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Accuracy and Safety of Fluoroscopy-Assisted Transpedicular Screw Insertion in Thoracolumbar Spine Surgery: Evaluation of 122 Screws

Imad-Eddine Sahri[1] Zakaria Chandid Tlemcani[1] Sofia El Akroud[1] El Asri Abad Cherif[1] Miloudi Gazzaz[1]

[1] Department of Neurosurgery, Mohammed V Military Hospital Rabat, Rabat, Morocco

Address for correspondence Imad-Eddine Sahri, MD, Department of Neurosurgery, Mohammed V Military Hospital Rabat, Souissi Street, 10100, Rabat, Morocco (e-mail: imadeddine.sahri@gmail.com).

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Abstract

The objective of this study is to determine the accuracy and safety of trans-pedicular screws' insertion in the thoracolumbar spine using a fluoroscopy-assisted surgical technique. We retrospectively evaluated all patients who underwent a postoperative computed tomography scan to assess the location of the pedicular screws following thoracolumbar spinal surgery, at the Mohammed Vth Military Training Hospital-Rabat, from January 2020 to April 2022. We used Gertzbein's classification to grade pedicular cortex breaches. A screw penetration greater than 4 mm (grades D–E) was considered critical and one less than 4 mm was classified as noncritical (grades A–C). A total of 122 screws inserted in the T1 to L5 vertebrae were included from 25 patients. The average age was 46 years old. Pathologies included degenerative disorders (5 patients), tumors (8 patients), and trauma (12 patients). All screws were inserted using lateral and anteroposterior fluoroscopic guidance. A total of 11 transpedicular screws breaches were identified. The breaches incidence was significantly higher in thoracic pedicles (8 screws) than in lumbar pedicles (3 screws). Of these, three critical cases occurred in two patients and one of them required reintervention. The remaining eight exceedances were not critical and were closely monitored and followed up. Transpedicular screws fluoroscopy-assisted surgical fixation can be performed for the stabilization of the thoracolumbar spine with satisfactory safety and precision.

Keywords

- transpedicular screw insertion
- thoracolumbar spine
- fluoroscopy
- accuracy
- safety

Introduction

Pedicle screw fixation is one of the most widely used procedures for instrumentation and stabilization of the lumbar spine and has gained acceptance in recent years for thoracic spine.[1]

The pedicle screw traverses all three columns of the spine and plays a role of strong bridge across these columns allowing a strong fixation even in cases of three columns disruption.

As vital anatomic structures surround the pedicle (the dural sac medially, the nerve roots superiorly and inferiorly, and the vascular structures anterolaterally), the risk of iatrogenic injury must be minimized and reduced.

New complaints of pain or new neurological deficit during the postoperative period following a pedicle screw fixation procedure must alert the surgeon and a casual relation

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between the procedure and neurological complications should be excluded.

Accuracy and safety of pedicle screws have been the subject of many studies since the introduction of this technique and the rate of misplaced screws still may be considerable and has been reported to range up to nearly 40%.[2]

Transpedicular screw procedure is linked with a wide range of complications including wrong-level surgery, nerve root lesion, vascular injury, dural tearing, surgical site infections, and screw malposition 0.28.1 to 39.9% pedicle screw malposition rate in clinical studies and a 5.5 to 31.3% malposition rate in cadaver studies have been reported in a literature review.[3]

Pedicle screw fixation remains technically challenging with a long learning curve; it can be performed using a freehand technique with preoperative imaging and anatomic landmark.

For more accuracy and safety, many tools have evolved like fluoroscopy and, more recently, image-guided technology.[4]

The purpose of this study is to evaluate the accuracy and the safety of fluoroscopy-assisted transpedicular screw insertion in thoracolumbar spine surgery using postoperative computed tomography (CT) imaging to determine pedicle screw position and to detect pedicle breaches.

Materials and Methods

We retrospectively evaluated all patients who underwent a postoperative CT scan following transpedicular screw insertion in thoracolumbar spinal surgery, transpedicular screw insertion, at Mohammed Vth Military Training Hospital-Rabat, from January 2020 to April 2022.

The patients without a postoperative CT scan were excluded from the study.

Pathologies related with spinal instability including traumatic thoracic and/or lumbar fractures, spondylolisthesis, and spinal tumors were treated with posterior transpedicular screw application.

The size of the transpedicular screws was determined separately for each patient and each level by calculating the pedicle diameters and corpus length by using a preoperative CT scan.

