Vertebral body spread in thoracolumbar burst fractures can predict posterior construct failure

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Clinical Study

Vertebral body spread in thoracolumbar burst fractures can predict posterior construct failure

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Abstract

BACKGROUND CONTEXT: The load sharing classification (LSC) laid foundations for a scoring system able to indicate which thoracolumbar fractures, after short-segment posterior-only fixations, would need longer instrumentations or additional anterior supports.

PURPOSE: We analyzed surgically treated thoracolumbar fractures, quantifying the vertebral body's fragment displacement with the aim of identifying a new parameter that could predict the posterior-only construct failure.

STUDY DESIGN: This is a retrospective cohort study from a single institution.

PATIENT SAMPLE: One hundred twenty-one consecutive patients were surgically treated for thoracolumbar burst fractures.

OUTCOME MEASURES: Grade of kyphosis correction (GKC) expressed radiological outcome; Oswestry Disability Index and visual analog scale were considered.

METHODS: One hundred twenty-one consecutive patients who underwent posterior fixation for unstable thoracolumbar burst fractures were retrospectively evaluated clinically and radiologically. Supplementary anterior fixations were performed in 34 cases with posterior instrumentation failure, determined on clinic-radiological evidence or symptomatic loss of kyphosis correction. Segmental kyphosis angle and GKC were calculated according to the Cobb method. The displacement of fracture fragments was obtained from the mean of the adjacent end plate areas subtracted from the area enclosed by the maximum contour of vertebral fragmentation. The "spread" was derived from the ratio between this subtraction and the mean of the adjacent end plate areas. Analysis of variance, Mann-Whitney, and receiver operating characteristic were performed for statistical analysis. The authors report no conflict of interest concerning the materials or methods used in the present study or the findings specified in this paper. No funds or grants have been received for the present study.

RESULTS: The spread revealed to be a helpful quantitative measurement of vertebral body fragment displacement, easily reproducible with the current computed tomography (CT) imaging technologies. There were no failures of posterior fixations with preoperative spreads <42% and losses of correction (LOC)<10°, whereas spreads >62.7% required supplementary anterior supports whenever LOC>10° were recorded. Most of the patients in a "gray zone," with spreads between 42% and 62.7%, needed additional anterior supports because of clinical-radiological evidence of impending mechanical failures, which developed independently from the GKC. Preoperative kyphosis (p<.001),

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load sharing score (p=.002), and spread (p<.001) significantly affected the final surgical treatment (posterior or circumferential).

CONCLUSIONS: Twenty-two years after the LSC, both improvements in spinal stabilization systems and software imaging innovations have modified surgical concepts and approach on spinal trauma care. Spread was found to be an additional tool that could help in predicting the posterior construct failure, providing an objective preoperative indicator, easily reproducible with the modern viewers for CT images.

Keywords: Anterior support; Burst fracture; Circumferential fixation; CT scan; Mechanical failure; Spine trauma; Spread; Thoracolumbar

Introduction

Vertebral body burst fractures represent 10%–20% of all spinal fractures, accounting for more than 50% of those involving the thoracolumbar segment. Their management still remains a controversial topic [1]. The surgical treatment aims to protect or recover neurologic function, to correct local deformity, to obtain the most stable fixation limiting the number of instrumented motion segments, and to allow rapid mobilization [2–5]. The selection of the most appropriate surgical approach, particularly with evidence of neurologic signs, severe anterior column destruction, and a high-grade segmental kyphosis, still represents a matter of debate [6]. Likewise, the loss of postoperative kyphosis correction and its expected correlation with clinical outcome is still a topic of discussion among surgeons [7]. However, both loss of reduction and mechanical failure of posterior fixations have been correlated with the degree of comminution of the fractured vertebral body [8].

The load sharing classification (LSC) adopts a scoring system able to predict in which fractures posterior-only instrumentations are more prone to fail [3,9], identifying those injuries needing a longer fixation or an anterior column support [10].

We experienced premature failures of posterior thoracolumbar fixations, whenever an initial severe kyphosis, an extreme vertebral body fragmentation, together with vacuum disc and bone resorption, were encountered [6,8,11]. We therefore retrospectively analyzed computer tomography (CT) scans of those cases presenting an early failure of the posterior instrumentation. Comparing these cases with those in which a posterior short-segment fixation resulted adequate, we were able to predict the posterior construct failure and therefore identify a potential radiological indicator that could preoperatively support the surgical planning.

