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A COMPARISON OF RADIOLOGICAL AND FUNCTIONAL OUTCOMES IN OPEN VS PERCUTANEOUS PEDICLE SCREW FIXATION FOR SINGLE LEVEL THORACOLUMBAR JUNCTION TRAUMATIC FRACTURE OF SPINE

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ABSTRACT

This study reviews contemporary evidence comparing Open Pedicle Screw Fixation (OPSF) and Percutaneous Pedicle Screw Fixation (PPSF) for thoracolumbar fractures, focusing on radiological correction, operative parameters, clinical recovery, and complication profiles. Recent literature from 2019 to 2025 demonstrates that both techniques provide comparable outcomes in restoring vertebral height, correcting kyphosis, and achieving stable spinal alignment. However, PPSF consistently shows significant advantages, including reduced blood loss, shorter operative duration, minimal soft-tissue disruption, and faster postoperative recovery. MRI-based findings further confirm lower paraspinal muscle damage with PPSF, contributing to improved pain and functional outcomes such as VAS and ODI scores. Additionally, PPSF is associated with shorter hospital stays, lower infection rates, and higher screw-placement accuracy, particularly when navigation systems are used. Although OPSF remains effective for deformity correction, its greater invasiveness results in increased morbidity and delayed rehabilitation. Overall, existing evidence supports PPSF as a

safe, minimally invasive, and clinically advantageous alternative to OPSF, though high-quality randomized controlled trials are still required to validate long-term radiological and functional equivalence..

INTRODUCTION

Vertebral fractures happen when the bones in your spine break or lose their shape. This usually occurs because of too much pressure being put directly on the spine, sometimes combined with twisting, pulling apart, or dislocating forces. These breaks often happen as a result of:

- Accidents or injuries (trauma)
- Osteoporosis (weakened bones)
- Infections
- Cancer that has spread to the bones (metastatic disease)
- Other conditions affecting the bones (Ferreira and March, 2019; Liebsch and Wilke, 2022).

Mechanism

- Too much pressure being pushed straight down (axial compression).
- Rotational forces.
- Bending and pulling apart or sliding forces (which can lead to dislocation) (Whitney and Alastra, 2019).