Table 1 Gertzbein–Robbins classification

Grade	Breach distance (mm)
A	0
B	< 2
C	< 4
D	< 6
E	> 6

The screws insertion was done by approximately all neurosurgeons in our department, junior and seniors irrespectively, using lateral and anteroposterior fluoroscopic guidance.

Accuracy of the placement of pedicle screws was evaluated with postoperative CT scan.

We assessed the location of the pedicular screws, and used Gertzbein's classification to grade pedicular cortex breaches.

Gertzbein–Robbins classification is a grading system that reflects the deviation of the screw from the "ideal" intrapedicular trajectory. The grades are as follows: grade A, an intrapedicular screw without breach of the cortical layer of the pedicle; grade B, a screw that breaches the cortical layer of the pedicle but does not exceed it laterally by more than 2 mm; grades C and D, penetration of less than 4 and 6 mm, respectively; and grade E, screws that do not pass through the pedicle or that, at any given point in their intended intrapedicular course, breach the cortical layer of the pedicle in any direction by more than 6 mm[5] (►**Table 1**, ►**Fig. 1**).

A screw penetration greater than 4 mm (grades D–E) was considered critical, and one less than 4 mm was classified as noncritical (grades A–C).

Surgical Technique

The patient was placed in the prone position, fluoroscopy was used for level localization, and to assess the spinal alignment and a posterior midline incision was made. Dissection of paraspinal musculature from the posterior element of the spine was done and decompressive procedures were performed, including partial or total facetectomies, discectomies, and laminectomy, if necessary.

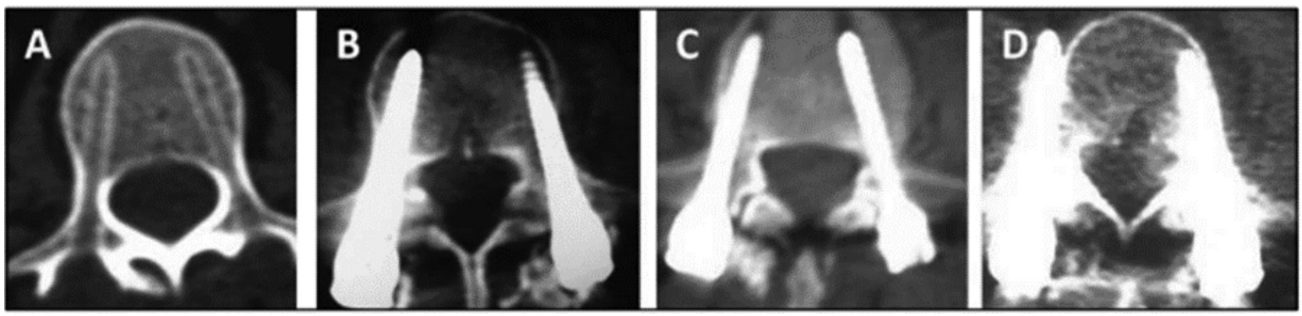

Fig. 1 (**A**) Axial computed tomography image showing the pedicle screw is completely contained within the pedicle, (**B**) ≤ 2 mm perforation of the lateral wall of the right pedicle, (**C**) 2.1 to 4 mm perforation of the lateral wall of the right pedicle, (**D**) > 4 mm perforation of the lateral wall of the right pedicle.[1]

The screw entry point was identified by using anatomical landmarks and it was confirmed by lateral and anteroposterior fluoroscopy. In the lumbar spine, the junction of the transverse process and the superior articular process was accepted as the entry point. In the thoracic spine, the junction of the superior articular facet, transverse process, and pars interarticularis was accepted as the entry point.

The cortex overlying this site was removed with a rongeur and an awl or drill was used to create a hole at the pedicle entry. The pathway was opened with a pedicular probe that was advanced manually 30 to 35 mm. The position of the probe was checked with fluoroscopy. A pedicle feeler was used to confirm the presence of bone in all four quadrants and to detect a pedicle wall breaches. Then the screw was inserted using only a fingertip pressure and fluoroscopy was used to confirm the pedicle screw trajectory.

After surgery, the patients were examined neurologically by an independent observer to assess neurological deficits preoperatively not present.

Postoperative anteroposterior and lateral plain radiographs were performed within 48 hours after surgery, before patient mobilization.

The data including age, gender, operation levels, number of screws placed, preoperative and postoperative neurological conditions, complications, number of screw malpositions, and revision surgeries of the patients were gathered.

