	4 (3–5)	2.298	0.235
Immediate postoperative VAS back	1.5 (0–3)	1 (0–6)	1 (1–1)	2.464	0.292
Late postoperative VAS back	0 (0–1)	0 (0–1)	0 (0–0)	0.942	0.624
P (Fr)	<0.001**	<0.001**	0.135		
VAS LL	5 (3–7)	6 (3–8)	6.5 (6–7)	2.783	0.249
Immediate postoperative VAS LL	2 (2–4)	3 (1–4)	2.5 (2–3)	0.224	0.894
Late postoperative VAS LL	1 (0–2)	1 (0–1)	1 (1–1)	0.263	0.877
P (Fr)	<0.001**	<0.001**	0.135		

t Independent sample t-test, ∞Mann–Whitney U-test, F repeated measure ANOVA, Fr Friedman test, **P≤0.001 is statistically highly significant, LL: Lower limb, VAS: Visual analog scale, CT: Computed tomography

Table 4: Malpositioned screws underwent revision surgery, radiological and clinical outcomes.

Patient	Age	Gender	Lumbar spine level	Direction of pedicle violation	Intraoperative dural injury detection	Postoperative clinical manifestation	Allocated time from CT scan to revision surgery
1	33	F	L4	Lateral	No	Obtained good fusion with low back pain improvement	Next day elective
2	56	M	L3	Medial	Yes	Improved weakness	Urgent basis
3	68	F	L1	Medial	Yes	Improved weakness	Urgent basis
4	54	M	L5	Medial	No	Improved radicular pain	Next day elective
5	44	F	L3	Lateral	No	Good fusion with low back pain improvement	Next day elective
6	37	F	L2	Medial	Yes	Improved weakness and radicular symptom	Next day elective
7	52	M	L4	Medial	No	Improved weakness and radicular pain	Urgent

CT: Computed tomography

Table 5: Grading of cortical bone breach of the pedicle by transpedicle screw.

Grade	Breach of pedicle	Clinically
I	≤2.0 mm breach	Acceptable
II	2–4 mm	Usually stable
III	>4 mm	Critical

Postoperative neurological improvement

Nearly 87% of the patients showed immediate postoperative improvement in sensory function that increased to 100% at 6 postoperative months. Motor recovery was immediately seen in 70% of patients, with only minimal additional improvement (73.1%) at 6 postoperative months.

DISCUSSION

CT grading of screw placement and safety zones

In this study, we grade pedicle screw position as adequate (within the pedicle), or minor (< 2 mm), moderate (>2–< 4 mm), and severe (>4 mm) [Table 5].[7]

Notably, there is a "safe zone of 4 mm," comprised 2 mm of epidural space and 2 mm of subarachnoid space (i.e., which can accommodate part of a misplaced screw). If the infringement is more than 4 mm, it should be considered critical and revision should be planned.[2] New postoperative neurological deficits after pedicle screw insertion are reported as occurring from 0.4 up to 16.6% of the time; here, this was encountered in 7 (4.8% of total breached screws) patients. We readily diagnosed these seven patients utilizing CT studies at 2 postoperative weeks; clearly these CT scans should be optimally performed intraoperatively or within 24–48 h of surgery to more timely perform needed revisions.

