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Original Article

Surgery Section

Minimally Invasive Transpedicular Screw Fixation for Thoracolumbar Fractures- A Retrospective Analysis in a Basic Neurosurgery Unit

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ABSTRACT

Introduction: Thoracic and lumbar fractures are among the most common type of traumatic spine fractures. With advanced surgical technique and instrumentation the use of minimally invasive pedicle screw fixation for thoracolumbar fractures has increased. Minimally invasive spine procedures avoid excessive muscle dissection and decreases trauma to tissues during surgery.

Aim: To study the outcome with minimally invasive spine surgery for thoracolumbar fractures.

Materials and Methods: This study was designed as a retrospective descriptive study. All patients with thoracic and lumbar fractures who had undergone minimally invasive percutaneous pedicle screw fixations from June 2016 to May 2019, in the Department of Neurosurgery were included. Cases requiring laminectomy were excluded. A total of 25 patients were included in this study. Mean blood loss, operative time, hospital stay, postoperative pain and complications were assessed. Data was entered in excel sheet and statistically analysed using charts and graphs.

Results: Nineteen males (76%) and six females (24) were included in this study. Mean age of the study population was 41.45 years. Mean blood loss was 125 mL and no patient required blood transfusion. Average duration of the procedure was 104±34.9 minutes. Improved pain score was noted during postoperative period. No patient developed Cerebrospinal Fluid (CSF) leak, new onset neurological deficits and bowel or bladder involvement during the postoperative period.

Conclusion: Minimally invasive spine fixation surgery is safe and less destructive procedure which is fast and is associated with minimal morbidity. Percutaneous techniques are associated with less blood loss, shorter hospital stay and improved perioperative pain scores. From the present study it was noticed that there was an increased risk for radiation associated with minimally invasive pedicle screw fixation.

Keywords: Minimally invasive spine surgery, Pedicle screw, Traumatic spine fracture

INTRODUCTION

Treatment of pathology with minimal disturbance of normal anatomy is the basic principle of surgery. This can be accomplished by procedures that require smaller incisions which results in less soft-tissue disruption. There has been a profound evolution in the past two decades to treat disorders of the spine using minimal access [1]. Minimally invasive spine surgery avoids excessive tissue dissection and decreases tissue injury. Muscle sparing technology has come into use with tubular access [2], which involves percutaneous placement of spinal instrumentation, including intervertebral spacers, rods, pedicle screws and artificial discs. It is aided by technological advances in microscopy, diagnostic imaging, intraoperative neuro monitoring and intraoperative fluoroscopy/Computed Tomography (CT) [1,2].

The benefits over traditional open surgery include smaller incisions, brief surgery, less soft tissue damage, reduced estimated blood loss, decreased postoperative pain, minimal postoperative stay and early ambulation. The results of these efforts have reduced healthcare costs by limiting morbidity, shorter hospital stay, faster recovery and quicker return to work [3]. The influence of spine fractures on the patients' financial and social environment is more significant than other injuries. With advanced treatment options interest in spine fractures grew in the last 20 years [4]. Minimally invasive fixation of the lumbar spine was first described by Magerl in 1982. Later Lowery and Kulkarni described a percutaneous lumbar pedicle screw fixation device using rods as longitudinal connectors. Pedicle screws engage all the three columns of spine thus providing better stability and fusion for numerous spinal pathologies [5]. Faubert C and Caspar W in 1991 first reported tubular access to lumbar disc which led to the development of tubular retractor systems. These procedures lessen the pain and morbidity of disc access by effectively sparing the muscles [2]. Foley made a significant contribution in 2001 with his invention of technique to pass rods in a minimally traumatic fashion using an arc based system called Sextant (Medtronic) [6].

According to Phan K et al., percutaneous pedicle screw fixation is a potential option in the setting of thoracolumbar fractures, where the pedicles are amenable to percutaneous placement of screws [7]. Minimally invasive percutaneous transpedicular screw fixation showed a significant role in minimising approach related morbidity, decreased blood loss, and decreased recovery time. These characteristics eventually results in improved long term results, with decreased muscle denervation, atrophy, and pain [7]. This method could fix the vertebrae and reduce kyphosis, and identify the reduction and fixation of displacement of the spine. It reduced the concentration of stress internal fixation device and the stress load of rod greatly. Biomechanical stability was improved and normal vertebral height can be restored in time, which then reduced the occurrence of intervertebral space collapse [8].

