

Radiologic Evaluation of Proper Pedicle Screw Placement after Pedicle Screw Fixation in Degenerative Lumbar Disc Disease

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Objective : With the increasing popularity of pedicle screw fixation devices for several indications, the safety and reliability of screw insertion in the small pedicle has become a major issue. Many studies have investigated the accuracy of screw placement after pedicle screw fixation using various method. The reported displacement rates have been very different. The purpose of the study is to investigate the proper placement of pedicle screw insertion in the lumbar spine on 26 consecutive patients.

Methods : Between September and December 2003, 26 consecutive patients (16women and 10men) were analyzed after transpedicular screw fixation of the lumbar and lumbosacral spine. After pedicle screw fixation in this study, 2-mm slices of CT scan were performed in all patients to detect caudal and cranial deviation of screw and medial and lateral deviation. Pedicle screw placement related complication was evaluated clinically.

Results : A total of 144 inserted pedicle were analyzed in 26patients, and 58pedicle screws (40.3%) were detected to be improper placement. There were 14level (9.0%) of caudal or cranial deviation and 44level (30.6%) of medial or lateral deviation to the pedicle. Extra-pedicle placement was found on 4levels (2.7%) with only 1case of neurologic injury.

Conclusion : Proper screw placement, though complication rate is low, is important not only for clinical symptom but also for biomechanics. Further study for screw placement related biomechanical changes is needed.

KEY WORDS : Pedicle screw · Accuracy · CT scan.

Introduction

In 1969, Harrington and Tullos were the first to describe the use of transpedicular screws for spinal fixation⁷⁾. Initially, pedicle screws were used to obtain rigid internal fixation of the spine for fractures. The technique has been widely used for various indications. The superiority of pedicle screw fixation in biomechanical properties, fusion rate, early mobilization and versatility has been shown conclusively⁸⁾. Presently, pedicle screw fixation represents the so-called gold standard of spinal internal fixation. However, the use of pedicle screws is technically demanding and associated with certain risks⁹⁾. Violation of the pedicle cortex by pedicle screws may increase the risk of neurologic injury. Pedicle screw misplacement could also decreased the original spinal stability provided by the instrumentation¹⁾. Therefore, proper placement of pedicle screws is important not only for the prevention n of neurologic injury but also for the maintainence of long-term spinal stability.

In this matter, many studies have investigated the accuracy of screw placement using simple radiograph, computed tomography(CT) scan or magnetic resonance imaging(MRI)²⁻⁶⁾. The reported displacement rates have been very different depending on several factors such as surgical experience, indications, or different methods of screw evaluation. Only recently have clinical studies reported a significant improvement in screw accuracy with the use of computer-assisted surgery systems^{11,14)}.

The purpose of the study was to investigate the proper placement of pedicle screw insertion in the lumbar spine on 26 consecutive patients. To evaluate the proper screw position, post-operative CT scan analysis of the pedicle screw was performed.

Materials and Methods

Between September and December 2003, 28 consecutive patients (17women and 11men) were analyzed after

