

Correlation of interpedicular distance widening and spinal canal narrowing to neurological status of thoracolumbar burst fracture

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Abstract

Burst fracture, the injury of anterior and middle column of vertebrae, resulting to retropulsion of posterior vertebral body into the canal spinal. This injury often occurs in thoracolumbar region. Widening of the interpedicular distance as a result of axial trauma and allowing for invasion of vertebral body fragments into the spinal canal, resulting in compression of the spinal cord. This interpedicular distance can be easily measured on plain x-rays. Axial findings on CT-Scan or MRI can demonstrate narrowing of the spinal canal and contribute to understanding the severity of injury, and may be useful for predicting potential neurologic recovery. Undiagnosed and untreated spinal injuries can result in neurological deficits that affect the patient's function and quality of life. This observational analytical study aimed to analyze the correlation between interpedicular distance widening and spinal canal narrowing to the neurological status of thoracolumbar burst fracture patients. In our study, 67 patients with thoracolumbar burst fracture from January 2015 to December 2022 were investigated with respect to interpedicular distance and spinal canal diameter. These variables were correlated to neurological deficit with ASIA score calculation. Our study found that the average widening of the interpedicular distance in this study was 18.80%, and the average spinal canal narrowing was 28.92%. The correlation coefficient of 0.794 shows a very strong positive correlation between widening of the interpedicular distance and ASIA score ($P < 0.001$). And correlation coefficient with a value of 0.807 indicates a very strong positive correlation between spinal canal narrowing and ASIA score ($P < 0.001$). It was concluded that the wider the interpedicular distance, and the narrower the spinal canal, in thoracolumbar burst fracture patients, the more the patient's neurological status will decrease.

Keywords : Burst fracture; Thoracolumbar; Interpedicular distance; Spinal canal narrowing; Neurologic deficit

1. Introduction

Burst fractures include injuries of the anterior and middle columns of the spine, generally causing retropulsion of the posterior part of the vertebral body against the spinal canal.¹ Approximately 50% of these injuries are unstable and can result in significant disability, deformity, and neurological deficits.² In burst fractures, retropulsion of the fracture fragments into the spinal canal from the posterior corpus can cause neurological deficits due to compression of the spinal cord in the canal. The ratio of narrowing of the canal by bone fragments is one of the important parameters in determining the indication for treatment of burst fractures.³ As a characteristic of burst fractures, widening of the interpedicular distance as a result of axial

trauma and allows for invasion of vertebral body fragments into the spinal canal, resulting in compression of the spinal cord. behind. Widening of the interpedicular distance can be easily measured on plain x-rays.⁴ Axial findings on CT-Scan or MRI can demonstrate narrowing of the spinal canal and contribute to understanding the severity of injury, and may be useful for predicting potential neurologic recovery.⁶ In this study, we were interested in analyzing the correlation between interpedicular distance widening and spinal canal narrowing to the neurological status of thoracolumbar burst fracture patients.

2. Materials and methods

This study is the result of analytic observational research that carried out at the Haji Adam Malik Central General Hospital, Medan, after obtaining approval from the Research Ethics Commission, Faculty of Medicine, University of North Sumatra. The data were collected from the medical records of patients who experienced thoracolumbar burst fractures and received treatment at RSUP H Adam Malik Medan in January 2015 - December 2022. The desired subjects for research were taken from the entire population that met the inclusion criteria, namely patients with burst fracture injuries to the spine between Thoracic 10 to Lumbar 2 levels. Patients with fractures of more than one level, head injury, history of previous spinal fracture or surgery, malignancy, congenital spinal abnormalities, and spinal infections were excluded in this study.

Patients who met the inclusion criteria were recorded for age, gender, ASIA Score, burst fracture level, and mechanism of injury. The widening of the interpedicular distance and the narrowing of the spinal canal were measured and their relationship to the patient's neurological status based on the ASIA score was analyzed.

The widening of the interpedicular distance were measured based on the AP projection Xray results of the patient's spine (Fig. 1). The widening of the interpedicular distance was calculated by finding the average of the interpedicular distance values of the upper and lower vertebral segments via X-Ray AP projection. The measured interpedicular distance value of the fractured vertebrae is divided by the original interpedicular distance estimate.

