Percutaneous Posterior Fixation for Treatment of Thoraco-Lumbar Fractures

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Abstract

Object: Many complications have been commonly seen after posterior pedicle instrumentation for a thoracolumbar fracture. The newly used percutaneous technique seems to be beneficial in this issue. The aim of this study was to investigate the approach, its benefits, hazards and difference in outcome compared to ordinary open posterior fixation.

Methods: Seventeen patients who had undergone posterior percutaneous screw fixation for thoracolumbar burst fractures (T12-L2) were investigated prospectively. The mean follow-up period was 2 years (mean 18.2 months). Pain was assessed using visual analogue scale. Complete neurological examination assessed by Frankle grading system was done, also operative, measures; Duration of surgery, Hospital stay, blood loss, time between surgery and mobilization of the patient, duration and intensity of postoperative pain, and surgical complications were all assessed. Changes in the anterior vertebral height ratio, Cobb angle, were measured preoperatively, postoperatively, and at final follow-up. The canal decompression was also measured.

Results: Immediately after surgery, percutaneous approach had a significantly better results compared to open procedures, this was regarding to operative time, Hospital stay, early mobilization of the patient and postoperative pain. At the final follow-up, there was significant clinical and radiological improvement according to Frankle grading scale and measured Cobb angle and degree of canal encroachment respectively (p=0.001).

Conclusion: Surgeons who perform percutaneous posterior fixation procedures should understand that the procedure may be helpful for immediate postoperative outcome, better cost-benefit results, but no long term superiority over traditional open spinal fixation regarding either clinical or radiological outcome or back pain.

Key Words: Percutaneous – Posterior fixation – Thoraco-lumbar fractures.

Introduction

FRACTURES of thoracolumbar area constitute about 12.8 per 100,000 aviators per year of spinal trauma. They cost an average of 4.2 thousand dollar per case; this price includes surgery costs, price of implants, Hospital stay, postoperative medica-
tions and rehabilitation. So thoracolumbar fractures are considered a heavy impact on the health sector and the general economy of any country [1,2].

Pedicle screw fixation is considered the most common method for fixation of thoracolumbar fractures in many centres all over the world. It is considered safe, effective and can be used in most of thoracolumbar fractures types even with significant retro-pulsed fragment [3-6]. The standard open approach is accompanied by many hazards [7,8]:
- Long time for exposure to anaesthesia because of skin and muscle opening.
- Unnecessary muscle dissection leading to postoperative muscle atrophy [9].
- Injury to posterior osseous structures (lamina, spinous process) which can results in dural tears or neural injury if were fractured previously.
- Sub-periosteal stripping that is not necessary, devitalizes tissues, and causes postoperative pain.
- Considerable blood loss which can necessitate blood transfusion which is expensive, sometimes not available and has hazardous sequela for the patient.
- Long hospital stay, prolonged recovery, postoperative pain secondary to skin and muscle opening, which can lead to restricted mobilization of the patient which can lead to thrombosis, renal or chest troubles.

Abbreviations:
CT : Computerized tomography.
MRI : Magnetic resonance images.
SD : Standard deviation.
VAS : Visual analogue scale.
Minimally Invasive Spinal Fixation

- Large opening surface with large areas of dissection and cautery can lead to infection.
- The need of more than one surgeon to minimize surgeon fatigue.

Percutaneous transpedicular spinal fixation was introduced in spinal field since 1980, when Magerl [10] described the technique and its benefits. Percutaneous spinal fixation seems to offers the patients many benefits and need to be thoroughly evaluated because it seems to be the future of all spine surgeries.

The aim of our study is to evaluate the surgical approach, its benefits, hazards and the long-term clinical and radiological outcome for those patients subjected to this approach.

Patients and Methods

A prospective study on patients with unstable thoracolumbar fracture between T1 and L2 vertebrae, no significant retro-pulsed fragment needing direct open surgical decompression, only ligamentotaxis or mild percutaneous transpedicular decompression was decided to be enough. Decision was decided by the committee of the department.

From April 2010 to May 2012, a consecutive series of 17 cases (13 males and 4 females) received percutaneous spinal fixation caused by dorso-lumbar unstable fractures. Cases needing open fixation due to need for direct spinal decompression (laminectomy) were excluded from this study.

