Evaluation of the Image Guided Pedicle Screw Insertion: Limited Experience

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ABSTRACT

Background: Image-guided technology has greatly broadened the scope of modern surgery. Objective: Evaluation of the accuracy of pedicle screw placement using navigation and the safety offered to the surrounding structure during screw placement and affection of the workflow. Methods: eight patients with dorsal and dorso-lumbar instability were operated upon by pedicle screw fixation using 3D image guidance. BrainLAB Vector Vision (BrainLAB, Inc.). all patients had preoperative, intra-operative and postoperative imaging. Results: no vascular or neural complications were encountered, accuracy in choosing the entry point was high (100%) and accepted in medio-lateral inclination (62.5% perfect match and the rest showed minimal deviation less than five degrees). Conclusion: The use of spine navigation in the placement of pedicular screws provides higher accuracy, and is safer to the patient with less percentage of misplacement. [Egypt J Neurol Psychiat Neurosurg. 2010; 47(3): 471-476]

Key Words: instrumentation, spine navigation, spine instability

INTRODUCTION

The use of pedicle screw instrumentation was described by Boucher in 1950s, and was popularized by Roy- Camille et al in 1960s. The initial use of pedicle screws began in the lumbar spine and as the surgeons became more comfortable with the complex anatomy required for accurate screw placement, they evolved the use of pedicle instrumentation in the thoraco-lumbar and thoracic spine.1

Transpedicular screw fixation has many advantages over other spinal instrumentations such as Harrington rod fixation, Luque’s instrumentation, etc., in various pathologies. Pedicle screws also prevent the need to place instrumentation within the spinal canal like sublaminar wiring, which creates the risk of neurological injury.1

Safety concerns on the violation of the spinal canal leading to potential harm to vascular, neural and other vital structures have been encouraging surgeons to improve the accuracy of pedicle screw placement by trying various approaches.2

The reported pedicle screws 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.3

The accuracy of pedicle screw placement has been discussed, as misplacement rates of up to 30% in the lumbar spine an up to 55% in the thoracic spine have been reported. Different techniques of pedicle screw placement have been described in the past. However, none of these techniques reduced the incidence of misplacement.4

Image-guided technology has greatly broadened the scope of modern surgery. Studies indicated that pedicle screw insertion accuracy could be significantly improved with image-assisted systems compared with conventional approaches. Among them, computed tomography-based navigation was the most popular.5

Aim of the work:
Evaluation of the accuracy of pedicle screw placement using navigation and the safety offered to the surrounding structure during screw placement and affection of the workflow.

PATIENTS AND METHODS

Eight patients with spine instability needing stabilization were operated upon by pedicle screw fixation in national bank hospital, Egyptian ministry of Health, in the period between September 2009 and February 2010 using the neuro-navigation BrainLAB Vector Vision (BrainLAB, Inc.). All cases were subjected to complete history taking, general and neurological examinations and routine laboratory investigations. All patients had
preoperative x rays of area of pathology, computed
tomography with 3D reconstruction and magnetic
resonance imaging in most of the cases.

The technique of screw placement was the same
in all patients. After registration was accomplished,
navigation accuracy was confirmed by touching
anatomical landmarks with the image-guided probe.
The intra-operative planning function on the image-
guided system, which places a phantom screw on the
tip of the probe, was then used to ascertain the entry
point and trajectory of the screw. The optimal length
and diameter of the screw were also determined using
this function, and it should be noted that in each case
effort was made to place the maximum diameter
screw that the anatomy could accommodate. This
intra-operative plan was locked into place, and all
subsequent drilling/probing was done with image-
guided instruments through this plan. After the
pedicle was either probed or drilled, a pedicle feeler
was then used to confirm that there was no pedicle
breach, and the hole was then tapped in the same
trajectory. After a pedicle feeler again confirmed no
pedicle breach, the screw was placed. Navigation
accuracy was briefly checked again prior to placement
of the next screw by touching anatomical landmarks.
In most cases, the tap and screwdriver were not image
guided.

After completing the procedure, intra-operative
X-ray of the surgery site was routinely done to
confirm proper placement of the instrumentation.

Routine plain X-ray film, both antero-posterior
and lateral on the second day post-operative were
done, in some cases, post-operative CT scan at the
surgery site was also done.

**Technical notes:**

During the procedure, good care should be
taken at the time of registration. The degree of
inclination and rotation of the vertebral body should
considered and should corrected on the navigation
screen.

Proper exposure and good dissection of the soft
tissue off the spinous process, the lamina, and the
pedicles should be achieved, to reach the highest
accuracy percent.

Using the navigation added about 10 to 15
more mints to the time of surgery. This time was
spent during the process of registration. On the other
hand it reduces the need to use the intra-operative
fluoroscopy and hence decreased the radiation
exposure time for the operating room personnel.

**RESULTS**

Out of eight patients (Three females and five
males, with age ranging from 25 years to 56 years
with a mean of 40.5 years), three cases had fracture
in the dorsal spine, two of which were traumatic
(D10 and D11), and one case was pathological
fracture (D6-7). The other 5 cases had degenerative
spondylolisthesis, (L4-5 in three cases, and LSS1 in
two cases). (Table 1)

All patients complained of back pain before
surgery. In the post-traumatic cases, none of them
had spinal cord compression, and hence there was no
weakness in the lower limbs, or sphincteric
dysfunction. (Table 2)

All patients with degenerative spondylolisthesis
had back pain and radiculopathy, with failure of
medical treatment that was tried for an average of
three months. None of these patients had weakness
or sphincteric dysfunction pre-operatively.