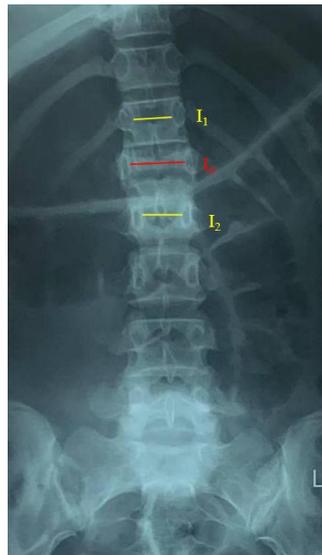


Fig. 1. Measurement of the interpedicular distance on AP x-ray projection

To calculate the widening ratio of the interpedicular distance at the fracture level, an estimated value of the original interpedicular distance is required. This value is calculated by finding the average of the interpedicular distance values of the upper and lower vertebral segments. The measured interpedicular distance value of the fractured vertebrae is divided by the estimated original interpedicular distance. The obtained value is multiplied by 100 to find the degree of increase in interpedicular distance as a percentage. The same way was done in spinal canal narrowing calculation.

$$\frac{\left[\frac{(I1+I2)}{2} - I0 \right]}{\frac{(I1+I2)}{2}} \times 100$$

Narrowing of the spinal canal is measured from the results of an MRI or CT scan of an axial section (Fig. 2). The spinal canal area was measured using the polyline feature in the AutoCAD program to determine the diameter of the spinal canal. The spinal canal diameter value measured in the fractured vertebrae is divided by the estimated diameter of the original spinal canal. The patient's neurological status is measured based on the patient's ASIA Score. Correlation analysis was carried out between the widening of the interpedicular distance and the narrowing of the spinal canal to the patient's neurological status based on the ASIA score.

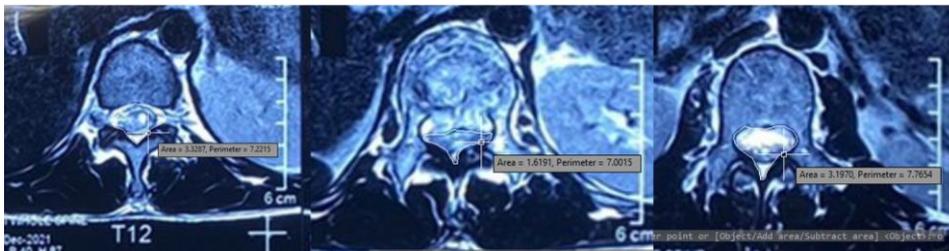


Fig. 2. Measurement of spinal canal diameter on axial MRI

Data is collected and sorted systematically and analyzed through a computer-based statistical analysis program. The significance level used is 5% (0.05) and the trend significance level is 10% (0.1). The descriptive analysis was carried out to determine the demographic frequency distribution and mean values of the variables measured. Inferential analysis is preceded by a normality test to determine the distribution of the data. The Pearson correlation test will be used if the data is normally distributed, while the Spearman correlation test will be used if the data is not normally distributed. All analyzes will be carried out using statistical software and the results are declared significant with a *p* value <0.05.

3. Results

This research of 5 years data of a total 67 patients results with a distribution of 48 male patients and 19 female patients, with an average patient age of 41 years. The most common trauma mechanism in these patients was a fall from a height, namely 52 patients (77.6%). The vertebral level most frequently injured in thoracolumbar burst fractures in this study was the L1 level in 28 patients (41.8%), with the most frequent ASIA score being ASIA Score E in 17 patients (25.4%).