Materials and methods

Study population

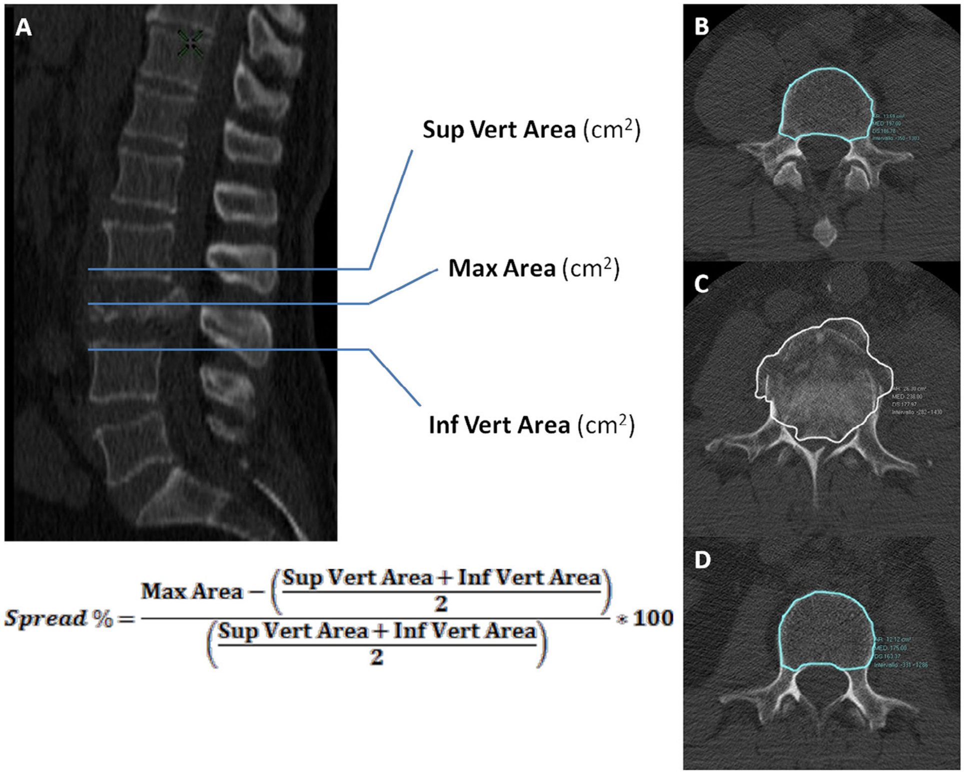
From January 2008 through December 2014, 121 consecutive cases treated for traumatic unstable thoracolumbar spine fractures were included in this retrospective analysis. The institutional ethics committee approved the study. Inclusion criteria required the presence of a single-level burst fracture from T10 to L2, with or without posterior ligament disruption, neurologic deficit, and extraspinal fractures. Patients with pathologic fractures, previous spine surgery, and active infectious disease were excluded from the study. All of the enrolled patients underwent a baseline CT evaluation at the hospital admission, a CT between 1 and 2 months after surgery, or whenever a complication occurred. During postoperative follow-up, orthostatic x-ray images were taken within 60 days and then annually to evaluate the stability of kyphosis correction over time. Functional outcome was evaluated through the Oswestry Disability Index 12 months postoperatively in the 108 patients available at that follow-up time. Disability was classified as minimal (0%–30%), moderate (31%–50%), and severe (51%-100%). Pain was assessed using a visual analog scale at 6 and 12 months after surgery in 119 and 108 patients, respectively.

AO Spine classification and radiological evaluation

Computed tomography scans of the spine were performed using a clinical multidetector scanner (Philips Center, Amsterdam, The Netherlands). Images always contained multiplanar reconstructions with a thickness of 1.5 mm, which were systematically reviewed by two operators (GL, MC), in single-blind fashion, to classify each fracture according to the AO Spine classification and the LSC. Pre- and postprocedural segmental kyphosis were calculated on CT spine images according to the Cobb method, tracing the angle enclosed by a line drawn parallel to the inferior end plate of the intact vertebra above and a line parallel to superior end plate of the intact vertebra below the fractured one. Cobb angle, recalculated on images acquired at the admission and 12 months after the decisive posterior-only or two-step circumferential procedure, provided the degree of kyphosis correction named "grade of kyphosis correction" (GKC).

Spread calculation

The baseline axial CT slice showing the most extensive destruction and fragmentation of the vertebral body was selected. The spread was calculated in single blinding using local RIS/PACS platform (Carestream Health, Inc, Rochester, NY, USA, Version 11.4.1.1102) by contouring the largest area inscribed in the scattered fragments of the



$$\textit{Spread}\,\% = \frac{\text{Max Area} - \left(\frac{\text{Sup Vert Area} + \text{Inf Vert Area}}{2}\right)}{\left(\frac{\text{Sup Vert Area} + \text{Inf Vert Area}}{2}\right)} * 100$$

Fig. 1. Spread quantification method: (A) Sagittal computed tomography (CT) image of the thoracolumbar spine with bone window showing a fracture of the L3. (B) Axial CT image of the same patient at the level of L2 showing the semiautomatic contouring of the superior vertebral area (blue line). (C) Axial CT image at the level of maximum spread area which is semiautomatically contoured (white line). (D) Axial CT image at the level of L4 showing the semiautomatic contouring of the inferior vertebral area (blue line).

fractured vertebral body (*Max Area*). The same delimitation was made contouring the inferior end plate of the vertebra above (*Sup Vert Area*) and the superior end plate of the vertebra below (*Inf Vert Area*). The mean of these two areas was subtracted from the *Max Area*. The spread, which indicates the percentage of displacement, was derived from the ratio between this subtraction and the mean of the adjacent end plate areas (Fig. 1). Lin's correlation concordance coefficient was performed to assess the agreement between the two operators on spread calculation.