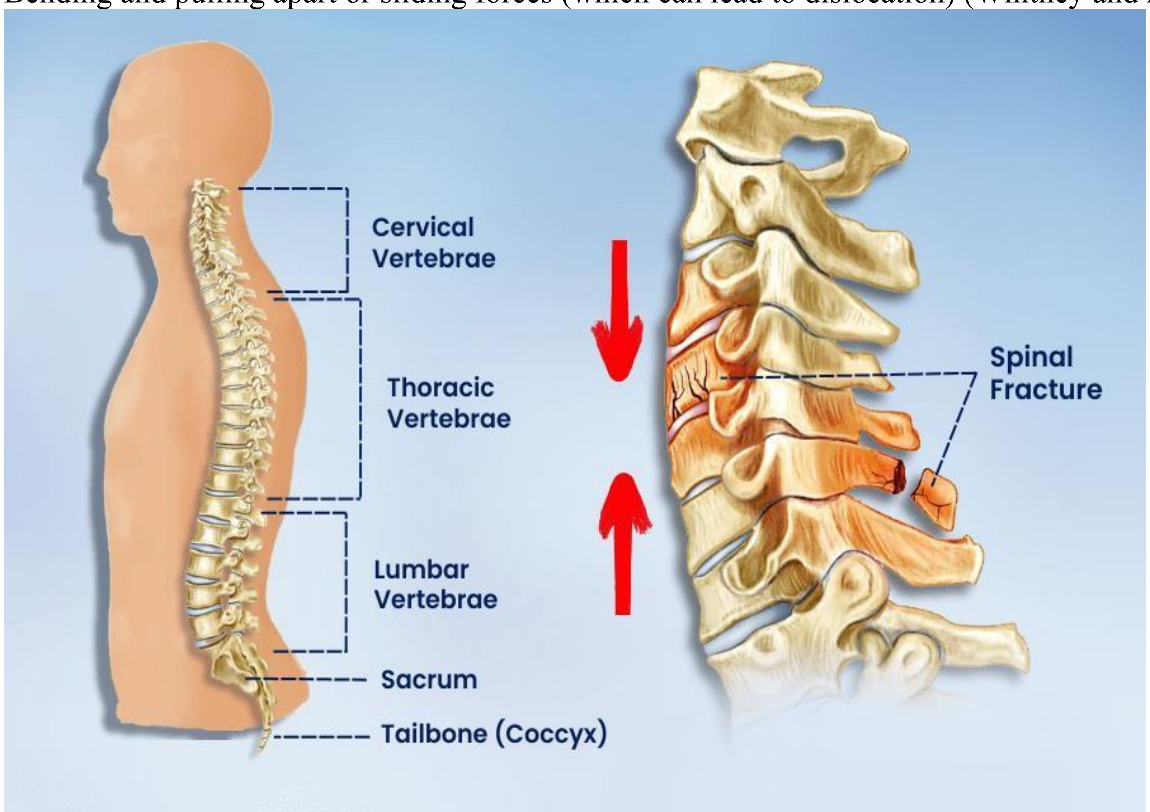

Figure 1. 1: The spine's structure and the various spinal fractures that can happen due to different reasons

Thoracolumbar Junction in Spinal Trauma Fixation

The area where the upper and lower back meet specifically the single level disc space between T12-L1 or L1-L2 is a weak spot in the spine. This spot accounts for a large percentage, between 30% and 60%, of all spinal injuries. It's tricky because it's where the relatively stiff, rounded upper back transitions into the more flexible, arched lower back, which unfortunately means it bears more mechanical stress during an impact. Around 60% of injuries in this thoracolumbar region happen between T12 and L2, and they often just affect one single vertebra. While treating these injuries without surgery used to be the common approach, experts have increasingly highlighted the benefits of using screws in the back of the spine for stability. Right now, a lot of research is focused on figuring out if fixing just the short section of the spine that includes the fracture known as short segment fixation provides enough stability compared to fixing a longer section for injuries in this thoracolumbar area (Vihar et al., 2021).

Thoracolumbar Injury Classification and Severity Score (TLICS)

The Thoracolumbar Injury Classification and Severity Score (TLICS) is a tool used to assess back injuries, specifically in the thoracic and lumbar spine. It helps doctors understand the injury better by assigning points based on three main factors. Here's how it works:

Type of Injury & How It Happened (based on X-rays or CT scans)

- **Compression:** When pressure crushes the front of a vertebra (1 point).
- **Burst Fracture:** When the vertebra shatters and breaks outward in multiple directions (2 points).
- **Translation/Rotation:** When parts of the vertebra slide or twist abnormally (3 points).
- **Distraction:** When the spine is pulled apart, like a stretching injury (4 points).

Health of the Back Ligaments (based on MRI)

- **Intact:** The strong ligaments supporting the back are healthy and undamaged (0 points).
- **Suspected/Indeterminate:** It's not clear if the ligaments are damaged; the MRI results are uncertain (2 points).
- **Injured:** The MRI shows that the ligaments are definitely damaged (3 points).

Nerve Function (based on a physical exam)

- **Intact:** No nerve damage is found during the exam (0 points).
- **Nerve Root:** There are signs of damage to a specific nerve root (2 points).
- **Complete Spinal Cord Injury:** The spinal cord below the injury level shows no sign of function; it's completely damaged (2 points).
- **Incomplete Spinal Cord Injury:** Some function remains in the spinal cord below the injury level (3 points).
- **Cauda Equina Syndrome:** This is a specific type of severe nerve damage affecting multiple nerve roots at the bottom of the spine (3 points) (Fernández-de Thomas and De Jesus, 2023).

Pedicle screw fixation

Posterior pedicle screw fixation is a surgical technique widely regarded as the gold standard for treating most fractures in the thoracolumbar spine (the area where the thoracic and lumbar vertebrae meet). In this procedure, surgeons insert special, threaded screws through the small bony canals (pedicles) of each vertebra, starting from the back (posterior approach). These screws are then connected along the spine with long metal rods. This setup helps achieve several important goals:

- It helps correctly align the fractured bones (fracture reduction) while creating a stable support structure that reinforces the spine's three main columns.
- It allows patients to start moving around more quickly after surgery (early postoperative mobilization).
- It helps prevent long-term spinal deformities and protects against further nerve damage related to the injury.

When this technique is performed using a minimally invasive approach (percutaneously), guided by real-time X-ray imaging (fluoroscopic guidance), it achieves the same goals while also minimizing damage to the muscles around the spine and helping patients recover faster (Guo et al., 2022).

Open pedicle screw fixation (OPSF)

Open pedicle screw fixation is a standard way surgeons go in from the back to stabilize fractures in the lower back and upper lumbar spine. With this technique, the surgeon makes a cut down the middle of the back and carefully moves aside the muscles next to the spine to get a clear view. They then place special screws directly into the bones under this clear view. After the screws are securely in place, long rods are attached to them. This helps restore the spine's normal height, corrects any bending forward (kyphosis, measured by the Cobb angle), and creates a stable connection across the spine's entire structure.