At the time of surgery, the age of patients ranged from 18 to 54 years (mean 24). Patients were operated by percutaneous posterior pedicle fixation, 9 patients were presented by road traffic accident, and 4 patients had fallen from height.

Forty-three levels were operated on; single level procedure (one level above and one level below) was performed in 3 patients and double level in 10 patients as follow: 7 patients had two levels above and two level below, and three patients had two levels above and one level below.

Surgical technique:

Under general anaesthesia, patient was put in prone position, on a radiolucent table. Chest rolls may be used, but the knee to chest position should be avoided. Adequate clearance around the surgical table for the fluoroscopic C-arm is ensured. It is recommended that preoperative planning be used to help determine the proper entry point and trajectory.

Using fluoroscopic imaging, the anterior-posterior and lateral images of the spine are verified with adequate delineation of the pedicle morphology and geometry.

After identifying the pedicle entry point, the Targeting Needle is used to initiate the entry point (Fig. 1-B). Adjustments to the entry angle and the trajectory should be made as often as needed with the assistance of fluoroscopic imaging until the proper position is attained. We remove the inner stylet of the Targeting Needle. We insert the Guide-wire through the cannulated Targeting Needle sheath into the pedicle to the desired depth. Unintentional advancement can potentially be very dangerous. Horizontal lines in increments of 10mm can be used to monitor advancement. Once the Guide-wire is inserted, we remove the targeting needle. Screws are self-tapping; however, taps may be used to facilitate screw insertion. Appropriate tap size is selected and connected with a Quick Connect Axial or T-Ratcheting. The collar on the Handle is set to the forward position and tapped to desired depth. Etching on Tap shaft indicates depth of insertion. Then we attach a Quick Connect Axial or T-Handle to the Screwdriver and place the Polyaxial Scredriver over the selected screw and engage the hex tip with the recessed hex of the screw. We ensure the collar on the Ratcheting Handle is in the forward (R) position then advance the screw into the prepared pedicle. To disengage the Screwdriver, we turn the knurled barrel counterclockwise and remove. The Guide-wire is removed once the screw is advanced into the pedicle. The screw is Positioned and aligned heads with the Head Positioner (Fig. 1-A).

Rod placement:

Rod length is determined using the Rod Template. The selected rod is grasped with the Rod Inserter and place into the Polyaxial Screw heads. To contour a rod, the rod is placed in the French Rod Bender and applied bending pressure to achieve the desired contour. Set screws were loaded from the caddy with the tapered tip of the Set Screw Inserter. The set screws were placed into the screw heads. Rotate clockwise until provisionally tightened (Fig. 2).

Persuader is attached to the screw by placing the tip on the screw head and rod. Trigger handle is squeezed to engage tip with screw head notches and secured in place using lock rack.

Once Persuader is firmly attached to screw head, trigger handle is squeezed until desired reduction is achieved.
Set Screw is inserted with Set Screw Remover through inner Cannula into screw head and turned clockwise until provisionally tightened. Compression and distraction may be achieved using the Compressor and Distractor.

Final tightening:
The 100 in-lb T-Handle Torque Wrench is assembled with the Torque Wrench Shaft. The Torque Wrench Assembly is inserted through the cannula of the Cannulated Anti-Torque. The male portion of the Set Screw Driver is engaged into the female portion of the desired Set Screw. The Anti-Torque is slid down until the instrument is fully seated over the rod on each side of the screw head. T-Handle is turn clockwise. Final tightening is achieved when the T-Handle audibly clicks.

Assessment of outcome:
Clinical assessment:
March 31, 2012, was the follow-up closing-date, with a median follow-up of 18 months (average 18.2 months; range 6-31 months). In addition to the complete neurological examination (assessed by Frankle grading system) [11], patients were clinically assessed using a complete survey that measured pain and functional outcome. Duration of surgery, Hospital stay, blood loss, time between surgery and mobilization of the patient, duration and intensity of postoperative pain, and surgical complications were all also assessed.

Neuro-radiological assessment:
Lateral and antero-posterior X-rays were done for all patients determining the level of spinal fracture, kyphotic angle measured by Cobb angle. The Cobb angle is the angle between the superior endplate of the upper and the inferior endplate of the lower adjacent vertebra by the Cobb method. Computerized tomography was the diagnostic cornerstone for those patients with thoraco-lumbar fractures. Stability of fracture spine was assessed according to Denis classification [12]. Degree of canal encroachment was measured on the CT cuts. Kyphotic angle was also measured on sagittal reconstructed CT images added to those previously measured on lateral view X-rays. The screw position was determined postoperatively by the CT scan and was classified into:
I- Satisfactory: Intact intra-pedicular position,
II- Accepted; Screw outside the pedicle but violating cortex of no more than 3mm, and
III- Not accepted; violating cortex of more than 3mm.