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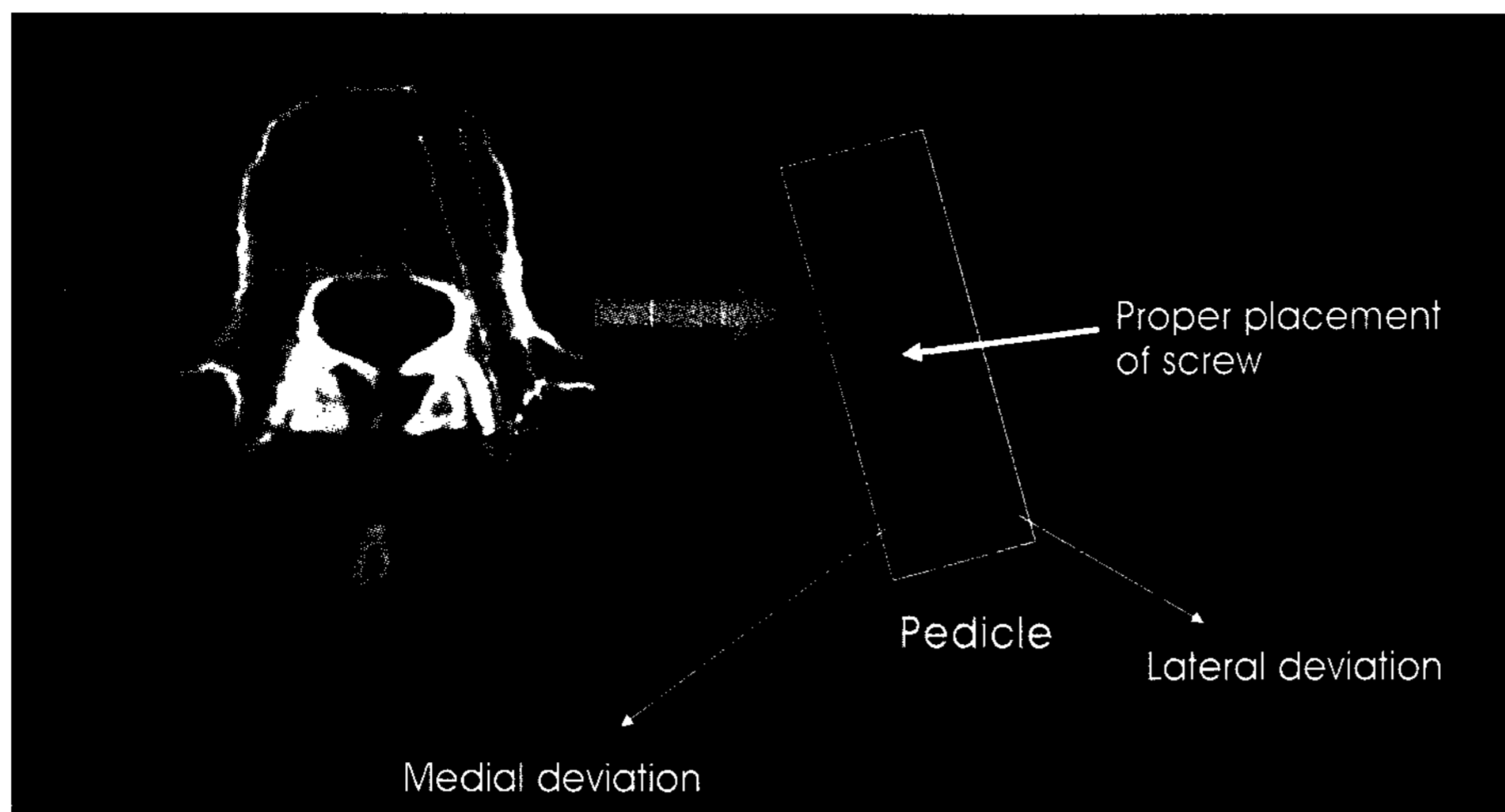


Fig. 1. Illustrative figure of medial or lateral pedicle screw evaluation. Axial computed tomography scan of instrumented pedicle is imaginary divided into 3portion, parallel to the pedicle. Mid-portion is regarded as the proper screw placement zone, and lateral or medial portion is considered as lateral and medial pedicle screw deviation.