Although there are some disadvantages and complications of percutaneous transpedicular systems with conventional pedicular screw applications like misplaced screws, nerve root injury, spinal cord injury, pedicular fracture, and CSF fistula, there is increased popularity for minimally invasive techniques [4]. Electromagnetic Field (EMF)-based navigation reduces fluoroscopic exposure and help in accurate placement of percutaneous pedicle screws

[9]. The minimally invasive pedicle screw fixation of spine helps to decrease approach-related morbidity and iatrogenic soft tissue trauma [10]. In our institution, we started minimally invasive spine surgery in 2016. This is a study to report the outcome with minimally invasive transpedicular screw fixations for thoracolumbar spine fractures.

MATERIALS AND METHODS

The present study was designed as a retrospective descriptive study. All patients with thoracic and lumbar fractures who had undergone minimally invasive percutaneous pedicle screw fixations from June 2016 to May 2019, in the Department of Neurosurgery, Government Medical College, Thrissur, Kerala, India, were included. Total time period of study including data collection was three years and six months.

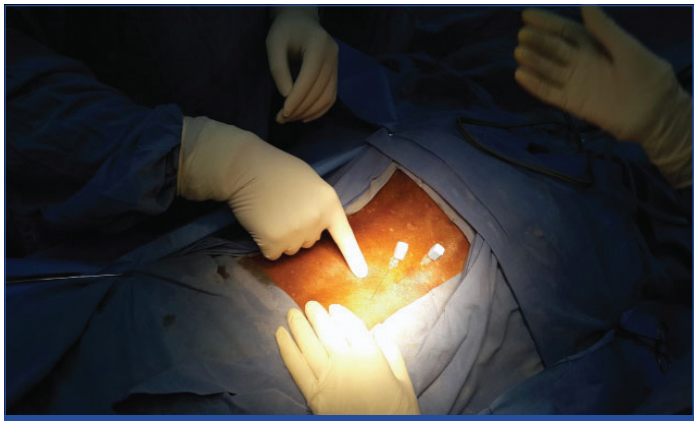
Inclusion criteria: Single level thoracic and lumbar fractures (AO type-A) [11] with no neurological deficits, requiring only fixation were included in the study.

Exclusion criteria: Cases requiring laminectomy were excluded.

The study was conducted after the approval and clearance from Ethical Committee {B6-155/2019/MCTCR (13)}. The data was collected from medical and Operation Theatre (OT) records in the Department of Neurosurgery. A total of 25 patients who gave consent were included in the study.

Surgical Technique [12]

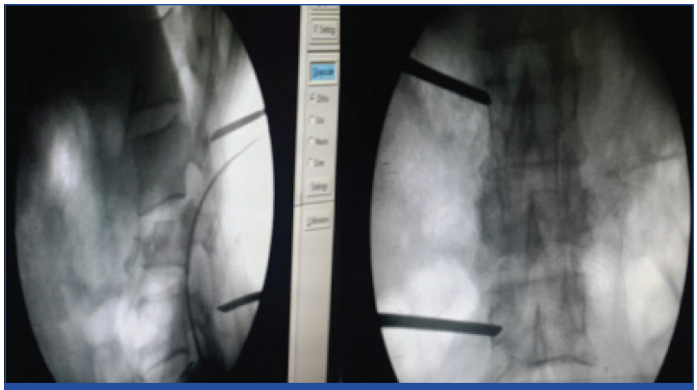
Minimally invasive spine surgery includes three main steps: locating pedicle, serial dilation and screw insertion. Patient was kept prone. Locating the pedicle percutaneously required serial AP and lateral C-Arm exposures [Table/Fig-1]. Pedicle was localised with jamshidi needle under C-Arm guidance [Table/Fig-2]. K-wire was guided through jamshidi needle [Table/Fig-3]. Serial dilators were applied over K-wire [Table/Fig-4]. Through the K-wire, cannulated polyaxial screws were introduced [Table/Fig-5]. Once the screws were in position, rods were introduced with the help of a specially made rod inserter [Table/Fig-6,7]. Distraction was achieved if required with the help of a distractor. Minimally invasive spine surgery set manufactured by Jayon surgicals, Palakkad, Kerala was used for all the cases. Postoperative image is shown in [Table/Fig-8].



