RESEARCH ARTICLE

# Accuracy Assessment of Freehand Pedicular Screw Placement

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## Abstract

**Background:** The purpose of this prospective study was to determine the accuracy of pedicular screw insertion without the use of fluoroscopy.

**Methods:** This study was conducted on patients with spinal diseases in need of pedicular screw fixation and fusion. The included patients suffered from such conditions as vertebral fracture, spinal stenosis, kyphosis, tumor, and pelvic fractures and were managed with triangular osteosynthesis fixation. However, those with scoliosis deformity were excluded from the study. A total of 760 pedicular screws were inserted in C7 to S1 vertebrae without using fluoroscopy. The locations of the screws were assessed by means of computed tomography scan after the surgery. The data were analyzed in SPSS software (version 22) using the Chi-square test.

**Results:** Out of 387 thoracic screws and 373 lumbar screws, 65 (16.8%) and 34 (9.1%) screws perforated the pedicle wall or vertebral body, respectively. The most frequent locations of perforation in the thoracic and lumbar spine were the anterior cortex of the vertebral body and medial wall of the pedicle, respectively. Except for the perforation of the anterior vertebral body (*P=0.0001*), there was no difference between the left and right sides or between thoracic and lumbar sites in terms of the preformation of the screw. No complication was observed due to screw perforation.

**Conclusion:** Our findings revealed the unnecessity of using fluoroscopy in spine surgeries for the insertion of pediculate screws. In this regard, the use of fluoroscopy for the placement of pedicular screw resulted in similar accuracy and complications, as compared to the free hand procedure.

**Level of evidence:** I

**Keywords:** Fluoroscopy, Lumbar, Pedicular screw, Spine fixation, Thoracic

## Introduction

Spinal column consists of motion segments attached together with discs and ligaments. Instrumentation of the spine is one of the most common procedures in spine disorders (1, 2). Harrington introduced the first spinal instrumentation in 1950 (3). Thereafter, various systems were introduced involving the use of hooks, which were then replaced by pedicular screws introduced by Roy Camille in 1970 (4). Today, the insertion of pedicular screws is a routine procedure for spine surgeons.

General principles of the insertion of the pedicular screw include the identification of the insertion point, creation of a hole in the outer cortex by a microdrill or a pedicle owl, deepening of the hole into the pedicle and vertebral body by a pedicle probe, examination of the hole walls by a ball-tipped filler, and insertion of the screw. Fluoroscopy

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and computed tomography (CT) scan are common modalities used intra-operatively to confirm the correct entry point and trajectory of the screw and reduce the complications caused by the malposition of the screws (5-8). There are some techniques for detecting the entry point of screws. However, the intersection technique is the most popular method for lumbar spine which involves the intersection point of the intertransverse line and a line through the lateral edge of the facet joint (9, 10). In the thoracic spine, the superior edge of the transverse process and lateral border of the facet joint are used for screw trajectory (9, 10).

Penetration of the screw into the pedicle of the vertebral body can lead to the injury of the anatomic elements around the spine. The most dangerous directions of perforation include the medial cortex and inferior cortex of the pedicle involving the dural sac and nerve root, respectively. Perforation of the anterior cortex of the vertebral body may damage the vessels of this region (11, 12).

The use of fluoroscopy in the operative room results in the elongation of surgical time, thereby increasing the rates of infection and radiation to the operation room personnel. With this background in mind, the purpose of this study was to investigate the necessity of the routine use of fluoroscopy for the safe insertion of pedicular screws. The achievement of results confirming the safety of pedicular screw insertion without using fluoroscopy can benefit the physicians to save operation time and prevent radiation exposure to patients and operating room personnel.

## Materials and Methods

This prospective study was performed on 82 patients older than 12 years requiring the internal fixation of the spine with pedicular screws at Bahonar Hospital between March 2016 and March 2017. The patients with scoliosis and congenital anomalies of the spine were excluded from the study (13). All operations were performed in a prone position with midline incision. After exposing the laminae and facet joints, the screw insertion points were identified by means of the mentioned techniques. Subsequently, a hole was made in the pedicle, and the pedicular screw was inserted in the determined site.

