International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2016; 2(4): 154-159

www.orthopaper.com
Received: 10-08-2016
Accepted: 20-09-2016

Dr. Ajay MB
Consultant, Orthopedic Surgeon, Puttur, Mangalore, Karnataka, India

Dr. Vijayakumar AV
Assistant Professor, AJ Shetty Medical College, Mangalore, Karnataka, India

Correspondence
Dr. Ajay MB
Consultant, Orthopedic Surgeon, Puttur, Mangalore, Karnataka, India

Comparative study between conventional open spine pedicle screw fixation surgery minimally invasive percutaneous pedicle screw fixation in the management of thoracolumbar spine fracture in adult

Dr. Ajay MB and Dr. Vijayakumar AV

DOI: http://dx.doi.org/10.22271/ortho.2016.v2.i4c.26

Abstract
Documented treatment of spine fractures dates back several thousands of years. Closed treatment and manipulation to correct the sustained deformity were typically used. In the early 20th century, most treatment consisted of immobilization in hyperextension. The present study was conducted in the Department of Orthopaedics, from October 2011 to October 2013. 25 randomly selected cases admitted through hospital with unstable dorso-lumbar spinal fractures and dislocations in each group. All these patients were managed by posterior pedicle screw fixation. All cases were followed up for a minimum period of 1 year. In the percutaneous pedicle fixation group, 12 patients had excellent results, 10 patients had good results & 3 had fair outcome. In the conventional pedicle fixation group, 8 patients had excellent results, 12 patients had good results & 5 had fair outcome.

Keywords: Conventional open spine pedicle screw fixation, minimally invasive percutaneous pedicle, thoracolumbar spine fracture

Introduction
A spinal fracture is a serious injury. The most common fractures of the spine occur in the thoracic and lumbar spine or at the connection of the two (thoracolumbar junction). These fractures are typically caused by high-velocity accidents, such as a car crash or fall from height.

Men experience fractures of the thoracic or lumbar spine four times more often than women. The male-to-female ratio is roughly 4:1. Seniors are also at risk for these fractures, due to weakened bone from osteoporosis.

The vast majority of spine fractures occur as a result of motor vehicle accidents (45%), falls (20%), sports (15%), acts of violence (15%), and miscellaneous activities (5%). The percentage secondary to acts of violence is higher in urban areas

Because of the energy required to cause these spinal fractures, patients often have additional injuries that require treatment. The spinal cord may be injured, depending on the severity of the spinal fracture [1].

Documented treatment of spine fractures dates back several thousands of years. Closed treatment and manipulation to correct the sustained deformity were typically used. In the early 20th century, most treatment consisted of immobilization in hyperextension.

Treatment of spine fractures did not begin to evolve from universally closed treatments to the surgical modalities that are in place today until the advent of current anesthesia and radiographic techniques. Internal fixation was first seen after World War II. Initially, it was in the form of spinous process plating. Harrington then introduced his posterior spinal instrumentation. From this, modern surgical techniques and instrumentation have developed. Although the spinal stability and alignment established with these newer techniques have dramatically improved, improvement in neurologic deficits sustained in these injuries has remained relatively unchanged over the years of spine fracture management [2].

The primary goals of treatment for thoracic & lumbar spine fractures include protecting the neural elements and preventing deformity and instability. Surgery often facilitates achieving these goals and often hastens the patient's rehabilitation. Surgery is particularly often beneficial in patients with multiple traumatic injuries. The ultimate decision to operate is based on many factors, including fracture morphology, and the choice is often complex. Surgical management should be strongly considered when neurologic deficit or significant deformity or instability is present.

An exaggerated curvature (kyphosis) at the end of treatment may predispose to later back pain and a poor functional outcome. If the nerve root or spinal cord is damaged, partial or complete loss of sensory and motor function in the legs, and urinary and faecal incontinence may result.