Table 2 Pedicle screws distribution from T1 to L5

Pedicle number	Number of screws inserted	(%)
T1	0	0.00%
T2	2	1.64%
T3	2	1.64%
T4	2	1.64%
T5	2	1.64%
T6	4	3.28%
T7	2	1.64%
T8	2	1.64%
T9	6	4.92%
T10	10	8.20%
T11	12	9.84%
T12	14	11.48%
L1	14	11.48%
L2	14	11.48%
L3	12	9.84%
L4	14	11.48%
L5	10	8.20%
Total	122	100%

Results

One-hundred sixty-seven patients underwent transpedicular screw insertions of the thoracolumbar spine between January 2020 and April 2022, among which only 25 (13 female and 12 male) patients had a postoperative CT (15%), with a total of 122 inserted pedicular screws.

As in many institutions, CT is not routinely performed after surgery. Postoperative CT assessment was limited to only those patients whose condition deteriorated postoperatively or those participating in experimental or prospective studies.[6]

In our study, CT scan was performed postoperatively after an unsatisfactory X-ray control, or for patients who developed symptoms as a neurological deficit preoperatively not present.

The mean age at the time of surgery was 46 years, and the sex ratio was close to 1.

Trauma was the most common surgical indication (12 cases), followed by tumors (8 cases) and spondylolisthesis (5 cases). The thoracolumbar junction was the most common site affected by trauma, and the maximum number of screws were inserted in the lower dorsal spine and the lumbar spine (►**Table 2**, ►**Fig. 2**).

In total, 11 out of 122 screws (9%) were found to breach the pedicle on postoperative CT evaluation. These breaches occurred in 5 out of 25 patients (20%). The breaches' incidence was significantly more frequent for thoracic pedicles (8 screws) than lumbar pedicles (3 screws). In regard to the direction of the breach, 6 were medial, and 5 were lateral. A pedicle breach more than 4 mm in any direction was considered as critical because of their close proximity to vital structures (►**Table 3**).

Three critical breaches were noted in two patients. One of them required reintervention to correct the malpositioned screw; this patient presented a nerve root injury with radicular pain and a neurological deficit.

The patient in question with neurological deficit had completely recovered his motor function after repositioning screw. The remaining patient with critical breach was completely asymptomatic.

The three remaining patients with noncritical breaches did not require revision surgery because they were asymptomatic and showed no radiographic signs of instability.

No patient developed adjacent segmental instability after surgery. No assembly disengagement or broken screws were noted in any patient during follow-up. No infections were observed in the study group. The malpositionings were not related to any specific level.

Discussion

Posterior spine stabilization with the pedicle screws had seen a great change in technique and accuracy over the past decades. Accurately placing pedicle screws is important to the biomechanical integrity of spinal implant construct as well as the safety of the patient. Lumbar pedicle screws are one of the most-used forms of spinal fixation in a wide variety of spinal pathologies. Thoracic pedicle screws are used less commonly, although their popularity has increased in recent years, especially in trauma and deformity surgery.[2]

