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Original Article

Pedicle screw placement accuracy impact and comparison between grading systems

Marios Theologou[1,2], Theologos Theologou[1], Dimitrios Zevgaridis[1], Nikolaos Skoulios[2], Slavisa Matejic[3], Christos Tsonidis[2]

[1]Department of Neurosurgery, Euromedica Geniki Kliniki of Thessaloniki, [2]Department of Neurosurgery, Aristotle University of Thessaloniki, Ippokration General Hospital, Thessaloniki, Greece, [3]Faculty of Medicine, University of Pristina, Temporarily Settled in Kosovska Mitrovica, Serbia

E-mail: *Marios Theologou - theologou_marios@dr.com; Theologos Theologou - theologou-secretary@dr.com; Dimitrios Zevgaridis - zevgarid@gmail.com; Nikolaos Skoulios - tsonidis@hol.gr; Slavisa Matejic - matejic.slavisa@gmail.com; Christos Tsonidis - tsonidis@hol.gr
*Corresponding author

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Abstract

Background: Pedicle screw instrumentation is widely used for spinal stabilization. However, the accuracy for free-hand screw placement ranges from 69% to 94%. This study assesses the value of the existing classification systems, and investigates their impact on the ability to assess the accuracy of free-hand screw placement.

Methods: Data were collected retrospectively from the medical records of 34 patients who received 224 pedicle screws placed utilizing a free-hand technique. Screw placement was evaluated employing the 2-mm increment and Zdichavsky *et al.* classification systems. Kappa coefficient and Landis and Koch interpretations were employed for statistical analysis.

Results: The 2-mm increment classification system resulted in a total of 18 (8.03%) misplaced screws. Lateral screw misplacement was observed in 13 (5.8%) instances, with medial pedicle wall penetration being noted in 5 (2.23%). Of the 18 misplaced screws, 4 (22.22%) were classified as minor (≤2 mm), 12 (66.67%) as moderate (2–4 mm), and 2 (11.11%) as severe (>4 mm) (K = 0.882). The Zdichavsky *et al.* grading system categorized 208 (92.84%) pedicle screws as Ia, 10 (4.46%) as Ib, 1 (0.45%) as IIa, 2 (0.90%) as IIb, 2 (0.90%) as IIIa, and 1 (0.45%) as IIIb grade; this resulted in a total of 16 (7.14%) misplaced screws (K = 0.980). One patient exhibited a new postoperative radiculopathy attributed to poor screw placement. There were no additional early or late postsurgical complications attributed to screw misplacement.

Conclusion: The free-hand pedicle screw placement technique is both safe and effective. Postoperative computed tomography studies; however, are useful to confirm the accuracy of screw placement. Although, the available grading systems

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proved reliable, easy to use, and clearly reflected the individual surgeon's skills, they do not clearly document whether screws are safely placed.

Key Words: Accuracy, evaluation, grading, pedicle screw

INTRODUCTION

Pedicle screw instrumentation is widely used for the stabilization of the subaxial cervical, thoracic, and lumbar spine.[1] The accuracy for free-hand screw placement technique varies from 69% to 94%.[2] Computer-assisted computed tomography (CT) techniques have improved the overall accuracy for pedicle screw placement, and has reduced complication rates. When we compared the two major pedicle screw misplacement evaluation grading systems, the 2-mm incremental system proved to be the most useful.

MATERIALS AND METHODS

In this retrospective observational study, data were collected from the medical records of 34 patients operated on by a single-surgical team utilizing a free-hand technique for the placement of lumbar pedicle screws utilizing a posterior approach with conventional techniques (e.g., anatomical landmarks for guidance). Patients were followed up for a minimum of 12 months. A postoperative CT allowed for direct assessment of the accuracy with which 224 pedicle screws were placed. CT images were independently reviewed by both a neurosurgeon and a radiologist. They employed the two of the most popular grading systems: the 2-mm increment based grading system and the Zdichavsky *et al.* grading criteria. CT's were evaluated using the RadiAnt DICOM Viewer v. 2.2.9. statistical analysis was performed using the IBM SPSS v. 21. A literature review identified these two and other popular grading systems.

RESULTS

The use of the 2-mm increment classification, resulted in 18 (8.03%) misplaced screws; lateral screw misplacement was observed in 13 (5.8%) instances; medial pedicle wall penetration in 5 (2.23%). Of the 18 misplaced screws, 4 (22.22%) were classified as minor (≤2 mm), 12 (66.67%) as moderate (2–4mm), and 2 (11.11%) as severe (>4 mm) [Table 1]. Interobserver reliability was K = 0.882. Using the Zdichavsky *et al.* grading system, we categorized the placement of all 224 pedicle screws; 208 (92.84%) pedicle screws were Ia, 10 (4.46%) as Ib, 1 (0.45%) as IIa, 2 (0.90%) as IIb, 2 (0.90%) as IIIa, and 1 (0.45%) as IIIb grade, resulting in a total of 16 (7.14%) misplaced screws [Table 2]. Interobserver reliability was K = 0.980. Only one patient developed a new radiculopathy, requiring early corrective surgery for screw revision. There were no other early or late postsurgery complication.

