Zagazig University Medical Journal
www.zumj.journals.ekb.eg

https://doi.org/10.21608/zumj.2024.265983.3152 Volume 30, Issue 8.1, NOV. 2024, Supplement Issue

Manuscript ID: ZUMJ-2402-3179
DOI: 10.21608/ZUMJ.2024.271069.3179

REVIEW ARTICLE

The Role of Percutaneous Pedicle Screw Fixation in Management of Thoracolumbar Fracture

Islam Abdalla Mohamed Elsayed*, Hossam Mohamed Khairy, Tarek ElHewala, Ahmed Mohamed Elshaer
Orthopedic Surgery Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

***Corresponding author**:
Islam Abdalla Mohamed Elsayed

E-mail:
eslammansi222@gmail.com

Submit Date: 18-02-2024
Revise Date: 20-02-2024
Accept Date: 20-02-2024

ABSTRACT

Background: There is a great deal of variety in vertebral spine injuries. The assessment of spinal stability or instability is crucial for comprehending and treating these ailments. Improvements in posterior minimally invasive spine surgery have remained consistent over the previous decade. It is believed that minimally invasive surgery will reduce morbidity while producing identical outcomes to invasive procedures. The original goal of developing percutaneous fixation of the lumbar spine was to enhance the functional outcomes of surgical procedures for spine injuries. We aimed to provide an outline of role of percutaneous pedicle screw fixation in management of thoracolumbar fracture.

Methods: We searched for eligible relevant articles from 2002 to 2022 in five electronic databases.

Conclusions: Preservation of posterior musculature, reduced blood loss, faster operation time, decreased infection risk, less postoperative pain, shorter rehabilitation time, and shorter hospital stay are some of the advantages of percutaneous pedicle screw fixation compared to open surgery. Direct spinal canal decompression and the capacity to execute a fusion are two of the limitations of percutaneous fixation. The combination of minimally invasive spine surgery with open approaches, however, can overcome these constraints.

Keywords: Percutaneous pedicle; Screw fixation;Thoracolumbar Fracture

INTRODUCTION

There is a fulcrum at T10-L2 in the thoracolumbar spine area between the lumbar segment, which allows flexion-extension movement, and the more inflexible thoracic segment, which prevents translation, rotation, and flexion-extension with its coronally oriented facets. Additionally, the ribs are considered to be floating ribs at the thoracic spine transitional points (T11 and T12) since they do not articulate anteriorly with the sternum. The kyphotic thoracic spine and the caudal lordotic lumbar spine meet at the thoracolumbar junction. Due to its location in the spine, the T10-L2 section is both the most movable and the most susceptible to injury [1]. One thing that makes the T12 special is that it marks the change from thoracic to lumbar spine. Because of its costal and superior articular facets, which enable rotation, flexion, and rotation, it is classified as thoracic. The lack of rotational mobility in its articular processes defines it as lumbar. Flexion and extension are its only motions [2].

Spinal stability refers to the spine's individual's ability to preserve its structural integrity under physiological stress. The interplay of the skeletal framework with ligaments, the connected muscles, and the neurological system ensures the stability [3].

The types of injuries that can occur to the vertebral spine are extremely varied. Determining whether the spine is stable or unstable is crucial for both diagnosis and treatment of these injuries [4].

Injuries were classified by Denis as either minor or major: Articular, transverse, spinous, and pars interarticularis fractures were among the minor injuries. Compression fractures, burst fractures, flexion-distraction injuries (also known as seatbelt injuries), and fracture dislocations were the four main categories of major spinal injuries [4]. In the AO Spine Thoracolumbar Spine Injury System classification, the morphologic fracture classification, neurological condition, and clinical modifiers are the three main criteria used for this classification (Fig. 1) [5].

Thoracolumbar fracture treatment aims for the following: spine healing without kyphosis progression, Stop the decline of brain function and, if it has already begun, restore it, The alleviation of pain and instability, To facilitate early mobilization and prevent complications associated with prolonged bed rest, Lessening the duration of hospital stays [6]. Minimally invasive spinal procedures, such as lumbar and thoracic spine percutaneous pedicle screw fixation, have been increasingly popular in recent years [7].

We aimed to provide an outline of role of percutaneous pedicle screw fixation in management of thoracolumbar fracture.

