

# Percutaneous Fixation as an Option for Traumatic Neurologically Intact Thoracolumbar Vertebral Fractures

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## Abstract

**Background:** The most frequent spinal fracture is the thoracolumbar fracture. Minimally invasive percutaneous fixation of cases having thoracolumbar vertebral fractures without neurological impairments has remained controversial. The advantages of minimally invasive percutaneous fixation are decreasing muscle and soft tissue injury, decreasing blood loss and infection rate, in addition to shortening hospital stay and recovery times. In comparison to the open technique, percutaneous fixation is adequate for treating thoracolumbar (TL) fractures without causing neurological impairments & with satisfactory outcomes in terms of kyphosis decline. Elevated radiation exposure to the surgeon & the patient, lack of decompression and fusion via bone graft, & a steep learning curve are all disadvantages of percutaneous fixation of vertebral fractures. **Methods:** This study was retrospectively conducted on forty-eight patients, age ranging from 16 to 65 years old, with a thoracolumbar (TL) fracture without causing neurological impairments who were meeting the eligibility criteria for fixation in the period from July 2019 to January 2024. **Results:** We included the forty-eight patients who met the inclusion criteria (34 males and 14 females) their ages ranged from 16 to 65 years. The most common pathology was L1 fracture in 38 patients. No major complications were experienced, only wound infection in five patients which was treated efficiently with repeated dressings and broad-spectrum antibiotics. Four patients experienced misdirected screws, only in one patient the screw encroached into the spinal canal with no deficit experienced, while the other three showed minimally laterally deviated screws. **Conclusion:** The advantages of percutaneous pedicle screw fixation in thoracolumbar fractures through preservation of posterior musculature, are less blood loss, shorter operative time, lower infection risk, less post-operative pain, shorter rehabilitation time as well as a shorter hospital stay. Limitations of percutaneous

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fixation include the inability to achieve direct spinal canal decompression and, not having the option to perform a fusion and also requiring a learning curve to master the anatomy and technique.

## Keywords

Thoracolumbar Fractures, Fracture Stability, Percutaneous Fixation

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## 1. Introduction

TL spine fractures account for 75% of all spinal injuries. The majority of TL fractures manifest at a young age, at the levels of T11 to L2. The most common cause is motor vehicle accidents. However, osteoporosis increases the incidence of these fractures among the elderly people. [1]-[3] Although conservative treatment may be successful for certain TL fractures in cases without neurologic dysfunction, short-segment pedicle screw fixation has been demonstrated to be a more efficient method for restoring vertebral height, correcting kyphosis, & stabilizing fractures. [4] [5] The aim of the surgical intervention in these fractures is stabilization of the spine to restore the neurological function, protect the neural elements, prevent or correct collapse and kyphosis, and reestablish regular spinal mechanics. An agreement regarding the necessity of surgical decompression, fixation, & fusion for vertebral fractures accompanied by neurological deficiency, the surgical management of cases with vertebral fractures devoid of neurological disorder remains a subject of controversy. [6]-[9] Thoracic compression & burst fractures that are unstable (loss of anterior vertebral height greater than 50%, angular deformity greater than 20°, & contiguous fractures) may progress to additional kyphosis. [6] [10] There exists certain evidence suggesting that those who chose to undergo surgery in these particular cases achieved superior clinical & radiological results compared to those who were treated non-operatively. [11] long-term follow-up revealed enhanced local kyphosis. [12]

Posterior fixation and instrumentation using open approaches is considered the classical surgical treatment of TL fractures. [6] The past decade has seen a steady advancement in minimally invasive posterior spine surgery. It is believed that minimally invasive procedures will induce less morbidity & yield comparable outcomes to conventional procedures. The percutaneous technique was originally used to treat degenerative spine diseases; Foley *et al.* documented the first case of degenerative spine disorder treated with percutaneous fixation in 2001, [13] while the first percutaneous fixation of spinal fracture was described by Assaker in 2004. Since then, Numerous publications have been published explaining the advantages & disadvantages of this method. [14] While the minimally invasive thoracolumbar fracture method does offer comparable benefits, the available evidence is primarily restricted to observational studies that utilize low-level & low-energy approaches. In addition, the available evidence for this method is further limited by its ineffectiveness over time in the treatment of TL spine fractures. [15]