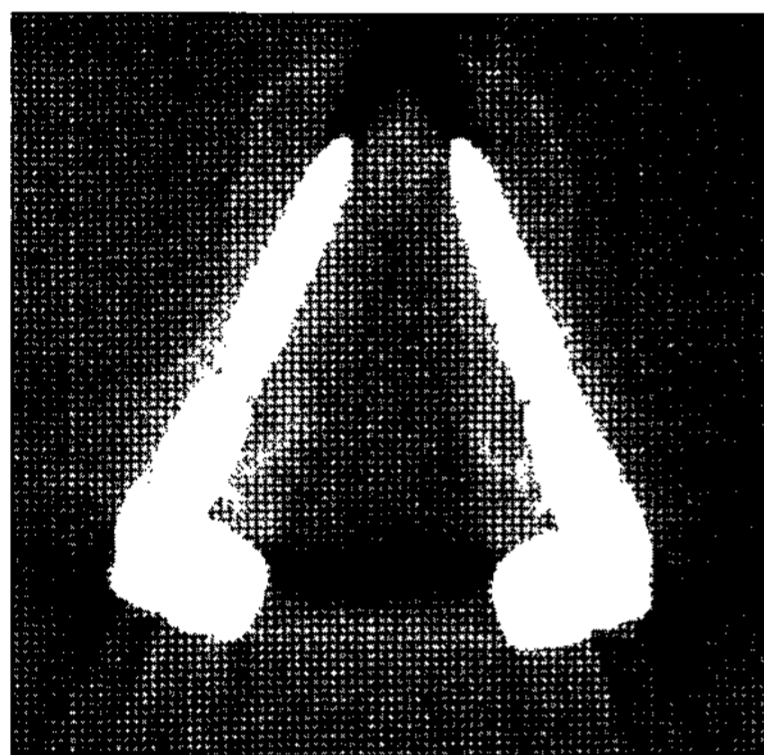


Fig. 2. One of the example of properly placed screw in all direction on the basis of our standard.

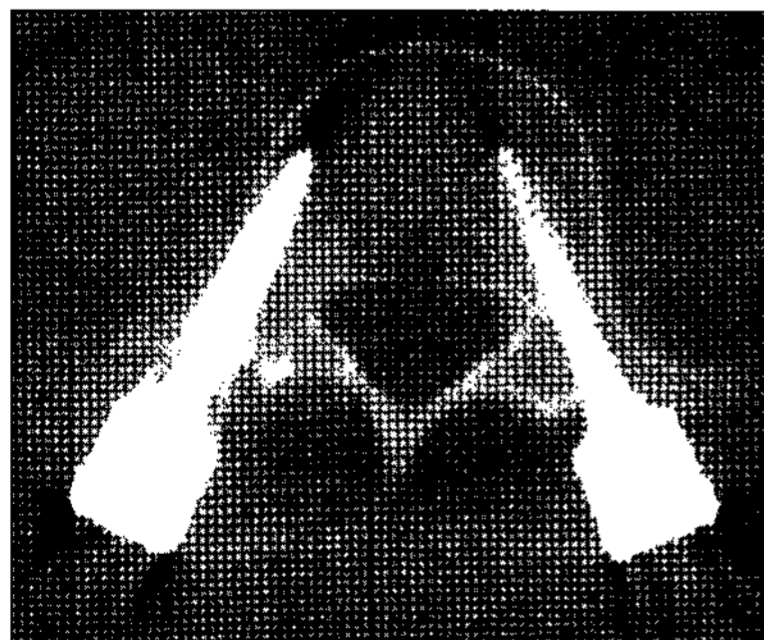


Fig. 3. One of the example of caudal deviation to the pedicle on computed tomography scan. Right pedicle screw is detected whereas left is not definitely.

process and angled 10° to 20° medially.

After pedicle screw fixation in this study, a CT scan was performed in all patients. One independent observer analyzed 2-mm slices of all instrumented pedicles. The cortical wall of the pedicles was examined for bone defects, firstly,

transpedicular screw fixation of the lumbar and lumbosacral spine. Two patients were excluded to reduce the evaluation error because of severe scoliosis of lumbar. The age range of the patients was 42 to 69years (mean, 57years). All patients were operated on by the same surgeon at a single institution. All surgical procedures including pedicle screw fixation were performed with fluoroscopic control while the patient was under general anesthesia. Under lateral fluoroscopic control, the pedicle screws were inserted at the base of the transverse process

midportion is regarded as the proper screw placement zone, and lateral and medial portion was considered as lateral and medial pedicle screw deviation, respectively (Fig. 1).

Pedicle screw placement related complication was evaluated clinically by review the medical records.

Results

A total of 144 inserted pedicle were analyzed in 26patients, and 86pedicle screw (59.7%) were placed properly on the basis of our standard(Fig. 2). 58pedicle screws (40.3%) were detected to be improper placement.