Magnetic resonance imaging was performed in all patients preoperatively and at follow-up closing date, with 1.5 Tesla MRI (MRI). T1- and T2-weighted images were obtained in sagittal and axial views, with slice width of 5mm. All MR images were read by two neuro-radiographers blinded for the clinical state of patients.

The following issues were analyzed:
A) Spinal cord signal intensity, before and after surgery.
B) Transverse diameter of the spinal cord at the level of maximal compression on axial T1-weighted images, both before and after surgery.

Statistical analysis:
The Microsoft Excel-sum test was used to analyze differences in preoperative clinical and demographic characteristics (age, number of involved levels, duration of symptoms), and in variables affecting the outcome (Frankle grading scale, and motor and sensory deficit improvement). Data are presented as mean values ± standard deviation (SD). Statistical significance was set at \( p<0.05 \).

Results
The age of the patients at the time of presentation ranged from 17 to 62 (mean; 31). The cause of trauma was road traffic accident in 13 patients and fall from height in 4 patients.

The level of fracture was D 11 in 1 patient, D 12 in 8 patients, L 1 in 6 patients and D2 in 2 patients.

Clinical outcome:
All patients had complete neurological examination preoperatively, immediately postoperative and at the final follow-up: Preoperatively, Nine patients had Frankle grade of E, five had grade D, three patients had C grade, and only one patient had grade A on Frankle scale. 16 patients (94%) showed good outcome; the nine patients in grade E still in same grade at final follow-up, patients with grade D are changed to grade E and the 3 patients with grade C had shown significant improvement to grade D. The patient who had preoperative grade A still in the same grade at final follow-up.

All the patients who had neurological deficit (Frankel grade D or less), had subjected to percutaneous transpedicular decompression plus the fixation done. The patients without neurological deficit had no surgical decompression of the fracture except in one patient only who had preoperative
canal encroachment of 50% but no neurological deficit for fear of possibility of stenotic symptoms in the future.

The surgical and postoperative data (Table 1); mean operative time was 117 minutes (range 60-215 minutes); this time is calculated from start of first surgical incision till final closure of last incision. Intra-operative blood loss was calculated in the suction bag and in the tissues used for cleaning, it was always less than 100ml.

Regarding hospital stay, it was ranged from 30 to 93 hours postoperatively; this was calculated from start of recovery to final discharge of the patients with a mean of 44 hours. Only one patient, who had deep infection, was admitted for about 1 week for receiving IV antibiotics and for following up the wound.

The postoperative pain at surgical site was assessed by VAS, it was ranged between 2 and 5 with only one patient who had deep infection later and who had VAS of 8, with a mean of 2.7.

Radiological outcome:

Immediate postoperative radiological assessment of the screws position was necessary to evaluate the efficacy of the procedure; lateral and antero-posterior views X-rays, and computerized tomography with 3-D reconstruction were done for the patients to evaluate the screw position in either the cephalo-caudal or medio-lateral directions.

Kyphotic angle was an important factor in our assessment. At all, percutaneous system has an easy ways to reduce the kyphotic deformity. Sagittal deformity was measured by Cobb angle (The Cobb angle is the angle between the superior endplate of the upper and the inferior endplate of the lower adjacent vertebra by the Cobb method); it reflects the changes in the segmental curve. There was a significant decrease in the Cobb angle \( p=0.001 \) following surgery, thus indicating a significant correction. The average Cobb angle changed from \( 18.6 \pm 7.3 \) preoperatively and changed to \( 3.1^\circ \pm 8.5^\circ \) immediate postoperative (Fig. 3).

We found satisfactory screw position in 12 patients (70%), and some mild deviation of the screw position of the remaining 5 patients (30%); penetrating the medial cortex of the pedicle with 2-3mm, but no patient required revision of the screw position, and it was not affecting the neural tissues or stability of the fixation system.