Generally, 6.5- and 5.5-mm screws were used for the lumbar and thoracic spine, respectively. No imaging techniques were used in the operating room for the insertion of the screws. All operations were performed by the same surgeon (i.e., the first author of the manuscript). The position of the screws after the surgery was determined via sagittal and coronal reconstructed CT scans at 1-mm slice intervals. We considered pedicle screw as a screw not encroaching any of the surrounding walls. However, in case of the incidence of any encroachment, depending on the penetrated wall, it was classified into the medial, lateral, superior, and inferior cortex of the pedicle, as well as anterior cortex of the body (14). This study was approved by the Ethics Committee of Kerman University of Medical Sciences, Kerman, Iran (code: 96000296).

### *Statistical analysis*

The data analysis was performed in SPSS software (version 22) using the Chi-square test. A *P-value* less than 0.05 was considered statistically significant.

## Results

In the current study, 76.8% and 23.2% of the participants were respectively male and female with the mean ages of 31±4.2 (age range: 16-1 years) and 34±5.6 (16-59 years) years. A total of 760 screws were used for all patients, 387 and 373 of which were respectively applied for the thoracic spine (193 and 194 screws in the right and left sides, respectively) and lumbar spine (187 and 186 in the right and left sides, respectively). Table 1 presents the frequency of the conditions for which the patients underwent screw insertion.

The highest number of screws used in a surgical operation was 10 (29.3%) screws, followed by 8 (13.4%) screws, used for fractured patients. In addition, the greatest number of screws used for one patient was 28 screws used for the treatment of kyphosis deformity. On the other hand, the lowest number of screws used in a surgery was 1 screw in patients with the fracture of the pelvis managed with a triangular osteosynthesis technique.

After the evaluation of the insertion site by means of CT scans, it was determined that 322 (83.2%) screws in the thoracic spine were exactly within the pedicle and body of the vertebrae, while 62 (16.8%) screws (26 and 36 cases in women and men, respectively) were out of the pedicle of the vertebral body. In the lumbar spine, 339 (90.9%) screws were exactly within the pedicle and vertebral body; however, 34 (9.1%) screws (16 screws in women and 18 screws in men) perforated the pedicle or vertebral body.

In the thoracic spine, the most common site of perforation was the anterior cortex of the vertebral body (33 screws, 8.5%), followed by the medial cortex of the pedicle (21 screws, 5.4%). However, in the lumbar spine, the results were vice versa. In this regard, the medial cortex of the pedicle (15 screws, 6.7%), followed by the anterior cortex of the body (8 screws, 2.1%), were the most common sites of perforation. Positions of the screws are listed in tables 2 and 3 for thoracic and lumbar spine, respectively.

In the thoracic spine, there was a significant difference

**Table 1. Frequency of the conditions for which the patients underwent screw insertion**

| Etiology | Number | Percent |
|---|---|---|
| Spine Fracture | 56 | 68.2 |
| Pelvic Fracture | 11 | 13.4 |
| Kyphosis | 8 | 9.8 |
| Tumor | 4 | 4.9 |
| Stenosis | 3 | 3.7 |
| Total | 82 | 100 |

**Table 2. Position of the screws in the thoracic spine**

| | Within pedicle | Medial wall of the pedicle | Lateral wall of the pedicle | Superior wall of the pedicle | Inferior wall of the pedicle | Anterior cortex of the body |
|---|---|---|---|---|---|---|
| **Right side** | 162 (83.9%) | 10 (5.2%) | 3 (1.6%) | 1 (0.5%) | 0 | 17 (8.8%) |
| **Left side** | 165 (85.1%) | 11 (5.7%) | 1 (0.5%) | 1 (0.5%) | 0 | 16 (8.2%) |
| **Total** | 327 (84.6%) | 21 (5.4%) | 4 (1%) | 2 (0.5%) | 0 | 33 (8.5%) |

**Table 3. Position of the screws in the lumbar spine**

| | Within pedicle | Medial wall of the pedicle | Lateral wall of the pedicle | Superior wall of the pedicle | Inferior wall of the pedicle | Anterior cortex of the body |
|---|---|---|---|---|---|---|
| **Right side** | 170 (90.9%) | 13 (7%) | 0 | 0 | 0 | 4 (2.1%) |
| **Left side** | 169 (90.9%) | 12 (6.5%) | 1 (0.5%) | 0 | 0 | 4 (2.1%) |
| **Total** | 339 (90.9) | 25 (6.7%) | 1 (0.3%) | 0 | 0 | 8 (2.1%) |

between the perforation of the anterior of the vertebral body and the superior, inferior, and lateral cortices of the pedicles (*P=0.0001* for all). The difference between the medial penetration of the pedicle and other mentioned regions was also significant (*P=0.0001*, *P=0.0001*, and *P=0.001* respectively); however, the difference between the other sites was not significant.

