A systematic review of advantages of percutaneous pedicle screw fixation for neurologic intact thoracolumbar burst fractures

Aly Ibrahim Abdellatif Hussien, MD; Zakaria Hassan Ibrahim Abu-Elgait, MD and Mohamed Elsaba Ali Abdellatif, MBBCH

Department of Orthopedic Surgery, Faculty of Medicine – Ain Shams University

Corresponding author: Mohamed Elsaba Ali Abdellatif,
Mobile: 01011529673;
Email: mohamedelsaba2010@gmail.com

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ABSTRACT

Background:
Fractures in the thoracolumbar spine are frequent injuries that can lead to substantial disability, deformity, and neurological impairment. Controversies arise concerning the suitable radiological examinations, the criteria for surgical intervention, and the time, method, and nature of the surgery.

Objective:
The objective of this literature review is to analyze the advantages and disadvantages of percutaneous pedicle screw fixation compared to open surgery for thoracolumbar burst fractures in patients with intact neurological function.

Materials and Methods:
We examined randomized controlled trials, which include cluster randomized controlled trials, controlled (non-randomized) clinical trials or cluster trials, prospective and retrospective comparative cohort studies, as well as case-control or nested case-control studies. We excluded cross-sectional studies, case series, and case reports. The search results are submitted to software designed for managing systematic reviews and are assessed manually to determine if they meet the criteria for inclusion. The PRISMA flowchart was developed using the search results and criteria for inclusion and exclusion.

Results:
The percutaneous approach demonstrated superior efficiency compared to the open procedure in terms of surgical duration, postoperative visual analog scale (VAS) scores, intraoperative blood loss, and infection rate. The data indicate that the percutaneous approach is minimally invasive, resulting in less damage to the paraspinal muscles and a more effective repositioning impact.

Conclusion:
Similar results have been achieved by the percutaneous fixation group as by the open surgery group, and it can reduce approach-related complications.

Keywords:
Percutaneous spine fixation, thoracolumbar burst fractures, posterior spinal fixation.

INTRODUCTION

Spine injuries most commonly include thoracolumbar burst fractures. Nevertheless, there is ongoing debate regarding the management of unstable thoracolumbar burst fractures, particularly in individuals who do not have any neurological impairments. (1)

Although nonoperative approaches such as bed rest, brace, or cast have shown positive outcomes for patients, it is widely recognized that these methods can lead to certain complications, both immediate and delayed. These complications may include persistent kyphosis, prolonged immobility, pressure ulcers, and delayed neurological impairment. (2)

Surgical procedures have been demonstrated to yield excellent results through the use of enhanced surgical techniques and implants. Surgical intervention offers prompt spinal stabilization and consistently improves sagittal alignment, vertebral height, and canal dimension more effectively than cast or brace care. (3)

The posterior short-segment pedicle instrumentation is the most commonly utilized operative option for thoracolumbar fractures worldwide due to its ability to provide fixation in all three columns. (4)

Nevertheless, the open posterior technique with short-segment pedicle instrumentation requires very large exposures, which can lead to considerable morbidity due to elevated intraoperative blood loss, heightened infection rates, and denervation or damage of the para-spinal muscles. (5)

In recent times, there has been a growing trend in the field of spine surgery towards the use of less

invasive techniques, such as percutaneous pedicle screw fixation (PPSF). [6]

Magerl[7] established the technique of percutaneous lumbar pedicle screw fixation in 1977, primarily for temporary external fixing purposes.

Several publications later documented the use of the percutaneous procedure to temporarily stabilize individuals with suspected segmental lumbar instability. [8]

In a recent study, Foley et al. [9] documented the use of pedicle screw internal fixation for low lumbar fusion. Kim et al demonstrated that PPSF resulted in lower levels of paraspinal muscle injury compared to open pedicle screw fixation.

As far as we know, there have been no clinical reports that discuss the effectiveness and safety of PPSF in treating thoracolumbar burst fractures. [10]

AIM OF THE WORK

The objective of this study is to examine existing literature to gather information on the benefits and drawbacks of Percutaneous Pedicle Screw Fixation for Neurologic Fully intact Thoracolumbar Burst Fractures, in comparison to the open surgical approach.

MATERIALS AND METHODS

Selection criteria for inclusion in this review: Categories of research: We incorporated randomized controlled trials, which encompassed cluster randomized controlled trials, controlled (non-randomized) clinical trials or cluster trials, prospective and retrospective comparative cohort studies, as well as case-control or nested case-control studies. We omitted cross-sectional studies, case series, and case reports. The search results are submitted to software for systematic review management and then manually reviewed to determine if they meet the criteria for inclusion. A PRISMA flowchart was created using the search results and the inclusion/exclusion criteria. Categories of individuals involved: Only research involving human participants with thoracolumbar burst fractures and intact neurological function were included.