Advantages

- **Gold-standard stability:** This approach offers top-tier stability, giving strong support from the back and reliably correcting any spinal deformities.
- **Proven efficacy:** It works effectively to restore the height of the spinal bones and correct forward curvature (kyphosis) in fractures that happen suddenly.
- **Early mobilization:** Patients can start getting mobile relatively early. Once the surgical hardware is securely in place, they can begin moving around, though they'll need some support.

Disadvantages

Invasive Surgery Needed

This technique often requires a more extensive operation. It involves getting wide access to parts of the spine (like the facet joints and transverse processes) by carefully separating the muscles along the spine. This can lead to:

- More blood loss during the procedure.
- Potential nerve damage or weakening of the muscles involved.
- Longer-lasting pain after the surgery.

Longer Time Commitment

Compared to less invasive methods, this surgery generally takes more time in the operating room, and the recovery period in the hospital tends to be longer as well. Because it requires more resources, the overall cost is typically higher too.

Less Ideal Front-of-Spine Correction

Restoring the height at the front of the vertebrae (AVH) and correcting angles (like the Cobb angle) mainly relies on pulling with the metal rods used in the surgery. This can sometimes result in incomplete or only temporary restoration of the front part of the spine's height.

If the correction isn't fully maintained over time, it might lead to ongoing spinal instability, chronic low back pain, and potentially needing a second operation down the line (Rui et al., 2023).

Percutaneous pedicle screw fixation (PPSF)

Percutaneous pedicle screw fixation is a less invasive technique that's becoming more popular for stabilizing the lower back, especially in cases of age-related issues like narrowing of the spinal canal (stenosis), slipped vertebrae (spondylolisthesis), or instability after spinal decompression surgery. Using X-ray guidance or navigation tools, surgeons make small cuts in the skin to carefully insert guide wires and special screws directly into the bones connecting to the spine (pedicles). This method avoids the need for large muscle stripping and extensive tissue separation. Because it protects the muscles around the spine, this approach often leads to less blood loss during surgery, less pain afterward, and a shorter hospital stay compared to the more traditional open fusion techniques. After the screws are set, surgeons can place bone grafts or special cages either

between the vertebrae or alongside them through the same or slightly larger incisions to promote bone fusion. All in all, this percutaneous method provides strong support for the spine, helps patients recover more quickly, and lowers the risk of wound problems, making it a very appealing choice for carefully

selected individuals (Love et al., 2021).
Figure 1 highlights the differences between the three methods: traditional open fusion (B) involves spreading the muscles around the spine quite widely, which can result in nerve damage, muscle wasting, loss of blood supply, and a higher risk of bleeding and infection. On the other hand, the minimally invasive, percutaneous technique (C) uses smaller tubes inserted through tiny cuts, allowing surgeons to bypass the need for muscle stripping and its associated problems (Mobbs and Phan, 2016).