Surgical technique

Surgery was performed within 8 hours after trauma in patients neurologically compromised and within 3 days in patients without neurologic deficits. One hundred twenty-one patients underwent posterior pedicle screw fixation and 34 of them needed an additional anterior support through anterolateral retroperitoneal or thoracotomy approach 1–2 months after posterior fixation or whenever a mechanical failure occurred. Laminectomy was performed in patients suffering from neurologic impairment due to spinal cord compression and laminar bone chips were exploited for posterolateral fusion. When needed, indirect canal decompression by ligamentotaxis was performed. Short segment fixations one above-one below with monoaxial screws were favored whenever a mild vertebral body fragmentation and a segmental kyphosis<5° were recorded, whereas in the other cases, two above-one below implants with polyaxial screws were chosen. Screws with diameters of 5.5 and 6.5 mm, respectively, for thoracic and lumbar vertebrae, and a length of 35 to 55 mm were used, preferring constructs with tulip heads and rods in cobalt-chrome alloy. No pedicle screws were introduced in the fractured vertebral body, nor transpedicular augmentations were performed. Postoperative bracing was not recommended. Additional anterior approaches plus posterior screw-rod revisions were always performed as soon as possible in case of breakdown of instrumentation. Anterior column reconstructions were generally needed 2 to 4 months after the posterior fixation in those patients showing signs of impending mechanical failure such as vertebral body's cancellous bone resorption, vacuum disc, progressive kyphosis without posterior ligament disruption, weight-bearing pain, screws or rod bending, screw loosening. An additional plate was implanted in those patients operated anteriorly as a consequence of a posterior fixation loosen or broken. Left-sided mini-open retroperitoneal laparotomy and mini-open retropleural thoracotomy were, respectively, performed for L2 and T10–L1 fractures. The support was usually provided by a hollow expandable titanium cage filled with autologous bone chips.

Statistical analysis

Statistical analyses were performed with MedCalc, version 15.4 (MedCalc bvba 1993-2015, Ostend, Belgium). Qualitative variables were expressed as number of cases (percentages), whereas quantitative variables were expressed as median and interquartile range or minimum and maximum values whether appropriate. For preoperative kyphosis, load sharing score (LSS), and spread, the Mann-Whitney test and the analysis of variance were adopted to identify factors affecting surgery. Spearman rank correlation was used to analyze nonparametric variables. The GKC correlated with the posterior fixations with or without the additional anterior approach was analyzed with the analysis of variance. The role of the different factors to address surgery toward the most appropriate strategy of spinal realignment was investigated with a logistic regression model: receiver operating characteristic (ROC) curves and area under curve (AUC) [95% CI] were displayed for the most significant results.

Results

All of the 121 patients (79 male and 42 female) with thoracolumbar fractures underwent posterior screw-rod–based fixations, but 34 of them needed an additional anterior approach because of an impending or true posterior instrumentation failure. The mean age of these latter was 41.5 years, whereas the group who took advantage of a posterior-only fixation revealed a mean age of 51.2 years (*t* test, p=.004) (Table 1). The median follow-up was 46 months (min-max: 20–104 months), with 13 patients lost and 108 available for 12 months follow-up.

AO classification and kyphosis

The majority of traumas (n=63 of 121) involved the first lumbar vertebra. A complete burst fracture (A4) was recorded in 53% of patients who required an additional anterior support, but only in 24.4% of patients who underwent a posterior-only procedure (chi-square test, p=.002). The median preoperative kyphosis in the group who underwent posterior-only procedures was 6° (95% CI 3°–9.1°), whereas that of the group requiring a secondary anterior approach as consequence of a posterior mechanical failure was 18° (95% CI 15°–20.7°) (U=537.5, p<.0001) (Table 2). A significant effect of preoperative kyphosis on the final surgical treatment (posterior vs posterior plus anterior) was noted (F[1,118]=42.442, p<.001).

Table 1
Clinical features of the 121 patients who underwent surgical treatment for thoracolumbar burst fractures

Characteristic		n=121
Age, median (range)		48 y (43.2–52 y)
Male:Female (%)		n=79:42 (65.3%:34.7%)
Osteoporosis risk (%)		n=25 (20.7%)
Body mass index	<18.5	n=4 (3.3%)
	18.5–24.9	n=51 (42.1%)
	25–29.9	n=55 (45.5%)
	>30	n=11 (9.1%)
Type of fracture/AO Spine classification (number of patients)		A3=68 A4=53
Preoperative kyphosis, median (min-max)		10° (0°–34°)
LSS, median (min-max)		6 (3–9)

Table 2
Differences in terms of preoperative kyphosis, LSS, and spread between patients who underwent posterior-only fixation and those who needed an additional anterior support (Mann-Whitney, CI: confidential interval 95%)

	Posterior approach	Posterior+Anterior approach	p
Preoperative kyphosis, median (CI)	6° (3°–9.1°)	18° (15°–20.7°)	<.0001
LSS, median (CI)	6 (5–7)	7 (6–8)	.003
Spread, median (CI)	42% (37.4%–47.6%)	62.7% (54.2%–86%)	<.0001

LSS, load sharing score.

