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Burkay Kutluhan KAÇIRA[1, a]
İsmail Hakkı KORUCU[1, b]

[1] Necmettin Erbakan University,
Faculty of Meram Medicine,
Department of Orthopedics,
Konya, TURKEY

[a] ORCİD: 0000-0002-7783-7373
[b] ORCİD: 0000-0002-3566-9391

Is Pedicle Screw Placement for Traumatic Thoracolumbar Fractures Safe with Free-Hand Technique? Avoiding Excessive Radiation Exposure is Possible

Objective: Pedicle screw instrumentation is gold standard for unstable traumatic thoracolumbar fractures. Techniques for pedicle screw placement are free-hand 2D fluoroscopy guidance and stereotactic navigation. Aim of this study is to evaluate the reliability of free-hand technique.

Materials and Methods: 450 polyaxial pedicle screws used by 62 patients were evaluated. All screws were placed with free-hand technique at an education hospital. Accuracy of the screws were graded with Zdichavsky grading system.

Results: 397 (88.21%) of 450 screws were graded as 1a (best position) and 1b (good position). Except 8 malpositioned ones positions of 442 (98%) by 450 screws positions were acceptable.

Conclusion: Regardless of the pedicle screw placement technique the skill and experience of the surgeon designates the success of the surgery. For unstable traumatic thoracolumbar fractures pedicle screw placement with free-hand is a reliable technique and avoids excessive radiation exposure both for surgeon and patient.

***Key words**: Vertebra, spinal fractures, pedicle screws, fluoroscopy, accuracy*

Travmatik Torakolumabar Kırıklar için Serbest El Tekniğiyle Pedikül Vidası Yerleştirmek Güvenli mi? Aşırı Radyasyon Maruziyetini Engellemek Mümkün

Amaç: Pedikül vida enstrümentasyonu unstabil travmatik torakolumbar kırıklar için altın standarttır. Pedikül vida yerleştirilmesi için teknikler serbest el, 2D floroskopi kılavuzluğu ve stereotaktik navigasyondur. Bu çalışmanın amacı serbest el tekniğinin güvenilirliğini değerlendirmektir.

Gereç ve Yöntem: 62 hasta için kullanılan 450 poliaksiyel vida değerlendirildi. Tüm vidalar bir eğitim hastanesinde serbest el tekniğiyle yerleştirildi. Vidaların isabetleri Zdichavsky skorlama sistemi ile derecelendirildi.

Bulgular: 450 vidanın 397'si (%88.21) 1a (en iyi pozisyon) ve 1b (iyi pozisyon) olarak derecelendirildi. 8 kötü pozisyondaki vida hariç 450 vidanın 442'si (%98.22) kabul edilebilir pozisyondaydı.

Sonuç: Pedikül vidası yerleştirme tekniğinden bağımsız olarak, cerrahinin başarısını cerrahın yeteneği ve deneyimi belirler. Unstabil torakolumbar kırıklar için serbest elle vida yerleştirmek güvenilir bir tekniktir ve hem cerrahı hem de hastayı aşırı radyasyon maruziyetinden korur.

***Anahtar Kelimeler:** Vertebra, omurga kırıkları, pedikül vidaları, floroskopi, isabet*

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Correspondence
Yazışma Adresi

Burkay Kutluhan KAÇIRA
Necmettin Erbakan University,
Faculty of Meram Medicine,
Department of Orthopedics
Konya - TURKEY

burkaykacira@hotmail.com

Introduction

Although the diagnosis, classification and treatment of fractures of spine are controversial, management of unstable traumatic thoracolumbar fractures are operative procedures for most of the cases in last decades according to physical examination and radiological findings. Pedicle screw instrumentation becomes the most popular method after described by Boucher (1). It is a successful fixation device because it stabilizes all three columns of the vertebra. As it passes through all three columns serious complications may occur because of malpositioned screws(neural, vascular and visceral structure injuries. Pedicle screws biomechanical superiority to hooks and sublaminar wiring depends on its perfect trajectory through the pedicle. Malpositioned screws may not be stable enough and loose easily. Standard and most matured techniques for pedicle screw placement are free-hand technique and 2D fluoroscopy guidance. Although the complication rates are very low when performed by experienced surgeons, recent technologies such as stereotactic navigation systems are developed and used to improve screw placement accuracy (2). These high-tech navigation systems are not available in most of the developing countries. Cost effectiveness and radiation exposure for both the patient and surgeon are still being discussed.

The aim of this study is to evaluate if the pedicle screw placement with free-hand technique for thoracolumbar fractures is a safe technique or not, by evaluating screw accuracy and complication rate.

