Original Article

Role of Minimally Invasive Percutaneous Transpedicular Screws in Lumbar Fracture

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ABSTRACT

Background: Pedicle screws for spinal stabilization are used worldwide for degenerative and traumatic spinal diseases. Minimally invasive percutaneous transpedicular lumbar fixation has showed a significant role in minimizing approach-related morbidity while achieving the same result as the traditional invasive approaches. Objectives: This study aimed to determine the outcome of the lumbar fixation using percutaneous transpedicular route in lumbar fractures and to evaluate the results of this developing surgical technique. Patients and Methods: This prospective study was conducted on twenty four adult patients with traumatic lumbar fractures. All of them had severe low back pain and were neurologically free. Seventeen were males and seven were females with a mean age of 34.5 years. The mode of trauma was fall from a height in nine patients (33%) and motor car accident in fifteen patients (55%). Fractures were in L1 in eleven patients, L2 in seven patients, L3 in four patients and L4 in two patients. Patients underwent personal history taking and general and neurologic examinations. Each patient was evaluated radiologically by plain x-ray, computerized tomography (CT) scan and magnetic resonance imaging (MRI). These patients were treated by percutaneous pedicle screw fixation. Results: Pain improved significantly in all patients after Surgery (P < 0.001). None of our patient had neurological deterioration after surgery. Postoperative radiological investigations showed improving of the preoperative canal compromise. The average pre-operative vertebral body angle improved significantly (P< 0.001) immediately after surgery. At the 12 months follow up visit, patients showed continuous improvement of their incapacitating pain. There was persistent improvement of their deformity in comparison to the preoperative imaging studies. Conclusion: Developing minimally invasive approaches to lumbar fusion have participated to minimize approach-related morbidity while achieving the same result as traditional invasive approaches. As the technology continues to evolve, it is expected that minimally invasive spine surgery becomes a prominent part of spinal surgery and that indications for minimally invasive spinal fusion will expand.

INTRODUCTION

Lumbar spine injuries were divided into minor and major injuries. Minor injuries, which accounted for over 15% of fractures, included fractures of the spinous and transverse processes, the pars interarticularis, and the facet articulations. While major spinal injuries were divided into compression fractures, burst fractures, seat-belt injuries, and fracture-dislocations. Only 20 to 30% of spine fractures require surgery.12 However, spinal column fractures often result in instability which might cause segmentary kyphosis with possible damage of neural tissue from long-time compression in most of cases.3,4

Surgical treatment for unstable spine fracture is indicated in cases of greater than 50% loss of body height, kyphosis greater than 20°, associated posterior element disruption, CT showing retro pulsed canal fragment with canal compromised more than 30% and Progressive neurological affection.5

On the other hand from conservative treatment, the surgical treatment provide rigid stability of the spine, help to Restore coronal and sagittal height, correct deformity and allow spinal canal decompression. Fixation of spine fractures can be done by open pedicle screw fixation or percutaneous fixation.6

Pedicle screw system engages all three columns of the spine and can resist motion in all planes. Standard traditional open surgery techniques for pedicle placement require extensive tissue dissection to expose entry points & to provide lateral to medical orientation for optimal screw trajectory. Open surgery drawbacks includes blood loss, hospital stay, and delayed functional recovery, beside possible complications.4,5

Compared with previously used percutaneous techniques, the new systems allow the screw/rod to be placed in a standard anatomical position. This optimizes the biomechanics of the fixation and allows the hardware to remain in place without irritating the

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superficial tissues of the low back. The percutaneous technique follows the same principles as open pedicle screw fixation, allowing the surgeon to perform biomechanically sound internal spinal fixation with minimal tissue trauma. Magerl first described percutaneous fixation of lumbar spine. Mathews & Long first described and performed percutaneous lumbar pedicle fixation technique in which they used plates as longitudinal connectors. Lowery and Kulkarni subsequently described a similar technique in which rods were placed. The developed new systems as Sextant Spinal system offer several distinct advantages over conventional pedicle screw fixation. Sextant system consist of cannulated screws with poly-axial head with a specially designed rod inserter that attaches to the screw extension sleeves combined with pre-contoured rods to be placed in a standard anatomical position. Beside the treatment of Compression fracture without neurological deficit, percutaneous fixation is used also for lumbar fixation in degenerative disc disease and Grade 1 or 2 spondylolisthesis as well.