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Treatment depends on the individual characteristics of the fracture, with options including bed rest alone, closed reduction of the fracture and functional bracing, and surgery involving open reduction and internal fixation of the fracture. Surgery frequently involves posterior pedicle screw fixation, where typically screws are placed in the 'pedicle' parts of the vertebrae (bones of the spine) adjacent to the damaged vertebrae and connected by rods to hold the bones in place and stabilise the fracture while it heals.

Pedicle screw instrumentation enables a rigid construct to promote stability and fusion for numerous spinal pathologies. The safety of traditional open techniques for pedicle screw placement has been well documented; however, due to the advantages of minimally invasive surgery (MIS), demand for percutaneous pedicle screw insertion has increased. Improvements in minimally invasive instrumentation have also broadened the scope of spinal disorders that surgeons can operate on.

Conventional open spine surgery has several reported limitations including extensive blood loss, post-operative muscle pain and infection risk. The paraspinal muscle dissection involved in open spine surgery can cause muscular denervation, increased intramuscular pressure, ischaemia, necrosis and revascularization injury resulting in muscle atrophy and scarring, often associated with prolonged post-operative pain and disability.

Spinal fixation utilizing muscle-dilating approaches to minimize surgical incision length, surgical cavity size and the amount of iatrogenic soft-tissue injury associated with surgical spinal exposure, without compromising outcomes, is thus a desirable advancement.

there is a trend towards MIS of the spine due to lower complication rates and approach-related morbidity, with minimal soft tissue trauma, reduced intra-operative blood loss/risk of transfusion, improved cosmesis, decreased post-operative pain and narcotic usage, shorter hospital stays with faster return to work and thus reduced overall health care costs. Despite this, some reports believe that minimal exposure is associated with incomplete treatment of pathology due to significantly decreased visualisation with MIS. Another potential limitation includes the use of imaging-guided pedicle screw placement. Imaging increases operating times and patient / surgeon exposure to ionising radiation. Non-radiological navigation methods thus need to be explored to further improve MIS.

Methodology

The present study was conducted in the Department of Orthopaedics, from October 2011 to October 2013. 25 randomly selected cases admitted through hospital with unstable dorsolumbar spinal fractures and dislocations in each group. All these patients were managed by posterior pedicle screw fixation. All cases were followed up for a minimum period of 1 year.

Selection of Cases for operative treatment

All those cases of unstable dorsolumbar fractures were included in the study who fulfilled following criteria:

- All closed dorsolumbar junction injuries between D-10 to L-5.
- Patient's age more than 18 years.
- Duration of injury less than 1 to 7 days.

Criteria for exclusion of cases for operative treatment

- Multilevel injuries.
- Those unable to cooperate in post operative rehabilitation because of psychosis, mental retardation, head injury or cerebrovascular accidents.
- Poor anesthetic or general risk patients or patient's refusal for surgery

Criteria for Instability [3]:

Loss of 50% body height.

- Angulation > 30°
- Canal compromise > 50%
- Failure of at least 2 columns
- Kyphotic deformity > 20^0

Indication for surgical stabilization

- Patient with one of the following were considered to have an indication for surgical stabilization of spine -
- - Presence of neurological involvement caused by fracture.
- - All neurological stable patient within instability criteria[4]
- - Loss of 50% body height of vertebrae.
- - Angulation > 30^0
- - Kyphotic deformity > 20^0
- - Canal compromise > 50^0
- - Failure of at least 2 column

Clinical History and Examination

Detailed history was elicited in all cases regarding the following variables:

- Mode of injury
- Date and time of injury
- Date and time of reporting to hospital
- Associated injuries
- Treatment taken before reporting to the hospital

General and systemic examination

A detailed examination was carried out with regard to general condition of the patient and any systemic disorder.

Local examination of spine
Local examination included the presence of any visible deformity over back, local tenderness over the back was noted. Whole of the spine was examined for deformity and tenderness to prevent detection of missed injuries.

