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Research Article

Evaluation of accuracy of computed topographic- based navigation assisted pedicle screw placement in thoracolumbar spine fracture

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ABSTRACT

Background: Although pedicle screw fixation is a well-established technique for the thoracolumbar spine fracture, but the screw placement in the thoracolumbar spine is more challenging because more complex 3D anatomy. Incorrect placement of pedicle screws may lead to neurovascular injury, so the accuracy of pedicular screw placement is very crucial task. CT based navigation devices may allow surgeons a safe and more accurate method for placing pedicle screws with no radiation exposure intraoperative.
Method: A Computed topographic (CT) based image guided navigation system was used for pedicle screw insertion. The accuracy of the pedicle screw placement was analyzed According to 'Learch and Wiesners classification' and 'Heary classification' for pedicle screw malplacement with a review of postoperative radiograph and CT scan image.
Result: Under the guidance of CT based navigation 52 pedicle screws were inserted, out of which 02 pedicular screw shows lateral pedicle cortex breach.
Conclusion: The accuracy of pedicle screw placement is crucial for thoracolumbar spine fracture fixation. The placement of pedicle screws can be done more accurately and safely with the aid of a CT-based navigation system. Furthermore, this opens the possibility for surgeons to reduce radiation exposure by eliminating the need for intra - operative fluoroscopy.

Key words: Navigation, Thoracolumbar spine fracture, Pedicular screw, Unstable fracture, Computed tomography

INTRODUCTION

The thoracolumbar injuries are the most common spinal injuries occur due to fall from height, road traffic accident and sports injuries. Although majority of spine fractures can be treated conservatively, surgical stabilization is warranted in grossly unstable fractures and in presence of concomitant neurological deficits.[1,2] Pedicle screw has emerged as the most preferred modality of posterior spinal stabilization because of its superior biomechanical characteristics, feasibility in presence of disrupted posterior elements and possibility of concomitant decompression.[3] The goal of the treatment of the unstable thoracolumbar injuries is to optimize neural decompression while providing stable internal fixation over the least number of spinal segments. Misplacement of screws can lead to vascular injury, neurological injury, dural tear, and pedicle fractures that can compromise stable fixation, so the position of pedicle screws is critical in fixation of fracture spine.[4] The incidence of neurological complications associated with pedicle screw placement has been reported to be 1% to 3%.[5] The advent of high speed computers and computer tomography has revolutionized medical imaging in preventing postoperative complications, and allows spine surgeons to perform CT-based image guided surgery. The

image-guided system has appeared to improve the surgical accuracy and safety of pedicle screw placement.[6]

METHODS

Total 13 patients who received CT-based navigation-assisted pedicle screw insertion for thoracic or lumbar spine fractures were evaluated during the study period from September 2012 to September 2014.

All the patients with age group >18 years with traumatic thoraco - lumbar unstable fractures of vertebrae, fracture dislocations with neurological symptoms. The causes of injury included falls from a height, road traffic accidents or fall of hard object etc. All patients were initially assessed and their epidemiological and physical findings were noted. After initial investigations and hemodynamic stabilization, pre-operative neurological status was graded on the basis of ASIA grading. It was also used to assess postoperative recovery and follow-up. All the patients had routine X-rays of thoraco - lumbar spine in both anterio - posterior and lateral views. In all the patients CT-based navigation used for pedicle screw insertion.

For all patients, thin-section (2mm slice) CT scans of the spinal segments to be instrumented done preoperatively and uploaded in the navigation brain lab monitor to reconstruct a three-dimensional bone structure model of the involved spinal segments. The patient was put in prone position on a spinal frame on OT table. Operative site prepared and infiltrated with 1:5000 epinephrine solutions. A posterior midline incision approach used to expose the involved vertebrae.

Now X-clamp with Y-array applied over the spinous processes of vertebrae to be registered, one level above the fracture vertebra. Then 3 spherical balls placed over the Y-array and another 3 spherical balls placed over navigation probe.

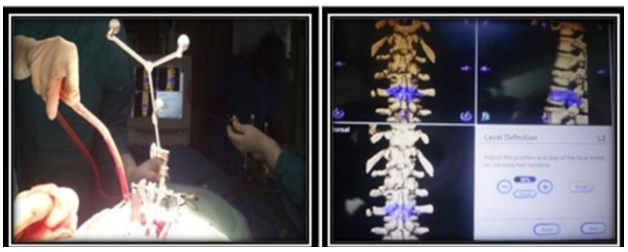

Figure 1: Spherical balls placed over the Y-array and over navigation probe.