LSS and spread

Among patients who needed an additional anterior support after posterior construct loosening or breakage, 82.4% had an LSS≥6. No circumferential fixations with an LSS<5 were recorded. The median LSS in posterior-only and posterior plus anterior fixations was 6 (95% CI 5–7) and 7 (95% CI 6–8) (U=942, p=.003), respectively, with a significant effect of the LSS on the different surgical treatments (posterior vs posterior plus anterior) (F[1,118]=10.083, p=.002). The median spread was 48.6% with higher percentages in fractures of L1 and L2. The spread distribution in the fractures treated with posterior-only approaches and in those that needed an additional anterior support considerably differed (U=534, p<.0001) (Table 2) with spread being significant if it would have been considered as an indicator of posterior construct inadequacy, thus suggesting one-step circumferential fixation (F[1,118]=48.96, p=<.001). The intraobserver and interobserver Cohen kappa for the LSS were >0.8 and >0.61, respectively, whereas the Lin's coefficient for the spread showed a correlation of 0.99, indicating a good reproducibility and reliability.

Radiological outcome (GKC)

Whenever the anterior approach became necessary, this additional support ensured a median GKC of 13° (95% CI 9.8°–14.1°) instead of the 8° (95% CI 6°–9°) obtained with screw-rod fixations (U=884, p=.0006), thus revealing the circumferential fixation as a key determinant of the GKC (F[1,118]=10.858, p=.001). According to GKC distribution (Fig. 2), different trends were deduced: the posterior-only fixation revealed sufficient in fractures with an LSS≤5 and a spread percentage <42% (Fig. 3), whereas LSS=9 and spreads >62.7% required an additional anterior support for posterior construct failures in 100% of cases (Fig. 4). A "gray zone"

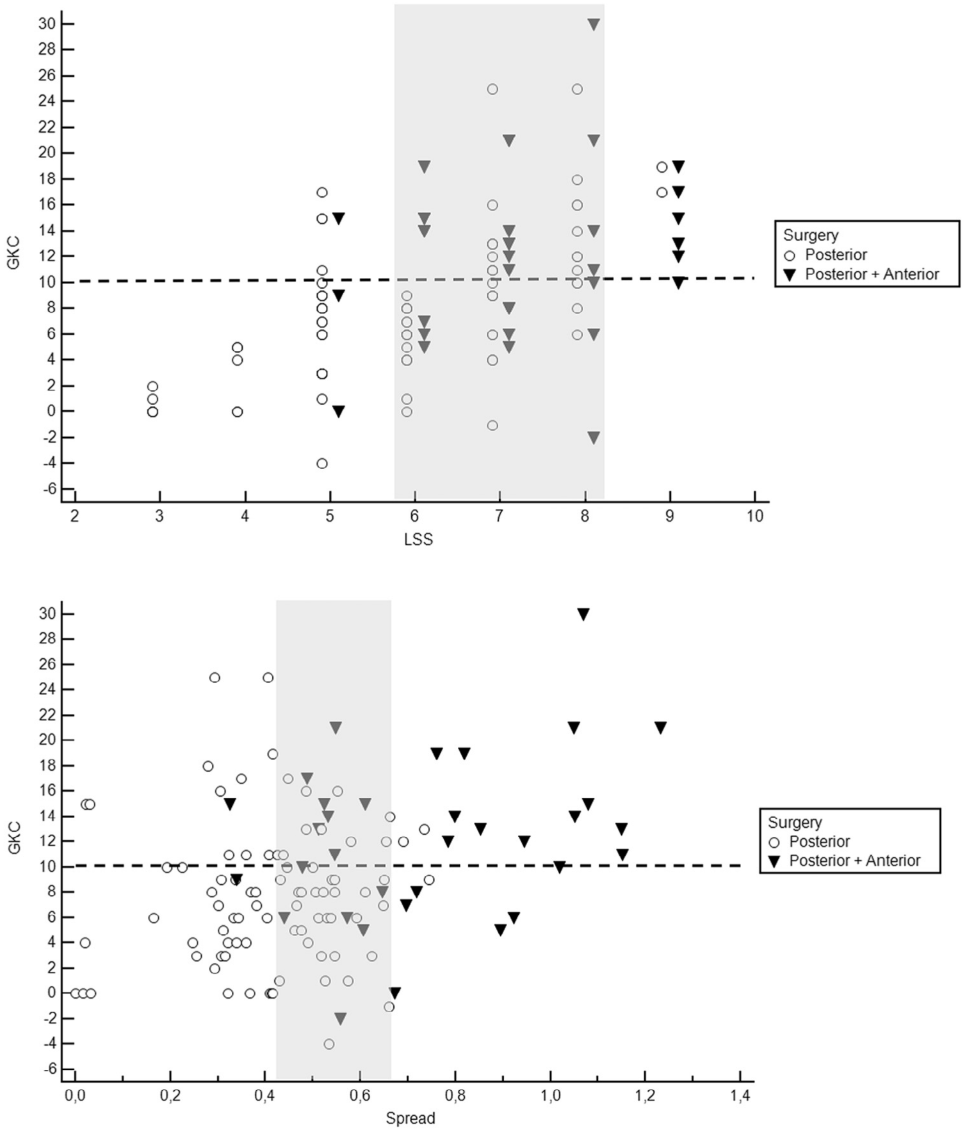


Fig. 2. Grade of kyphosis correction (GKC) distribution in posterior-only and posterior plus anterior fixations in relation to load sharing score (LSS) and spread.