Table 1. Characteristic of the patients

| Characteristic | Score |
|-------------------------------------|-------------------|
| Gender | |
| Male (%) | 48 (71.6) |
| Female (%) | 19 (28.4) |
| Age (mean \pm deviation standard) | 41.72 \pm 14.70 |
| Trauma mechanism | |
| Motor vehicle accident (%) | 11 (16.4) |
| Fall from height (%) | 52 (77.6) |
| Hit by heavy load (%) | 4 (6.0) |
| Level of injury | |
| T10 (%) | 5 (7.5) |
| T11 (%) | 7 (10.4) |
| T12 (%) | 17 (25.4) |
| L1 (%) | 28 (41.8) |
| L2 (%) | 10 (14.9) |
| ASIA Score | |
| A (%) | 14 (20.9) |
| B (%) | 9 (13.4) |
| C (%) | 13 (19.4) |
| D (%) | 14 (20.9) |
| E (%) | 17 (25.4) |

It was found that the average widening of the interpedicular distance in this study was 18.80% of the estimated normal interpedicular distance. Meanwhile, the average spinal canal narrowing in this study was 28.92% of the estimated normal spinal canal diameter.

Table 2. Interpedicular distance widening and spinal canal narrowing measurement

| Characteristic | Score |
|--|-------------------|
| Interpedicular distance widening (mean \pm SD) | 18.80 \pm 8.50 |
| Spinal canal narrowing (mean \pm SD) | 28.92 \pm 16.55 |

In relation to the widening of the interpedicular distance on neurological status based on the ASIA score, patients with ASIA score A had a significantly greater increase in the interpedicular distance when compared with ASIA E (51.04% and 11.68%). And in terms of the relationship between spinal canal narrowing and neurological status based on ASIA score, patients with ASIA score A have significantly greater spinal canal narrowing when compared with ASIA E (55.50% and 12.35%).

Table 3. Average interpedicular distance widening and spinal canal narrowing in relation to neurological status

| ASIA Score | N | Interpedicular distance widening | Spinal canal narrowing |
|------------|----|----------------------------------|------------------------|
| A | 14 | 51.04% | 55.50% |
| B | 9 | 49.61% | 44.78% |
| C | 13 | 42.69% | 38.85% |
| D | 14 | 25.96% | 27.36% |
| E | 17 | 11.68% | 12.35% |
| Total | 67 | | |

Analysis using the Kolmogorov-Smirnov test found that the data was not normally distributed, so the Spearman correlation test was used to assess the correlation between these variables. The correlation coefficient of 0.794 shows a very strong positive correlation between widening of the interpedicular distance and ASIA score ($P < 0.001$). The correlation coefficient with a value of 0.807 also shows a very strong positive correlation between spinal canal narrowing and ASIA score ($P < 0.001$).

Table 4. Correlation of interpedicular distance widening and spinal canal narrowing to neurological status

| | | Interpedicular distance widening | Spinal canal narrowing |
|------------|----------------|----------------------------------|------------------------|
| ASIA Score | <i>r</i> value | .794 | .794 |
| | <i>P</i> value | <.001 | <.001 |

4. Discussion

Thoracolumbar burst fractures are caused by high-energy trauma, which causes morbidity and affects the patient's quality of life.¹³ In this study, it was found that the most patients experiencing thoracolumbar burst fractures were males, as 48 patients (71.6%), with an average age of 41 years old. This is in accordance with previous research conducted by Patil et al, explaining that the male population and those of productive age are more often involved in work that is at risk of trauma. The most frequent mechanism of injury is a fall from a height, where most patients are workers with poor safety systems or lack of awareness of the patient's own safety.⁶ The most frequent level of injury was L1 level in 28 patients (41.8%), with the most common neurological status was ASIA Score E in 17 patients (25.4%), this is in line with research conducted by Li et al where 49.51% of samples had injuries at the L1 level, and 68.93% of samples had ASIA score E.⁴

In burst fractures, the widening of interpedicular distance results from axial trauma and allows for invasion of fragments from the vertebral body into the spinal canal, causing neurologic compression. Retropulsion of the fracture fragments into the spinal canal from the posterior corpus in burst fractures can be a cause of neurological deficits due to compression of the spinal cord in the canal. In this study, it was found that the average widening of the interpedicular distance in thoracolumbar burst fractures was 18.80% of the estimated normal interpedicular distance. In research conducted by Li et al, an average interpedicular widening was found to be 10.92%, another study conducted by Caffaro et al found an average interpedicular widening of

17.2%. While the average spinal canal narrowing in this study was found to be 28.92%, research conducted by Li et al found an average spinal canal narrowing of 40.15%.