Neurological examination
Detailed neurological examination including tone, bulk, power at different joints, coordination, any abnormal movements, superficial and deep tendon reflexes, sensory deficit, bowel and bladder involvement was noted. Perianal sensation and bulbocavernosus reflex was tested in all patients to differentiate between complete and incomplete cord lesion. After thorough neurological examination patients were categorized according to ASIA score.

Routine investigation
All the patients were routinely investigated to determine fitness to anesthesia. Following investigations were routinely done:

- Haemogram
- Blood sugar, blood urea, serum creatinine
- Complete urine examination
- X-ray chest – PA view
- ECG (all leads)

Radiological examination

- A good quality radiographs with anterior posterior and lateral views of injures spine were done to evaluate and classify dorsolumbar injuries. The lateral X-ray was used to measure Cobb's kyphosis angle and anterior vertebral body height.
- In all cases an MRI scan was done to evaluate extent of canal compromise from retropulsed fragment, assess degree of communition of vertebral body, status of the cord and posterior ligament complex.

Results

Table 1: Pre-operative neurological status (ASIA's score)

ASIA's scoring	Pts in percutaneous pedicle fixation group	Pts in conventional pedicle fixation group
A	0	0
B	0	0
C	0	0
D	3	4
E	22	21
Total	25	25

Out of the 50 patients, 7 patients (14%) were grade D, and 43 pts(86%) were grade E according to ASIA score.

Table 2: Distribution of cases according to fractured vertebrae

Vertebrae level	No. of patients	Percentage
T10	0	0
T11	4	8
T12	18	36
L1	20	40
L2	6	12
L3	2	4

76% of the patients sustained injury at the level of thoracolumbar junction T12-L1.
Most common vertebra involved was L1 (40%), followed by T12 (36%), L2 (12%) and T11 (8% each) in that order.

Table 3: Interval between injury and surgery

Duration	No. of patients	%
< 2 days	20	40%
3-7 days	24	48%
8-21 days	4	8%
> 21 days	2	4%

The average interval between injury and surgery was 7 days. 88% patients were operated within first week, while rest were operated after 1 week after injury, either due to late presentation, medical complications & economical condition of the patient.

Table 4: Associated injuries

Associated injury	No. of patients (50)	%
Chest injury	4	8
Lower limb:	12	
Fracture femur	4	8
Fracture calcaneum	8	16
Fracture pelvis	2	4

Most common associated injury in our series was fracture calcaneus (8 cases), followed by fracture femur and chest injury (4 cases each).

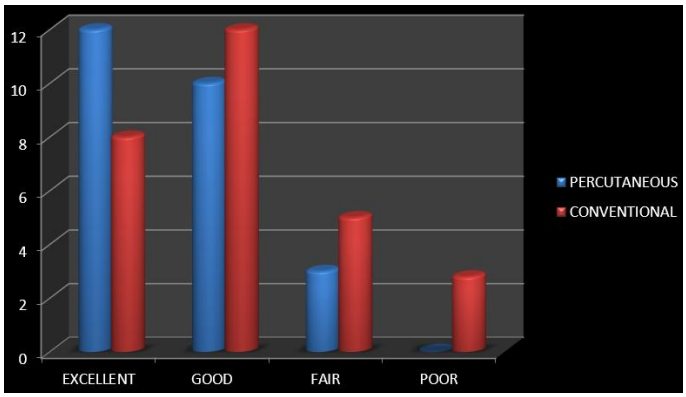
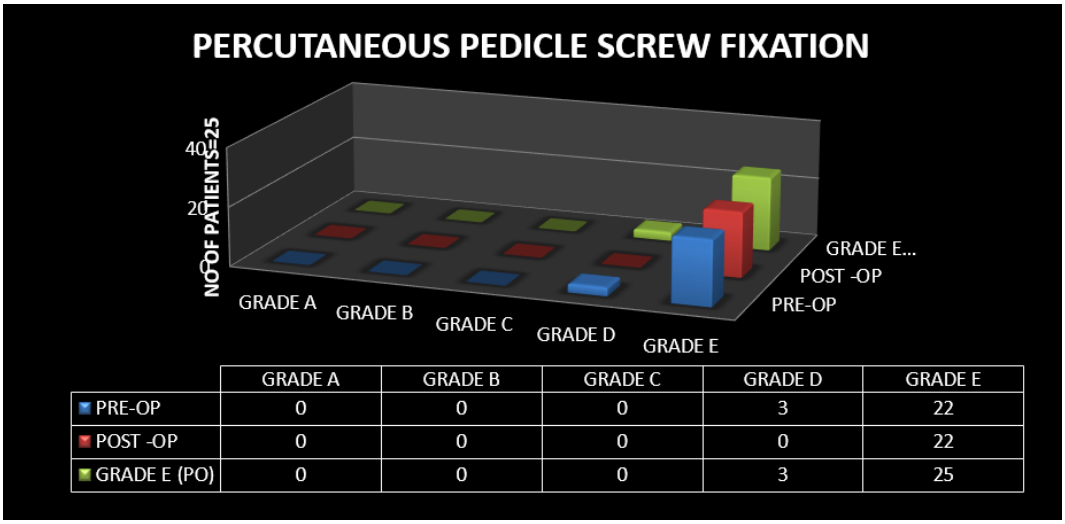