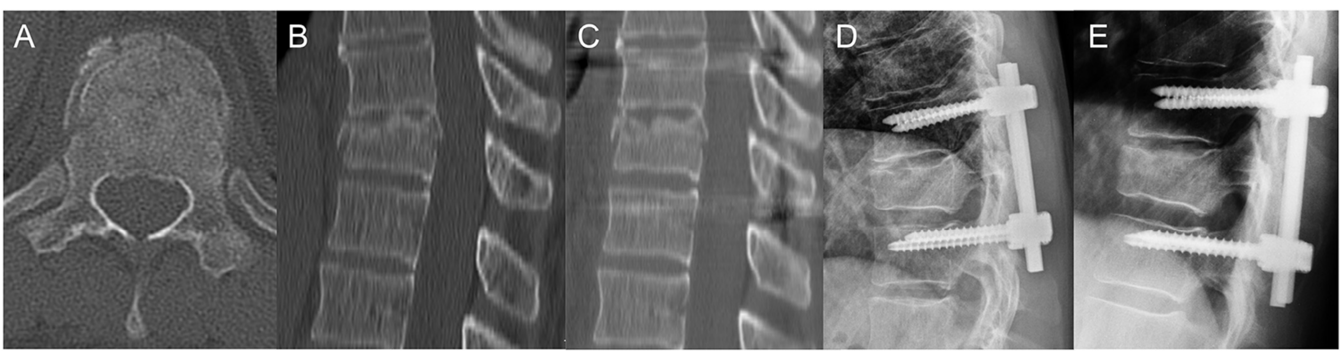


Fig. 3. Spread <40%: 43-year-old male patient with T12 burst fracture (A3) showing a spread of 35%; preoperative computed tomography (CT) scan (A,B), postoperative CT scan (C), and standing x-ray 2 months (D) and 12 months (E) after surgery with preserved correction of sagittal alignment.

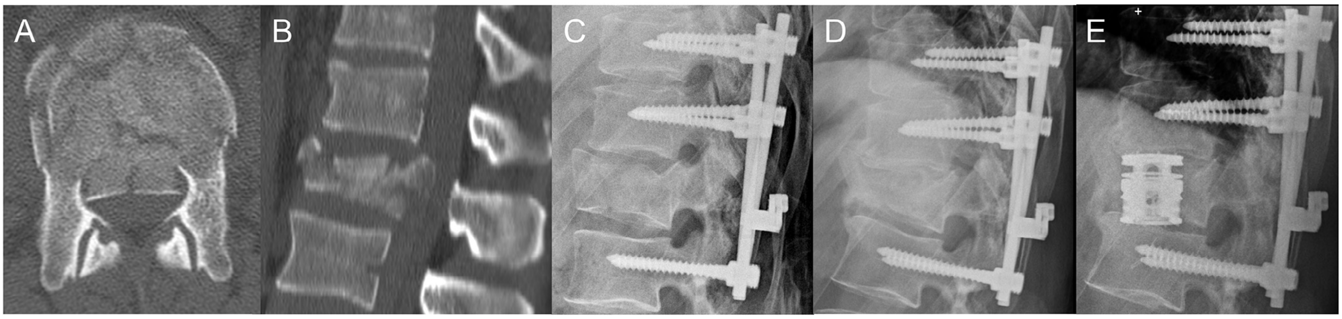


Fig. 4. Spread >60%: 39-year-old male patient with T12 burst fracture (A4) showing a spread of 68%; preoperative computed tomography (CT) scan (A,B); postoperative standing x-ray 1 month (C) and almost 2 months after surgery (D) with these latter showing a mechanical failure with bending rods and symptomatic segmental kyphosis; postoperative standing x-ray (E) 1 month after the rescue anterior procedure with positioning of an expandable cage.

came out from those fractures showing an LSS between 6 and 8 and spread between 42% and 62.7%. Most of the patients in the gray zone underwent additional anterior approach for evidence of true or impending mechanical weakness or whenever a symptomatic loss of kyphosis correction ≥10° was noted after the screw or rod fixation. More specifically, although posterior instrumentation failures with LSS between 6 and 8 were associated with heterogeneous fixation strengths, in the 42%–62.7% range of spread, the vast majority of impending mechanical failures was related to progressive symptomatic kyphosis frequently associated with vacuum discs, screw loosening, and vertebral body's cancellous bone resorptions (Fig. 5). Thanks to timely additional anterior procedures, no variability in terms of effectiveness of surgery and maintenance of GKC was noted, comparing single- and two-step surgeries at 12-month follow-up.

Factors affecting surgery

The analysis on factors affecting surgery showed that preoperative kyphosis (OR 1.18 [1.09–1.28]; $p<.0001$), LSS (OR 0.81 [0.53–1.25]; $p=.3$), and spread (OR 4808.83 [70.09–329926.88]; $p=.0001$) were independently associated to the different surgical treatments. Both groups of patients presented a satisfactory preservation of GKC at 12-month follow-up. Comparison of ROC curves between preoperative kyphosis, LSS, and spread was performed (preoperative kyphosis AUC 0.81 [CI 95% 0.73–0.87]; LSS AUC 0.67 [0.58–0.75] and spread AUC 0.81 [CI 95% 0.73–0.87]), with spread emerging as a useful additional tool that is able to suggest when posterior-only implants are more prone to fail (Fig. 6).