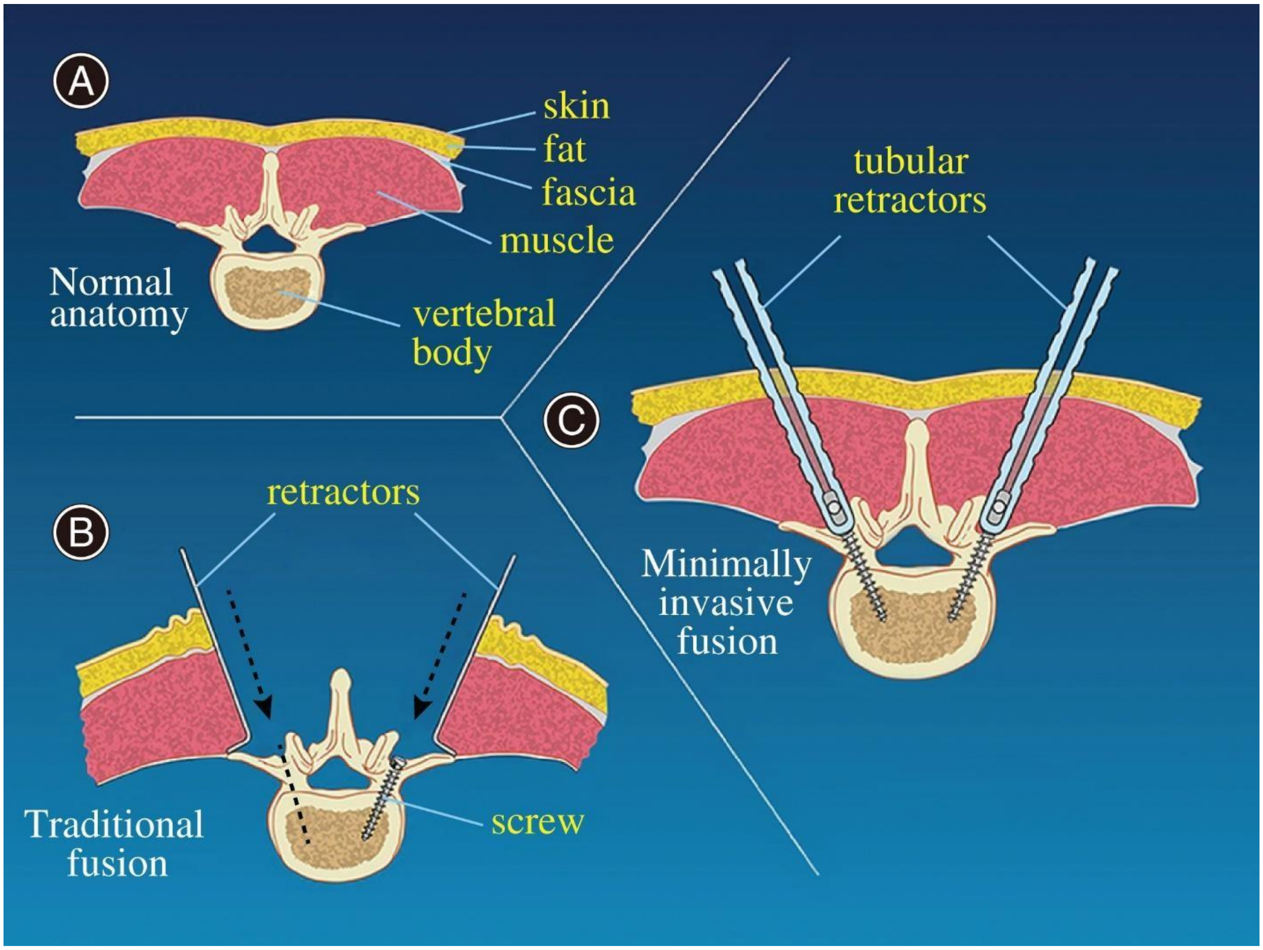

Figure 1. 2: (A) This shows a normal spine, highlighting the pedicle's depth and angle. (B) With traditional open surgery, pulling back the muscles often involves widely separating the muscles along the spine. (C) But with percutaneous pedicle screws, since the tool's entry angle aligns with the pedicle's angle, the special tubular retractors needed only require minimal muscle retraction (Mobbs and Phan, 2016)

Advantages of PPSF

Less Soft-Tissue Damage

This approach is kind to the tissues. It uses smaller skin cuts and a technique that spares the muscles along the spine, protecting them from injury.

Quicker Hospital Stay and Recovery

Patients tend to leave the hospital sooner and get back to their normal routines faster.

Fewer Complications Around Surgery

It generally involves less blood loss during the operation, causes less pain afterward, and might lead to fewer problems with the surgical site.

Comparable Results to Other Methods

Research shows that in terms of healing fractures and correcting alignment; the results are often similar whether fusion is part of the procedure or not [10–16].

Regaining Movement (When No Fusion)

If the surgery doesn't include fusion, removing the implants later can allow the affected parts of the spine (like the L3 to L5 area) to move normally again [5,12–14,16].

Limitations / Gaps

Lack of Long-Term Data for Lower Back Fractures

There isn't enough long-term information yet specifically for burst fractures in the lower lumbar spine (L3-L5). We don't have studies looking at the results after implant removal in these cases without fusion.

Concerns About Skipping Fusion

Choosing not to fuse the spine brings up questions about whether the front part of the spine (the anterior column) stays stable enough and if the spine might become biomechanically unstable later on.

Technical Challenges and Reliance on Imaging

Performing PPSF requires using special X-ray guidance (like fluoroscopy or navigation), and it has a steep learning curve. This can impact how accurate and safe the procedure is, especially for less experienced surgeons (Moon et al., 2023).

LITERATURE REVIEW

Radiological and Functional Outcomes of OPSF vs. PPSF

Recent literature consistently compares **Open Pedicle Screw Fixation (OPSF)** with **Percutaneous Pedicle Screw Fixation (PPSF)** for thoracolumbar fractures, focusing on radiological correction, clinical recovery, complications, and functional outcomes.