METHODS

We searched for eligible relevant articles from 2002 to 2022 by a computerized research in PubMed, Scopus databases, Web of science, Cochrane Library and Embase with search terms of 'Percutaneous pedicle'; 'Screw fixation' and 'Thoracolumbar Fracture'.The inclusion criteria were thoracolumbar fractures of spine, strategy of fixation surgery for treatment, minimal follow up 1 year, prospective randomized controlled trial studies and publication date between 2002 and 2022..

Meta-analysis was done according to the availability of randomized controlled trials using Review Manager software (RevMan version 5.4.1).We reached eligible eleven studies that met our inclusion criteria (Table 1).

Stages of development of percutaneous Pedicle Screw fixation: In 1977, Magerl invented percutaneous pedicular screw fixation using an external fixator. In 1995, Mathews and Long presented and accomplished completely percutaneous lumbar pedicle fixation techniques using plates as longitudinal connectors [19 ,20]. In 2000, Lowery and Kulkarni detailed a novel technique that utilised a rod connector placed beneath the fascia. They reported a 61% fusion rate within 8 months, which was considered successful. Mathews and Long reported a significant rate of non-union, in contrast to the authors who described a similar approach using rods [21, 22]. Alternative percutaneous spine fixation systems have been developed to address the drawbacks of conventional posterior spinal fixation and hardware put superficially. These techniques allow hardware to be placed in close contact to the bone, providing fixation similar to open placing of screws. Specifically, rods and plates are utilized as longitudinal connectors in the (SEXTANT), (path finder), and (World Spine Highlight W.S.H.) systems, respectively [23].

Indications of percutaneous Pedicle Screw fixation: Patients with no neurological deficits, recent fracture (within a week) and most of A and B types of AO classification system [24].

***Contraindications and limitations of percutaneous Pedicle Screw fixation*:** Fracture dislocation, neurological affection, previous surgery at site of fracture and exposure to high dose of radiation during the precise placement of screws [24].

Advantages of percutaneous Pedicle Screw fixation: To prevent muscle atrophy caused by denervation and devascularization, it is helpful to spare the paravertebral muscles. Research suggests a number of benefits, including less blood loss during surgery, smaller skin incisions, less need for blood transfusions, lower infection risk, less postoperative discomfort, less loss of muscular strength, shorter hospital stays, and easier and faster rehabilitation. Despite lack of consensus, it is common practise to remove the fixation material utilized in percutaneous osteosynthesis 8-12 months following fracture stabilization through the scar at the screw insertion site. This allows for the removal of the material without invasive procedures (Fig. 2) [24].

***The importance of percutaneous fixation was shown as*:** Sixty adults diagnosed with a single thoracolumbar fracture between 2014 and 2016 were enrolled in a study by Yang M and colleagues. They were randomly assigned to either the open fixation group (group A) or the minimally invasive percutaneous fixation group (group B). Although there is reduced discomfort, bleeding, and operation time with percutaneous minimally invasive pedicle screw fixation, there is a higher radiation requirement [17].

Kocis and colleagues [15] performed a prospective investigation to assess 46 patients in a row who had thoracolumbar fractures of types A3 and A4. Two groups of patients were created: one that underwent percutaneous pedicle screw fixation and another that underwent open pedicle screw fixation. The two groups differed significantly with respect to the average cumulative radiation time, radiation dose, and operation time. Additionally, the amount of blood lost during the operation was substantially less in the percutaneous group.

Combination of percutaneous fixation with open surgery: In such instances, percutaneous fixation serves as a stopgap measure until an open procedure can be performed to do the necessary bone grafting and anterior spine repair. Spinal fractures make therapy more difficult for those who have had many traumas. Sometimes, these fractures are operated on after the fact, particularly in cases where the patient experienced complications during resuscitation. However, this approach can cause complications arising from non-anatomical reduction of the spinal deformity, which in turn makes the second surgery considerably more intricate. To stabilize the spine in an emergency situation while limiting the dangers of making the patient's condition worse, percutaneous fixation plays a crucial role because to its speed and minimal invasiveness. Patients in the emergency room can undergo skin care, semi-upright seating positioning for ventilation, and imaging examinations without fear of the fracture shifting and creating neurological difficulties because the fracture is stabilised there. A second minimally invasive anterior fusion and fixation surgery will be conducted when the patient has transitioned out of acute intensive care. As long as the posterior structures are not dislocated or significantly displaced laterally, which would need an open posterior reduction, this method can be used to treat any fracture—including Type A3.3, Type B1, and Type C fractures—in the absence of neurological complications. Early spinal fracture repair reduces breathing difficulties and allows the patient to be moved and engage in therapy following chest damage [25].

