Iraqi JMS

Published by Al-Nahrain College of Medicine
ISSN 1681-6579
Email: iraqijms@colmed-alnahrain.edu.iq
http://www.colmed-alnahrain.edu.iq

# Pedicle Screw Placement versus Classic Surgery in Lumbothoracic Spine Disorder

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## Abstract

**Background** Pedicular screw fixation surgery for thoracolumber disorders is well established surgical method to treat instability due to different etiologies due to trauma, infection, tumor as well as spondylopathic deformity.

**Objective** To evaluate surgical modalities in the treatment of lumbothoracic disorders.

**Methods** Prospective study of 30 patients 6 lower dorsal trauma, 2 treated by screw and 4 by decompressive laminectomy and bone graft using rib, 4 spondylolesthsis treated by screw and 8 cases by decompessive laminectomy and fusion, 4 spondylosis treated using screw and 8 treated only decompressive and foraminotomy .

**Result** Spinal fusion using pedicle screws has become popular worldwide in treating a variety of disorders of the spine. Treatment of thoracolumbar fracture with pedicle screws at injury level is easy and worthy. Compared to the lumbar region, the insertion of thoracic pedicle screws remains a challenge, despite of modern technology and computer assistance especially in the upper thoracic spine, where misplacement rates of up to 40% CT-navigation leading to the conclusion that pedicle screw instrumentation in the middle and upper thoracic area should be carried out with the help of navigation only. The availability of an intraoperative CT seems to be of particular importance. An accurate assessment of screw positions becomes hereby possible without any significant time delay and with utmost accuracy.

**Conclusions** Transpedicular fixation of thoracolumbar and lumbar spine fractures has become a frequently used technique. Transpedicular screw fixation provides the greatest stability in the unstable spine.

**Keyword** Pedicle screw, accuracy, lower dorsal trauma, hydatid spine

**List of Abbreviation:** CT = computerized tomography, AP = antero-posterior, PSD = pedicular screw diameter, TSA = transverse section angle, MRI = magnetic resonance image.

## Introduction

Pedicle screw fixation use for spinal instability was first reported for the lumbosacral region and has been extensively studied and is widely performed today [1].

The relative ease of implantation is mainly due to the larger size of both the vertebral body and the pedicle diameters, as compared to the mid and upper thoracic vertebral anatomy [2] Interest in thoracic pedicle screw use has gained momentum recently, especially in the lower thoracic spine [3,4].

Lumbar spinal fusion is a commonly performed surgical procedure. It is used in a variety of spinal pathologies including degenerative disease, trauma, spondylolisthesis and deformities.

A mechanically stable spine provides an ideal environment for the formation of a fusion mass. Though the degree of stability required for spinal fusion is unknown, increased stiffness of the spine improves fusion rates, and lowers the chances of nonunion at the graft site. Instrumented spinal fusion also allows early ambulation with minimal requirement of a post operative external immobilizer [5,6]. The first attempt at spinal fusion with internal fixation was reported in 1891 [5] with the use of a wiring technique. Currently, pedicle screws are frequently used to provide spinal stability till the formation of a fusion mass. Pedicle screw fixation has numerous advantages over other methods of spinal fixation for the last two decades points towards their efficacy and consistency in outcomes ([7-9].

Concerns have been raised regarding the extensive paraspinal muscle retraction required for their insertion, and the consequent increased infection rates and muscle injury [10]. Also improperly placed screws may cause neural and vascular damage [11].

Small pedicle width, altered pedicle morphology, and shift of the surrounding structures by rotation causes a consistently smaller safe zone in terms of pleural, spinal cord, and vascular injury. In thoracic pedicle fixation of pediatric idiopathic scoliosis [12,13] however, despite their common use, safety concerns related to screw malposition have been described [14-16].

Violation of the pedicle by a screw can cause injury to the neural structures along any of the four quadrants of the pedicle. When this occurs, the negative consequences of screw placement may outweigh the advantages offered by the systems [17].