Multiple studies from **2019–2025** reveal that:

Effectiveness of Correction

- OPSF generally provides **strong deformity correction**, especially in restoring **kyphosis** and **vertebral height** (Chen 2025; Choovongkomol 2024).
- PPSF achieves **comparable radiological outcomes**, sometimes offering **better anterior vertebral height recovery** (Rui 2023).

Soft-Tissue Damage & Muscle Preservation

- MRI studies show significantly **less paraspinal muscle damage** with PPSF (5–10%) than OPSF (10–20%), leading to better functional recovery (Liao 2024).

Recovery, Pain, and Functional Scores

- PPSF is repeatedly associated with:
  - **Lower VAS pain scores**
  - **Better ODI functional improvements**
  - **Earlier mobilization and return to work**

(Hashmi 2024; Furtado 2024; Faizan 2022; Botros 2023).

Operative Metrics

Across most studies:

- PPSF → **Less blood loss**, **shorter operation time**, **smaller incisions**, **shorter hospital stay**.
- OPSF → Larger surgical exposure, more tissue trauma, and longer hospitalization

(Choovongkomol 2024; Rui 2023; Botros 2023; SHAikh 2021).

Complications and Safety

- PPSF is consistently reported as **safe**, with low rates of:
  - infection

- screw misplacement
- neurologic complications

(Elbaz 2023; Perna 2022; Tamburrelli 2019).

Navigation-assisted PPSF significantly increases **screw placement accuracy** (Echt 2020).

Special Conditions

- In metastasis cases, PPSF combined with PVP shows sustained improvement with **no infections or hardware failure** (Ma 2023).
- For burst fractures (A3–A4), minimally invasive fixation maintains alignment with minimal functional impact even when mild kyphosis correction loss occurs (Perna 2021).
- PPSF shows clear benefit when combined with kyphoplasty for Magerl A3 and B2 fractures (Salle 2021).

Comparative Reviews

Systematic reviews (Perna 2022; Choovongkomol 2019) support PPSF as:

- equally effective in radiological correction
- superior in short-term clinical recovery
- associated with **significantly fewer complications**

Overall Conclusion from Literature

Across nearly all recent studies:

PPSF provides equivalent radiological correction to OPSF but with fewer complications, less soft-tissue damage, shorter surgery, lower blood loss, faster recovery, and better short-term functional outcomes.

OPSF remains effective but is more invasive and associated with slower recovery and more morbidity.

High-quality randomized trials are still needed for definitive long-term comparisons.

Objectives

The objective of this study is to compare radiological and functional outcomes of percutaneous pedicle screw fixation (PPSF) and open pedicle screw fixation (OPSF) work for fixing single-level fractures in the thoracolumbar junction of the spine, looking at both imaging results and how the patient's function.

Hypothesis

The outcomes of PPSF and OPSF differ, whether you're looking at functional measures like VAS and ODI scores or radiological findings such as changes in Cobb's angle and implant failure rates.

Operational Definitions

Open Transpedicular Screw Fixation

This surgery involves placing special screws called transpedicular screws into the spine to help stabilize it. They use standard tools for this, and it often requires quite a bit of cutting and separating tissue to get to the area.

Percutaneous Transpedicular Screw Fixation

This is a type of minimally invasive surgery where transpedicular screws are inserted through small skin punctures. The doctor uses special X-ray guidance (fluoroscopy) to place them accurately, while being very careful to cause minimal disturbance to the surrounding tissues.

Outcomes

Radiological Outcome

Flexion–extension X-rays taken at the 3-months will be reviewed by two separate musculoskeletal radiologists who won't know the details of the cases (they'll be blinded).

Cob's/ Kyphotic Angle

Each radiologist draws one line that runs parallel to the top edge of the vertebra above the fracture, and another line parallel to the bottom edge of the vertebra below it and perpendiculars drawn to both lines.

They then take the average of the two angles they measure and record that number.

Implant failure

Any issues with the surgical hardware within the first 6 months are recorded by both the surgeon who performed the operation (during the clinic check-up) and a radiologist.

Screw pull-out

Considered a problem if the screw shifts by 2 millimetres or more along its length, either when looking at the X-ray from the front (flexion) or the back (extension).

Screw/rod breakage

Any break or crack that can be seen running through a screw or rod.

Screw loosening

A radiolucent halo (a dark area around the screw) that's at least 1 mm wide can be seen around where the screw meets the bone.