Fig 1: Final Outcome

In the percutaneous pedicle fixation group, 12 patients had excellent results, 10 patients had good results & 3 had fair outcome. In the conventional pedicle fixation group, 8 patients had excellent results, 12 patients had good results & 5 had fair outcome.

Table 5: Change in neurological status in patient treated with percutaneous pedicle screw fixation

Preoperative ASIA grade (25)	Postoperative ASIA grade				
	A	B	C	D	E
Grade A (0)	--				
Grade B (0)		0			
Grade C (0)			0		
Grade D (3)				0	3
Grade E (22)					22



	GRADE A	GRADE B	GRADE C	GRADE D	GRADE E
PRE-OP	0	0	0	3	22
POST -OP	0	0	0	0	22
GRADE E (PO)	0	0	0	3	25

Fig 6: Percutaneous Pedicle Screw Fixation

22 Patients (88%) with grade E had same neurological status even after post-op ASIA grade. 3(12%) patients with grade D had shifted to grade E after post-op period.

Table 6: Change in neurological status in patient treated with conventional pedicle screw fixation

Preoperative ASIA grade (25)	Postoperative ASIA grade				
	A	B	C	D	E
Grade (A)→0	0				
Grade (B) → 0		0	0		
Grade (C) → 0			0	0	
Grade (D) → 4				0	4
Grade (E) →21					21

4 patients with grade D improved to grade E from shows neurological improvement (16%), while 21 patients (84%) with grade E pre-op had no change in neurological status.

Table 7: Complications

Complications	Percutaneous pedicle screw fixation		Conventional pedicle screw fixation	
	No.	%	No.	%
Neurological worsening	0	0	0	0
Infection	1	4	4	16
Hardware failure	1	4	1	4
Chest infection	0	0	0	0
DVT/thromcoembolism	0	0	0	0
Worsening of UTI	0	0	0	0
Bed sores	0	0	3	12

Discussion

In this study it was observed that injuries of the lower limb (fracture calcaneum – 16% and fracture femur – 8%) were the most common associated injury followed by chest injury. The series presented by other studies [5,6] showed a wide variety of associated injuries like involvement of upper limb, central nervous system, urogenital system and abdomen.

Incision length: the average length of incision in our study for percutaneous pedicle fixation group was 8.4 ± 0.841 cms, compared to conventional pedicle fixation group where the average incision length was 13.96±1.274 cms. Our study results were comparable with the other studies[7] where the average incision length for percutaneous pedicle fixation group was 9.4 cms and for conventional pedicle fixation group was 11.6 ± 2.8 cms.

