

A Novel Intravertebral Fixation Technique of Lumbar Osteoporotic Vertebral Bipedicular Dissociation Fractures

Raphael Lotan, MD, MHA

Arsan Shpigelman, MD

Oded Hershkovich, MD,
MHA 

From the Department of Orthopedic Surgery, Wolfson Medical Center, Holon, Israel (Dr. Lotan and Dr. Hershkovich). Dr. Lotan and Dr. Hershkovich are now with the Tel Aviv School of Medicine, Tel Aviv University, Tel Aviv, Israel, and the Department of Orthopedic Surgery, Bnai Zion Medical Center, Haifa, Israel (Dr. Shpigelman).

Correspondence to Dr. Hershkovich: oded.hershkovich@gmail.com

None of the following authors or any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article: Dr. Lotan, Dr. Shpigelman, and Dr. Hershkovich

JAAOS Glob Res Rev 2025;9: e24.00372

DOI: 10.5435/JAAOSGlobal-D-24-00372

Copyright 2025 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of the American Academy of Orthopaedic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially.

ABSTRACT

Objective: A significant portion of traumatic spinal fractures involves the thoracolumbar spine. Fracture stabilization using pedicle screws initially demanded fixation of two levels above and below the fractured vertebra to achieve a stable construct. Over the years, a short-segment pedicle screw fixation was found to be adequate. Balloon kyphoplasty (BKP) is commonly used as a minimally invasive treatment for vertebral compression fractures. At times, lumbar burst fractures can extend to the posterior elements. These recently acknowledged subtypes of fracture do not cause posterior column instability other than coronal bipedicular dissociation. BKP alone is inadequate in these cases; a combination of BKP addressing anterior column reduction and support with a middle column stabilization by transpedicular fixation has the potential to treat all fracture elements without losing motion segments through a minimally invasive technique. This study aims to describe this novel concept and technique.

Methods: Five patients were treated with the intravertebral fixation (IVF) technique for coronal bipedicular dissociation fractures. We describe the surgical technique and review the pertinent literature.

Results: The IVF technique is clinically safe in stabilizing the specified fractures, with good clinical and functional outcomes.

Conclusion: IVF is a promising surgical technique and an exciting treatment concept for unique fracture types involving bipedicular coronal dissociation with or without burst fracture. Further studies are required to assess long-term results and possible complications.

Study Design: Case series for a new surgical technique.

A significant part of traumatic spinal fractures, 60% to 70%, involve the thoracolumbar (TL) spine.^{1,2} TL fractures are managed either by conservative treatment or surgically. Surgical decompression is usually reserved for neurologically compromised patients but is controversial in neurologically intact. Although conservative treatment provides favorable

clinical outcomes, some studies have shown that surgical treatment achieves better fracture reduction and long-term results.^{3,4}

Fracture stabilization using pedicle screws initially demanded fixation of two levels above and below the fractured vertebra to achieve a stable construct that can withstand load bearing without fracture displacement or construct failure. Over the years, a short-segment pedicle screw fixation (one level above and one level below the fractured level) was found to be adequate, and today, it is widely used for TL fractures worldwide. Short-segment pedicle fixation can provide immediate spinal stability, reduced kyphotic deformities, early painless mobilization, and indirect spinal canal decompression. However, many authors are concerned that short-segment pedicle screw fixation is inadequate to achieve and maintain fracture reduction and is associated with an unacceptable rate of failure.⁵⁻⁷

A relatively new concept, first reported in 1994, introduced the intermediate pedicle screws, pedicle screws inserted at the fractured vertebrae. Biomechanical studies⁸⁻¹¹ showed that short-segment fixation with intermediate pedicle screws improved spinal stability and decreased stress over pedicle screws in the upper and lower normal vertebrae.