Functional outcome and complications

The Oswestry Disability Index at 12-month follow-up showed 68% of patients had minimal disability, 23% of patients had moderate disability, and 9% had severe disability. In 119 patients available at 6-month follow-up, a mean visual analog scale score of 3 was noted, whereas an average score of 2 was recorded for 108 patients followed up 12 months after surgery. No significant differences were found whether patients underwent posterior-only or posterior plus anterior fixation. No major perioperative complications were observed on the posterior approach apart from two surgical wound revisions for superficial infection and one screw malpositioning without neurological injury. Three failures of abdominal wall not requiring further surgery and with uneventful clinical course were reported after the anterior approach. Three cage subsidence during its expansion required additional plating without compromising the final result.

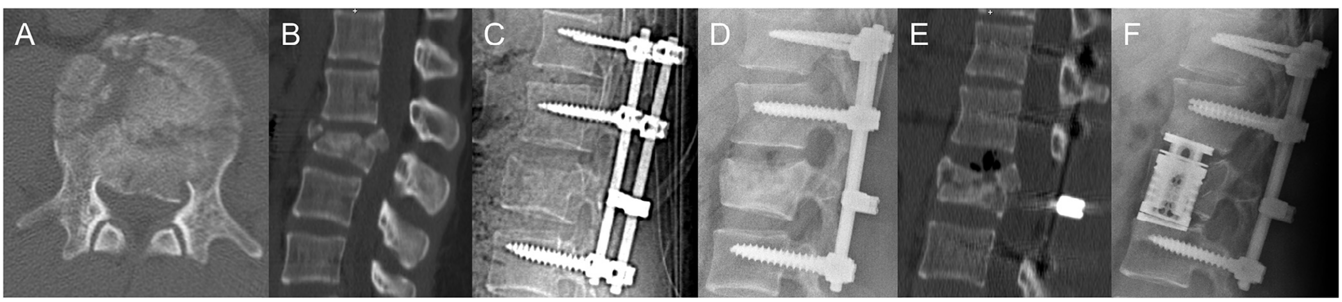


Fig. 5. Spread 40%–60%: 31-year-old male patient with L1 burst fracture (A3) showing a spread of 54%; preoperative computed tomography (CT) scan (A,B); postoperative CT scan scout view 1 month after surgery (C); standing x-ray (D) and CT scan (E) showing cancellous bone resorption and vacuum disc 2 months after surgery with patient suffering from intense dynamic back pain; postoperative standing x-ray (F) 1 month after the supplemental anterior procedure through positioning an expandable cage.

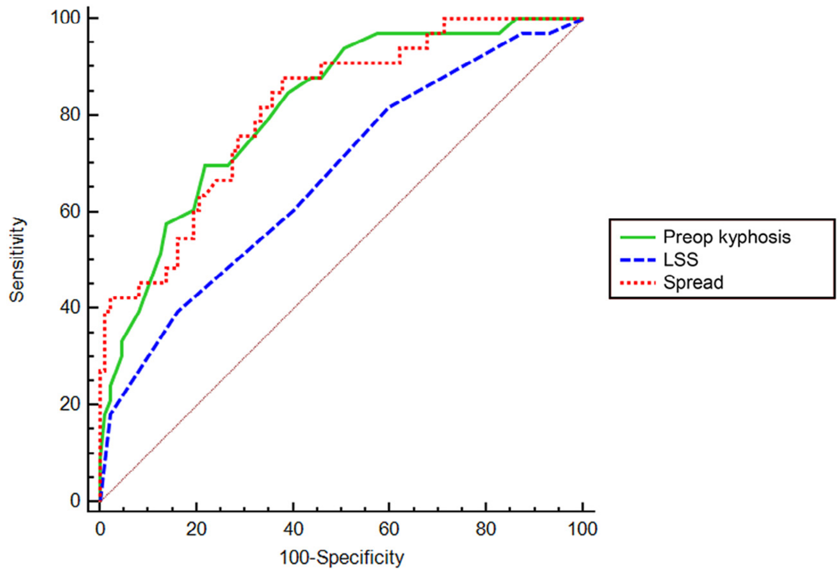


Fig. 6. Factors affecting surgery: comparison of receiver operating characteristic (ROC) curves between preoperative kyphosis, load sharing score (LSS), and spread.

After the anterior approach, no infections occurred, and no revision surgeries were required.