Registration of the vertebra done in brain lab monitor. After registration of the vertebra, the accuracy of the registration evaluated if it is less than 1.5 then proceeds to next step of screw trajectory, if not then repeat the registration process.

Now place the tip of navigation probe over the pedicle of the vertebra and plan pedicle screw trajectory, length and size. Then with the help of awl entry portal made over pedicle under guidance of 3D image shown on brain lab monitor. Similarly place another pedicle screw each side one level below the fracture vertebrae.

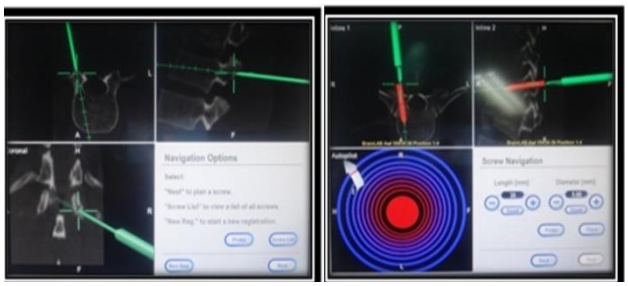

Figure 2: Registration of the vertebra in brain lab monitor.

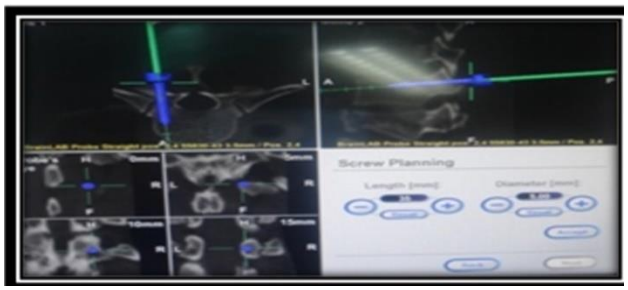

Figure 3: Placement of pedicle screws.

A contoured appropriate sized connecting rod is placed into the slots of the pedicular screws each side. Using angled spreader adequate distraction is applied for correction of deformity and the top screw is tightened and the assembly is constructed. A thorough haemostasis was achieved and a drain was placed then wound closer done and sterile dressing was applied.

Physiotherapy was started from first day post operatively. On the second day patients were allowed to roll from side to side. Sutures were removed on tenth day. A close watch was kept for any improvement or deterioration in the neurological status. The post-operative CT scans done to evaluate the position of pedicle screws placed according to the Learch and Wiesner classification.

RESULTS

Overall 52 pedicular screws were inserted between T10 and L3 with the assistance of the CT based computer navigation system. The postoperative CT scans revealed 50 (96.15%) screw placed within the pedicle with no breach in pedicular cortex whereas 02 (3.85%) screws had lateral penetration of the pedicle cortex with one screw had 3-6mm outside the pedicular boundaries and another screw had <3 mm outside the pedicular boundaries found (Figure 4). No medial cortical penetration or anterior vertebral cortical penetration was

observed. There was one case of deep wound infection, which was resolved by debridement and intravenous antibiotic treatment (Table 1 and 2).

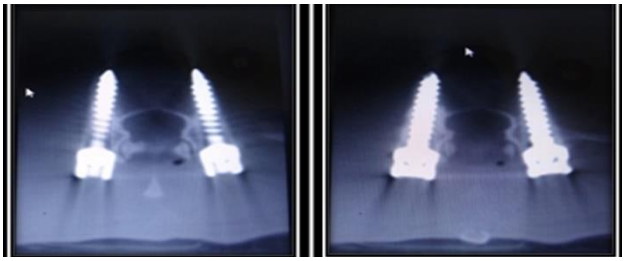

Figure 4: Screws with lateral penetration of the pedicle cortex.