[Table/Fig-1]: Localising the level of screw insertion.

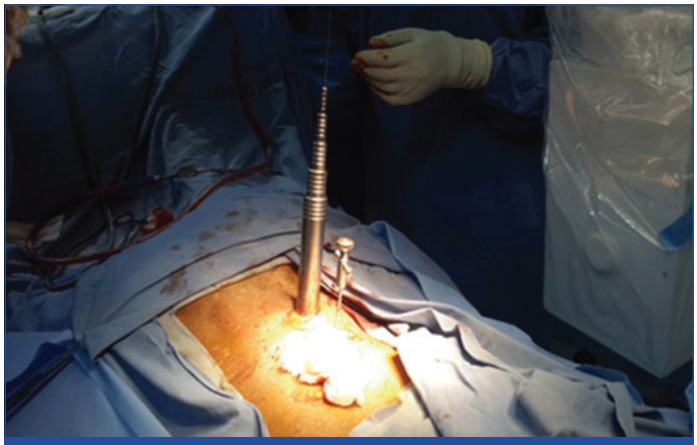
Outcome Measures

Pain (analysed by Visual Analog Score/VAS) [Table/Fig-9] [13], intraoperative blood loss in milliliter (mL) (amount of blood loss will be estimated by measuring the amount of blood collected in the suction jar with adjusted corrections for the saline used), C-Arm exposures by number of shots, mean hospital stay in days, kyphosis angle was derived from the slope of end plates of vertebrae [14] and postoperative complications like implant failure, CSF leak and wound infection were also assessed.

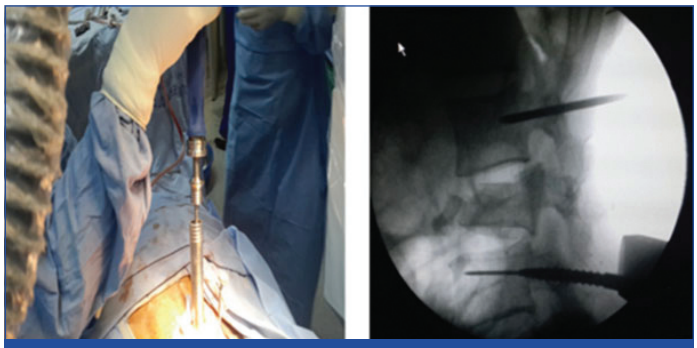


[Table/Fig-2]: Inserting Jamshidi needle into pedicle.

[Table/Fig-3]: K wire insertion through the Jamshidi needle.



[Table/Fig-4]: Placement of serial dilators.



[Table/Fig-5]: Polyaxial cannulated screw insertion.

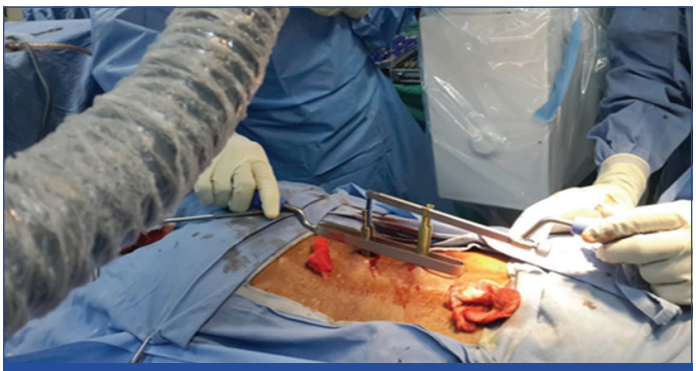
STATISTICAL ANALYSIS

Data was entered in excel sheet and statistically analysed using Statistical Package for the Social Sciences (SPSS) version 20.0, charts and graphs.