**PATIENTS AND METHODS**

This prospective study was conducted on twenty four adult patients with traumatic lumbar fractures, with no neurological affection, treated at Neurosurgery Department, Cairo University hospitals and Nasser Institute hospital from 2008 to 2012. Seventeen were males (70.8%) and seven were females (29.2%) The age varied from 18 to 51 years with mean age 34.5 years. Twenty two cases had only one level fracture and the rest had double level fractures. The mechanisms of injury were in nine patient fall from height (37.5 %) and in fifteen patients were motor car injury (62.5%) (Table 1).

<table>
<thead>
<tr>
<th>Data</th>
<th>Value</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>34.5 (18-51)</td>
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<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male: female</td>
<td>17male:7 female</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
</tr>
<tr>
<td>Fall from height</td>
<td>9 (37.5%)</td>
</tr>
<tr>
<td>Motor car injury</td>
<td>15(62.5 %)</td>
</tr>
<tr>
<td>Vertebral level</td>
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</tr>
<tr>
<td>One-vertebral level</td>
<td>22 (92.6%)</td>
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<tr>
<td>Two-vertebral level</td>
<td>2 (7.4%)</td>
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</tbody>
</table>

Inclusion criteria in our study were cases with unstable compression or burst fractures with no neurological deficits. The canal encroachment was less than 40%. Thirteen patients had a trial for conservative treatment with failed improvement in back pain and functional outcome. The other eleven Patients preferred to have minimal invasive surgical intervention rather than conservative treatment which necessitates longer period .The presenting clinical manifestations in all patients were severe low back pain following trauma. All patients underwent personal history taking, general and neurologic examinations and back pain assessment. This was done pre and postoperative and in every follow up visit. The back pain was assessed using Denis’s pain scale.

Each patient was evaluated radiologically which revealed unstable compression or burst fractures(Fig. 1). In plain x-ray, vertebral body angle (VBA) was measured to compare between the pre-operative, immediate post-operative and during the follow up period. In CT scan, the mid sagittal diameter (CTSD) was estimated to show the mean pre and postoperative canal compromise. Magnetic resonance imaging (MRI) used to identify potentially unstable occult ligamentous or soft tissue injury before surgery. The patients were followed for at least 12 months.

Fig. 1 a&b: Preoperative bone window CT showing L2 burst fracture.
Surgical Procedure

After induction of general anesthesia and endotracheal intubation, the patient was positioned in a prone position on a special radio-translucent table and the chest was well padded. The patient was placed on special radio-translucent frame so that lateral view of spine can be obtained. Routine perioperative broad spectrum antibiotics were given to all patients. Surgical procedure was carried without the need for hypotensive anesthesia. Pedicle screw Sextant system was used in this study.

By using the C-arm in antero-posterior view, a longitudinal 2cm skin incision was done being in the lateral half of pedicle and the entry points were identified in which sterile needles were placed. Pedicle screw entry was done by using the Jamshidi-needle. The tip of the Jamshidi-needle was placed in lateral half of the pedicle under C-arm image. In antero-posterior view, the medial cortex of the pedicle was not passed before the posterior aspect of the body is reached. The C-arm was placed in lateral view then the needle position was advanced till the posterior 1/4th of the body. The trochar was removed from the Jamshidi-needle and a wire was passed through the cannula till it reached the anterior half of the body to get a good bone grip. Unintentional advancement of the wire can be potentially dangerous. Once the guide wire is inserted, the needle was removed. The fascia and muscle were dilated to allow for screw placement using three dilators. The first two dilators were removed, leaving the third dilator to serve as a tissue protection sleeve during the tapping step.

The pedicle was prepared by placing the tap over the guide wire and through the third dilation sleeve guided by the C-arm image. After tapping, the dilator was removed but the guide wire was left in place. Screw in special connector sleeve (screw extenders) was introduced over the wire until the head was lying just above the bone in lateral view. The wire was then removed. After a pair of pedicle screws together with their attached extenders has been inserted, the screw extenders are aligned at their proximal ends. This manoeuvre arranges the distal ends which are connected to the multi-axial screw heads in a way that allows the openings in the screw heads to fit the same curvilinear path of the pre-contoured rod. After the screw extenders had been connected to the rod inserter, a trochar tip was attached to the inserter, the skin was marked where this tip intersects it and a small stab wound was made. The trochar tip serves to open the underlying fascia. Once the fascia has been penetrated, the tip was removed and an appropriate length rod was attached (Fig. 2, 3 & 4).