Materials and Methods

Patients Demographics: This study was designed to evaluate the patients who were operated for thoracolumbar fractures from January 2010 to December 2018 at one education and resaerch hospital. Only the patients stabilized with thoracolumbar pedicle screws and had postoperative computed tomography (CT) scans included in this study. CT scan is not a routine procedure for early postoperative evaluation for the authors. Some of the patients had CT scans for abdominal trauma control. As all the operations were done in a training hospital the operations were performed by one senior surgeon and accompanying residents. For 62 patients (40 male, 22 female), who had the inclusion criteria, 450 polyaxial pedicle screws were used for stabilization. Mean age was 36 (17–72). All the thoracic and lumbar segments had pedicle screws (T2 to L5).

Surgical Technique: All the patients are positioned prone and then the fracture level was determined with C-arm. Midline longitudinal incision was used. The facet joint and the transverse process were exposed. Anatomic land marks were used to determine the starting point for screw placement. Determined points for all levels were perforated with an awl. Marker pins were inserted at these starting points and checked if they were proper with an AP C-arm view. Then a pedicle finder was inserted through the pedicle with a proper orientation according to the level of the spine. Trajectory was checked with a pedicle probe for cortical wall violation and the length of the screw was determined also with the probe. All the pedicle screws were placed and then checked with AP and lateral C-arm views. For short segment fixation only three C-arm views were used for the entire operation.

Radiological evaluation: Axial CT scan views passing through the middle of the pedicle screws were used for radiological evaluation. All accuracy evaluations were performed by one senior surgeon according to the Zdichavsky grading system (3, 4) (Figure 1). All the percentage calculations were done with Microsoft Office Excel program (2007).

Results

Of the 450 screws 215 (47.77%) were at thoracic and 235 (52.22%) were at lumbar spine (Table 1). Approximately half (43.99%) of the screws were placed at T12–L1 level. According to Zdichavsky grading system only 3a and 3b malpositioned screws need revision. All the 3a and 3b malpositioned 8 (1.77%) screws were at thoracic levels where the 47.77% of the screws were placed (Table 2). While 2a and 3b positioned screws perforates the lateral pedicle wall, 2b and 3b perforates medial wall. Medial pedicle wall perforation rate was higher than lateral wall perforation (56.60%–43.39%). None of the patients, even the ones with malpositioned screws had early postoperative complications such as neurologic deficit, cerebrospinal fluid leakage or vascular injury. Only 7 (1.55%) of 8 malpositioned screws were revised early postoperatively due to concern of instability. 397 (88.21%) of 450 screws were graded as 1a (best position) and 1b (good position). Except 8 malpositioned screws 442 (98%) of 450 screws' positions were acceptable. All the patients were allowed to mobilize without any brace or walking aid and none of the patients had ongoing excessive pain which could be considered as a indicator of instability.

Table 1. Pedicle screw distribution over thoracolumbar spine

Level	Number of screws	Percent
T2	6	1.33%
T3	6	1.33%
T4	4	0.88%
T5	6	1.33%
T6	8	1.77%
T7	6	1.33%
T8	8	1.77%
T9	11	2.44%
T10	15	3.33%
T11	51	11.33%
T12	94	20.88%
L1	104	23.11%
L2	57	12.66%
L3	34	7.55%
L4	20	4.44%
L5	20	4.44%

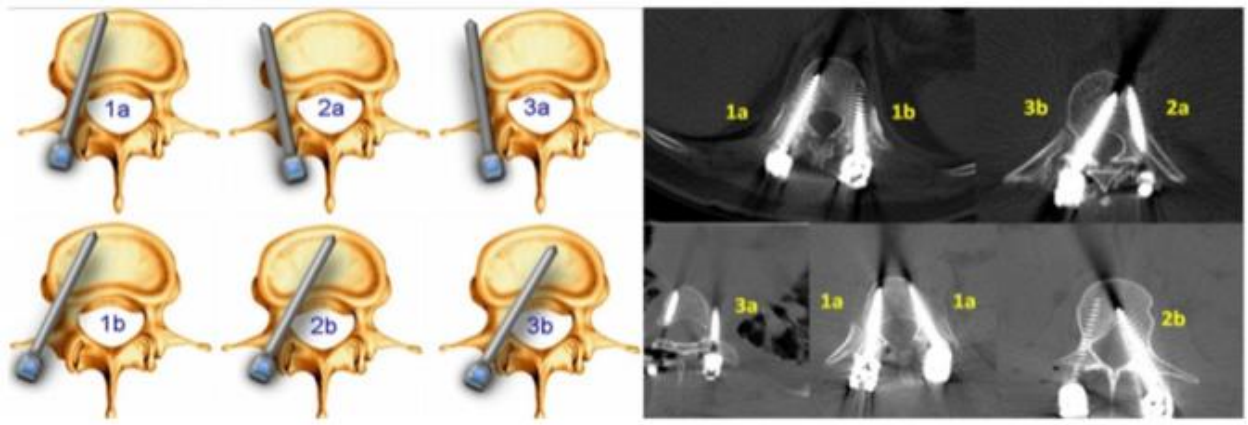

Figure 1. Zdichavsky grading system and radiological evaluation

Table 2. Grading of the screws according to Zdichavsky grading system for each level