Functional Outcome

Assessed at the time of discharge, and then again at the 2nd, 6th, and 12^{th} weeks follow-up by a trained research assistant who gave the tests and scored them.

Oswestry Disability Index (ODI)

The questionnaire has 10 parts, and patients fill it out themselves, giving a score from 0 to 5 for each part. The assistant then works out the total score, turns it into a percentage (from 0% to 100%), and records it right away (Fairbank & Pynsent., 2000). Scoring is done as

- 0% –20%: Minimal disability
- 21%–40%: Moderate Disability
- 41%–60%: Severe Disability
- 61%–80%: Crippling back pain
- 81%–100%: These patients are either bed-bound or have an exaggeration of their symptoms

Visual Analogue Scale (VAS)

A horizontal line, 10 centimetres long. At one end, it says '0 = no pain' and at the other, '10 = worst pain imaginable.' Patients use this line to mark how much pain they're feeling. Then, the research assistant measures how far their mark is from the 'zero' end in centimetres, which gives the pain score.

MATERIALS AND METHODS

Study Design

Quasi Experimental Study

Study Settings

Department of Neurosurgery Unit II Punjab Institute of Neurosciences, Lahore General Hospital, Lahore.

Study Durations

12 months after the approval of synopsis.

Sample Size

The study involves a sample size of 62 participants, divided equally into two groups of 31 each. This number was calculated to ensure the test has 90% power, uses a 5% significance level, and considers the mean ODI scores i.e. 6.1 ± 3.5 for the OSPF group and 3.7 ± 2.1 for the PPSF group. These calculations were done using a specific formula (Choovongkomol et al., 2024).

$$= \frac{\left(_{1-\frac{}{2}} + \ _{1-} \right)^{2} \left(\ _1^{2} + \ _2^{2} \right)}{\left(\ _1 - \ _2 \right)^{2}} \quad (1)$$

Table 3. 1: Confidence interval, power, mean SD, variance Sample size Ratio of sample size

Confidence Interval (2-sided)	95%		
Power	90%		
Ratio of Sample size (Group 2/Group 1)	1		
	Group 1	**Group 2**	**Difference**
Mean	6.1	3.7	2.4
Standard Deviation	3.5	2.1	
Variance	12.25	4.41	
Sample size of Group 1	31		
Sample size of Group 2	31		
Total	62		

Group A: OPSF n=31
Group B: PPSF n=31
Sampling Technique
We'll pick patients who fit our specific criteria using non-probability purposive sampling. Once they give their informed consent, we'll assign them Group A (OSPF) and Group B (PPSF). All surgeries will be scheduled in advance, done under general anesthesia, and performed by the same surgical team using standard implants and X-ray guidance during the procedure.
Sample selection
Inclusion Criteria

- Age 18 to 50 years
- Neurologically intact patients with TLICS ≥ 4
- Single level fractures involving thoracolumbar junction from T10- L2
- Patients with thoracolumbar junction vertebrae fracture with intact pedicle on CT scan

RESULTS

Table 4. 1: Sample size. mean, Standard deviation and variance of OPSF and PPSF

Group	Sample size (n)	Mean $(\bar{x})$	Standard Deviation (σ)	Variance (σ^2)
OPSF	31	6.1	3.5	12.25
PPSF	31	3.7	2.1	4.41

Unpaired t-test with Welch correction
t-statistics

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (1)$$

Degree of freedom (Welch's df)

$$df = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}} \quad (2)$$

p-value

$$p\text{-}value = 2 * P(T > |t|) \quad h \quad (3)$$

Confidence Interval (95 %)
Lower Confidence Interval

$$(\bar{\ } - \bar{\ })_{1\ 2} - \times \sqrt{\frac{^2_{\ 1}}{1} + \frac{^2_{\ 2}}{2}} \quad (4)$$

Upper Confidence Interval

$$(\bar{\ } - \bar{\ })_{1\ 2} + {}_{2} \times \sqrt{\frac{^2_{\ 1}}{1} + \frac{^2_{\ 2}}{2}} \quad (5)$$

Table 4. 2: df (Welch), t statistics, p value and CI (lower, upper)

Sr No.	df (Welch)	t statistics	P value	CI (Lower)	CI (Upper)	Cohens d
1.	49.1218	3.2738	0.00195	0.9268	3.8732	0.8316