The procedure is based on the same principles of polytrauma patients' spine damage control. In a study conducted by Schmidt et al., 27 patients with an ISS greater than 16 were treated in the emergency room with percutaneous long-segment thoracic fixation. Additionally, 20 of these patients had chest trauma [15]. Acute respiratory distress syndrome only occurred in two patients, while three others contracted a lung infection but had no infection in their posterior fixation system. One was for a paravertebral hemorrhage, and the other was for fixation system failure after six months. Both updates addressed the same issue. Following a second anterior operation, three patients required blood transfusions.

Combination of percutaneous fixation with minimally-invasive surgery: In situations where percutaneous fixation meets mechanical requirements, but the fracture necessitates an intersomatic graft to prevent the disc space from being lost in an angular direction, this applies. The grafting procedure is carried out using minimally invasive spine surgery procedures [26].

The intersomatic grafting component of this method incorporates a combination of percutaneous fixation and a minimally invasive approach, specifically keyhole access. Despite a corrective loss of 3–8 degrees, clinical outcomes were satisfactory. The method necessitated a surgeon with expertise in minimally invasive surgery and the ability to tolerate a lengthy operating time (4.5 to 7 hours), according to Maciejczak et al., making it more difficult than an open technique. Magerl Type A3 or B fractures with substantial comminution of the superior end plate and no neurological issues are the only ones that are treated with this approach. An arthrotomy and bilateral pediculectomy are necessary steps in this procedure, which increases the fracture's instability and may explain why some patients report no improvement after using this method. Combining minimally invasive transforaminal intersomatic fusion with contralateral percutaneous fixation is a viable option, similar to the strategy taken for degenerative diseases [26].

Combination of percutaneous fixation with percutaneous anterior spinal reconstruction techniques: This combination is used for non-graft fractures that nevertheless require anterior spinal reconstruction since fixation alone is not mechanically sufficient (LSC > 6). A further advantage is that secondary intervertebral loss of correction is prevented by reducing the subsidence of the superior endplate. Type A3.3 and Type B2 bone fractures, characterised by severe compression of the spinal cord, resulting in a loss of spinal body height and an anterior bone void, were among the fractures that fulfilled these criteria. The flexion moment on the pedicular screws is reduced by 59% in flexion and 38% in extension when cement is added to a posterior short-segment fixation, according to a cadaver study by Mermelstein et al., which results in a 40% increase in fixation system stiffness compared to a posterior fixation system alone. Type A3.1 and A3.3 fractures were the first to be treated with anterior spinal reconstruction utilising intravertebral expansion systems. This technique involved combining an open balloon kyphoplasty surgery with a posterior short-segment fixation device. The centre sinking was treated to an extent ranging from 66% to 80% with this procedure, the anterior subsidence from 71% to 91%, and the kyphosis from 11° to -1.6° was corrected as well [27].

Eighteen patients with Type A3 or A2 fractures were treated by Korovessis et al. [28] using a combination of percutaneous fixation and balloon kyphoplasty. Surgery resulted in a fourteen degree correction of local kyphosis and an eighty-seven percent reduction in anterior wall height loss. The patient's VAS score dropped from 7.5 out of 10 prior to surgery to 3.1 out of 10 during discharge, which happened on day two after the procedure. There were four instances of cement leaking into the intervertebral space throughout the 45-minute surgical procedure.

These limited case series show that percutaneous fixation together with balloon kyphoplasty reduces fractures satisfactorily and durably with less recovery time and hospital stays. Along with the great clinical outcomes and the absence of blood loss, this is an additional benefit. Confirmation of these conclusions, however, requires larger-scale prospective, ideally randomized, research. However, it is important to consider the indications because using these combined percutaneous reconstruction procedures increases the irradiation of the patient and surgical team.

Additional research is required to determine safety and efficacy of percutaneous pedicle screw fixation in management of thoracolumbar fracture.