Thirty six pedicle screws were used in this
study using the spinal navigation. All the screws
appeared in good position in the post-operative plain
X-ray. We didn’t have any breaches in our study.
The accuracy of the procedure was checked. We
compared the points, angles and endpoints we chose
on the planning screen and the postoperative CT
scans we have done to the patients and the results
were matching. The entry points with 100%
accuracy as planned. Five patients out of eight had
matching angles on medio-lateral inclination with
62.5% accuracy. The remaining cases had deviation
not exceeding 5 degrees.

Figures (1,2) are case presentations showing
pre- intra and postoperative images.

<table>
<thead>
<tr>
<th>Table 1. Level of the pathology in patients with spinal instability</th>
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<tr>
<td><strong>Number of patients</strong></td>
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<tr>
<th>Table 2. Pre-operative complaints in patients with spinal instability</th>
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<tr>
<td><strong>Complaint</strong></td>
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</tr>
<tr>
<td>Back pain</td>
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<tr>
<td>Leg pain</td>
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<tr>
<td>Weakness in the lower limbs/ sphincteric dysfunction</td>
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Figure 1. Case 1: Pathological fracture of the dorsal spine: (A) Pre-operative MRI for a case of pathological fracture dorsal spine (B) Intra-operative Plain X-ray during leveling (C) Intra-operative, during level definition using navigation (D) Starting registration (E) Intra-operative checking of the screw after insertion (F) Post-operative Plain X-ray.

Figure 2. Case 2: Degenerative L5,S1 Spondylolthesis: (A) Pre-operative MRI LSS. (B) Intra-operative during verifying registration. (C) Intra-operative during screw navigation. (D) Post-operative plain X-ray LSS.
DISCUSSION

Navigation technology is a widely available tool in spine surgery and has become a part of clinical routine in many centers.\(^4\)

Pedicle screw fixation was long used with the aid of intra-operative fluoroscopy. Even some surgeons with long practice don’t feel the need to use it especially in the lumbar spine. However, a number of complications are present in the literature related to misplacement of screws.

In a meta-analysis of the published literature on accuracy of PS placement, Kosmopoulos and Schizas\(^5\), reported a median accuracy of 90.3% in 12, 299 PSs placed in vivo without navigation versus a median accuracy of 95.2% in 3059 PSs placed in vivo with navigation. In another cohort, Nottmier and colleagues\(^6\), studied their results with 1084 screws placed using the navigation and they had no vascular or visceral complications. Two nerve root injuries occurred in 1084 screws placed, resulting in a 0.2% per screw incidence and a 0.9% patient incidence of nerve root injury. Neither nerve root injury was associated with a motor deficit. The breach rate was 7.5%. Grade 1 and minor antero-lateral “tip out” breaches accounted for 90% of the total breaches.

We didn’t have any breaches in our study; however we can’t state that we did better than Nottmier’s work due to the significant difference in the number of cases.

Pedicular screw placement using navigation has been used in this case study in different forms of pathologies, and at different levels. It was of real help in cases with fracture spine. During registration, orientation of the rotation and inclination of the vertebral body due to the fracture using the navigation helped in safe screw placement.

Moreover, the value of having higher safety margin during introduction of the pedicular screw, but the less time of radiation exposure is weighted against the more time consumed during surgery by using the navigation.

Conclusion

The use of spine navigation in the placement of pedicular screws provides higher accuracy, and is safer to the patient with less percentage of misplacement.

[Disclosure: Authors report no conflict of interest]

REFERENCES

الملخص العربي

إن الاستخدام جهاز الملاح الجراحى في جراحات المخ وعمود الفقرى ترجع بداياته إلى خمسينيات القرن الماضى وتعود أهميه استخدام الجهاز إلى أن نسبة الخطاء في توجيه مسامير العمود الفقرى تصل إلى 39.8% وتمكى خطوة هذا الخطأ في التوجيه من حدوث مضاعفات لمرضى تزيد خطورة وتسى هذه مضاعفات في المنطقة العقلية والصدرية أكثر من المنطقة العظمية والعجزية.

يهوى هذا البحث إلى تقييم دقة توجيه مسامير نثبت العمود الفقرى باستخدام جهاز الملاح الجراحى وما المدى الفائدة العامة من استخدامه. تم إجراء هذا البحث على تماىى مرضى يعانون من عدد ثبات العمود الفقرى وتم إجراء الجراحات بمستشفى النجع الإلتهى للرعاية المتكاملاة في الفترة من سبتمبر 2009 إلى فبراير 2010. تم تركيب 36 سمار في هذا البحث. جميع الأشعة أثناء وما بعد الجراحة مرضى وسبى ما تم التخطيط له على شاشة جهاز الملاح الجراحى وأصلع ما بعد الجراحه للاحظنا الآتي:

- 60% دفه في اختيار نقطة دخول السمار. 62.5% دفه في زاوية الدخول مع ملاحظه أن يافي 37.5% كان نسبة الخطأ لا ترتيب 5 درجات.
- لا يوجد أي اختراق للقشرة من الجانى أو من الأمام أو من الأسفل.

في النهاية تستخلص أن جهاز الملاح الجراحى يؤرذ دفو أكثر في توجيه السمار ولا يطلب وقت إضافى ملاحظ أثناء سير الجراحه ويصح به دائما.