The objective of this study was to evaluate different surgical modalities used in the treatment of lumbothoracic disorders and study the percent of accuracy of pedicular screws placement

## Methods

This is a Prospective study of 30 patients in Al-Kadhimmiya neurosurgical centre from Feb. 2011 to Jan. 2013. In this study, the patients diagnosed and then treated by surgery we used either decompression with laminectomy, with or without pedicle screw in lumbar spine or thoracotomy and rib graft or pedicle screw in trauma. In pedicle screw, we use these steps, pedicle preparation, determination of screw length, screw placement, rod placement, lever placement. Using the distractor for reduction and then tightening of pedicle. In cases of screw, we use special operative table and C- Arm X-Ray that enable us to take AP and lateral view of the pedicle. Follow up of patients clinically, X-Ray of spine and or CT spine in cases of pedicle screw to determined accuracy of screw.

Criteria of pedicle screw placement were:

(1) Relation of pedicle screws to the pedicle.

(2) Relation of pedicle screws to the vertebral body.

Pedicle screws are scored as follows:

Grade Ia: optimally placed screws, rigidly anchored within the pedicle and vertebral body.

Grade Ib: screws are placed with > 50% of the pedicle screw diameter (PSD) lateral outside of the pedicle and with > 50% of the PSD within the vertebral body.

Grade IIa: screws are placed with ≥ 50% of the PSD within the pedicle and > 50% of the PSD is lateral outside of the lateral cortex of the vertebral body.

Grade IIb: screws are placed with ≥ 50% of the PSD within the pedicle and the tip of the screw crosses the midline of the vertebral body.

Grade IIIa: screws are located with > 50% of the PSD lateral outside of the pedicle and the lateral vertebral cortex.

Grade IIIb: screws are located with > 50% of the PSD medial outside of the pedicle and the tip of the screw crosses the midline of the vertebral body.

The need for revision of pedicle screws was estimated on consensus of the participating surgeons.

In spinal hydatidosis, we use thoracotomy, then dorsal corpectomy, we resects rib and use it as graft. In this study, we use the term decompressive laminectomy when we perform laminectomy, disctomy, foraminotomy, removal of lateral recess either all these procedure or some of them.

## Result

Second lumber wedge fracture was shown by plain X-ray (Fig. 1) and MRI (Fig. 2). Pedicular screws were fixed with rods or not (Fig. 3).

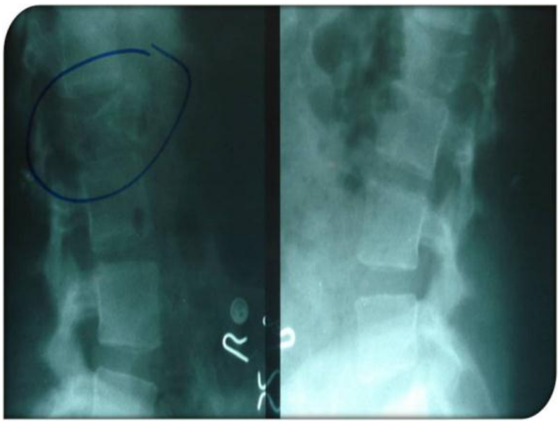

**Fig. 1. Plain x-ray of lumosacral spine showing L2 wedge fracture**

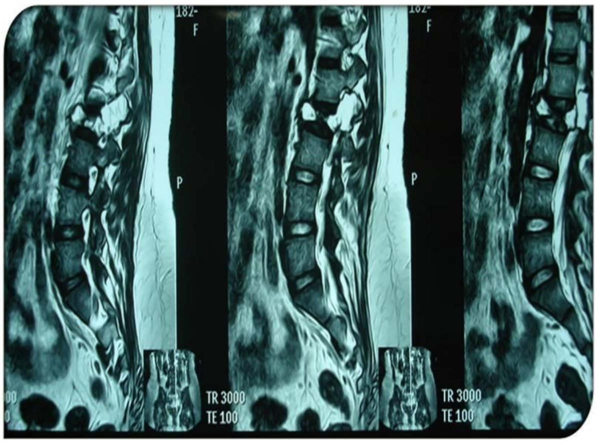


**Fig. 2. Lumbosacral MRI-T2 study showing L2 fracture**

Surgery done for all patients, classical laminectomy done for 8 patients and pedicular screw placement for 4 patients and in patients with spondylosis, 8 patients with classical laminectomy and 4 patients with pedicular screw, in thoracic region pathology, 2 pedicular screw surgery for traumatic injury and 4 thoracotomy and rib graft for patients with hydatid spine (Table 1).