Fourteen levels (9.0%) of caudal or cranial deviation of pedicle screw were detected. Caudal or cranial cortical wall of the pedicles was not injured, which implied no pedicle violation including extra-pedicle placement caudally or cranially to the pedicle. Number of cranial deviation to the midportion of pedicle was 6 level (3.9%) and caudal to the pedicle was 8level (5.1%)(Fig. 3).

Fourty four levels (30.6%) of pedicle screw were inserted improperly medial or lateral to the pedicle. Medial deviation of pedicle screw was detected in 16levels (11.4%), and lateral deviation to the pedicle, 28level (19.2%), respectively. Among 44level of medial or lateral deviation, extra-pedicle placement or pedicle violation was found on 4levels (2.7%), 1level medial and 3level lateral placement to the pedicle (Fig. 4). Fortunately, there was only 1level (0.7%) of complication related with screw misplacement clinically(Fig. 5). In this case, patient complain of a sensory deficit and muscle weakness at L5 dermatome which correlated with the L5 nerve root injury. Although revision surgery to correct the misplacement of pedicle screw was performed, but muscle

To detect caudal or cranial screw penetrations or deviations, the most superior and inferior slices of each pedicle were analyzed carefully. Caudal or cranial proper placement of pedicle screw was defined by authors that the most superior and inferior slices of each pedicle showed no screw and both side of screw must be seen in the same axial plane of CT scan.

To detect medial or lateral screw deviation including violation and dislocation, instrumented pedicle of axial plane of CT scan was imaginary divided into 3portion, parallel to the pedicle. Among 3portion of instrumented pedicle,