In correlation of interpedicular distance widening to neurological status based on ASIA score, patients with ASIA score A had a significantly greater increase in interpedicular distance when compared with ASIA E (51.04% and 11.68%). This supports the pathophysiology where axial pressure in a burst fracture which causes separation of the pedicle and widens the interpedicular distance, will cause invasion of fragments from the vertebral body into the spinal canal, causing compression and decreased neurological function. However, research conducted by Patil et al showed that widening the interpedicular distance did not correlate significantly with neurological status in thoracolumbar burst fracture patients. Initial nerve damage at the time of the accident is a major factor in neurological status. Meanwhile, Li et al stated that there was a significant correlation between interpedicular distance and neurological status. Supported by Caffaro et al who stated that the interpedicular distance measured from plain radiography has proven to be a reliable instrument in assessing spinal canal narrowing and neurological deficits.

Patients with ASIA score A had significantly greater spinal canal narrowing when compared with ASIA E (51.04% and 11.68%), this is in line with research conducted by Mohanty et al which stated that the average spinal canal narrowing with neurological deficit was equal to 50% and 36% in patients without neurological deficits. This shows that the narrower the spinal canal found in burst fracture patients, the more the patient's neurological condition will worsen. This is in line with research conducted by Aguilar et al which stated that the severity of spinal cord compression in retropulsive vertebral burst fractures correlated with the severity of the patient's neurological dysfunction.

In this study, it was found that there was a very strong correlation between the widening of the interpedicular distance and the neurological status in burst fracture patients, as well as the narrowing of the spinal canal in burst fractures, there was a very strong correlation with the neurological status. Based on the correlation values obtained, narrowing of the spinal canal has a greater value than widening of the interpedicular distance (0.807 and 0.794). However, in the interpretation, this relationship is no different because they both have a very strong correlation.

5. Conclusion

In this study, it was found that the wider the interpedicular distance in thoracolumbar burst fracture patients, the more the patient's neurological status will decrease. It can also be concluded that the narrower the spinal canal in thoracolumbar burst fracture patients, the more the patient's neurological status will decrease.

References

1. Diotalevi L, Bailly N, Wagnac E, Thiong JM, Goulet J, Petit Y. Dynamics of spinal cord compression with different patterns of thoracolumbar burst fractures: Numerical simulations using finite element modelling. Elsevier. 2020; 72(1): 186.
2. Vialle LR, Bellabarba C, Kandziora F. AO Spine Master Series Volume 6 Thoracolumbar Spine Trauma. New York: Thieme Medical Publishers; 2016.
3. Tanriverdi B, Aydingoz O, Unlu MC, Bilsel N, Hanci M. The relationship between the ratio of interpedicular distance increase and the ratio of spinal canal compromise in thoracolumbar burst fractures. Ulus Travma Acil Cerrahi Derg. 2022; 28(6): 857-61.
4. Li Y, Huang M, Xiang J, Lin Y, Wu Y, Wang X. Correlation of Interpedicular Distance with Radiographic Parameters, Neurologic Deficit, and Posterior Structures Injury in Thoracolumbar Burst Fractures. World Neurosurg. 2018 Oct 1;118:e72-8.
5. Alimohammadi E, Bagheri SR, Ahadi P, Cheshmehkaboodi S, Hadidi H, Maleki S, et al. Predictors of the failure of conservative treatment in patients with a thoracolumbar burst fracture. J Orthop Surg Res. 2020 Dec 1;15(1).
6. Patil TC, Chandawale AS, Kale A, Patil V, Wankhade U. Correlation between Interpedicular Distance to Severity Of Thoracolumbar Spine Burst Fractures – A Prospective Study. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2015: Pune. 1-2.
7. Garfin SR, Eismont FJ, Bell GR, Bono CM, Fischgrund JS. Rothman-Simeone and Herkowitz the spine. 7th ed. Philadelphia: Elsevier; 2018.