Level	Number of screws	1a	1b	2a	2b	3a	3b
T2	6	5	-	1	-	-	-
T3	6	4	-	2	-	-	-
T4	4	3	-	-	1	-	-
T5	6	4	2	-	-	-	-
T6	8	5	2	1	-	-	-
T7	6	3	2	-	1	-	-
T8	8	3	1	-	1	1	2
T9	11	7	2	2	-	-	-
T10	15	10	2	-	2	-	1
T11	51	40	4	2	4	1	-
T12	94	80	4	3	6	-	1
L1	104	86	9	4	5	-	-
L2	57	48	5	1	2	1	-
L3	34	28	2	1	3	-	-
L4	20	16	2	1	1	-	-
L5	20	16	2	1	-	1	-
Total	450	358 (79.55%)	39 (8.66%)	19 (4.22%)	26 (5.77%)	4 (0.88%)	4 (0.8 %)

Discussion

Recently pedicle screw instrumentation is the most popular and accepted surgical method for unstable thoracolumbar fractures (5). As it is widely used surgeons must give importance to correct positioning of the screws for preventing complications related with the procedure (6, 7). Although the improvements in surgical techniques and image guided technology, pedicle screw placement is still a demanding surgery. Malpositioned screws may result with injury of neural, vascular or visceral structures or fixation failure.

Parker et al. (8) reported accuracy of 6817 pedicle screws placed with free-hand technique in the thoracolumbar spine. It was reported that there are only 117 (1.7%) malpositioned screws and as expected most of them are in the thoracic levels. Only 0.8% required revision surgery.

Nevzati et al. (9) reported a series of o education center where the residents and trainees placed screws under the control of a supervising surgeon. 1236 screws of 273 patients was analyzed with Gertzbein classification (10). The ratio of malpositioned screws was 20 % and similar to previous studies malposition of the screws are significantly high in thoracic levels.

Meta-analysis of 85 studies comparing free-hand, fluoroscopy guidance and navigation techniques was reported by Gelali et al. (2). These studies contain total 1105 patients including 6617 screws. This meta-analysis indicates that navigation, especially CT navigation, has higher accuracy than free-hand technique and fluoroscopy guidance. According to this review screws placed with free-hand technique tend to perforate the medial cortex, where as the screws placed with CT navigation guidance seem to perforate more often laterally. This study noted the same situation for free-hand technique. However, CT navigation has higher accuracy, it is reported that there was no significant difference between the technique used and the complication rate.

Most of the studies about this subject reports, also as indicated in this studies result, pedicle screw placement for thoracic spine is more demanding. More recent meta-analysis compared CT navigation and fluoroscopy-guided navigation for thoracic pedicle screw placement (11). Two techniques were compared for accuracy, incidence of complications, time of insertion, blood loss and operative time. It was indicated that CT navigation is better on mentioned subjects than fluoroscopy except operative time. Authors conclude that despite all its' benefits high cost of devices and very high radiation exposure of patient and surgeons limits the use of CT navigation.

Most of the studies about this subject contains heterogenous patient population. Results were obtained from both trauma, deformity and fusion cases. This study was designed to evaluate only for trauma patients to homogenize the population. Verma et al. (12) also studied on trauma cases. It was reported that better accuracy of navigation systems did not improve the functional outcomes and reduce neurologic complications of trauma patients.

Warner et al. (13) examined the clinical effects of improved pedicle screw accuracy with computer navigation technology in reducing complication rates in 3168 patients undergoing multi-level spinal fusion. It was indicated that surgical time was significantly longer in the navigation group (391.41 versus 350.3 minutes), but there were no significant improvements in complication rates.

Main limitations of this study is relatively small population and the grading system that was used to evaluate the accuracy. Zdichavsky (4) grading system evaluates the screw position only at axial orientation. Despite the limitations our results are similar to such reports. It is also a limitation that there is no long-term functional outcome results because aim of this study is

to determine the accuracy of free-hand technique and early postoperative complication rates based on malpositioned pedicle screws.

Conclusion; in the recent decades pedicle screws became gold standard for stabilization of the thoracolumbar fractures. Especially for thoracic spine pedicle screw placement is a demanding procedure. However complication rate associated with pedicle screw malposition is quite low. Large series have reported high levels of accuracy for a variety of techniques including free-hand technique, 2D non-guided fluoroscopy, and with various types of intraoperative guidance. Despite better accuracy rates of CT navigation, it is not superior to conventional methods about functional outcomes and complication rates. Regardless of the pedicle screw placement technique the skill and experience of the surgeon designates the success of the surgery. For unstable traumatic thoracolumbar fractures pedicle screw placement with free-hand is a safe technique and avoids excessive radiation exposure both for surgeon and patient.

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