Types of interventions:

First: Percutaneous Pedicle Screw Fixation for burst fracture.

Second: Open surgical fixation for burst fracture. Types of outcome measures: The intraoperative bleeding, the operation time, the infection rate, the patient satisfaction.

Methodology for locating relevant studies: The search was performed utilizing the databases MEDLINE, Cochrane Library, JBJS (Journal of Bone and Joint Surgery), and PubMed. The search was conducted using the terms "percutaneous fixation" and "burst spine fracture" to identify published publications in the English language from 2000 to 2017.

Methods of the review:

The process of locating and selecting research involved reviewing the abstracts of papers found through the search method mentioned above. papers that seemed to meet the criteria for inclusion were then obtained in their entirety. Statistical considerations: The outcomes from the studies that were included were integrated using the systematic review management software and then manually assessed to determine if they met the criteria for inclusion. A PRISMA flowchart was generated using the search results and the criteria for inclusion and exclusion. To evaluate the potential bias in each trial, data was gathered using the Cochrane collaboration tool for assessing the risk of bias. After consolidating the gathered data from the targeted research studies, the relative risk of each desired outcome measure was computed and compared between the two primary approaches for treating burst spine fractures, to reach a conclusive result. The presence of publication bias was investigated using the funnel plot technique: A funnel plot is a basic scatter plot that displays the intervention effect estimates from individual studies concerning a measure of each study's size or precision. (Figure 1)

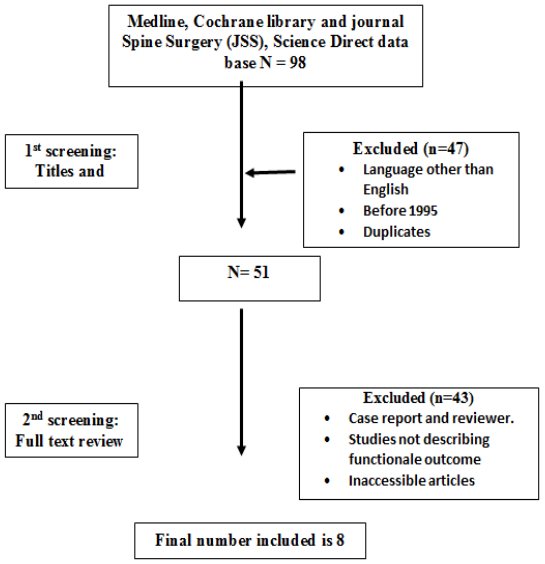

Figure 1: PRISMA flowchart and funnel plot

RESULTS

Table (1): Outcomes.

	Years	MIS			Open		
		Event	Total	%	Event	Total	%
Infection							
Bronsard et al. [11]	2013	0	30	0.0%	3	30	10.0%
Vanek et al. [12]	2014	0	18	0.0%	1	17	5.9%
Grossbach et al. [13]	2013	0	11	0.0%	1	27	3.7%
Screw malposition							
Bronsard et al. [11]	2013	0	30	0.0%	1	30	3.3%
Vanek et al. [12]	2014	0	18	0.0%	0	17	0.0%
Grossbach et al. [13]	2013	1	11	9.1%	1	27	3.7%
Wild et al. [14]	2007	0	10	0.0%	0	11	0.0%
Operative time							
Bronsard et al. [11]	2013	83	30		148	30	
Yang et al. [15]	2016	96	30		51	30	
Lyu et al. [16]	2016	64	30		77	30	
Dong et al. [17]	2013	51	18		49	21	
Grossbach et al. [13]	2013	195	11		257	27	
Fitschen-Oestern et al. [18]	2015	76	58		103	46	
Vanek et al. [12]	2014	53	18		60	17	
Wild et al. [14]	2007	87	10		80	11	
Mean		**88.13**	**205**		**103.13**	**212**	
Visual analogue score (VAS)							
Bronsard et al. [11]	2013	0.17	30		0.63	30	
Yang et al. [15]	2016	0.95	30		1.25	30	
Mean		**0.56**	**60**		**0.94**	**60**	
Blood loss							
Bronsard et al. [11]	2013	50	30		318	30	
Yang et al. [15]	2016	63	30		125	30	
Dong et al. [17]	2013	18	18		27	21	
Mean		**43.67**	**78**		**156.67**	**81**	
Cobb's angle correction							
Bronsard et al. [11]	2013	12	30		11	30	
Yang et al. [15]	2016	12	30		12	30	
Dong et al. [17]	2013	15.5	18		21.5	21	
Fitschen-Oestern et al. [18]	2015	7.5	58		9.5	46	
Wild et al. [14]	2007	2.6	10		2.4	11	
Mean		9.92	146		11.28	138	
Radiological exposure							
Wild et al. [14]	2007	5.7	10		3.1	11	
Dong et al. [17]	2013	3.7	18		1.2	21	
Mean		**4.7**	**28**		**2.15**	**32**	

DISCUSSION

The use of percutaneous screw fixation and open screw fixation for thoracolumbar fractures, especially in cases without neurological impairments, remains a subject of debate and uncertainty.