Discussion

In the latest AO classification system, the simplification of thoracolumbar burst fractures from three types (A3.1, A3.2, A3.3) to two types (A3, A4) has highlighted the load-bearing capacity of the vertebral body but has lowered the emphasis on fragmentation [12]. When evaluating the risk of posterior fixation failure, the vertebral body morphology still plays a crucial role and it should be considered in terms of "apposition/displacement of fragments" as valued in the LSC [9]. The TLICS classification by its part revealed a major limitation not differentiating thoracolumbar burst fractures between complete or incomplete [13,14]. In this scoring system, the PLC integrity is pivotal to estimate spine instability representing a strong prognostic factor whenever a conservative treatment is considered but, while such evaluation strengthens indications for posterior fixations, its capacity in suggesting posterior fixation failure needing an additional anterior approach drops down. Nonetheless, after posterior fixation, the posterior tension band is restored, thus the need for an additional anterior column reconstruction could not depend on the PLC condition anymore. The vertebral body fragment displacement instead expresses both ability of the anterior column to transfer load and fracture healing attitude [9]. Starting from the assumption that the wider the fracture fragments are displaced, the more poorly they transmit load, we found the spread to be a useful additional tool that could provide an objective quantification of displacement degree. Differently from LSC, through the spread contouring, the dislocation of each single fragment contributes to the final result, which is therefore extrapolated from 100% of the cross-sectional area and normalized with the cross-sectional areas of the adjacent intact end plates. Although the LSC has been validated through biomechanical studies, it does not seem to be predictive of posterior instrumentation failure [15]. Despite a controversial interobserver reliability with a debated consistency in assigning an LSS>6 [10,16,17] and a learning curve to obtain trustworthy determinations of the amount of vertebral body comminution, the LSS still counts as an irreplaceable post-surgical assessment tool [17]. Nevertheless, inappropriate applications of the LSC are increasingly encountered in the literature, characterized by pretreatment LSS, not knowing the real kyphosis correction and presuming a perfect match between the surgical planning and the true post-treatment angular correction [13,18–20]. Finally, two of the three parameters used for the LSC are not quantitative and their calculation completely relies on the examiner opinion. On these grounds, looking for elements aiding in defining instability, able to predict the risk of posterior construct failure, and driving the surgical indication, we found the quantification of the vertebral body spread as a useful tool in line with imaging innovations of our times. The switching from the LSC "apposition of fragments," based on an estimation on CT axial images, to the value obtained from spread calculation, results as a sort of LSC updating to the contemporary multidetector computed tomography technology and software imaging, which respectively provides images reconstructed at narrow intervals and new measurement tools [21]. Current indications for anterior surgery, although widely accepted, do not highlight the importance of burst fractures' morphology when considering combined strategies [22]. According to other authors, we observed that radiological outcomes are affected by localization, fracture type, and, in our study sample, spread percentage [23]. Screws at the level of the fracture and vertebral body filling techniques have been proposed to prevent implant failures avoiding anterior surgeries [23,24]. Few evidence and no comparative studies support their safety and effectiveness with LSS≥7 and severe kyphosis [14]. In these cases, instead, the more a burst fracture reveals fragmentation, with spread percentages >62.7%, the more a circumferential approach should be considered from the onset [25]. In the most debatable cases with symptomatic fast developing loss of correction, prevalently distributed in the spread's "gray zone" (42%–62.7%), the choice of an additional anterior support was further corroborated by evidence of impending mechanical incompetence of the posterior fixation at the short-term follow-up [26]. Circumferential fixations could account for better radiological outcomes as well as greater clinical results in 5–8 year follow-up [27]. Together with the LSC, the spread could predict the mechanical failure of posterior short segment fixations, being even helpful in suggesting when a posterior-only approach may be sufficient. Differently from the LSC, the spread provides information on the base of the first preoperative CT, and supplies values easy to calculate (with the aim of modern CT viewers) with low interobserver-related biases, being extrapolated through a software-assisted procedure. The evaluation of the grade of kyphosis correction and the spread area revealed both crucial in defining the specific surgical necessity. Receiver operating characteristic curves showed that spread is sensitive and specific in identifying patients most at risk of posterior instrumentation failure, thus demonstrating that a strictly numeric assessment of the vertebral body fragments distribution might be favored.

Study limitations

The present study is limited by a relatively small sample size, a short radiological follow-up, and the lack of a comparative group whose second step surgery was planned relying on the LSC. The relatively small number of posterior plus anterior fixations represents another limitation. On the contrary, the strength of the present study lies in the homogeneous population of thoracolumbar burst fractures, in the anterior support provided always with titanium expandable cages, and in the easy reproducibility of the spread's calculation.

Conclusions

Indicators supporting the choice of a supplementary procedure during the surgical planning could play a role in the prevention of posterior fixation failures. Twenty-two years after the LSC, both improvements in spinal stabilization systems and software imaging innovations of our times have modified the surgical concepts and approach on spinal trauma care [28]. Spread calculation could be helpful to predict in which fractures a load-bearing support would have to be restored and, by taking in account signs evocative of fast developing kyphosis, the choice of a posterior-only or one-step circumferential fixation could be more rational and timely [29].