Balloon kyphoplasty (BKP) is a minimally invasive surgical treatment for pain reduction, vertebral stabilization, and potentially spinal deformity reduction of vertebral compression fractures.^{12,13} Most of the deformity correction is achieved by patient positioning. The BKP allows further fracture reduction and alignment maintenance with the polymethylmethacrylate, which maintains the achieved reduction. BKP is frequently used for single and multilevel fractures¹⁴⁻¹⁷ and has been described in conjunction with a short-segment fixation.¹⁸⁻²¹ BKP has been found to be a valid treatment option for AO type A3 burst fractures as a single treatment.^{12,22}

Thoracolumbar burst fractures can sometimes extend to the posterior elements, such as laminar or pedicle extension. These fractures do not cause posterior column instability other than the pedicular dissociation. BKP alone is inadequate in these cases because it does not stabilize the posterior elements, leaving the vertebra prone to collapse further and progressive pedicular dissociation. The current alternatives are adding pedicle screw fixation around the fractured vertebra by short or long fixation. The downside of these fixations is losing spinal motion and increased risk of juxtafusal fractures.^{23,24}

In a recent study of 105 patients surgically treated for thoracolumbar osteoporotic vertebral fractures (OVFs) between 2016 and 2020,²⁵ we have described a new

lumbar osteoporotic fracture pattern, unrecognized previously, a bipedicular dissociation fracture. The study evaluated the clinical and radiological outcomes, comparing the characteristics and management of OVFs and bipedicular dissociation fractures. Of 105 patients, 85 had classifiable OVFs, and 20 had unipedicular dissociation fractures ($n = 10$, 9.5%) or bipedicular dissociation fractures ($n = 10$, 9.5%). Both cohorts mainly had single vertebral fractures and upper end plate involvement with cleft signs found in 30% of pedicular dissociation fractures versus 15.3% of OVFs ($P < 0.001$) and a higher incidence of burst fractures (40% vs. 25.9%; $P < 0.001$). Posterior vertebral body collapse was higher for pedicular dissociation fractures ($13.2 \pm 9.3\%$ vs. $18.3 \pm 8.5\%$; $P = 0.02$). Most OVFs underwent BKP (94%). Most bipedicular dissociation fractures were regarded unstable; six patients underwent posterior spinal fusion (PSF; 2 short PSF, 1 PSF + BKP, and 3 BKP with intravertebral pedicular lag screws at the fractured vertebra). Half of the bipedicular dissociation fractures underwent BKP-developed non-union. The results indicate notable differences between the cohorts in fracture characteristics, prefracture functional status, and surgical management. OVF and pedicular dissociation fracture cohorts were predominantly female and elderly, with similar ages, heights, weights, and body mass index. The time from fracture to surgery was similar between the cohorts. Notably, the prefracture functional status was markedly better in the OVF cohort than in the bipedicular dissociation cohort. The greater dependence on caregivers and mobility aids in the pedicular dissociation cohort suggested a higher burden of disability in this patient population. This difference in functional status may have implications for postoperative recovery, rehabilitation, and discharge planning. Most patients in both cohorts sustained fractures because of a fall, with a lower proportion of spontaneous nontraumatic vertebral fractures, suggesting that the bipedicular dissociation fractures, as osteoporotic vertebral compression fractures, can be traumatic or osteoporotic pathological fractures. OVF fractures were primarily located around the thoracolumbar junction, whereas bipedicular dissociation fractures mainly involved T11-L3. Notably, pedicular dissociation fractures had a higher incidence of burst fractures and cleft signs, which may indicate a more severe injury pattern and greater instability than OVFs, parameters not included in current OVF classification systems. OVFs and bipedicular dissociation fractures had the same preoperative percentage of anterior vertebral body collapse, $26.8 \pm 16.2\%$ vs. $25.9 \pm 17.6\%$,

respectively ($P = 0.99$), whereas the percentage of posterior vertebral body collapse was significantly higher for the bipedicular dissociation fractures, $13.2 \pm 9.3\%$ vs. $18.3 \pm 8.5\%$, respectively ($P = 0.02$). Posterior vertebral body collapse may explain the fracture mechanism; as the upper posterior vertebral body collapses, the pedicles are fractured and dissociated from the vertebral body, separating the fractured anterior and middle columns from the posterior column, causing vertebral instability as defined by Dennis classification.