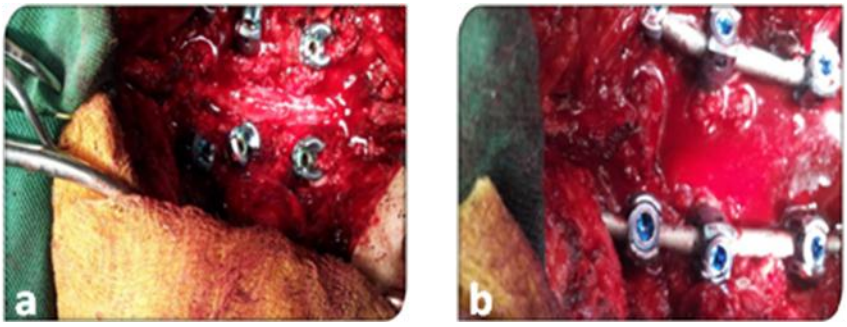


**Fig. 3. Intraoperative picture showing (a) placement of pedicular screws with decompressive laminectomy, (b) placement of pedicular screws with rods for fixation.**

**Table 1. Distribution of patients according to the pathological disorder and type of operation**

| Character | | Lumbar spondylosis | Lumber spondylolesthesis | Dorsal trauma | Dorsal hydatid |
|---|---|---|---|---|---|
| Number | | 12 | 12 | 2 | 4 |
| Operation | Classical laminectomy | 8 | 8 | - | - |
| | Pedicle screw | 4 | 4 | 2 | - |
| | Thoracotomy and rib graft | - | - | - | 4 |

Postoperative complications were presented in table 2. One patient with classical laminectomy had sphenicteric problem, 1 patient with lumbar screw surgery had ipsilateral lower limb parasthesia and 4 patients with thoracotomy had lower limb motor weakness preoperatively and continued postoperatively.

**Table 2. Operative complications**

| Treatment type | | Motor | Sensory | Sphinecteric |
|---|---|---|---|---|
| Lumber | Classic laminectomy | Nil | Nil | 1 |
| | Screws | Nil | Paraesthesia | Nil |
| Dorsal | Thoracotomy | 4 | Nil | 1 |
| | Screw | Nil | Nil | Nil |

The accuracy of pedicular screw using post operative CT scan as scoring system (42 screw of ten patients)shows that 14 patients with 1A score, 10 with 1B score, 12 with score 2A, and 6patients with score 2B but none with 3A and 3B.

## Discussion

A variety of conditions resulting from degenerative, traumatic, and other abnormalities of the lumbar spine are best managed by achieving spinal stability and attaining a solid fusion. To decrease failures in arthrodesis, a number of different devices have been developed to provide internal stability while the fusion is healing.

Because the pedicle offers the strongest point of attachment to the spine, most spinal instrumentation systems use screws for fixation placed into the pedicle and then the vertebral body. However, a number of complications associated with pedicle screw fixation have been reported. One of the most serious complications related to pedicle screw usage is neurologic injury, secondary to misplaced pedicle screws abutting, or injuring, a nerve root (18).

There are a number of techniques described to determine the location to enter the posterior aspect of the pedicle. The three we chose are often discussed and used (Roy-Camille, Magerl, and Du). Roy-Camille and Magerl suggest that the starting point for inserting a pedicle screw should be based on the anatomic relation of the facet joint and transverse process (19).

Roy- Camille's entry point is the closest to the midline of the spine as the line through the plane of the facet joint is one of the crossing points (20). Magerl's entry point is further lateral, located at the nape of the neck of the superior articular process. Du's described entrance to the pedicle is located between Roy-Camille and Magerl's (21).

Pedicle violations by pedicle screws have been reported to occur more often through the medial and lateral walls than the superior and inferior walls (22). One reason for this is that the pedicle heights are often greater than widths. Additionally, the cortical thickness of the superior and inferior walls is generally more than 2 mm, whereas the medial and lateral walls are less than 2 mm.

If different starting holes are chosen to enter the pedicle, the angle of insertion will differ and can lead to a relative diminution in the safe range for pedicle insertion through the isthmus of the pedicle. The key to a successful transpedicular screw insertion is that the small pedicle is correctly entered, and the walls not penetrated by Du are closest to the pedicle access at L1 and L2.

There were significant differences in the safe range of TSA between the three methods from L3 to L5, as the pedicle diameters and pedicle axis increase in obliquity, while the facet joints become more coronal. The latter is used as one point in the anatomic localization of the posterior pedicle. Both Du and Magerl's techniques can be applied at L3 and L4 because of their larger safe range of TSA. At L5, however, Magerl's method is a better choice because of the larger safe range of TSA. Roy-Camille's described technique gives the least amount of freedom in insertion angle of a pedicle screw as its safe range for TSA is the smallest.