Table 1: Malplacement of screw (Learch and Wiesner's classification).[7,8]

Grade	No. of pedicle screw
Encroachment	50
Minor penetration	01
moderate penetration	01
Severe penetration	00

Table 2: Malplacement of screw (Heary classification).[9]

Grade	Breach
1	None
2	Lateral, but screw tip is within VB
3	anterior or lateral breach of screw tip
4	Medial or inferior breach
5	Breach that requires immediate revision (due to proximity to sensitive structures)

Table 3: Malplacement of screw (Learchand wiesner's classification).[7,8]

Grade	Breach
Encroachment	Pedicle cortex could not be visualized
Minor penetration	screw trajectory <3 mm outside the pedicular boundaries
Moderate penetration	screw trajectory 3-6mm outside the pedicular boundaries
Severe penetration	screw trajectory >6 mm outside the pedicular boundaries

Table 4: Malplacement of screw (Heary classification).[9]

Grade	No. of pedicle screw
1	50
2	01
3	01
4	00
5	00

No medial cortical penetration or anterior vertebral cortical penetration was observed. There was one case of deep wound infection, which was resolved by debridement and intravenous antibiotic treatment.

DISCUSSION

Transpedicular screw fixation offers three-column stabilization and has become an innovative treatment of thoracic and lumbar fractures.[10] Pedicle screw insertion is a technically demanding procedure because of the smaller and varying size of the pedicle and intra - operative fluoroscopic imaging is difficult to perform for consistently reliable anatomic entry points and the trajectory for screw insertion. The documented overall complication rate for the use of pedicle screws ranges between 21% and 27%.[11] The potential risks of screw misplacement, including significant neurological damage to the spinal cord, aorta, vena cava, iliac vessels and azygos vein, are higher because of the smaller size of the pedicle and its proximity to the spinal cord and neurovascular structures of the spine.[12,13]

In 2003, Carbone et al published a retrospective review on the placement of 126 thoracic screws under fluoroscopic image guidance in 22 patients with thoracic and thoracolumbar injuries. Postoperative computed tomography scans revealed that 16 screws (12.7%) penetrated the pedicle cortex. A fluoroscopic-guided technique tends to be less expensive than a computer-assisted technique. However, it has several disadvantages, including radiation exposure, rib cage interference, bulky apparatus, and increased operating time.[10,14]

Rampersaud et al demonstrated that the radiation exposure level was significantly greater for surgeons and patients in fluoroscopically-assisted thoracolumbar pedicle screw placement. The dose of radiation exposure was up to 10-12 times greater than for other fluoroscopically assisted non-spinal musculoskeletal procedures. The author suggested that spine surgeons who perform fluoroscopically- assisted thoracolumbar procedures monitor their annual radiation dose and reduce radiation exposure by avoiding body and hand positions at high radiation exposure levels, and minimizing fluoroscopy time.[10,15] Fluoroscopy does not provide an axial plane view, which is important for spinal screw fixation because it provides critical trajectory information that neither the sagittal nor coronal plane view can provide. Fu TS et al at have indicated the limitations of the fluoroscopic image-guided technique by showing five out of 74 screws exhibited pedicle wall violation on the axial plane with no violation on the sagittal plane, which is caused by lack of an axial plane view. Fluoroscopy can only provide real-time two-dimensional images of a complex three-dimensional spine structure (Table 5).[10,16]

In this study the most number of patients with thoraco-lumbar spine fracture were in the 2nd and 3rd decade of life with an average age of 29 years. There was a significant male predominance with 84.61% male patients. In this study the most common mode of injury is fall from height in 92.31% patient, about 76.92% patients with AO Type - A fracture and 84.61% cases showed at least one ASIA Grade improvement at 6th month of post-OP follow up (Table 6).

In this study accuracy of pedicle screw placement was 96.15% (50 pedicle screw) with 3.85% (02 pedicle screw) malplaced with two lateral pedicle cortex breach (Table 3 and 4).

Table 5: Accuracy pedicle of screw.

Author	Accuracy pedicle of screw
Allam Y et al[17]	99%
Chiang CYF et al[10]	97.1%
Waschke et al[18]	95.5%
Kosmopoulos and Schiza[19]	94.3 %
Present study	96.15%

Table 6: Summary of the present study.

Observation	Navigation method
Male predominance	84.61%
Mean age (year)	29
Mode of injury	Fall from height(most common)
Neurological improvement	84.61% atleast one Asia grade
Accuracy	96.15%
Malplacement	3.85%
Post -op infection	07.69%

CONCLUSION

The accuracy of pedicle screw placement is critical for thoracic and lumbar spine fracture fixation. With the aid of CT-based navigation assisted technology, the placement of pedicle screws can be done more accurately by reducing the perforation rate, require less revision surgery with less risk of postoperative neurological complications. The learning curve of computer navigation technique is high and requires slight more operating time. Furthermore there is no intra - operative radiation exposure to surgeons, patient and OT staff.

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