The surgical management of OVFs and bipedicular dissociation fractures varied. OVFs were primarily treated with BKP. At the same time, pedicular dissociation fractures were treated by a range of stabilization techniques, including short PSF, BKP combined with PSF, or intravertebral fixation (IVF) combining pedicular lag screws with BKP. Four bipedicular fractures that underwent BKP without additional stabilization resulted in 50% of fracture nonunion. This finding suggested that pedicular dissociation fractures may present a more notable surgical challenge due to their inherent instability and complexity.

The rationale of IVF surgical technique is treating the two components of the bipedicular dissociation fracture, augmenting the vertebral body fracture with a BKP, and stabilizing the coronal plane bipedicular dissociation with pedicular screws. The theoretical advantage of the IVF technique is that it addresses anterior column reduction and support combined with posterior-middle column stabilization while preserving intervertebral motion. This study aims to describe this novel concept and technique.

Methods

This study included patients older than 65 years who suffered thoracolumbar burst or compression fractures

with bipedicular dissociation fractures (Figure 1, A–D) between 2016 and 2023. All patients underwent surgery by two fellowship-trained spine surgeons.

Exclusion criteria included patients younger than 65 years who sustained a pathological fracture due to malignancy or infection. Patients who underwent a previous spinal surgery at the fractured vertebra or a single level adjacent to it were excluded.

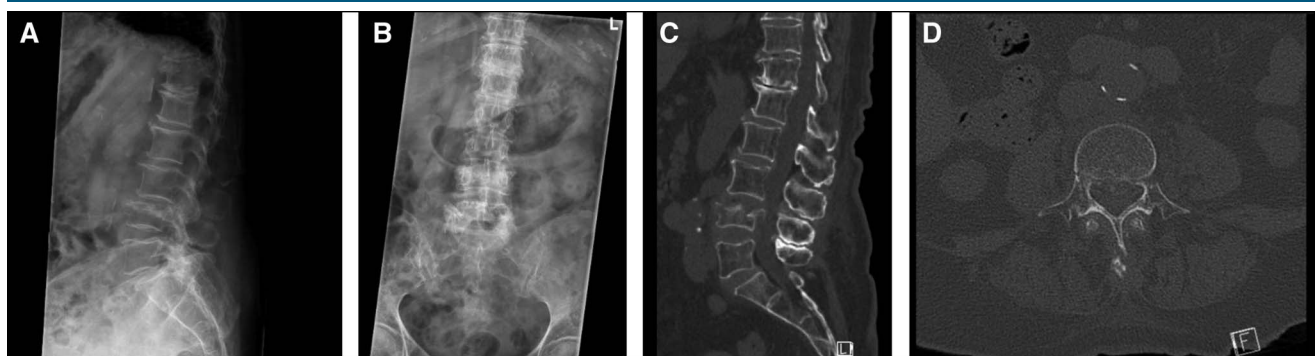
All patients were followed up to 2024. Electronic medical records and imaging studies were examined.