Mann-Whiteny U test

Median

$$= \left(\frac{+1}{2}\right) = \quad (7)$$

$$= \frac{(\frac{}{2}) + - (\frac{+1}{2})}{2} = \quad (8)$$

Interquartile Range (IQR)

$$= {}_3 - {}_1 \quad (9)$$

U-statistics

$$_1 = {}_1\,{}_2 + \frac{_1(_1 + 1)}{2} - {}_1 \quad (10)$$

$$_2 = {}_1\,{}_2 + \frac{_2(_2 + 1)}{2} - {}_2 \quad (10)$$

Mean and Standard Deviation of U

$$= \frac{_1\,_2}{2}$$

(11)

$$\sqrt{\ _1\ _2(\ _1 + \ \ _2 + 2} = 12 \quad (12)$$

Z score

$$= \quad (13)$$

p-value (2 tailed)

$$= 2 \cdot (1 - \ (| \ |)) \quad (14)$$

Effect size (r)

$$= \frac{\quad}{\sqrt{\ _1 + \ _2}} \quad (15)$$

Table 4. 3: Median, IQR, Sum of Rank, U-statistics of OPSF and PPSF

Group	Median	IQR	Sum of Rank	U-statistics
OPSF	7	4	1223.5	233.5
PPSF	5	2	496	961

Table 4. 4: μ_U, σ_U, z score, p value and effect size

Sr No.	μ_U	σ_U	Z score	P value	Effect size (r)
1.	480.5	71.030	-3.4774	0.000506	-0.4416

Radiological Outcomes

Table 4. 5: Radiological outcomes of pre-op and post-op Cobb's and p value

Outcomes	Pre-op Cobb's (º)	Post-op Cobb's (º)	Δ Cobb's (º)	p-value
OPSF	25.4 ± 4.6	8.2 ± 3.7	17.2 ± 4.1	0.032
PPSF	24.9 ± 4.8	9.5 ± 3.3	15.4 ± 3.8	

Table 4. 6: Radiological outcomes include Implant failure, screw pull-out, screw/rod breakage, screw loosening

Outcomes	OPSF (n %)	PPSF (n %)	P value
Implant Failure	4 (12.9 %)	1 (3.2 %)	0.16
Screw pull-out	3 (9.7 %)	0 (0.0 %)	0.08
Screw/rod breakage	2 (6.5 %)	1 (3.2 %)	0.24
Screw loosening	5 (16.1 %)	2 (6.5 %)	0.09

Functional Outcomes

Table 4. 7: Functional outcomes of ODI and VAS at 6 months and p-value

Outcomes	ODI at 6 months (mean ± SD)	VAS at 6 months (mean ± SD)	p-value (Manny-Whiteny U)
ODI Score	6.1 ± 3.5	8.0 ± 1.9	0.0004
VAS Score	3.7 ± 2.1	6.0 ± 1.6	

Table 4. 8: Functional outcomes include ODI Score and VAS Score

Outcomes	Median (OPSF)	IQR (OPSF)	Median (PPSF)	IQR (OPSF)
ODI Score	7	4	5	2
VAS Score	8	3	6	2

DISCUSSION

Our study looked at patients with single-level fractures right where the thoracic and lumbar parts of the spine meet. We found that the open surgical approach (OPSF) corrected the spinal angle much better on average – by 6.1 degrees, give or take 3.5 degrees – compared to the percutaneous approach (PPSF), which corrected it by 3.7 degrees, plus or minus 2.1 degrees (check Table 1 for these numbers). Statistical analysis (using Welch's t-test, as shown in Table 2) confirmed this difference is highly significant ($t = 3.27$, $df \approx 49.1$, $P = 0.00195$), meaning it's very unlikely to have happened by chance. The difference was likely between 0.93 and 3.87 degrees, and the effect size was quite large ($d = 0.83$). This suggests that being able to directly see the fracture and perform controlled movements during the open surgery allows for a more precise realignment at this specific spinal level.

We also considered that the data might not follow a typical bell curve, so we used the Mann–Whitney U test (see Table 3) for further confirmation. This test also supports that OPSF achieves better correction, showing a higher median correction of 7 degrees (with an interquartile range of 4 degrees) compared to PPSF's median of 5 degrees (IQR = 2 degrees). The results of this test were very significant ($U = 233.5$, $Z = –3.48$, $P = 0.0005$), with a moderate effect size ($r = 0.44$, see Table 4). This strong, non-parametric evidence further confirms that, for single-level fractures in this part of the spine, the open surgical technique consistently results in a greater correction of the spinal angle (reducing the kyphosis).