Surgical blood loss: the surgical blood loss was more in conventional pedicle fixation group with the average loss of 159.80 ± 35.133 ml, in percutaneous pedicle fixation group the blood loss was far less the average blood loss was 84.40 ± 21.081 ml.

Post – op blood loss: the post-op drain was more in conventional pedicle screw fixation group with an average loss of 130 ± 16.330 ml. the post-op drain was more in percutaneous pedicle screw fixation group with an average loss of 21.60 ± 6.410 ml. the percutaneous pedicle fixation group had less post-op blood loss. 5 patients operated with conventional pedicle group required post-op blood infusion due to extensive operative and post-op blood loss, whereas none of the patients in percutaneous pedicle screw fixation needed post-op blood transfusion.
In one study[8] the post-operative loss was 14.4 ± 4.3 ml in percutaneous pedicle screw fixation & 350.1 ± 204.5 ml in conventional pedicle fixation group.

Surgical time: the conventional pedicle fixation group is 103.48 ± 12.258 mins required more time than percutaneous pedicle screw fixation, 69.76 ±11.766 mins.
The average operative time was 78 minutes (range 62 to 117 min) for percutaneous pedicle screw fixation group[7].
The average time for percutaneous pedicle screw fixation was 97±15.3 mins compared to the conventional pedicle fixation group 161.0 ± 72.5 mins [9].

Post-op stay: the average post-op stay for the conventional pedicle fixation group is 13.12 ± 2.587 days & for percutaneous pedicle screw fixation 10.60 ± 1.915 days.
Ralph J. Mobbs (2011) minimally invasive techniques in spinal surgery are increasing in popularity due to numerous potential advantages, including reduced length of stay, blood loss and requirements for post-operative analgesia as well as earlier return to work.

Saggital cobb's angle: in percutaneous pedicle screw the average pre-op Saggital cobb's angle was 26.36 ± 4.290°, the immediate post-op 15.12 ± 5.380 ° & at final follow-up the

correction was 19 ± 5.408 °.
In conventional pedicle screw the average pre-op Saggital cobb's angle was 29.08 ± 8.301, the immediate post-op 15 ± 7.118 & at final follow-up the correction was 19 ± 7.867. The average correction was 9.96 ± 3.634.
Conventional pedicle group had better correction than percutaneous pedicle screw group.
Mean preoperative kyphotic deformity in the OPSF (open pedicle screw fixation group) group was 16.0° (1°- 29°). An average of 9.3° of kyphosis correction was achieved, improving kyphotic angulation to 6.8° in the immediate postoperative period in the OPSF group, but 5.2° (0-28°), 10.3°, 3.9° respectively in the PPSF group (percutaneous pedicle screw fixation). Among the patients whose 9-month follow-up films were available, (3.0°±1.5°) of kyphosis correction was lost in the OPSF group, but (3.2°±1.6°) in the SPPSF group [10].

Fractured vertebral body (°) angle: in percutaneous pedicle screw the average pre-op Fractured vertebral body angle was 15.20 ± 4.628, the immediate post-op 25.04 ± 4.628 & at final follow-up the correction was 23.36 ± 4.040. The correction of 8.28 ± 2.052 was achieved.
In conventional pedicle screw the average pre-op Fractured vertebral body angle was 17.40 ± 5.315, the immediate post-op 26.72 ± 5.496 & at final follow-up the correction was 23.36 ± 4.040. The correction of 9.12 ± 2.052 was achieved conventional pedicle group had better correction than percutaneous pedicle screw group.
Mean preoperative angle of the fractured vertebral body in the OPSF group was 15.9° (4°-25°). Average 7.9° of kyphosis correction was achieved, improving kyphotic angulation to 8.0° in the immediate postoperative period in the OPSF group, but 14.9° (3°-25°), 6.6°, 8.2° respectively in the PPSF group. Among the patients whose 9-month follow-up films were available, (1.0°± 1.0°) of the angle of the fractured vertebral body correction was lost in the OPSF group, but (1.5°±1.2°) in the PPSF group[10].