The Intravertebral Fixation Surgical Technique

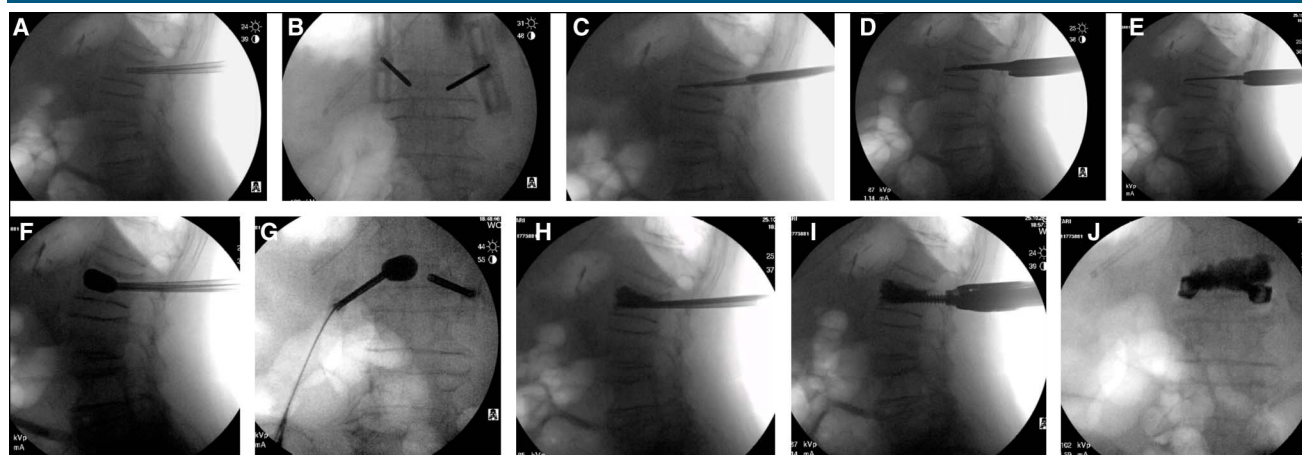
Under general anesthesia, patients were placed prone on a Jackson carbon operating table. Following draping, 2-cm skin incisions were made over the lateral portion of the fractured vertebra pedicles under lateral and frontal fluoroscopy to allow for future pedicle screw insertion. Under fluoroscopic guidance, two pedicular cannulas, Jamshidis, were inserted through the fractured vertebra's pedicles (Figures 2, A and B).

Bilateral transpedicular guidewires were inserted through the cannulas, and the cannulas were removed (Figure 2, C). Gradual soft-tissue expanders were used to prepare the pedicle screw insertion tract (Figure 2, D). A 5.5-mm taper was inserted over the guidewires beyond the pedicles and into the fractured vertebral body and removed to allow rapid pedicle screw insertion following the BKP (Figure 2, E). Trochar needles were inserted over the transpedicular guidewires. A 15- to 20-mm inflatable balloon was introduced through the trochars and inflated under fluoroscopic control (Figures 2, F and G). Following balloon deployment and fracture attempted reduction, the BKP balloon was deflated and retracted. Polymethyl methacrylate

Figure 1



Radiographs of an 80-year-old independent woman (patient 4) who fell at home showing diagnosis with an L4 burst fracture involving a bilateral pedicle fracture. Anterior-posterior and lateral radiographs (A and B), CT scan, midsagittal and axial views (C and D) are presented.

Figure 2

Fluoroscopic images showing the intravertebral fixation (IVF) surgical technique. Bilateral pedicular cannulas were inserted for patient 3 under fluoroscopic guidance (A and B). Bilateral transpedicular guidewires were inserted through the cannulas (C). Soft-tissue expanders were used to prepare the pedicle screw insertion tract (D). A 5.5-mm taper was inserted over the guidewires and removed to allow rapid pedicle screw insertion following the Balloon kyphoplasty (BKP) (E). Trochar needles were inserted over the transpedicular guidewires. A 15- to 20-mm inflatable balloon was introduced through the trochar and inflated under fluoroscopic control (F and G). PMMA was injected through each trochar (H). Bilateral transpedicular guidewires were reinserted through the BKP cannulas; percutaneous pedicle screw insertion towers were inserted with 45 to 50 × 6.5 mm pedicular screws (I and J). PMMA = polymethyl methacrylate.

(PMMA) was mixed, achieving toothpaste-like viscosity. Under lateral and anterior-posterior imaging, 2 to 5 mL of PMMA was injected through each trochar (Figure 2, H). PMMA spread was monitored fluoroscopically to avoid posterior spinal canal or anterior/lateral PMMA leakage. PMMA injected volume varied depending on the vertebral level, being higher in lumbar vertebrae.