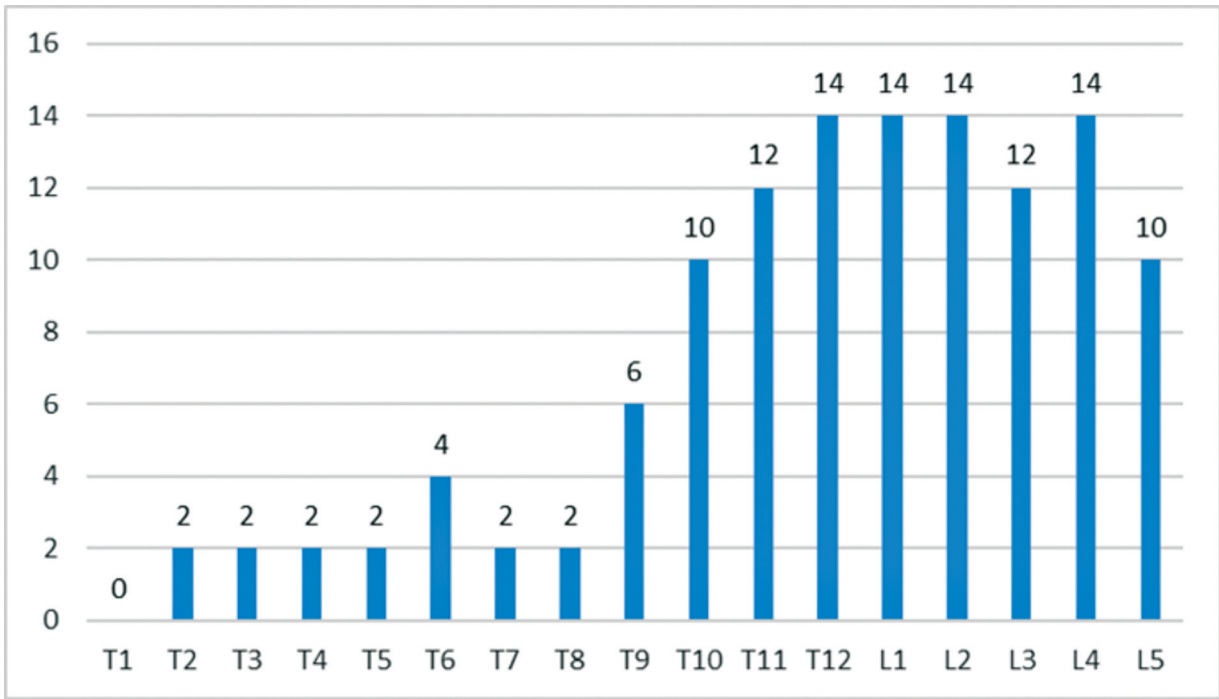

Fig. 2 Bar diagram showing pedicle screws distribution from T1 to L5.

It was considered accurately placed when the entire screw remains within the cortices of the pedicle.

In our study, trauma was the most common reason for which pedicle screws were placed. And the maximum number of screws were inserted in the lower dorsal spine and lumbar spine.

This predilection of fractures for the thoracolumbar region is commensurate with the biomechanical compromise that occurs at these sites and it is observed in most studies. The articulation between the relatively rigid thoracic spine (reinforced by the thoracic cage) and the freely mobile lumbar segments maximizes anterior compressive stresses in this region.[7]

Table 3 Distribution of breaches

Pedicle number	Number of screws inserted	Number of breaches	Medial	Lateral		
T1	0	0	0	0	8	Thoracic
T2	2	0	0	0		
T3	2	0	0	0		
T4	2	2	1 (noncritical)	1 (critical)		
T5	2	0	0	0		
T6	4	2	1 (critical)	1 (noncritical)		
T7	2	0	0	0		
T8	2	1	0	1 (noncritical)		
T9	6	1	1 (noncritical)	0		
T10	10	1	1 (noncritical)	0		
T11	12	0	0	0		
T12	14	1	1 (noncritical)	0		
L1	14	2	1 (critical)	1 (noncritical)	3	Lumbar
L2	14	0	0	0		
L3	12	0	0	0		
L4	14	1	0	1 (noncritical)		
L5	10	0	0	0		
Total	122 (100%)	11 (9%)	6	5		

In this study, postoperative follow-up CT scan was performed in 25 patients, the incidence of cortical breach was 9%, which occurred in five patients, and it was higher in the thoracic pedicle (6.5%) than in the lumbar pedicle (2.5%). The thin pedicle size of the dorsal spine may be the reason for this.

Surgeons should be more careful in thoracic transpedicular screw fixation because the thoracic spine has very small pedicle diameters and the spinal cord occupies the majority of the spinal canal. It is necessary to have good anatomical and biomechanical knowledge to avoid complications.

According to Parker et al, the higher number of lateral breaches is due to the presence of a thicker cortical wall of the medial side of the pedicle and to the surgeon's tendency to keep pedicle probe laterally to avoid spinal cord injury due to medial violation.[8] In our study, lateral (5) and medial (6) breaches' incidences were relatively identical.

We considered 4 mm to be the safest limit for pedicle breaches in various direction. Although in different series the acceptable degree of pedicle breaches in all directions is still controversial. Gertzbein and Robbins believed that the "safe zone" for allowable medial breach was 4 mm in relation to the intradural contents. They demonstrated that 2 mm of the epidural space with 2 mm of subarachnoid space existed from T10 to L4 level using a CT myelogram 5. For Belmont et al, 2 mm was the acceptable limit for medial breaches and 6 mm for lateral breaches.[9]

Transpedicular screw malposition rates ranging from 21.1 to 39.8% have been reported in the literature.[3] Our results with less than 2.5% of critical breaches document that it is possible to place thoracolumbar pedicle screws accurately and in a safe manner with fluoroscopy guidance.

Conclusion

Our retrospective case review found that fluoroscopy-assisted transpedicular screw insertion is a safe, useful, and potentially accurate for the placement of thoracolumbar spinal instrumentation.

Conflict of Interest
None declared.

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