Anterior vertebral body height: in percutaneous pedicle screw the average pre-op Anterior vertebral body height was 1.62 ± 0.286 cms, the immediate post-op 2.43 ± 0.318 cms & at final follow-up the average correction was 2.04 ± 0.359 cms. the average correction was 0.41 ± 0.22 cms.
In conventional pedicle screw the average pre-op Anterior vertebral body height was 1.69 ± 0.31 cms, the immediate post-op 2.57 ± 0.27 cms & at final follow-up the average correction was 2.19 ± 0.37 cms. the average correction was 0.44 ± 0.17 cms.
Mean anterior vertebral body height (% of normal) was 67.3% (44.4%- 92.3%) before surgery and 95.8%after surgery, yielding an average vertebral body height restoration of 28.6%, but 69.1% (51.5%-93.2%), 90.1%, 21.0%respectively in the PPSF group. Among the patients whose 9- month follow-up films were available, (3.0±1.7) % of the anterior vertebral body height correction was lost in the OPSF group, but (2.2±1.4) %in the PPSF group [10].

Posterior vertebral body height: in percutaneous pedicle screw the average pre-op Posterior vertebral body height was 2.50 ± 0.21 cms, the immediate post-op 2.82 ± 0.14 cms & at final follow-up the average correction was 2.74± 0.15 cms. the average correction was 0.24 ± 0.12 cms.
In conventional pedicle screw the average pre-op Posterior vertebral body height was 2.40 ± 0.25, the immediate post-op 2.80 ± 0.76 cms & at final follow-up the average correction was 2.72 ± 0.91 cms. the average correction was 0.30 ± 0.19 cms.
Mean posterior vertebral body height (%of normal) was 93.3% (83.5%-100%) before surgery and 99.5%after surgery, yielding an average vertebral body height restoration of 6.2%, but 88.9% (81.3%-98.0%), 93.3%, 4.4%respectively in the PPSF group. Among the patients whose 9-month follow-up films were available, (3.0 ±1.3) % of the posterior vertebral body height correction was lost in the OPSF group, but (2.5±1.1) % in the PPSF group.

Final Outcome: it was assessed using modified macnab criteria,
In the percutaneous pedicle fixation group, 12 patients had excellent results, 10 patients had good results & 3 had fair outcome. In the conventional pedicle fixation group, 8 patients had excellent results, 12 patients had good results & 5 had fair outcome.

Complications: In patients treated with percutaneous pedicle screw fixation one patients had developed superficial infection on post-op day 3, compared four patients operated with conventional pedicle screw fixation on post-op day 3. Patients were treated with higher antibiotics & regular dressing. none of the patients had deep infection.
One patient had developed hardware failure (implant loosening) after a period of 14 months in percutaneous pedicle screw fixation, one patient had developed implant loosening in conventional pedicle fixation after a period of 17 months. Both patients were treated by implant removal.
None of the patient had complications of neurological deterioration, chest infection, DVT, worsening of UTI, bedsore in percutaneous & conventional pedicle screw fixation group.

Conclusion

- The average length of incision in our study for percutaneous pedicle fixation group was 9.4 ± 0.841 cms, compared to conventional pedicle fixation group where the average incision length was 13.96±1.274 cms.
- The surgical blood loss was more in conventional pedicle fixation group with the average loss of 159.80 ± 35.133 ml ml, in percutaneous pedicle fixation group the blood loss was far less the average blood loss was 84.40 ± 21.081 ml.
- The post-op drain was more in conventional pedicle screw fixation group with an average loss of 130 ± 16.330 ml. the post-op drain was more in percutaneous pedicle screw fixation group with an average loss of 21.60 ± 6.410 ml.
- The conventional pedicle fixation group 103.48 ± 12.258 mins required more time than percutaneous pedicle screw fixation 69.76 ±11.766 mins.

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