In a hastened fashion to avoid PMMA setting, bilateral transpedicular guidewires were reinserted through the BKP cannulas, the BKP trocars removed, and under fluoroscopic control, over the wires, percutaneous pedicle screw insertion towers were inserted with 45 to 50 × 6.5 mm pedicular screws (Figure 2, I and J). Following screw insertion, the percutaneous towers were removed, and the two 2-cm skin incisions were irrigated using saline and sutured. Patients were mobilized two hours following surgery, and the next day, predischARGE standing radiographs were taken (Figure 3, A and B).

Patient History

Between 2016 and 2023 six patients were diagnosed with a bipedicular dissociation fracture and underwent IVF surgery (Table 1). The cohort included three women and three men; the average age was 82.7 ± 6.5 . The average follow-up was 19.5 ± 17.6 months, from 48 days to 3 months. All except one patient sustained a low-energy fall, whereas one fell from a 3-m ladder. The most

common fractured vertebrae were L4, three cases, followed by L2, two cases, and L3, one case.

Patient 1

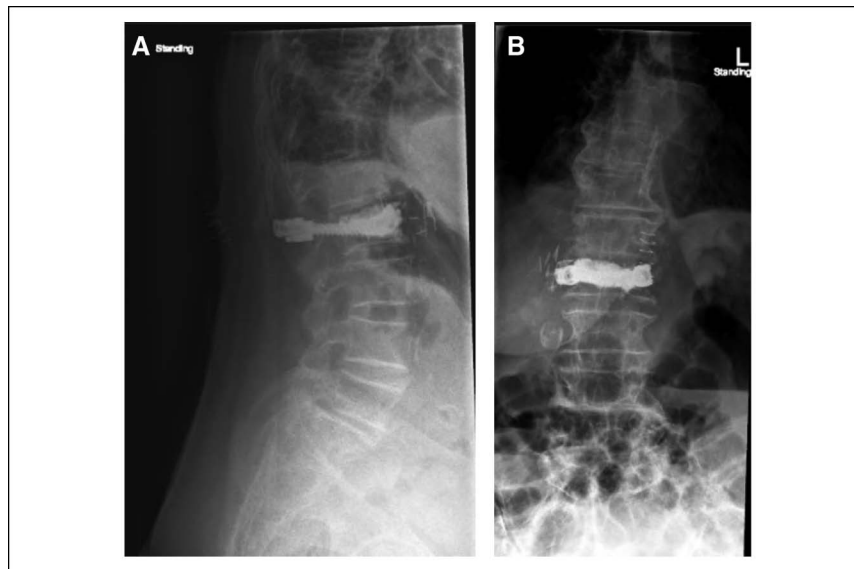
An 88-year-old independent woman who fell at home and was diagnosed with an L2 bipedicular dissociation fracture. The patient underwent L2 IVF surgery, gained ambulation the next day, and was discharged home. A 4-year follow-up was uneventful.

Patient 2

An 80-year-old independent woman who fell at home and was diagnosed with an L4 bipedicular dissociation fracture (Figures 1, A–D). The patient underwent L4 IVF surgery, ambulated the following day, and was discharged home (Figure 3). Six months following surgery, she fell again and was diagnosed with rami pubic fractures without displacement of the L4 IVF. Following discharge, a 30-month follow-up was uneventful (Figure 4, A and B).

Patient 3

A 72-year-old independent man fell at home and was diagnosed with an L3 bipedicular dissociation fracture. The patient underwent L3 IVF surgery and was able to ambulate the following day, but because of congestive heart failure, he continued treatment at an internal medicine department. Following discharge, a 22-month follow-up was uneventful (Figure 5).

Figure 3

PredischARGE standing radiographs showing anterior-posterior and lateral views of patient 3 at postoperative day 1.

Patient 4

An 88-year-old independent woman who fell at home and was diagnosed with an L4 bipedicular dissociation fracture. The patient underwent L4 IVF surgery, gained ambulation the next day, and was discharged home. An 11-month follow-up was uneventful.