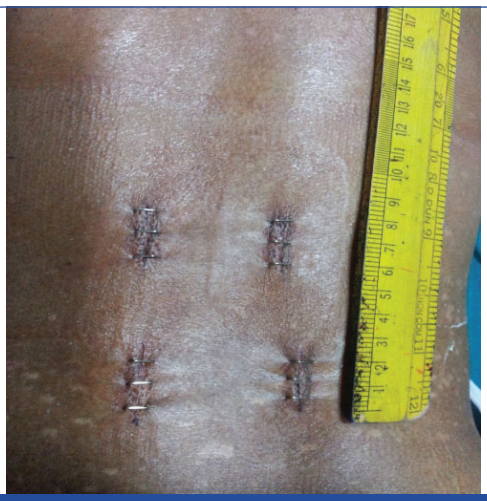
RESULTS

Twenty-five patients underwent minimally invasive percutaneous transpedicular screw fixation. Mean age of total study participants was 41.45 years. Mean age of patients were 41.3 years for males and 42.5 years for females {19 males (76%) and 6 females (24%)}.

[Table/Fig-6]: MIS Screws in place.



[Table/Fig-7]: Placement of rods.



[Table/Fig-8]: Postoperative image.

Parameters	Values
No pain	0-4 mm
Mild pain	5-44 mm
Moderate pain	45-74 mm
Severe pain	75-100 mm

[Table/Fig-9]: Visual Analog Score/VAS [13].

Most common site of fracture was lumbar vertebrae [Table/Fig-10]. Mean blood loss was 125 mL and no patient required blood transfusion. Average number of shots of C-arm exposure was 38. The number of exposures were very high (64 shots per case) during initial cases which was effectively brought down to 25 shots per case as we gained experience. Average operative time was 104±34.9 minutes. Postoperative VAS for 1 to 7 days averaged at 12±3.2. Mean postoperative kyphosis angle was 7.4±4.3° (measured at 3rd and 6th month from digital radiographs). Length of incision was 2 to 2.5 cm. No patient experienced implant failure, wound infection, CSF leak or new onset neurological deficits. Mean hospital stay averaged 2±1 days [Table/Fig-11].

Fracture level	Number	Percentage
Upper thoracic	1	4
Mid thoracic	4	16
Lower thoracic	6	24
Lumbar	14	56

[Table/Fig-10]: Distribution of fracture level.

Sl. No.	Variable	Outcome
1	Mean blood loss	125±23.6 mL
2	Mean operative time	104±34.9 min
3	Mean hospital stay	2±1 days
4	Postoperative kyphosis angle	7.4±4.3°
5	Postoperative VAS for 1 to 7 days	12±3.2 mm
6	Average number of C-arm shots	38
7	Postoperative complications	Nil
8.	Size of incision	2-2.5 cm

[Table/Fig-11]: Variables and outcome.

DISCUSSION

Faubert C and Caspar W in 1991 first reported tubular access to lumbar disc [2]. According to most of the studies the advantages of minimally invasive spine surgery include limited blood loss, less tissue injury, shorter duration of surgery and good postoperative outcome [15-17]. Small paraspinal incisions ranging from 2.0-2.5 cm were used in this study. Reduced muscle dissection using tubular retractors resulted in minimal damage to spinous process and muscle attachments. During open spine surgery excessive muscle dissection can lead to atrophy and irreversible muscle injury that destabilise spine framework and can cause deformity of spine [18-20].

In this single centre study, evidence were collected to support that, MIS fixation is a safe and less invasive option to manage thoracolumbar spine fractures. In this study patients encompass a wide age range and overall a good representation of the general population, making the results relevant. According to Mannion RJ et al., and Dahlberg D et al., duration was comparable with open surgeris in the case of spinal tumour excisions [21,22], whereas it was significantly longer in case of spinal fusions [23-25]. In a study by Elenany SA et al., the length of the procedure varied from 120-180 minutes with mean time of 154.50 minutes and mean blood loss of 174.25 mL [4]. De lure F et al., reported an average surgical time of 113 minutes [26]. The average operative time in present study was 104±34.9 minutes which was comparable to this study and well within the range.

Average blood loss in this study was 125 mL for pedicle screw fixations and no patient required blood transfusions. Grossbach AJ et al., reported an estimated blood loss of 93.6±66.2 mL in their patients and an average operating time of 192±42 minutes [27]. The average operating time reported by Wang H et al., in their study on thoracolumbar fractures in 2014 was 98.4±35.9 minutes [28]. The results of these international studies were similar to present study, even though the operative time by Grossbach AJ et al., was a bit on the higher side [27]. This might be due to the evolution of technique and better instrumentation in subsequent years of which we were the benefactors.