Posterior open screw fixation is a feasible surgical method used to treat fractures in the thoracolumbar region.

The utilization of percutaneous screw fixation has been on the rise since its initial application in thoracolumbar injuries by Assaker [18]. Percutaneous fixation, characterized by lower incision length and less paravertebral muscle damage, effectively minimized intraoperative and postoperative blood loss, recovery time, and postoperative back pain scores.

The percutaneous approach had a shorter surgical duration compared to the open route, and the surgical time in the percutaneous approach was also shorter than in the traditional way. Our study also found that the use of intraoperative fluoroscopy during the percutaneous technique

was lower as compared to the standard route. According to Lehmann et al. [19], it is important to consider the surgeon's expertise in minimally invasive surgery.

The surgeon who possessed the ability to do the percutaneous technique typically had a higher level of experience.

Thus, these findings could perhaps be attributed to the specific attributes of this methodology and the expertise of the surgeons.

According to McAnany et al. [20], there was no significant difference in the Visual Analog Scale (VAS) across the groups.

Phan et al. [21] showed that the percutaneous group had lower VAS scores.

Our study found that the percutaneous technique had superior VAS scores compared to the standard approach.

Lehmann et al. [19] found that CK-MM (CPK Creatine Phosphokinase), a marker for muscle injury, was much lower in percutaneous techniques compared to open procedures, confirming previous research.

Extensive dissection and retraction not only result in the denervation and atrophy of the paraspinal muscles but also cause further damage due to a heating effect and ischemia [22]. These factors would lead to prolonged back discomfort or dysfunction of the back muscles [23]. Hence, our study determined that the percutaneous technique yields a greater tissue-protective impact in comparison to the conventional open approach.

Our examination of the postoperative Cobb angle revealed no significant difference between the percutaneous group and the open group. In addition, we thoroughly examined the correction of the postoperative Cobb angle. The results of our investigation indicated that the percutaneous group exhibited a smaller Cobb angle correction compared to the open group. The duration of the Cobb angle correction followup was less than 1 week, which was less than the duration of the postoperative Cobb angle followup. These findings suggest that while the percutaneous technique initially resulted in reduced reduction ability compared to the open approach, there was no significant difference in the postoperative Cobb angle between the two groups over time.

While percutaneous treatments have the limitation of only being compatible with polyaxial screws, which enable modification in the angle of pedicle screws [24], studies have shown that there is no difference in the loss of Cobb angle correction between mono-axial and polyaxial screws [25]. The reason for this was the increased resistance to rotational slippage between the rod and polyaxial screw head, which was caused by the combination of bending loads and shear stress on the rod [26]. In their study, Cimmatti et al. [27] demonstrated the benefits of minimally invasive spine surgery (MISS) in terms of reduced blood loss and muscle damage. Furthermore, they found that the long-term results of kyphosis correction achieved with MISS were similar to those achieved through open surgery.

The extent of vertebra compression was milder in the percutaneous group as compared to the open group.

Furthermore, our findings indicate that there was no notable disparity in screw misalignment between the percutaneous cohort and the open cohort.

The findings of our investigation were comparable to the research conducted by Phan et al. [21]. The findings revealed that while the percutaneous technique requires a significant amount of time to master and is associated with a higher risk of complications due to screw placement in the initial stages [28], it can achieve comparable accuracy in screw placement to the open approach when aided by radiation equipment [29,30].

The open method necessitates thorough dissection of the paraspinal area, leading to increased blood loss during surgery, longer surgical duration, and the development of deep wounds. These factors contribute to a higher infection rate in both superficial and deep wounds [30].

Superficial wound infections would be addressed by performing debridement and administering oral antibiotics [22], whereas deep infections would require reoperation to flush out and remove infected tissue [23].

Thankfully, by administering the right antibiotics before and after surgery, the infection rate in open screw fixation was effectively reduced to a lower level [30].

CONCLUSION

The findings of this review indicate that there was no significant disparity observed in terms of intraoperative fluoroscopy, postoperative Cobb angle correction, and screw misplacement between the percutaneous method and the open approach. The percutaneous method outperformed the open approach in terms of surgery length, postoperative VAS (Visual Analog Scale), intraoperative blood loss, and decreased infection rate. These findings further support the notion that the percutaneous approach is a minimally invasive method that causes minimum damage to the

paraspinal muscles and has a superior repositioning impact. The percutaneous fixation group has demonstrated comparable efficacy to the Open Surgery group while also reducing the occurrence of approach-related complications. Additionally, it encounters several disadvantages, such as higher levels of radiation exposure for novice surgeons and a more extended period of time required for learning.

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