CONCLUSIONS

Preservation of posterior musculature, reduced blood loss, faster operation time, decreased infection risk, less postoperative pain, shorter rehabilitation time, and shorter hospital stay are some of the advantages of percutaneous pedicle screw fixation compared to open surgery. Direct spinal canal decompression and the capacity to execute a fusion are two of the limitations of percutaneous fixation. The combination of minimally invasive spine surgery with open approaches, however, can overcome these constraints.

Table (1): The included studies with basic outcome data.

Study	Year	Percutaneous group	
Vanek et al., 2014 [8]	2014	Blood loss (ml)	Operative time (min)
SHAIKH et al., 2021 [9]	2021	56 ± 17	53 ± 10
PISHNAMAZ et al., 2015 [10]	2015	262.55± 86.91	83.22± 26.11
Hong- wei et al., 2010 [11]	2010	500±50	114.3
Patil et al., 2016 [12]	2016	83.5± 51.8	97.1± 15.3
Chao Lee et al., 2019 [13]	2019	85 ± 20	69.76 ± 11.76
Tu et al., 2021 [14]	2021	82± 22	138± 38
Kocis et al., 2020 [15]	2020	18.2± 24.6	44.1± 8.6
Lyu et al., 2016 [16]	2016	29	49.7
Yang et al., 2018 [17]	2018	100.7 ± 18.9	72.1 ± 12.5
Lee et al., 2013 [18]	2013	63.75 ± 13.46	51.55 ± 7.10

Open Group											
Radiation exposure (sec.)	Incision length (cm)	Vertebral Body height	phosisnangle						Visual analogue scale	Blood loss (ml)	Operative time (min)
		67 ± 12	−14.4 ± 6.5		331 ± 149	60 ± 9			0.68 ± 0.12	−13.5 ± 5.5	
			15.84± 8.26	2.90±1.52	684.33± 239.90	154.91± 39.20				16.74± 7.62	4.02± 1.33
143.1				4.5±2.9	1000±300	110.1	105.9				4.9± 2.1
	0.94± 0.09		15.2±0.9	1.5±0.9	304.8± 209.1	161.0± 72.5		1.18± 0.28		16±9.3	2.2± 0.8
	8.4 ± 1.321	1.62 ± 0.286	26.36 ± 4.29		150 ± 35	103.48 ± 12.25		13.96 ± 1.274	1.69 ± 0.311	29.08 ± 8.30	
			22		300± 205	189± 43				16	
	1.7±0.6	62.5± 10.5	15.7±5.7	2.6± 0.4	268.3± 45.7	66.7± 17.4		12.6± 3.5		16.8± 6.0	3.1± 0.5
29			− 10.9		328.7	52	17.3			− 12.1	
		65.1 ± 9.3	16.7 ± 5.5	2.2 ± 0.5	202.1 ± 42.0	77.8 ± 8.2					3.3 ± 0.5
11.93 ± 2.49		67.20 ± 8.40	26.20 ± 6.19	0.95 ± 0.69	125.01 ± 19.87	96.60 ± 8.844	4.40 ± 1.50		62.35 ± 8.28	23.95 ± 7.14	1.25 ± 0.72
			15.8± 8.2	2.9± 1.5	684.3± 239.9	154.9± 39.2				16.7± 7.6	4.0± 1.3