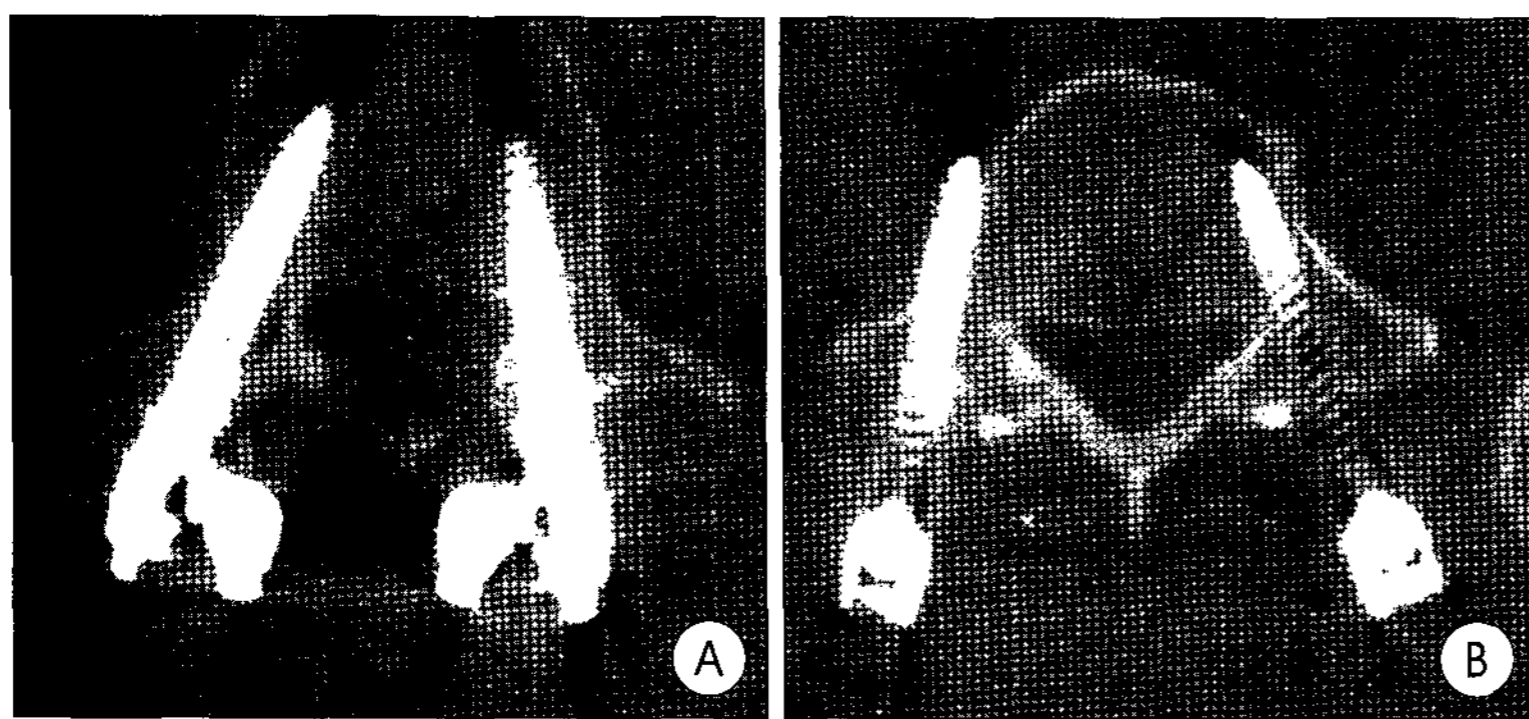


Fig. 4. These were the examples of improper placement of screw medial or lateral to the pedicle. A : left screw is medially deviated on computed tomography scan, while right side screw is laterally placed. B : Lateral and extra-pedicle placement of screw with pedicle violation is detected on right sided pedicle.

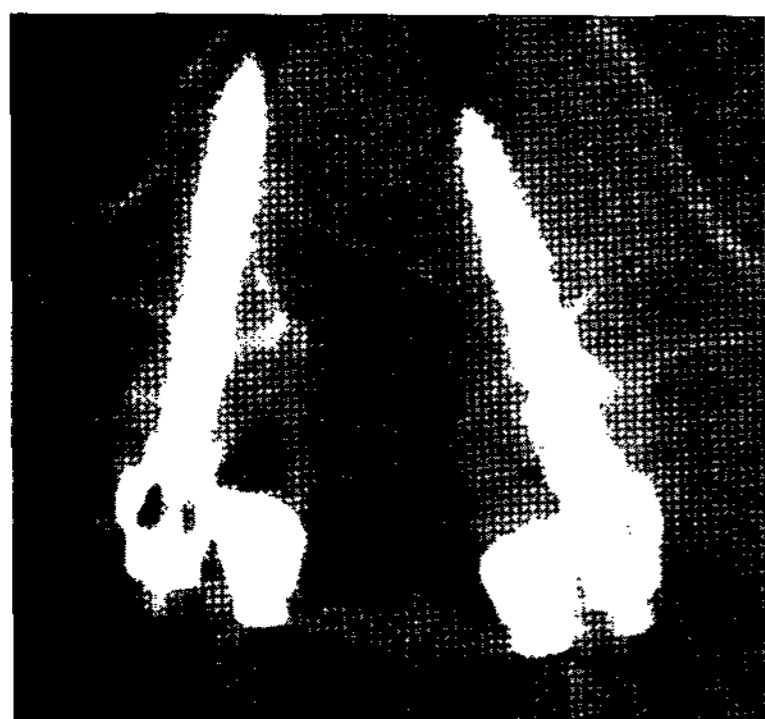


Fig. 5. This is computed tomography scan of patient with screw misplacement complication. The screw is placed medially with pedicle violation and resulted the neurologic deficit.

weakness and sensory deficit were not improved during follow up period.

Medial or lateral improper placement to the pedicle was more commonly seen than caudal or cranial deviation.

Although improper placement rate of pedicle screw on the basis of author's criteria were estimated

to be 40.3%, screw placement related complication rate was only 0.7%.

Discussion

In the past 10 years, transpedicular screws have been used increasingly in operations for spinal fusions and become an established technique for instrumentation of the lumbar and thoracic regions⁸.