Patient 5

An 88-year-old man in need of nursing, having dementia, fell at home and was diagnosed with an L4 bipedicular dissociation fracture. The patient underwent L4 IVF surgery and was able to ambulate the following day. He was discharged to a rehabilitation center. Three months follow-up was uneventful.

Patient 6

An 80-year-old independent man fell from a 3-m ladder and was diagnosed with an L2 bipedicular dissociation fracture. The patient underwent L2 IVF surgery, was able to ambulate the following day, and was discharged home. Three months follow-up was uneventful.

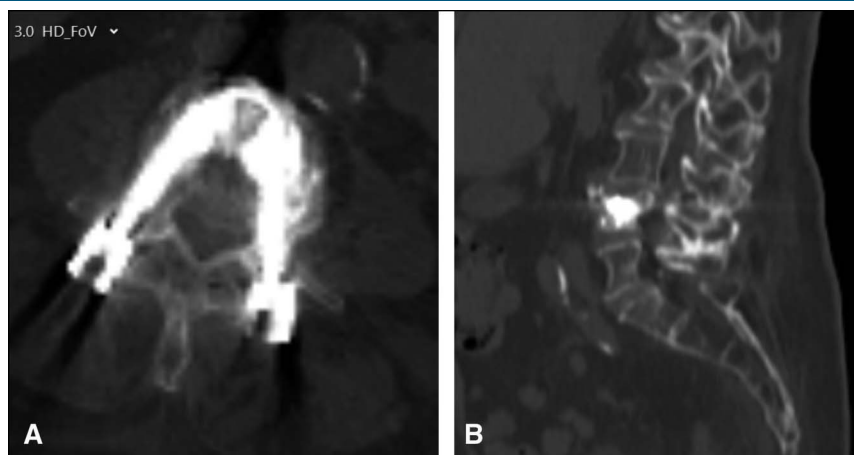
Discussion

Motion sparing has been a notable issue in spine surgery, from noninstrumented surgeries to short-segment fixations and disk replacement surgeries.²⁶⁻²⁸ The proposed IVF technique is the most motion-preserving option for treating pedicular coronal plane dissociation with or without burst fractures. As previously published

Table 1. Patient Characteristics

Patient No.	Sex	Age	Fractured Vertebra	Mechanism	Pre-operative Function	Pre-operative VAS	POD-1 Function	POD-1 VAS	Follow-up
1	F	88	L2	Minor fall	Independent	8	Unlimited	3	48 m
2	F	80	L4	Minor fall	Independent	10	10 m walk	4	30 m
3	M	72	L3	Minor fall	Independent	10	12 m walk	5	22 m
4	F	88	L4	Minor fall	Bedridden	9	8 m walk	4	11 m
5	M	88	L4	Minor fall	Nursing assistance	10	12 m walk	5	3 m
6	M	80	L2	Fall from a 3 m ladder	Independent	9	20 m walk	4	3 m

POD = post-operative day; VAS = visual analog scale

Figure 4

PET-CT, axial and sagittal images of patient 4 presenting pedicular fracture union and Balloon kyphoplasty (BKP) by two-year follow-up.

in the bipedicular dissociation fracture description study, the posterior fixation of two motion segments surrounding the fracture did not show implant failure or secondary fracture displacement.²⁵

The surgical series presented includes a variety of cases, all with bilateral coronal pedicle dissociation, experiencing notable pain, and functional limitation, attesting to vertebral instability (Table 1). An obvious consideration in these fractures is the posterior vertebral wall fracture, which may carry an increased risk of epidural PMMA extravasation. This concern is not a contraindication for BKP and can be avoided by increased vis-

cosity PMMA injection and vigilant fluoroscopic evaluation of PMMA dispersion. In these cases, the coronal plane pedicle dissociation with preserved posterior column stability, the combination of BKP addressing anterior column reduction and support with a middle column recontraction, and stabilization by transpedicular fixation have the potential to treat all fracture elements without losing motion segments all through a minimally invasive technique. Using the standard 2- or 4-level, percutaneous, posterior, pedicle screw fixation would have resulted in notable spinal motion loss.