Excellent results in postoperative pain scores were observed after MIS fixation procedures which averaged at 12±3.2 mm for 1 to 7 postoperative days. In our experience, we found improved postoperative pain score after MIS procedures which was comparable to previous studies [26,28].

In the study by Wang H et al., infection rate was 0% and average length of hospital stay was 2±1 days [28]. Most of the patients were discharged on the second postoperative day itself and they started their daily routine activities within one week after surgery. There were nopostoperative infections in present study patients. In another

Sl. No.	Author's name	Place of study	Number of subjects	Age (years) of subjects considered	Outcomes compared	Compared to present study	Conclusion
1	Elenany SA et al., (2019) [4]	Egypt	9	45±16.5	Length of procedure-154.5 minutes Mean blood loss-174.25 mL	Length of procedure-104±34.9 minutes Mean blood loss-125 mL	Less or comparable to present study
2	Grossbach AJ et al., (2013) [27]	Chicago	11	32 (14-85)	Operative time-192±42 minutes Blood loss-93.6±66.2 mL	Operative time-104±34.9 minutes Blood loss-125 mL	Less operative time
3	Wang H et al., (2017) [28]	China	61	43.1 (14-80)	Average length of hospital stay 2±1 days kyphotic angle was 8.6±3.1°.	Average length of hospital stay-2 days Kyphotic angle-7.4±4.3°	Comparable
4	Zhang ZC et al.(2011) [29]	China	21	32.7 (23-55)	Average length of hospital stay 7.7±2.3 days	Average length of hospital stay-2 days	Less hospital stay in present study
5	Present study, (2021)	India	25	41.45	Operative time-104±34.9 minutes Blood loss-125 mL Average length of hospital stay-2 days Kyphotic angle-7.4±4.3°		

[Table/Fig-12]: Comparison of outcomes of previous studies and present study [4,27-29].

study by Zhang ZC et al., length of stay was 7.7±2.3 days [29]. Present study turned out better than Zhang ZC et al., and similar to Wang H et al., in this aspect (length of hospital stay) [28,29]. In the study by Abdel-AAl M and Kornah B [30], incision size was 2 cm. In present study, incisions ranged from 2-2.5 cm; which apart from their functional role, appealed to the senses of cosmetically vigilant female sex.

In the present study, mean postoperative kyphosis angle was 7.4±4.3° (measured at 3rd and 6th month from digital radiographs). In the study by Wang H et al., kyphotic angle was 8.6±3.1° [28]. Partial spontaneous reduction was achieved commonly when the patient was turned to prone position. Further, indirect reduction and decompression was achieved by correction of kyphosis and recreation of normal lordosis through application of contoured rods [30]. Spinal stability was achieved in every patient at the end of follow-up period. Satisfactory kyphosis angle was achieved by MIS fixation postoperatively in all patients. In fact, the natural kyphosis of the thoracic spine and lordosis of the lumbar spine were maintained. A comparative evaluation of the outcomes of this study with similar previous studies have been given in [Table/Fig-12] [4,27-29].

Main drawback faced during our humble attempt at MIS pedicle screw fixation procedures was a significant increase in C-arm exposures which averaged at 38 shots per case. The number of exposures were very high (64 shots per case) during initial cases which was effectively brought down to 25 shots per case as we gained experience. All patients did well during postoperative period and no one developed fresh neurological deficits. MIS spinal techniques have a steep learning curve. It is always better to have adequate experience in open procedures before attempting minimally invasive spine procedures [19].

Limitation(s)

These data described first experiences in the use of minimal-invasive instrumentation implants. Fractures with spinal cord compression were excluded and this study was done on patient without neurological deficits. This was a descriptive study with limited number of cases and without any comparison or control group.

CONCLUSION(S)

Minimally invasive spine surgery is a safe and less destructive reliable alternative to open surgery. It decreases postoperative morbidity and hospital stay there by reducing hospital bill significantly. Radiation exposure and learning curves of operating surgeons are limitations. Further studies with more sample size are needed for validation of findings.

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