Regarding postoperative complications; no cases showed hardware failure at final follow-up. One patient developed postoperative retroperitoneal collection; he had an ileus for two days improved spontaneously. Postoperative abdomino-plevic ultrasound compared to preoperative one revealed this mild collection. It can be explained by some manipulation of the peri-vertebral muscles due to slippage of the taper intramuscularly in the first case.

Infection was the main problem in our study, three patients showed superficial infection which improved by daily dressings and medical treatment, one patient showed deep infection three weeks after surgery in the form of progressive swelling and pain at site surgery, the patient had an opening on the most caudal previous incision done for the caudal screw, pus was drained, surgical drain was inserted deeply in the wound above the screws and left for two weeks to drain, IV antibiotics were given according to culture and sensitivity; result was Staff aureus (showed significant sensitivity to vancomycin).
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Fig. (2): Intra-operative photo showing the technique of rod insertion.

Fig. (3): Postoperative X-ray showing good alignment and average position of the screws and rods.

Fig. (4): End view of the skin at follow-up showing very small incisions about 5 mm lengths each.

Table (1): Demographic data of the patients showing the immediate postoperative results.

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Discussion

At the beginning, percutaneous spinal fixation was used for cases of spinal fractures as an external fixator [13,14]. The rod placement was the limiting point for final percutaneous trans-pedicular fixation. Trials of inserting the rod subcutaneously were made by some surgeons [15,16], followed by trials of Muller [17] to put the rod intramuscularly, till the development of sextant system by Foley [18,19] which made the insertion of the percutaneous screws and sub-muscular rods easy and very acceptable [20]. Still, also theoretical trails to make an inflatable rod under research [21].

In our study we discussed the either the clinical or radiological outcome of percutaneous fixation to find the actual benefits of this approach. Regarding immediate operative and postoperative findings, we found that operative time was ranged between minutes (range 61-215 minutes), this is very close to most published papers in this era, for example, Sakari A in his series of 14 patients subjected to percutaneous spinal fixation, he had an average operating time ranged from 65-195 minutes (mean 95.7±34 minutes), with decreasing time subsequently with getting more experience in the approach [22].

In a study done by Michael Y. Wang, et al., about minimally invasive posterior fixation, the mean operative time was 244 minutes (range, 32-420min), Surgical blood loss averaged 284mL.
(range, 50-700mL). There were no intra-operative complications related to pedicle screw placement or electrophysiological stimulation parameters, and no screws were repositioned on the basis of neuro-monitoring [23]. We have similar but somewhat better results than this study.

If we compare our results regarding long term clinical and radiological outcome with the other literature review dealing with either percutaneous or traditionally open methods, we found that 94% showed good clinical outcome according to Frankle score, and statistically significant improvement of kyphotic angle, and also ground a satisfactory screw position in 70% of patients with no case of symptomatic cortical violation.

If we compare these results by the previously published ones in literatures about clinical outcome in traditionally open thoraco-lumbar fixation which are extensively discussed before, we found nearly similar clinical and radiological outcome, with usual good clinical outcome more than 90% and good restoration of kyphotic angle. Also, in our previous work assessing the anterior versus posterior fixation in thoraco-lumbar fractures (under revision), we found that 90% showed either grade E or D according to Frankle grading scale at final follow-up, this is nearly similar results to that one using percutaneous spinal fixation.

This can be matched with the results of Kim et al [24], who compared percutaneous spinal fixation with open internal fixation; he found that percutaneous approach had less postoperative muscle atrophy, less amount of blood loss, less postoperative pain intensity. However these results did not mean that there was either clinical or radiological superiority of percutaneous approach over open approach. Both approaches had similar end results according to Japanese Orthopaedic Association scale, final pain score, or general patient satisfaction.

At the end, the benefits of percutaneous spinal fixation still not very clear until recently [24]. However, thus, the main advantage seems to be within the immediate postoperative period, where a significant pain reduction is obvious. This allows for earlier and easier mobilization of the patients.

Conclusion:

Less postoperative pain, less blood loss, early mobilization of the patient, and short hospital stay, can be causes to justify the use of percutaneous fixation, the global cost benefit of the procedure due to the previous causes compared to the high cost impact of the ordinary open fixation can be also very important determining factor to shift to percutaneous spinal fixation.

Disclosure:

The Authors have no financial interest in the instrumentation and methodology advanced in this manuscript. The paper comply with the current laws of our country, with a consent was taken from all the patients underwent the study.

References

value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia.