With the increasing use of pedicle screws for internal stabilization of the lumbar spine, there have been numerous reports about the accuracy of this procedure^{2-6,12}. These would be closely related with the main problem of this blind technique, that is the surgeon does not see the pedicle¹⁰. Accurate and proper placement of pedicle screw may be important because neural elements are closely located to the pedicles, in case of penetration of the medial cortex of the pedicle, neural damage may occur. Moreover postoperative long-term spinal stability will be closely related with proper placement of pedicle screw¹.

Interestingly, the reported misplacement rates have been very

different, ranging from 8% to 40%^{5,6,11,14}. Roy-Camille et al.¹³ reported an incorrect location of the screw in 10%, whereas Gertzbein et al.⁶ noted 81% of the screws inserted within 2mm or less of the medial border of the pedicle. In addition to important factors such as different surgical experience and indications, this discrepancy may result from different methods of screw assessment^{11,15,16}.

To evaluate the proper placement of pedicle screw, many methods including radiologic modality and measurements, have been used.

Weinstein et al.¹⁵ showed that simple roentgenograms were insufficient for the evaluation of screw accuracy in 1988. This finding was confirmed by Farber et al.⁵, who found that CT scans showed 10 times more pedicle violations than radiographs. This was the reason why authors analyzed with 2-mm slices CT scan to detect the proper placement of screw.

Regarding the measurement of pedicle screw placement, authors designed the new method of measurement. Design of this method was started on the conception that pedicle screw must place the central to the pedicle in all direction. This method could evaluate not only pedicle violation, but also central screw placement to the pedicle. On the review of the literatures, Wiesner et al.¹⁶ evaluated the pedicle by screw tracts after removal of screw and analyzed the direction and degree of the pedicle violations on 2-mm slices of CT scan and transverse screw angle was determined by measuring the angle between a line parallel to the vertebral midline and a line through the center of the screw tract. Although decreased image artifacts caused by the implants would provide the accurate assessment of the pedicle wall integrity, that is, the screw tracts could be analyzed without any disturbing artifacts, patients must have bitter experience of operation to remove the screw. Furthermore, Wiesner et al.¹⁶ already mentioned at discussion of literature, accuracy of data could be lack of confidence. We assumed that method of authors may be unique measurement. However, authors did not study the effect of improper screw placement on stability, that is, we did not compare the long-term biomechanical effect between group of screw placement central to the pedicle in all direction (proper placement) and group of deviated screw to the pedicle (improper placement). This is the certain limitation of this study. Fortunately many literatures mentioned that proper placement of pedicle screw, though implication of "proper" might be different, depending on definition of authors, had the close relation to the stability of spine. Acikbas et al.¹¹ asserted in his article, the effect of transpedicular screw misplacement on late spinal stability that screw misplacement should be

considered to violate biomechanical stability as it causes deviation in the screw axis. Moreover, screws with misplacement never filled up the desired portion of the pedicle and could not reach the proposed penetration depth. They also persisted that, such a deviation in screw trajectory, screw-pedicle mismatch and short depth penetration caused inadequate correction of the deformity and led to failure of stability which was closely connection to reduction of the pull-out strength¹⁾.

As for the result of this study, medial or lateral improper placement was more commonly detected than caudal or cranial deviation. This result would be correlation with lateral fluoroscopic control. On assist of lateral fluoroscopic control, operator could easily identify the pedicle caudally or cranially. Though improper placement rate of pedicle screw were estimated to be 40.3% in our result, screw placement related complication rate was very low. We would presume that pedicle violation may affect the immediate postoperative results and improper placement such as screw deviation could influence the late spinal stability. Proper screw placement, though complication rate is low, is important not only for clinical symptom but also for biomechanics. To place the screw more properly and accurately, computer-assisted navigation systems would give the assistance in increasing the accuracy of pedicle screw with reducing surgery-related morbidity¹⁴⁾.

Conclusion

We evaluated the proper placement of pedicle screw insertion in the lumbar spine with our distinctive method and reviewing the literatures. On the basis of authors, definition, improper placement rate of pedicle screw is 40.3%, proper placement rate, 59.7%, screw placement related complication rate, 0.7%. Further study for screw placement related biomechanical changes is indispensable.

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