Acknowledgments

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References

[1] Dai LY, Jiang LS, Jiang SD. Posterior short-segment fixation with or without fusion for thoracolumbar burst fractures. A five to seven-year prospective randomized study. J Bone Joint Surg Am 2009;91:1033–41.
[2] Jindal N, Sankhala SS, Bachhal V. The role of fusion in the management of burst fractures of the thoracolumbar spine treated by short segment pedicle screw fixation: a prospective randomised trial. J Bone Joint Surg Br 2012;94:1101–6.
[3] Wood KB, Li W, Lebl DR, et al. Management of thoracolumbar spine fractures. Spine J 2014;14:145–64.
[4] Kaneda K, Taneichi H, Abumi K, et al. Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits. J Bone Joint Surg Am 1997;79:69–83.
[5] Haiyun Y, Rui G, Shucai D, et al. Three-column reconstruction through single posterior approach for the treatment of unstable thoracolumbar fracture. Spine 2010;35:E295–302.
[6] Payer M. Unstable burst fractures of the thoraco-lumbar junction: treatment by posterior bisegmental correction/fixation and staged anterior corpectomy and titanium cage implantation. Acta Neurochir (Wien) 2006;148:299–306 discussion.
[7] Weinstein JN, Collalto P, Lehmann TR. Thoracolumbar "burst" fractures treated conservatively: a long-term follow-up. Spine 1988;13:33–8.
[8] Defino HL, Canto FR. Low thoracic and lumbar burst fractures: radiographic and functional outcomes. Eur Spine J 2007;16:1934–43.
[9] McCormack T, Karaikovic E, Gaines RW. The load sharing classification of spine fractures. Spine 1994;19:1741–4.
[10] Radcliff K, Kepler CK, Rubin TA, et al. Does the load-sharing classification predict ligamentous injury, neurological injury, and the need for surgery in patients with thoracolumbar burst fractures? Clinical article. J Neurosurg Spine 2012;16:534–8.
[11] Chou PH, Ma HL, Wang ST, et al. Fusion may not be a necessary procedure for surgically treated burst fractures of the thoracolumbar and lumbar spines: a follow-up of at least ten years. J Bone Joint Surg Am 2014;96:1724–31.
[12] Reinhold M, Audige L, Schnake KJ, et al. AO spine injury classification system: a revision proposal for the thoracic and lumbar spine. Eur Spine J 2013;22:2184–201.
[13] Mattei TA, Hanovnikian J, H Dinh D. Progressive kyphotic deformity in comminuted burst fractures treated non-operatively: the Achilles tendon of the Thoracolumbar Injury Classification and Severity Score (TLICS). Eur Spine J 2014;23:2255–62.
[14] Vaccaro AR, Lehman RA Jr, Hurlbert RJ, et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status. Spine 2005;30:2325–33.
[15] Scholl BM, Theiss SM, Kirkpatrick JS. Short segment fixation of thoracolumbar burst fractures. Orthopedics 2006;29:703–8.
[16] Dai LY, Jiang LS, Jiang SD. Conservative treatment of thoracolumbar burst fractures: a long-term follow-up results with special reference to the load sharing classification. Spine 2008;33:2536–44.
[17] Dai LY, Jin WJ. Interobserver and intraobserver reliability in the load sharing classification of the assessment of thoracolumbar burst fractures. Spine 2005;30:354–8.
[18] Dai LY, Jiang LS, Jiang SD. Anterior-only stabilization using plating with bone structural autograft versus titanium mesh cages for two- or three-column thoracolumbar burst fractures: a prospective randomized study. Spine 2009;34:1429–35.

[19] Machino M, Yukawa Y, Ito K, et al. The complement of the load-sharing classification for the thoracolumbar injury classification system in managing thoracolumbar burst fractures. J Orthop Sci 2013;18:81–6.

[20] Parker JW, Lane JR, Karaikovic EE, et al. Successful short-segment instrumentation and fusion for thoracolumbar spine fractures: a consecutive 41/2-year series. Spine 2000;25:1157–70.

[21] Pizones J, Castillo E. Assessment of acute thoracolumbar fractures: challenges in multidetector computed tomography and added value of emergency MRI. Semin Musculoskelet Radiol 2013;17:389–95.

[22] Shawky A, Al-Sabrout AM, El-Meshtawy M, et al. Thoracoscopically assisted corpectomy and percutaneous transpedicular instrumentation in management of burst thoracic and thoracolumbar fractures. Eur Spine J 2013;22:2211–18.

[23] Altay M, Ozkurt B, Aktekin CN, et al. Treatment of unstable thoracolumbar junction burst fractures with short- or long-segment posterior fixation in Magerl type a fractures. Eur Spine J 2007;16:1145–55.

[24] Knop C, Kranabetter T, Reinhold M, et al. Combined posterior-anterior stabilisation of thoracolumbar injuries utilising a vertebral body replacing implant. Eur Spine J 2009;18:949–63.

[25] Hitchon PW, Torner J, Eichholz KM, et al. Comparison of anterolateral and posterior approaches in the management of thoracolumbar burst fractures. J Neurosurg Spine 2006;5:117–25.

[26] Xu GJ, Li ZJ, Ma JX, et al. Anterior versus posterior approach for treatment of thoracolumbar burst fractures: a meta-analysis. Eur Spine J 2013;22:2176–83.

[27] Soultanis KC, Mavrogenis AF, Starantzis KA, et al. When and how to operate on thoracic and lumbar spine fractures? Eur J Orthop Surg Traumatol 2014;24:443–51.

[28] Kanna RM, Shetty AP, Rajasekaran S. Posterior fixation including the fractured vertebra for severe unstable thoracolumbar fractures. Spine J 2015;15:256–64.

[29] Anghel S, Petrisor M, Buicu CF, et al. Predictive factors for postoperative deformity in thoracolumbar burst fractures: a statistical approach. Acta Orthop Traumatol Turc 2015;49:133–8.