In the lumbar spine, the perforation of the medial cortex of the pedicle was significantly different with that of the anterior cortex of the body and the superior, inferior, and lateral cortices of the pedicle (*P=0.003*, *P=0.0001*, *P=0.0001*, and *P=0.0001*, respectively); however, other differences were not significant.

There was a significant difference between the perforation of the medial wall of the pedicles of the lumbar and thoracic spine (*P=0.0001*). Nonetheless, the difference of other encroachments between the thoracic and lumbar spine was not significant. There was no significant difference between screws in the right and left sides. Additionally, no complication was observed due to the malposition of screws, and no patient required reoperation due to the malposition of the screws.

## Discussion

To the best of our knowledge, the current research is one of the most comprehensive prospective studies using a large number of screws inserted by the same surgeon. In this study, the accuracies of the pedicular screw insertion without intra-operative fluoroscopy were 84.6% and 90.9% in the thoracic and lumbar spine, respectively.

In the present study, the patients were subjected to CT scan after the surgery because according to multiple studies, this modality has a higher precision, compared to radiography (6). In many studies, perforation has been classified into three groups of < 2, 2-4, and > 4 mm encroachment. However, in the current study, the penetration or perforation of the cortex was considered even within 1 mm of the cortex of the pedicle or vertebral body.

Our results were nearly equal or even better than those of other studies using intra-operative fluoroscopy. Castro et al. investigating 131 lumbar pedicular screws in 4 human specimens and 30 patients using two-plane fluoroscopy found that 29% of screws were out of the pedicle, 40% of which encroached the medial wall of the pedicle (15), which is about three times higher than the rate obtained in the present study.

In a study performed by Weinstein et al., 21% of pedicular screws inserted under fluoroscopy were out of pedicle, 92% of which penetrated from the medial cortex of the pedicle (16), which is twice higher than the rate detected in our study. Gertzbein and Robbins examining 167 pedicular screws in patients with thoracolumbar fractures found that 71.9% of the screws were exactly within the pedicle, and 28.1% of them encroached the pedicle wall with a minimum of 2 mm (4).

In another study carried out by Sim on 200 pedicular screws inserted under fluoroscopy in the thoracolumbar and lumbar spine, the perforation rate of the medial wall or anterior cortex of the body was reported as 11% (17). In line with the previous studies, in the current research, the medial wall of the pedicle was the most common site of encroachment by the screws. This may be due to the trajectory of insertion which is usually from the lateral to the medial region (18).

Our results are consistent with those of other studies addressing the complications of penetrated screws. Gertzbein and Robbins reported two cases of neurologic deficit due to the entrance of the screws into the spinal canal (4). In a systematic review including 101 manuscripts, Yahiro reported the incidence rates of 1.9% and 1.1 for neurologic deficit and dural tear due to malpositioned screws, respectively (19). Nonetheless, Sim found no neurologic complications after the insertion of 200 pedicular screws in the thoracolumbar and lumbar spine (17). Likewise, no complications due to penetrated screws were observed in the current study.

Studies about the thoracic spine are much more limited

than those on the lumbar spine; in addition, they are commonly limited to the deformities of the spine. In a retrospective study conducted by Suk et al. on 462 patients with deformity, as many as 10.4% of the screws were out of the pedicle, and neurologic deficit was reported in 0.8% of patients (20). Liljenqvist et al. investigating 120 patients with scoliosis reported 25% screw perforation in the thoracic spine; however, no complication was seen at all (21).

In a retrospective study, Belmont et al. found that 14% of 279 pedicular screws in the thoracic spine encroached the pedicle wall; nevertheless, no neurologic or vascular injuries were noted (22). Upendra et al. reported a high rate of screw misplacement but a low rate of complications. In the mentioned study, the thoracic spine encroachment rates of the screws were 50% and 50.8% in nonscoliotic and scoliotic patients, respectively; however, the complication rate was reported as 1.6% (7).

Pedicular screws have many superiorities over hooks in spinal surgeries. Nonetheless, the routine use of fluoroscopy during the surgery is one of the disadvantages of using these tools due to exposing the patient and personnel of the operating room to increased radiation and elongating the time of the surgery (10).

One of the limitations of the present study is the lack of a control group. However, our findings revealed the unnecessity of using fluoroscopy for the insertion of the thoracic and lumbar pedicular screws for the experienced spinal surgeons.

***Conflict of Interests:*** There is no conflict of interest for this education.

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