8. Divi SN, Schroeder GD, Oner FC, Kandziora F, Schnake KJ, Dvorak MF, Benneker LM, Chapman JR, Vaccaro AR. AOSpine-Spine Trauma Classification System: The Value of Modifiers: A Narrative Review With Commentary on Evolving Descriptive Principles. *Global Spine J.* 2019 May;9(1 Suppl):77S-88S. doi: 10.1177/2192568219827260. Epub 2019 May 8. PMID: 31157149; PMCID: PMC6512201.
9. Devlin VJ. *Spine Secrets*. 3rd ed. Philadelphia: Elsevier; 2021.
10. Shetty A, Avadhani R, Mahesha KB, Bhandary Y. Thoracic pedicle morphometry study on cadaver and ct scan with its clinical applications. *International Journal of Anatomy and Research*, 2019; 7 (1): 6089-90.
11. Ramachandran M. *Basic Orthopaedic Sciences*. 2nd ed. Boca Raton: Taylor & Francis Group; 2017.
12. Miller MD, Thompson SR. *Miller's review of orthopaedic*. 8th ed. Philadelphia: Elsevier; 2020.
13. Bhaumik M, Bhaumik U. Study of inter pedicular distance of lumbar spinal canal in perspective of lumbar canal stenosis using plain antero-posterior radiographs in western population of Rajasthan, India. *International Journal of Research in Medical Sciences*. 2019; 7(5): 1.
14. Senturk S, Ogrenci A, Gurcay AG, Abdioglu AA, Yaman O, Ozer AF. Classification of Radiological Changes in Burst Fractures. *ID Design Press*. 2018; 6(2) : 361.
15. Mohanty SP, Bhat NS, Abraham R, Keerthi CI. Neurological deficit and canal compromise in thoracolumbar and lumbar burst fractures. *Journal of Orthopaedic Surgery*. 2008; 16(1) : 22.
16. Eismont, F. J., Bell, G. R., Garfin, S. R., Bono, C. M., Fischgrund, J. S. (2017). *Rothman-Simeone The Spine E- United States: Elsevier Health Sciences*.Book.
17. Egol KA, Koval KJ, Zuckerman J. *Handbook of Fractures*. 6th ed. New York: Wolster Kluwer; 2020.
18. Solomon L, Warwick D, Nayagam S. *Apley's system of orthopaedic and fractures*. 9th ed. Bristol: Hodder Arnold; 2010.
19. Aguilar OJM, Sida KKA, Olvera MD, Bernaldez GIL, Oropeza E, Flores GG, et al. Spinal canal invasion as a predictor of neurological deficit in traumatic vertebral burst fractures. *Surgical Neurology International*. 2022; 13(428) : 1.
20. Caffaro MF, Avanzi O. Can the Interpedicular Distance Reliably Assess the Severity of Thoracolumbar Burst Fractures? *Spine Journal Lippincot Williams & Wilkins*. 2012; 37(4): 231-5.
21. Vaccaro AR, Schroeder GD, Kepler CK, Cumhuri Oner F, Vialle LR, Kandziora F, et al. The surgical algorithm for the AOSpine thoracolumbar spine injury classification system. *European Spine Journal*. 2016 Apr 1;25(4):1087-94.
22. Kang WS, Kim JC, Choi IS, Kim SK. Indirect Reduction and Spinal Canal Remodeling through Ligamentotaxis for Lumbar Burst Fracture. *Journal Of Trauma and Injury*. 2017; 30(4): 212.
23. Rainone GJ, Patel Y, Woodhouse C, Sauber R, Yu A. Nonoperative Management in Intact Burst Fracture Patient With Thoracolumbar Injury Classification and Severity Score of 5: A Case Report. *Cureus*. 2022; 14(9): 3.
24. Garelnabi ME, Ahmed AT, Fathelrahman SA, Alqhtani AM, Althaiban SH. Study of pedicles and spinal canal diameters at the level of lumbar vertebral in normal adult Saudi population using computed tomography. *GSC Advanced Research and Reviews*. 2021 Dec 30;9(3):048-55.
25. Bhaumik M, Bhaumik U. Study of inter pedicular distance of lumbar spinal canal in perspective of lumbar canal stenosis using plain antero-posterior radiographs in western population of Rajasthan, India. *International Journal of Research in Medical Sciences*. 2019; 7(5): 1.