Following IVF surgery, all patients returned to ambulation and reported notable pain relief (Table 1). Most patients regained function, which allowed for home discharge, four out of the six patients. We did not encounter implant failure or early or late fracture displacement; patient two sustained a fall 6 months following surgery, with a diagnosed rami pubic fracture, without change to her IVF surgery, suggesting the firm stability of the construct.

The results of this surgical technique cohort are limited by the small cohort's size and the diversity of patients included, although small series are expected because this study deals with a newly published fracture pattern in octogenarians. This study was not preceded by a specific biomechanical study but was developed by integrating previous biomechanical and clinical studies, practices, orthopaedic trauma treatment principles, and surgical expertise. Although this cohort is small, this study suggests a novel, minimally invasive, motion-sparing technique worth considering.

Figure 5

A 22-month postoperative standing radiograph of patient 5 taken during follow-up.

Conclusion

We present a novel surgical concept for stabilizing a newly described complicated vertebral fracture pattern in elderly patients using a minimally invasive, motion-sparing technique. This technique is worth presentation and discussion. IVF is a promising surgical technique and an exciting treatment concept for unique fracture types involving bipedicular coronal dissociation with or without burst fractures. Further studies are required to assess long-term results and possible complications.

References

1. Leucht P, Fischer K, Muhr G, Mueller EJ: Epidemiology of traumatic spine fractures. *Injury* 2009;40:166-172.
2. Tian Y, Zhu Y, Yin B, et al: Age-and gender-specific clinical characteristics of acute adult spine fractures in China. *Int Orthop* 2016;40:347-353.
3. Siebenga J, Leferink VJ, Segers MJ, et al: Treatment of traumatic thoracolumbar spine fractures: A multicenter prospective randomized study of operative versus nonsurgical treatment. *Spine (Phila Pa 1976)* 2006;31:2881-2890.
4. Ni W-F, Huang YX, Chi YL, et al: Percutaneous pedicle screw fixation for neurologic intact thoracolumbar burst fractures. *J Spinal Disord Tech* 2010;23:530-537.
5. Wood K, Bohn D, Mehdor A: Anterior versus posterior treatment of stable thoracolumbar burst fractures without neurologic deficit: A prospective, randomized study. *J Spinal Disord Tech* 2005;18(suppl): S15-S23.
6. Scholl BM, Theiss SM, Kirkpatrick JS: Short segment fixation of thoracolumbar burst fractures. *Orthopedics* 2006;29:703-708.
7. Tezeren G, Kuru I: Posterior fixation of thoracolumbar burst fracture: Short-segment pedicle fixation versus long-segment instrumentation. *J Spinal Disord Tech* 2005;18:485-488.
8. Baaj AA, Reyes PM, Yaqoobi AS, et al: Biomechanical advantage of the index-level pedicle screw in unstable thoracolumbar junction fractures: Presented at the 2010 Joint Spine Section Meeting. *J Neurosurg Spine* 2011;14:192-197.
9. Norton RP, Milne EL, Kaimrajh DN, Eismont FJ, Latta LL, Williams SK: Biomechanical analysis of four-versus six-screw constructs for short-segment pedicle screw and rod instrumentation of unstable thoracolumbar fractures. *Spine J* 2014;24:1734-1739.
10. Wang H, Li C, Liu T, Zhao WD, Zhou Y: Biomechanical efficacy of monoaxial or polyaxial pedicle screw and additional screw insertion at the level of fracture, in lumbar burst fracture: An experimental study. *Indian J Orthop* 2012;46:395-401.