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Fig. 2 a&b: a: Preoperative lateral X-ray, b: preoperative CT coronal cuts showing L3 burst fracture

Fig. 3 a&b: a: Postoperative lateral X-ray, b: postoperative antero-posterior X-ray showing pedicle screw fixation
The rods are pre-contoured into a curvilinear shape that precisely matches the contour of the rod inserter. The rod was inserted through the same stab wound and intersects the screw heads; this was checked by C-arm. Appropriate forces (compression and/or distraction) can be applied to the construct prior to final tightening. Each case underwent postoperative radiological evaluation and follow-up neurologic examination was carried for estimation of the neurologic outcome.

Data were statistically described in terms of mean ± standard deviation (± SD), or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between pre and post operative data was done using paired t test for matched samples. For comparing categorical data, McNemar test was performed. P values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

RESULTS

The study included twenty four patients with traumatic lumbar fractures. The mode of fracture was fall from height in nine patients (37.5%) and motor car accident in fifteen patients (62.5%). These patients were treated by percutaneous pedicle screw fixation. Twenty two patients included had single level fracture (Fig.5) and their distribution was as follows: Fracture L1 in 11 patients (45.8%), fracture L2 in seven patients (29.2%), fracture L3 in four patients (16.7%) and fracture L4 in two patients (8.3%) (Fig.5).

![Fig. 5: Patients' distribution according the level fracture](image)
The total operative time ranged from 25 min to 70 min with an average of 48 min. The operative estimated blood loss was negligible ranging between 5 to 7 ml / case.

Before surgery, back pain was assessed using Denis's pain scale (Denis, 2004). one patients was P1 (4.2%), eleven were P2 (45.8%) and twelve were P3 (50%). In the immediate postoperative period, Pain scale showed improvement in pain intensity of the patients. Eight patients were P1(33.3%), thirteen patients were P2 (54%) and three were P3(12.7%). Twenty one cases needed analgesics for 2 days and three cases needed analgesics for 1 week. At 12 months follow up, the back pain improved in all patients (p< 0.001). The pain status was as follow: sixteen patients (67%) were P1, six patients (25%) were P2, and two patients (8%) were P3. None of the patients in this series had incapacitating pain (P4). All patients had no neurological deterioration after surgery or during follow up and they all were neurologically intact.

Postoperative radiological investigations showed improving of mean canal compromise after surgery from 20.3% preoperatively (ranged between 12% - 40%) to 18.7% after surgery (ranged between 10% - 38%) (Fig. 6).

There was significant improvement in the average preoperative vertebral body angle which was 22.95° (ranged between 12°-45°), post-operative it became 8.9° (ranged between 4°- 26°). The average vertebral body angle at 12 months follow up was 11.1° (Fig. 7).

![Fig. 6](image1.png)

**Fig. 6:** Mean percentage of pre and immediate post operative canal compromise among the studied cases

![Fig. 7](image2.png)

**Fig. 7:** Mean preoperative, immediate post operative and 12 months postoperative vertebral body angle (degrees) among the studied cases
Screws positions were adequate in all patients. None of our patient had neurological deterioration postoperatively or during follow up and they all were neurologically free. No infection or tenderness over the incision was found on palpation. No hematomas, dural tear, nerve injuries or CSF leak were reported.

**DISCUSSION**

The use of pedicle screws for spinal stabilization has become increasingly popular worldwide for degenerative and traumatic spinal diseases. Pedicle screw systems engage all three columns of the spine.\(^6\) Traditional open surgical pedicle screws fixation have many disadvantages including significant blood loss, serious infections risk and the need for extensive muscular dissection which may lead to prolonged disability and postoperative pain from muscular denervation and necrosis.\(^14\) As an alternative to standard open surgery, minimally invasive percutaneous placement of pedicle screws are widely accepted as being the less aggressive procedure and with a favorable outcome.\(^15\) In contrary to the cases with fracture of lumbar spine where solid fixation results in body fusion and no additional bony fusion is required, cases with degenerative spinal conditions like spondylolysis requires definitive bony fusion in addition to metallic fixation and decompression.\(^6,15\)

In our study we had included eleven patients with compression fracture who preferred minimal invasive surgical intervention rather than conservative treatment. Foley and Gupta reported indication according to patient preference to do minimal invasive surgery in order to shorten the time of recovery and return to work.\(^6\)