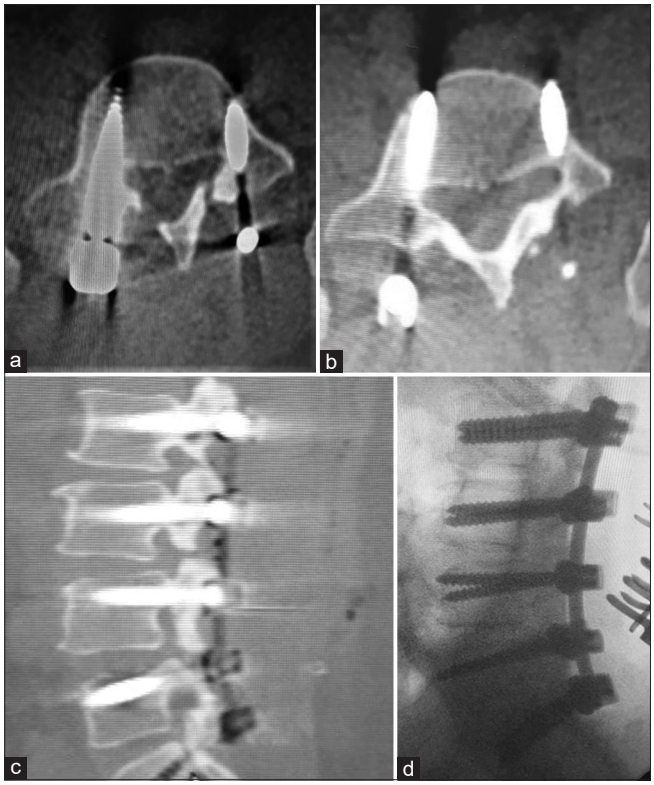

Figure 1: (a and b) Images of two axial cuts of computed tomography (CT) scan at L4 level in a case of transpedicle screws fixation from L1 to L5 due to lumbar canal stenosis with instability. Although the medial breach was located in the right pedicle, the patient was clinically silent. An anterior vertebral body breach with protrusion of the screws through cortical bone >4 mm at the left screw. (c) Sagittal reconstruction of CT scan with reasonable screws locations in the lateral view. (d) Intraoperative fluoroscopy image with good alignment of screws in the lateral plane.

Table 6: Data from other studies for the postoperative CT evaluation of the pedicle screw insertion in the lumbar spine degenerative disease/instability.

Study/ year	Surgical technique	Percentage of pedicle breach	Percentage of revision surgery	Most common level for pedicle violation	Intraoperative dural injury detection	Postoperative clinical manifestation
Smith *et al.*/2014	Percutaneous	37/601 (6.2%)	0%	L3 (10.2%)	No	Transient radiculopathy in two cases
Saarenpää *et al.*/2017	Conventional open surgery	15.2% (127/837) for surgeon 1 13.4% (112/837) for surgeon 2 (Up to 2 mm; surgeon 1 11.6% and 10.3% for surgeon 2 ≥4 mm; surgeon 1 3.6% and 3.1% for surgeon 2 ≥6 mm; surgeon 1 1.9% and 1.8% for surgeon 2)	0% No early revision. Total 24 patients out of 147 (16.3%) Re-surgery was mainly for re-fusion.	L5 (20.7% for surgeon 1 and 16.1% for surgeon 2)	No	New postoperative radicular pain and/or sensorimotor weakness
Kleck *et al.*/2018	Navigation guided percutaneous	GI 181/187 (96.8%) G II 4/187 (2.1%) G III 2/187 (1.06%) Grade IV 0/187 (0%)	0% 4 intraoperative screws revision (2.1%) One surgery at 1 year for fusion revision	S1	No	No
Murata *et al.*/2020	394 percutaneous screws, 445 conventional open	Percutaneous screws (28.9%), conventionally inserted screws (11.9%)	0%	L4 for percutaneous, L1 and L2 for open.	No	No