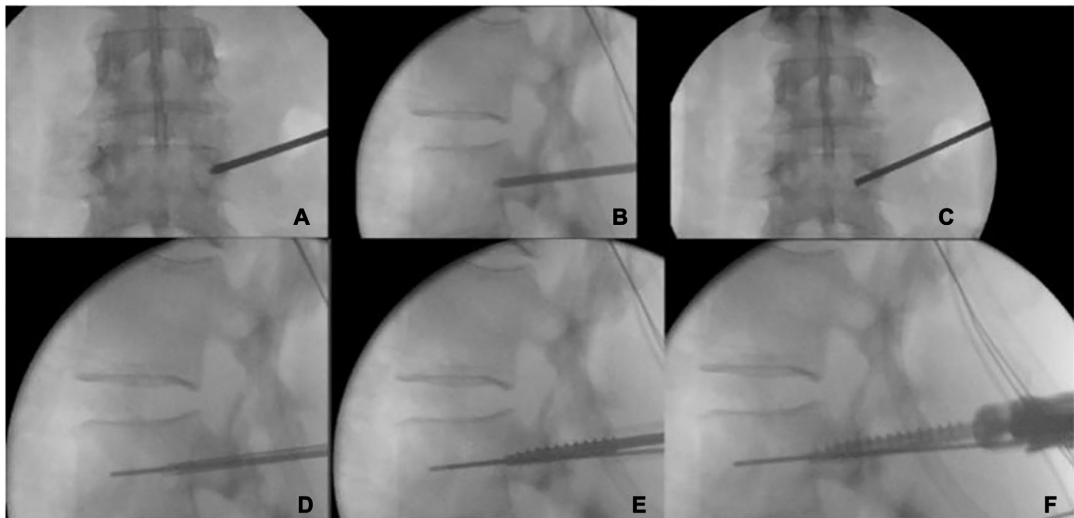
## 2. Materials and Methods

This study was retrospectively conducted on forty-eight patients, ages ranging from 16 to 65 years old, with a thoracolumbar (TL) fracture without causing neurological impairments who were meeting the eligibility criteria for fixation in the period from July 2019 to January 2024. Patients were operated upon in Fayoum University hospitals, Bani Suef University hospitals and private hospitals. All patients were subjected to thorough history taking, neurological examination and routine investigations. Investigations included preoperative labs, also, radiological in the form of X-Ray spine, CT (Computed tomography) Dorso-lumbar spine and (Magnetic resonance imaging) Dorso-lumbar spine to assess the pathology in detail with good visualization of neural tissue, nerve roots, discs and facet joints.

## 3. Steps of the Surgical Technique (Figure 1) [16]

- Surgical intervention was carried out on a radiolucent table (a Jackson frame), in the prone position, and under general anaesthesia.
- Percutaneous minimally invasive pedicle screw insertion was done fluoroscopy assisted.
- Accurate real anteroposterior (AP) & lateral views of the targeted vertebrae must be Carried out to localize the true image and true entry point.
- Local anaesthesia was given, & one cm of the lateral skin was incised to access the pedicle after accurate localization of the pedicle (Larger skin incisions are necessary for older instruments).
- The facial incision must be broader in diameter than the incision made on the skin.
- Following this, a Jamshidi needle is inserted via the entry point, which is ideally positioned at the intersection of the transverse process & articular facet.
- The entry points for the right & left pedicles must be between 2 & 3 o'clock also 9 & 10 o'clock, respectively.
- The Jamshidi needle is subsequently inserted into the pedicle while managing the AP & lateral views.
- On the lateral view, the Jamshidi needle must have reached the midpoint of the pedicle by the time it reaches that position on the AP view.
- The needle tip shouldn't come in contact with the inner border of the pedicle on the AP view when it reaches the posterior border of the vertebral body on the lateral radiograph.
- The guide wire is introduced into the vertebral body via the Jamshidi needle, ensuring that it doesn't traverse the anterior cortex, which could result in damage to the greater vessels.
- The Jamshidi needle is then eliminated without removing the wire.
- Kocher clamp is used to retract the guide wire.
- Following the insertion of the screws, the guide wire is extracted subsequently to the pedicle screw's tip traversing the vertebral body's posterior border as seen on the lateral radiograph.

- Bending the guide wire while pressing can be dangerous & inserting the screw, like doing so, could cause the guide wire to break. In order to prevent this complication, it is imperative to eliminate the guide wire promptly upon the screw tip penetrating the vertebral body through the posterior vertebral wall.
- Rods are applied and locked in place after the insertion of all desired screws.
- For construct control, final AP & lateral imaging must be performed.
- Post-operative antibiotics and Painkillers (acetaminophen and NSAIDs) were given for two days.
- Most patients were discharged on the 2nd post-operative day [16].