DISCUSSION

Innovative CT-guided techniques have greatly contributed to minimizing the incidence of pedicle screw misplacement, especially when utilized by experienced surgeons. The superiority of navigation systems is particularly obvious when applied to abnormal/anomalous spinal structures.[4] However, the cost of the CT-guidance may be prohibitive especially in developing/poor countries where the latter, surgeons must rely solely on their clinical experience and lateral fluoroscopy.

Grading systems

This study compared the value of two systems regarding the free-hand (under fluoroscopy) misplacement of the lumbar pedicle screws. Aoude *et al.* determined the 2-mm incremental based system was the most accurate to define screw malplacement[1] [Table 3]. This was compared to a second classification proposed by Zdichavsky *et al.*[5,6] [Figure 1].

We employed the Landis and Koch Kappa interpretation system for statistical assessment[3] [Table 4]. This resulted in almost perfect agreement between the two observers in using both grading systems, with a slightly better result using the Zdichavsky *et al.* classification. However, both grading systems were reliable and were easily employed in the classification process.

Screw misplacement/complication rates

Our misplacement and early/late complications rates proved to be comparable to the lowest in the literature,

Table 1: 2 mm increment classification system graded patients

Severity	Lateral misplacement	Medial misplacement
Minor	1 (0.45%)	3 (1.33%)
Moderate	11 (4.91%)	1 (0.45%)
Severe	1 (0.45%)	1 (0.45%)
Total	13 (5.81%)	5 (2.23%)

Table 2: Zdichavsky *et al* grading system categorised patients

Grade	Misplaced screws
Ia	208 (92.84%)
Ib	10 (4.46%)
IIa	1 (0.45%)
IIb	2 (0.90%)
IIIa	2 (0.90%)
IIIb	1 (0.45%)

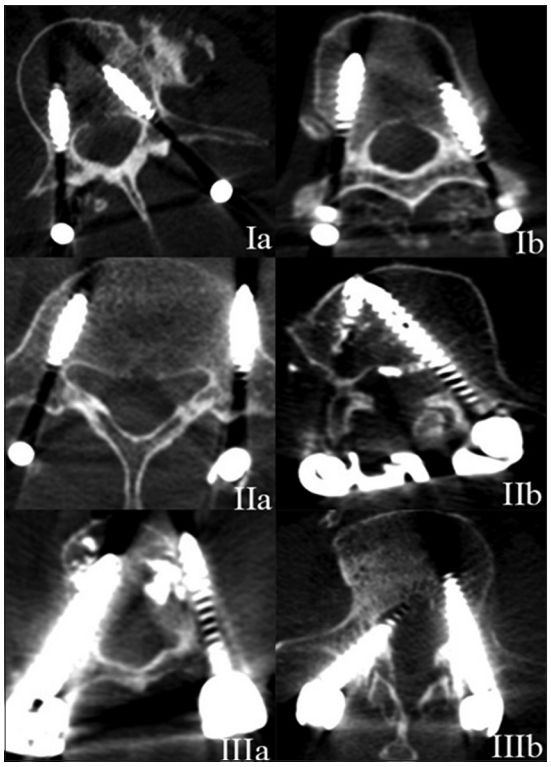

Figure 1: Zdichavsky grading system IA: ≥ 50% of pedicle screw diameter (PSD) within the pedicle & ≥ 50% of PSD within the vertebral body IB: > 50% of PSD lateral outside the pedicle & > 50% of PSD within the vertebral body IIA: ≥ 50% of PSD within the pedicle & > 50% of PSD lateral outside the vertebral body IIB: ≥ 50% of PSD within the pedicle & tip of PS crossing the middle line of the vertebral body IIIA: >50% of PSD lateral outside the pedicle & >50% of PSD lateral outside the vertebral body IIIB: >50% of PSD medial outside the pedicle & tip of PS crossing midline of the vertebral body

showing that our free hand, fluoroscopically guided technique (without using CT guidance) remains safe and effective. Although, the overall misplacement percentage in the literature is low, this does not reflect the potential for neurological/other morbidity.

CONCLUSION

Free-hand pedicle screw placement techniques performed under fluoroscopic guidance remain safe and effective for spine stabilization in the lumbar region. For experienced surgeons, there was only a slight difference in results between conventional vs. computer-assisted techniques for accurate screws placement. We advocate the routine postoperative CT assessment of lumbar instrumented pedicle/screw fusions to allow for accurate confirmation of screw placement. The future introduction of a grading system to better facilitate decision making would be useful.

Table 3: The 2 mm increment classification system

Classification	Borders
Grade I	Screws fully contained within the pedicle
Grade II (minor pedicle perforation)	Up to 2 mm of displacement
Grade III (moderate perforation)	2-4 mm of displacement
Grade IV (severe)	Greater than 4 mm of displacement

Table 4: Landis and Koch Kappa interpretation system for statistical

Classification	Borders
Poor	≤0
Slight	0.01-0.20
Fair	0.21-0.40
Moderate	0.41-0.60
Substantial	0.61-0.80
Almost perfect	0.81-1

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Conflicts of interest
There are no conflicts of interest.

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