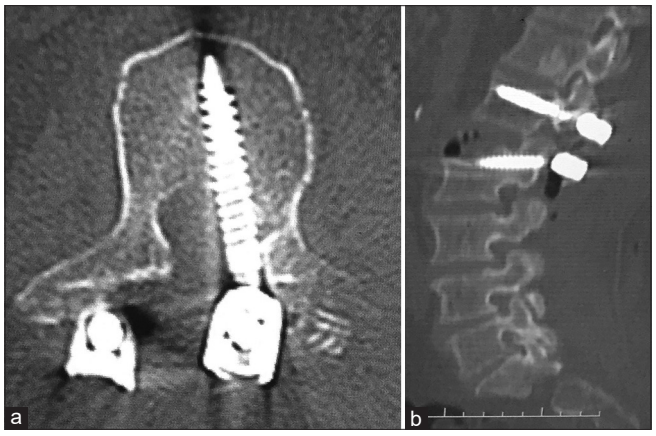

Figure 2: (a) Representative image of an axial computed tomography (CT) scan at L1 spine in a patient operated for fracture dislocation at L1-L2 with complete loss of function below level. Revision surgery was indicated because of direct contact of the hardware with neural elements in the spinal canal. (b) Sagittal reconstruction image of the aforementioned patient.

In a study by Kleck *et al.*, numbers of pedicle breach by transpedicular screws were as follows: Grade I 181/187 (96.8%), Grade II 4/187 (2.1%), Grade III 2/187 (1.06%), and Grade IV 0/187 [Table 6]. Although some of these studies demonstrate early revisions performed in up to 2.1% of patients, more delayed surgery for revision of pedicle breaches were noted up to 16.3% of the time.[4-6,8]

CONCLUSION

In our series, transpedicular screw insertion in the lumbar spine carried up to 1.1% be risk of pedicle violation/ misplacement as best confirmed on CT scans. In the future, CT studies should ideally be performed intraoperatively or no later than 24–48 h postoperatively so that necessary revision surgery may be performed in a more timely fashion to offer patients optimal outcomes.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Abdelbary TH, Arnaout MM. Bone graft alone versus cage with bone graft in lumbar spine interbody fusion. Zagazig Univ Med J 2019;68:85.
2. Caelers IJ, Rijkers K, van Kuijk SM, van Santbrink H, de Bie RA, van Hemert WL. Neurological events due to pedicle screw malpositioning with lateral fluoroscopy-guided pedicle screw insertion. J Neurosurg Spine 2020;33:806-11.
3 Epstein NE. Commentary: Utility of the O-Arm in spinal surgery. Surg Neurol Int 2014;5:S517.
4. Kleck CJ, Johnson C, Akiyama M, Burger EL, Cain CJ, Patel VV. One-step minimally invasive pedicle screw instrumentation using O-Arm and stealth navigation. Clin Spine Surg 2018;31:197-202.
5. Murata K, Fujibayashi S, Otsuki B, Shimizu T, Masamoto K, Matsuda S. Accuracy of fluoroscopic guidance with the coaxial view of the pedicle for percutaneous insertion of lumbar pedicle screws and risk factors for pedicle breach. J Neurosurg Spine 2020;34:52-9.
6. Saarenpää I, Laine T, Hirvonen J, Hurme S, Kotilainen E, Rinne J, *et al*. Accuracy of 837 pedicle screw positions in degenerative lumbar spine with conventional open surgery evaluated by computed tomography. Acta Neurochir (Wien) 2017;159:2011-7.
7. Scarone P, Vincenzo G, Distefano D, Del Grande F, Cianfoni A, Presilla S, *et al*. Use of the Airo mobile intraoperative CT system versus the O-Arm for transpedicular screw fixation in the thoracic and lumbar spine: A retrospective cohort study of 263 patients. J Neurosurg Spine 2018;29:397-406.
8. Smith ZA, Sugimoto K, Lawton CD, Fessler RG. Incidence of lumbar spine pedicle breach after percutaneous screw fixation: A radiographic evaluation of 601 screws in 151 patients. Clin Spine Surg 2014;27:358-63.
9. Theologou M, Theologou T, Zevgaridis D, Skoulios N, Matejic S, Tsonidis C. Pedicle screw placement accuracy impact and comparison between grading systems. Surg Neurol Int 2017;8:131.

How to cite this article: Arnaout MM, ElSheikh MO, Makia MA. Confirmation of accuracy/inaccuracy of lumbar pedicle screw placement using postoperative computed tomography. Surg Neurol Int 2021;12:518.