**Figure 1.** A fluoroscopic technique for inserting screws has been explained. (A) Point of entry for AP fluoroscopy; (B, C) Permission for the Jamshidi needle to make contact with the inner pedicle border on the AP image; (B, C) Specifically, once the needle passes through the spinal body's posterior wall. (D) Subsequently, the guide wire is introduced into the cannula while exercising caution to avoid traversing the anterior wall of the vertebral body. (E) Taping is performed on all guidewires with utmost care to prevent their removal. (F) Following screw insertion, the guidewire can be extracted once the screw tip contacts the posterior vertebral wall.

#### 4. Results

We included the forty-eight patients who met the inclusion criteria (34 males and 14 females) their ages ranged from 16 to 65 years. The most common pathology was L1 fracture in 38 patients. According to the duration of surgery, it varied from 90 to 150 minutes. In our series, blood loss was less than 100 millilitres in 46 patients, while only 2 patients experienced blood loss of 150, 200 millilitres respectively. Regarding chronic post-operative low back pain, only eight patients, 17% experienced chronic post-operative low back pain in a six-month follow-up period with VAS scores ranging from 2 to 4 maximum. Despite the absence of noticeable variations in pain scores during long-term follow-up, early follow-ups revealed reduced VAS scores in comparison to preoperative pain. Regarding the hospital stay, patients were only admitted to the ward for a maximum of 72 hours with mean of 32 hours hospital stay. No major complications were encountered. According to infection rate, it appears that percutaneous fixation resulted in a

reduced incidence of infection, only wound infection in five patients which was treated efficiently with repeated dressings and broad-spectrum antibiotics. In our study screw positioning was done using either with fluoroscopy-assisted pedicle screw placement or freehanded technique, utilizing the percutaneous technique, four patients (8%) experienced maldirected screws, only in one patient (2%) the screw encroached into the spinal canal with no deficit experienced while other three patients (6%) showed minimally laterally deviated screws.

## 5. Discussion

Classic open technique has been associated with muscle atrophy due to muscle devascularisation & denervation induced by muscle separation, detachment, & continuous contraction [17]. This results in intraoperative haemorrhaging, necessitates blood transfusions, & elevates the risk of infection [18]. Muscle separation further results in post-operative pain & strength loss, both of which impede functional recovery & contribute to the progress of chronic pain. Chronic low back pain has been linked to multifidus muscle weakness as a pathophysiological factor. [19] [20]. Reduced tissue dissection is the primary benefit of percutaneous fixation for vertebral fractures. Regev *et al.* demonstrated that the motor nerve of the multifidus muscle was damaged in as many as eighty percent of cases undergoing open procedures, whereas the percentage was only 20% in cases who underwent percutaneous procedures. [21] By avoiding damage to the paravertebral musculature, percutaneous surgery restricts bleeding, decreases infection rates, & decreases post-operative pain. In our study, only eight patients, 17% experienced weak paravertebral muscles and chronic post-operative low back pain in a six-month follow-up period. These benefits could potentially shorten the duration of hospitalization, accelerate rehabilitation, &, in theory, prevent long-term failure of adjacent segments. Preserving muscle innervation would also reduce muscle atrophy & scarring, as demonstrated by MRI & post-operative muscle enzyme dose. [22] Jiang *et al.* discovered that the percutaneous group had superior function & lower pain scores than the open cohort, the same finding as other studies. [22] Lee *et al.*, on the contrary, discovered little variance among the percutaneous & open fixation groups in terms of VAS scores. [23] Likewise, a current meta-analysis found no variance among the 2 techniques regarding pain during the medium-term follow-up period. [24] This may be accounted for by the increased heterogeneity among the variance researchers. Despite the absence of noticeable variations in pain scores during long-term follow-up, early follow-ups (three months) revealed reduced VAS scores following percutaneous fixation. This improvement in spinal stability led to earlier mobilization of the patient. [25]-[28] By facilitating earlier ambulation, cases can reduce their risk of developing complications related to bed rest & ulcers. [22] [24] By achieving this, the average length of hospitalisation for patients in our study was reduced by 5.72 days, which translates to substantial savings of hospitalisation expenses, involving the cost associated with the osteosynthesis material and this was matching results from several published studies.