11. Bolesta MJ, Caron T, Chinthakunta SR, Vazifeh PN, Khalil S: Pedicle screw instrumentation of thoracolumbar burst fractures: Biomechanical evaluation of screw configuration with pedicle screws at the level of the fracture. *Int J Spine Surg* 2012;6:200-205.
12. Garfin SR, Buckley RA, Ledlie J: Balloon Kyphoplasty Outcomes Group: Balloon kyphoplasty for symptomatic vertebral body compression fractures results in rapid, significant, and sustained improvements in back pain, function, and quality of life for elderly patients. *Spine* 2006;31: 2213-2220.
13. Lotan R, Haimovich Y, Schorr L, Goldstein AL, Hershkovich O: Double-balloon kyphoplasty results in better radiographic outcomes than a single-balloon kyphoplasty in treating osteoporotic spinal fractures. *J Clin Med* 2022;11:3407.
14. Lieberman I, Dudeney S, Reinhardt MK, Bell G: Initial outcome and efficacy of "kyphoplasty" in the treatment of painful osteoporotic vertebral compression fractures. *Spine* 2001;26:1631-1638.
15. Ledlie JT, Renfro MB: Kyphoplasty treatment of vertebral fractures: 2-year outcomes show sustained benefits. *Spine (Phila Pa 1976)* 2006;31: 57-64.
16. Voggenreiter G: Balloon kyphoplasty is effective in deformity correction of osteoporotic vertebral compression fractures. *Spine (Phila Pa 1976)* 2005;30:2806-2812.
17. Singh AK, Pilgram TK, Gilula LA: Osteoporotic compression fractures: Outcomes after single-versus multiple-level percutaneous vertebroplasty. *Radiology* 2006;238:211-220.
18. Li Y, Qian Y, Shen G, Tang C, Zhong X, He S: Safety and efficacy studies of kyphoplasty, mesh-container-plasty, and pedicle screw fixation plus vertebroplasty for thoracolumbar osteoporotic vertebral burst fractures. *J Orthop Surg Res* 2021;16:434.
19. Korovessis P, Mpountogianni E, Syrimpeis V: Percutaneous pedicle screw fixation plus kyphoplasty for thoracolumbar fractures A2, A3 and B2. *Eur Spine J* 2017;26:1492-1498.
20. Huang D, Ying J, Xu D, et al: Comparison of percutaneous kyphoplasty with or without pedicle screw fixation in osteoporotic thoracolumbar vertebral fractures: A retrospective study. *Dis Markers* 2021;2021:4745853.
21. He D, Wu L, Sheng X, et al: Internal fixation with percutaneous kyphoplasty compared with simple percutaneous kyphoplasty for thoracolumbar burst fractures in elderly patients: A prospective randomized controlled trial. *Eur Spine J* 2013;22:2256-2263.
22. Chen Y, Yin P, Hai Y, Su Q, Yang J: Is osteoporotic thoracolumbar burst fracture a contraindication to percutaneous kyphoplasty? A systematic review. *Pain Physician* 2021;24:E685-E692.
23. Kim WJ, Lee ES, Jeon SH, Yalug I: Correction of osteoporotic fracture deformities with global sagittal imbalance. *Clin Orthop Relat Res* 2006;443: 75-93.
24. Lonergan T, Place H, Taylor P: Acute complications after adult spinal deformity surgery in patients aged 70 years and older. *Clin Spine Surg* 2016;29:314-317.
25. Lotan R, Hershkovich O: A novel bipedicular dissociation fracture pattern of vertebral osteoporotic fractures of the elderly. *J Am Acad Orthop Surg Glob Res Rev* 2024;8:e23.00241.
26. Ohashi M, Bastrom TP, Marks MC, Bartley CE, Newton PO: The benefits of sparing lumbar motion segments in spinal fusion for adolescent idiopathic scoliosis are evident at 10 years postoperatively. *Spine* 2020;45: 755-763.
27. Ahmad A, Yazan I, Devan O H, Abdul Z, Scott M: The lateral approach in lumbar total disc replacement: A literature review. *Int J Spine Res* 2021; 3:004-010.
28. Alander DH, Cui S: Percutaneous pedicle screw stabilization: Surgical technique, fracture reduction, and review of current spine trauma applications. *J Am Acad Orthop Surg* 2018;26:231-240.