The study population in our series included twenty four patients, where seventeen were males and 7 females. The age of patients ranged from 18 years to 51years with mean age of 34.5. Prafulla reported 15 consecutive patients underwent placement of percutaneous Sextant insertion for traumatic fractures during Jan 2004 to Jun 2005. There were 10 men and 5 women, with ages ranged from 28 to 60 years.\(^12\)

Levels of fracture in our study was from L1-L4, single level in twenty two patients (91.7%) and double level in two patients (8.3%). While Federico et al in his serious which included twenty two patients treated by percutaneous transpedicular fixation, the most frequent fracture location was the thoracolumbar junction (T12-L1), Single level in 96 Cases (78.7%) and multilevel in twenty six cases (21.3%).\(^16\)

In our study, back pain improved in the immediate postoperative and last follow up period in all patients assessed by Denis’s pain scale. Preoperatively, one patient was P1 (4.2%), eleven were P2 (45.8%) and twelve were P3 (50%). At the last follow up, sixteen patients (67%) were P1, six patients (25%) were P2, and two patients (8%) were P3. Postoperatively twenty one cases needed analgesics for 2 days and 3 cases needed analgesics for one week. The analgesics were in the form of NSAIDs and no incapacitating pain was reported. Federico et al reported in his series that postoperative analgesia was performed in all cases with a 36-hour lasting elastomeric pump containing an opioid and an NSAID.\(^16\) Oliver et al in 2007 reported that the total need for analgesia following minimal invasive instrumentation using Sextant System was low.\(^17\) The majority of patients were sufficiently treated by oral analgesics only, in which NSAIDs were used as single medication in 53 patients. Only two geriatric patients required high potent opioids like fentanyl. Emdad et al mentioned in his series that regarding back pain improvement, he had excellent results in twelve patients out of fifteen (80%), good in two patients (13.5%) and fair in one patient (6.5%).\(^18\)

All of our patients had no neurological deterioration after surgery or during follow up. Federico et al reported one neurologic complication in immediately postoperative period. It was a cauda equina syndrome which appeared in one patient (0.8%) due to organized intradural hematoma.\(^16\)

Our aim was to correct as much as possible the vertebral body angle by reduction .The average angle improved from 22.95° before surgery to 8.9° immediate postoperatively and to 11.1° at the last follow up (P<0.001).This goes with Federico et al, who mentioned in his series that kyphosis of the fractured vertebrae showed improvement from 12.2 ° preoperatively to 5.9 ° postoperatively.\(^16\) Correction of kyphosis was achieved by the pre-contoured rod.\(^19\) Also the mean preoperative canal compromise improved from 20.3% preoperatively to 18.7% postoperatively. This result showed no significant correlation with preoperative outcome (p=0.409).

In this series, the total operative time ranged from 25 min to 70 min with an average of 48 min. The operative estimated blood loss was negligible ranging between 5 to 7 ml. This matches with all published percutaneous fixation studies. The amount of blood loss as compared to open technique is much less due to the minimal skin incision, lake of muscle separation and tissue exposure. Federico et al reported that average surgical time was 106 minutes in single level fixation and blood losses were not assessable.\(^16\) The hospital stay duration in this series was 5 to 7 days. The longest was due to the patients had poly trauma. Oliver et al reported that the mean hospital stay duration was 10.2 days in his study.\(^17\)

The others used percutaneous system is WSH system of Neuro-France. The main difference between the two systems is that the screw heads are connected in
the Sextant System by rods and in the WHS System by plates.\textsuperscript{20,21}

This study shows that minimally invasive percutaneous pedicle screw and rod fixation (Sextant) system offers several distinct advantages over conventional pedicle screw fixation. It eliminates the need for a large midline incision and significant paraspinal muscle dissection. Blood loss and tissue trauma are minimized in addition to optimizing the biomechanics of the fixation. Also it offers short hospital stay for polytraumatized, septic, morbid obese, geriatric and diabetic patients.\textsuperscript{22,23,24} Other authors as Gejo et al believed that the minimally invasive percutaneous stabilization of the spine might be the right concept to minimize such approach-related morbidity and secondary iatrogenic soft tissue trauma.\textsuperscript{25}

**CONCLUSION**

Evolving minimally invasive percutaneous transpedicular lumbar fixation has showed a significant role in minimizing approach-related morbidity while achieving the same result as traditional invasive approaches. The clinical utility of Sextant system appears promising allowing the surgeon to achieve same goal as traditional open surgery but in a less invasive procedure. This is particularly valuable in fracture cases without neurological compromise. In these cases no further intervention is needed to decompress nervous tissue or apply bone graft.

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