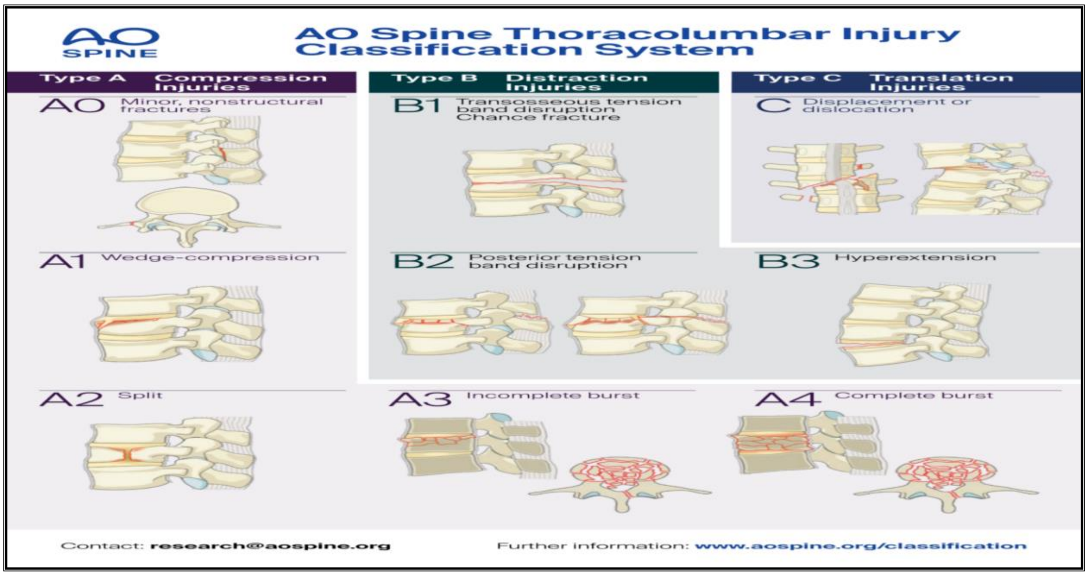

Figure (1): AO Spine Thoracolumbar Spine Injury Classification System. [5]

Figure (2): Percutaneous pedicle screw insertion with small skin incisions. [24]

REFERENCES

1. Wood KB, Li W, Lebl DS, Ploumis A. Management of thoracolumbar spine fractures. The spine journal. 2014; 14(1):145-64.
2. Waxenbaum JA, Reddy V, Futterman B. Anatomy, Back, Thoracic Vertebrae. In: StatPearls [Internet]. Treasure Island (FL) 2023.
3. Studnicka K, Ampat GLumbar Stabilization. In: StatPearls. Treasure Island (FL): StatPearls Publishing; August 14.2023.
4. Heinzelmann ,MA , Michael, and Guido A. Wanner. Thoracolumbar spinal injuries. Spinal Disorders: Fundamentals of Diagnosis and Treatment, edited by N. Boos and M. Aebi in Springer Berlin Heidelberg 2008; 883-924.
5. Vaccaro AR, Oner C, Kepler CK AO. Spine thoracolumbar spine injury classification system: fracture description, neurological status and key modifiers. Spine 2013; 38:2028–37.
6. Verheyden AP, Spiegl UJ, Ekkerlein H, Gercek E, Hauck S, Josten C, et al. Treatment of Fractures of the Thoracolumbar Spine: Recommendations of the Spine Section of the German Society for Orthopaedics and Trauma (DGOU). Global Spine J. 2018; 8(2 Suppl):34S-45S.
7. Fassett, D. R., & Brodke, D. S. 21 Percutaneous Posterior Insertion of Thoracic PedicIe Screws. Minimally Invasive Spine Surgery 2007; 203.
8. Vanek, P., Bradac, O., Konopkova, R., de Lacy, P., Lacman, J., & Benes,V. Treatment of thoracolumbar trauma by short-segment percutaneous transpedicular screw instrumentation: prospective comparative study with a minimum 2-year follow-up: Clinical article. Journal of Neurosurgery: Spine 2014; 20(2): 150-6.
9. Shaikh MA, Mehmood K, Shah I. Short Segment Pedicle Screw Fixation for Thoracolumbar Burst Fractures. Percutaneous without Fusion Versus Open Pedicle Screw Fixation with Posterolateral Fusion. 2021.
10. Pishnamaz M, Oikonomidis S, Knobe M, Horst K, Pape HC, Kobbe P. Open versus percutaneous stabilization of thoracolumbar spine fractures: a short-term functional and radiological follow-up. Acta Chir Orthop Traumatol Cech 2015 Jan 1; 82(4):274-81.
11. Hong-wei, Wang, Li CQ, Zhou Y, Zhang ZF, Wang J, Chu TW. Percutaneous pedicle screw fixation through the pedicle of fractured vertebra in the treatment of type A thoracolumbar fractures using Sextant system: an analysis of 38 cases. Chinese Journal of Traumatology 2010; 13(03):137-45.