In summary, choosing the proper entry point to inserting pedicle screws is penetration of the pedicle wall. Understanding pedicle angles and morphometry also helps decrease the risk of pedicle violation during screw insertion [23,24].

The technique utilized in this study involved a short-segment construct with pedicle screws one level above and one level below the fracture site only, while other use it with additional screws fixed at the level of the fracture.

The supporting point was set at the fractured vertebra body, which was repositioned with the appropriate connected vertebral bodies and stabilized by forces from the ligament and annulus fibrosus. In addition, the pedicle screw at the level of the injury may apply pressure to the fractured vertebral body in order to correct vertebral deformity and lateral displacement. This group found that the six screw model increased stiffness in axial loading.

In flexion testing, the six screw model demonstrated 84 % greater stiffness compared to the four screw construct. Furthermore, the six screw construct was 38 % stiffer than the four screw construct in torsional testing. Shen *et al* [25] have also suggested that six pedicle screw fixation is superior to four pedicle screw fixation. The intermediate screw is thought to function as a push point with an anterior vector, thus creating a lordotic force.

The intermediate screw also provides improved ''three point fixation,' In conclusion, under our experimental conditions, they found similar stability between the six pedicle screw model at the level of the injured vertebrae and the four pedicle screw model as we did in this study.

Additional screws placed at the fractured vertebra body may help reduce stress at both the superior and inferior pedicle screws, and may also disperse the stress load maintained by internal fixation, thus reducing screw fatigue and breakage. This study was limited to vertebral compression fracture, and thoracolumbar burst fractures.

Pedicle screw fixation is a challenging procedure in thoracic spine, as inadvertently misplaced screw has high risk of complications. The accuracy of pedicle screws is typically defined as the screws axis being fully contained within the cortices of the pedicle The use of thoracic pedicle screw instrumentation has become increasingly widespread in the treatment of scoliosis owing to the consistently superior results achieved in terms of fixation and deformity correction [26,27].

The diameters of screws were 4.5 or 5.5 mm. The accuracy of pedicle screws is typically defined as the screws axis being fully contained within the cortices of the pedicle [28,29].

The correct pedicle insertion is the aim of all surgeons so there are many scoring system ranging from free hand insertion to 3D Image, Correctly placed screw completely inside the pedicle with no breach or perforation of the pedicle wall. Minor perforation of the pedicle wall less than 2 mm to either side. Moderate displacement perforation of 2 mm to less than 4 mm to either side. Severe displacement perforation of more than 4 mm to either side of the pedicle but in this study no place for free hand pedicle screw.

The free hand pedicle screw insertion technique exhibits similar accuracy in experienced hands as compared to the image-guided techniques. It has been suggested that slightly medial 2 mm or lateral 6 mm violations have little clinical or anatomic consequence and, therefore, have been deemed as acceptably placed screws [30,31].

Medial screw malposition was measured between medial pedicle wall and medial margin of the pedicle screw. The distance between the lateral margin of the pedicle screw and lateral vertebral corpus was measured as lateral malposition.

A screw that violated medially greater than 2 mm was rated as an ''unacceptable screw'' while a screw that violated laterally greater than 6 mm was rated as an ''unacceptable screw [23]. Other they use the assessment of the inter- and intraobserver reliability of the scoring system is essential to ensure to work with an accurate tool.

Interobserver reliability refers to the level of agreement between different observers. Intraobserver reliability indicates the reproduce-ibility for one observer.

A reliable scoring system may be used as a basis for decision on pedicle screw revisions and may be helpful in terms of a better comparability of different studies.

Investigation of the interobserver agreement showed that revision of pedicle screws was recommended mainly for grade III screws with or without neurologic symptoms that occurred postoperatively. Grade IIIa screws should be revised due to mechanical reasons and grade IIIb screws due to a neurologic compromise.

Revision was additionally suggested for IIb screws in case of neurologic symptoms that appeared postoperatively. Similar results were obtained for the intraobserver agreement of pedicle screw revision, but calculated intraobserver agreement values were much lower for each grade. One reason might be that interpersonal discussions of the observers resulted in an increased tolerance of not optimally placed pedicle screws [32]. This is easy and simple we use it in this study in postoperative period to assess the accuracy of pedicle insertion of 42 screws done in current study.