[29] [30] Tromme *et al.* assessed over a thousand percutaneously inserted screws for fractures & discovered a number of intriguing results 15% of the cases involved moderate breaching of the facets, while a mere 0.6% of the cases involved serious damage [30]. Moreover, regarding intraoperative blood loss percutaneous fixation reduces both haemorrhaging & operative duration. In our series, blood loss was less than 100 millilitres in 46 patients, while only 2 patients experienced blood loss of 150, 200 millilitres respectively. Many researchers demonstrated that percutaneous fixation resulted in less blood loss than standard open fixation. The percutaneous technique resulted in fifty millilitres less blood loss (range: 200 - 500 mL) than the open group, as determined by Merom *et al.* Blood loss was significantly reduced in 32 additional patients who underwent the minimally invasive procedure. [31] Upon aggregating these findings into a meta-analysis, it was determined that percutaneous fixation substantially decreased surgical bleeding by 285.44 mL. [25] [26] Similar to the previous results, Wild *et al.* observed a statistically significant reduction in blood loss among trauma patients subsequent to percutaneous implantation of the Dick *et al.* internal fixation system as opposed to open procedure implantation [32]. Schmidt *et al.* documented a sequence of 76 cases involving percutaneous long-segment fixation of the thoracic spine. Only three cases required blood transfusion; in each of these cases, an additional anterior procedure was also required. [33]. Surgical duration is highly dependent on the experience of the operating surgeons. Our study lasted from 90 to 150 minutes. Initial reports failed to distinguish among the two methods. Current publications, however, indicate that operative times are shorter when compared to open techniques, a finding that operating surgeons have assimilated since their learning curve. [23] [25] According to a study by Merom *et al.* [31], the operative time for percutaneous fixation (73 to 85 min) was slightly lower than that of open fixation (78 to 102 min) when short-segment fixation was utilized. An average operative time of 70 min was documented by Ni *et al.* [34] for short-segment fixation. The average operative time in a series of 76 cases (16 with long-segment fixation) was 47 min, according to Schmidt *et al.* The total operative time for 56% of these patients was among 22 & 36 min [33]. According to infection rate, it appears that percutaneous fixation results in a reduced incidence of infection in comparison to open fixation. In our study, only superficial wound infection in five patients was treated efficiently with repeated dressings and broad-spectrum antibiotics. Schmidt *et al.* conducted a series of 74 patients undergoing percutaneous fixation & didn't find any infections (n = 74). In contrast, Ni *et al.* identified 1 infection in 36 cases (2.7%). [33] [34] When open fixation is carried out on trauma cases, these infection rates are slightly lower than the known infection rate. Phan *et al.* conducted a meta-analysis which revealed that the percutaneous fixation group had significantly lower infection rates than the open fixation group (0.3% vs 3.4%, respectively; relative risk (RR) = 0.36). [35] Out of the 36 cases who underwent percutaneous fixation, Ni *et al.* documented only one superficial infection that was only managed with antibiotics [34]. Schmidt *et al.* observed no infections in 76 patients;

however, they carried out one revision in the case of a paravertebral hematoma [33]. Merom *et al.* [31] found no infections in ten instances of percutaneous fixation & only one superficial infection in ten instances of open fixation. One infection necessitated the removal of instrumentation in one of 64 percutaneous fixation cases reported by Palmisani *et al.* [36]. In comparison to infection rates for open procedures, which range from approximately 3.1% to 10%, the total infection rate documented in these published research findings was comparatively modest [37]. Individuals who underwent percutaneous fixation in the Merom *et al.* study were capable of ambulating within one to two days following the operation, whereas those who underwent open fixation were required to wait 3 to 4 days [31]. Prior to percutaneous surgery for trauma indications, some patients documented shorter hospitalizations [31] [38]. Better screw positioning correlates with fluoroscopy-controlled pedicle screw placement as opposed to the freehand technique. Utilizing the percutaneous technique in our study, four patients (8%) experienced misdirected screws, only in one patient (2%) the screw encroach into the spinal canal with no deficit experienced, while the other three patients (6%) showed minimal laterally deviated screws. Rangel identified a mere 3% of improperly placed screws. In contrast, Ni *et al.* detected 6.7% of screw misplacements generally, all of which didn't involve neurological involvement. [34] Despite this, one meta-analysis found no significant variance among percutaneous fixation (4.0%) and open fixation (4.2%) with regard to screw malpositioning. [34] It is noteworthy that the method of open freehand has a tendency to misposition the screw medially, while fluoroscopy reveals that the mispositioned screw is more likely to occur in the "safer" lateral zone. [38]

## 6. Conclusion

The advantages of percutaneous pedicle screw fixation in thoracolumbar fractures through preservation of posterior musculature are less blood loss, shorter operative time, lower infection risk, less post-operative pain, shorter rehabilitation time as well as shorter hospital stay. Limitations of percutaneous fixation include the inability to achieve direct spinal canal decompression and not having the option to perform a fusion and also requiring a learning curve to masterize the anatomy and technique.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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