12. Patil RP, Joshi V, Pamecha C, Kumar P, Bisnoi UP. Comparative study between short segment open versus percutaneous pedicle screw fixation with indirect decompression in management of acute burst fracture of thoracolumbar and lumbar spine with minimal neurological deficit in adults. J Spine. 2016; 5(339):2.
13. Chao, Lee Y, Selby M, Zotti M, Roy D, Freeman B. Minimally invasive stabilization for thoracolumbar and lumbar fractures: a comparative study with short segment open Schanz screw constructs. Journal of Spine Surgery 2019; 5(1):13.
14. Tu P, Yan CC, Hao JX, Cao S, Jiang C. Effect of percutaneous minimally invasive pedicle screw internal fixation in the treatment of thoracolumbar vertebral fractures and its impact on quality of life. Pakistan Journal of Medical Sciences. 2022; 38(1):100.
15. Kocis J, Kelbl M, Kocis T, Návrat T. Percutaneous versus open pedicle screw fixation for treatment of type A thoracolumbar fractures. European Journal of Trauma and Emergency Surgery. 2020;46:147-52.
16. Lyu J, Chen K, Tang Z, Chen Y, Li M, Zhang Q. A comparison of three different surgical procedures in the treatment of type A thoracolumbar fractures: a randomized controlled trial. International orthopaedics.2016; 40:1233-8.
17. Yang M, Zhao Q, Hao D, Chang Z, Liu S, Yin X. Comparison of clinical results between novel percutaneous pedicle screw and traditional open pedicle screw fixation for thoracolumbar fractures without neurological deficit. International orthopaedics.2018; 43:1749-54.
18. Lee, J. K., Jang, J. W., Kim, T. W., Kim, T. S., Kim, S. H., & Moon, S. J. Percutaneous short-segment pedicle screw placement without fusion in the treatment of thoracolumbar burst fractures: is it effective? Comparative study with open short-segment pedicle screw fixation with posterolateral fusion. Acta neurochirurgica 2013; 155(12), 2305-12.
19. Magerl FP. Stabilization of the lower thoracic and lumbar spine with external skeletal fixation. Clin Orthop Relat Res.1984; (189):125-41.
20. Mathews HH, Long BH: Endoscopy assisted percutaneous anterior interbody fusion with subcutaneous superficial internal fixation: evolution of technique and surgical considerations. Orthop Int Ed. 1995 ; 3: 496-500.
21. Mobbs RJ, Phan K. History of Retractor Technologies for Percutaneous Pedicle Screw Fixation Systems. Orthop Surg. 2016; 8(1):3-10.
22. Lowery GL, Kulkarni SS. Posterior percutaneous spine instrumentation. Eur Spine J. 9 2000; (Suppl 1): 126-30.
23. Tropiano P, Giorgi H, Faure A, Blondel B. Surgical techniques for lumbo-sacral fusion. Orthop Traumatol Surg Res 2017; 103(1S):151-9.
24. Pinheiro AC, Areias M, Oliveira C, Sousa CV, Silva LP. Percutaneous fixation in the treatment of traumatic thoracolumbar fractures: a current view of this minimally invasive surgery. Int Phys Med Rehab J 2018; 3(3):00076.
25. Caruso G, Gildone A, Lorusso V, Lombardi E, Andreotti M, Gerace E, et al. Percutaneous fixation and balloon kyphoplasty for the treatment of A3 thoracolumbar fractures. J Clin Orthop Trauma. 2019; 10(1):163-7.
26. Fei G, Yan H. Clinical Effect of Minimally Invasive Percutaneous Pedicle Screw Internal Fixation Combined with Injured Vertebrae Bone Grafting in the Treatment of Thoracolumbar Fractures in Orthopedic Surgery [retracted in: Emerg Med Int. 2022; 24:9869248].
27. Sasagawa T. Minimally Invasive Surgery for Traumatic High-Grade Lateral Spondylolisthesis of L1 with Multiple Spinal Fractures: Closed Reduction and Internal Fixation Using Percutaneous Pedicle Screws. Asian J Neurosurg. 2021; 16(4):692-4.
28. Korovessis P, Hadjipavlou A, Repantis T. Minimal invasive short posterior instrumentation plus balloon kyphoplasty with calcium phosphate for burst and severe compression lumbar fractures. Spine 2008; 33(6):658-67.

Figure legend

Fig. (1): AO Spine Thoracolumbar Spine Injury Classification System.

Fig. (2): Percutaneous pedicle screw insertion with small skin incisions.

Citation

Elsayed, I., Khairy, H., ElHewala, T., Elshaer, A. The Role of Percutaneous Pedicle Screw Fixation in Management of Thoracolumbar Fracture. Zagazig University Medical Journal, 2024; (4184-4190): -. doi: 10.21608/zumj.2024.271069.3179