The improvement in the Cobb angle, which measures how straight the spine becomes, was greater with the OPSF technique (an average improvement of 17.2°, plus or minus 4.1°) compared to the PPSF technique (an average improvement of 15.4°, plus or minus 3.8°). This difference of 1.8° between the two groups was found to be statistically significant ($P = 0.032$) (Table 5). While both methods did a good job restoring the spine's natural curve (sagittal alignment), the slight advantage of about 2° seen with OPSF around the T10–L2 area might mean better mechanical stability for the spine. This is an important factor to consider, especially since that region of the spine experiences a lot of stress.

Looking at the complication rates (Table 6), we saw a tendency for more issues with the OPSF approach. These included implant failure (12.9% vs. 3.2%), screws pulling out (9.7% vs. 0%), rods breaking (6.5% vs. 3.2%), and screws becoming loose (16.1% vs. 6.5%). However, these differences weren't statistically significant, meaning they could potentially be due to chance. The

fact that OPSF requires an open incision in a flexible part of the spine might make the surrounding tissues more vulnerable and could potentially put more stress on the implants. On the other hand, the PPSF approach, which is less disruptive, seems to lower the chances of hardware problems, particularly in cases involving single-level junctional fractures.
By the six-months, patients who had OPSF surgery reported lower average ODI scores (6.1 ± 3.5) compared to those who had PPSF surgery (8.0 ± 1.9), and this difference was highly statistically significant (P = 0.0004) (see Table 7). However, looking at the middle values, the median ODI score was actually higher in the OPSF group (7, with an IQR of 4) than in the PPSF group (5, with an IQR of 2) (see Table 8). This suggests more variation in outcomes within the OPSF group and might indicate more intense pain affecting their early recovery. When it came to VAS pain scores, the OPSF group also had higher median values (8 compared to 6), hinting that despite achieving better results on X-rays, the open surgery at the thoracolumbar junction might come with more post-surgery discomfort. This is likely due to the muscle cutting and ligament disturbance involved in that type of procedure.
For single-level traumatic fractures in the junction area, OPSF surgery offers significantly better correction of the spinal angle. However, it also seems to be linked to a higher tendency for complications and more early post-surgery pain. On the other hand, PPSF provides good, though slightly less precise, correction and has fewer issues with the hardware used, along with better results regarding early pain and disability. So, if getting the spinal alignment just right is the top priority (like in unstable burst fractures), OPSF might be the preferred choice. But for patients who are more focused on recovering quickly and with fewer side effects, especially when the fracture allows for a less invasive approach, PPSF could be the better option. We still need longer-term studies to see if that small extra correction achieved with OPSF really leads to lasting biomechanical and functional benefits in the thoracolumbar junction area.

CONCLUSION

This study compared two surgical methods for fixing single-level fractures at the thoracolumbar junction. The research consistently found that the traditional open surgery (OPSF) was better at correcting spinal alignment on X-rays compared to the minimally invasive keyhole surgery (PPSF). To be specific, the open surgery corrected the spinal angle by an average of 6.1 degrees, while the minimally invasive approach corrected it by an average of 3.7 degrees. This difference was statistically significant (t = 3.27, P = 0.00195, d = 0.83). Similarly, looking at the middle improvement value, the open surgery achieved a 7-degree improvement, versus 5 degrees for the minimally invasive one (Z = –3.48, P = 0.0005, r = 0.44). The open approach also reduced the curve angle more significantly (a change of 17.2° ± 4.1°) than the minimally invasive one (a change of 15.4° ± 3.8°, P = 0.032), showing it's better at realigning the spine in this high-stress area.
However, the open surgery did come with more radiological outcomes – things like implant failures (12.9% vs. 3.2%), screws pulling out (9.7% vs. 0%), rods breaking (6.5% vs. 3.2%), and loosening (16.1% vs. 6.5%). It's worth noting that these differences didn't quite reach statistical significance. Despite the hardware issues, the open method also led to slightly lower average disability scores (6.1 vs. 8.0, P = 0.0004), though patients had more varied results in terms of pain and function after it. The percutaneous method, while providing slightly less correction, offered more consistent pain relief and had fewer complications overall, which really emphasizes the benefits of its minimally invasive nature.
For single-level thoracolumbar fractures, OPSF delivered better sagittal correction (Δ17.2° vs. 15.4°, P = 0.032; median 7° vs. 5°, P = 0.0005) and lower average disability (ODI 6.1 vs. 8.0,

P=0.0004), though it tended to have more hardware issues. PPSF provided slightly less realignment but with fewer complications and more reliable pain relief. Consequently, OPSF seems best suited when maximum deformity correction is the priority, whereas PPSF is likely the better choice for reducing surgical impact and speeding up recovery.

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