Other use CT-navigation versus fluoroscopy-guided placement of pedicle screws at the thoracolumbar spine: In the lumbar spine, the placement accuracy was 96.4 % for CT-navigated screws and 93.9 % for pedicle screws placed under fluoroscopy, respectively. This difference in accuracy was statistically significant (Fishers Exact Test, p = 0.001). The difference in accuracy became more impressing in the thoracic spine, with a placement accuracy of 95.5 % in the CT-navigation group, compared to 79.0 % accuracy in the fluoroscopy group (p\0.001).

The significance of CT-navigation, especially when instrumentation of the middle and upper thoracic spine is carried out. As an alternative to other modern 3D navigation techniques, the computed tomography based navigation is an indispensable tool in these cases. In the lumbar and lower thoracic spine, both methods seem comparable.

A post-instrumentation CT scan seems to be of particular importance, allowing the surgeon to evaluate the accuracy of instrumentation before wound closure and to replace it when necessary.

Computer-assisted surgery might improve the rate of optimal pedicle screw placement [33]. In this study s we used screw in thoracolumbar and lower dorsal spine, and all 42 screws in scoring 1A, 1 Band B1, B2 which means correct insertion of all screw with no single revision. We have no case in our work for height or midorsal spine, which is better to use CT scan navigated screws.

The reported pedicle screw misplacement in historical spinal literature can be as high as 20-39.8%, but only a small number leads to complications neurological, vascular or visceral injuries; but these complications can be potentially life and limb threatening [34].

Replacement of pedicle screws should be considered and discussed depending on the radiologic findings by CT scans and the clinical aspect of the patient [35].

Despite reports on this accurate insertion technique, results demonstrate pedicle screw penetrations of the lateral and medial pedicle wall and pedicle screw misplacement in 4.3% [36,37].

Additionally, computer-assisted surgery requires a higher radiation dose and an extended operation time than do fluoroscopically controlled procedures [38] fluoroscopy-guided in vivo placement of pedicle screws reached a transpedicular accuracy rate of 81.6% (grade Ia) of pedicle screws.

In this study, using fluoroscopy intraoperativly only no anterior vertebral perforation was noted. In none of the patients, neurovascular complications were caused by screw placement.

In one study of accuracy of pedicle screw placement conclude that the screws positioned with free-hand technique tended to perforate the cortex medially, whereas the screws placed with CT navigation guidance seemed to perforate more often laterally.

In conclusion, navigation does indeed exhibit higher accuracy in pedicle screw placement than free-hand technique and use of fluoroscopy even 3D scans after pedicle screw positioning cannot avoid false placement of screws and primary neurovascular damages. But screws in malposition can be detected with a high reliability.

Immediate correction of malplaced screws lowers the secondary revision rate of the patients and prevents patient's ahead secondary neurovascular problems and instability or dislocation of the fixateur [37].

Leakage of cerebro-spinal fluid after removal of a pedicular screw, a case of cerebrospinal fluid leakage occurring after the removal of a pedicular screw is reported. It allowed emphasizing the frequency of the dural tears in spinal surgery, particularly when pedicular screws are used. Moreover, the removal of screws having involved neurological complications can induce other lesions, such in the reported case. This removal procedure is not benign and requires precautions and a monitoring identical to the other spinal procedures [38].

Neurovascular risks of sacral screws with bicortical purchase, an anatomical study as a conclusion, anterior cortical penetration during sacral screw insertion carries a risk of neurovascular injury. The risk of sacral sympathetic trunk and minor vascular structures together with the major neurovascular structures and viscera should be kept in mind [39].

Regarding our complications in hydatid spine there is no motor and urine retention and only transit parasthesia in one case of pedicle screws, no CSF leak, and no neurovascular damage.

## Acknowledgments

Great thanks to Al-Saar scientific bureau for support in introducing pedicular screw sets and consumables to our teaching hospital and help us in treating patients perfectly.

## Conflict of interest

There is no conflict of interest that could influence the objectivity of the research reported

## Author contributions

Dr Kafaji collected part of the data and write the manuscript and Dr. Hamandi collected part of the data and designed the paper.

## Funding

There is no funding agency either official or private sector

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**Received 18th Jun. 2014: Accepted 3rd Sep. 2014.**