International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
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ARTICLE TITLE	MAIN OPERATIVE TREATMENT STRATEGIES FOR FRACTURES OF THE LUMBAR SPINE — A REVIEW OF THE CURRENT LITERATURE
DOI	https://doi.org/10.31435/ijitss.1(49).2026.4683
RECEIVED	21 November 2025
ACCEPTED	15 January 2026
PUBLISHED	23 January 2026
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MAIN OPERATIVE TREATMENT STRATEGIES FOR FRACTURES OF THE LUMBAR SPINE — A REVIEW OF THE CURRENT LITERATURE

Maciej Zachara *(Corresponding Author, Email: macdobzachara@gmail.com)*
Uniwersytecki Szpital Kliniczny im. Fryderyka Chopina w Rzeszowie, Rzeszów, Poland
ORCID ID: 0009-0008-9994-9182

Paulina Dybiak
Szpital Specjalistyczny im. Ludwika Rydygiera w Krakowie sp. z o.o., Kraków, Poland
ORCID ID: 0009-0002-4825-183X

Mateusz Bartoszek
Uniwersytecki Szpital Kliniczny im. Fryderyka Chopina w Rzeszowie, Rzeszów, Poland
ORCID ID: 0000-0003-4354-2566

Patryk Harnicki
Uniwersytecki Szpital Kliniczny im. Fryderyka Chopina w Rzeszowie, Rzeszów, Poland
ORCID ID: 0009-0008-2689-6366

Erwin Grzegorzak
Centrum Medyczne w Łańcucie Sp. z o.o., Łańcut, Poland
ORCID ID: 0009-0004-8720-0503

Oliwia Krawczyk
LUX MED Sp. z o.o., Cracow, Poland
ORCID ID: 0009-0005-7578-0202

Jakub Minas
Wojewódzki Szpital Specjalistyczny nr 4 w Bytomiu, Bytom, Poland
ORCID ID: 0009-0008-6190-5942

Adrian Morawiec
Szpital Specjalistyczny im. Ludwika Rydygiera w Krakowie sp. z o.o., Kraków, Poland
ORCID ID: 0000-0001-7083-7656

Paweł Słoma
Szpital Specjalistyczny im. Ludwika Rydygiera w Krakowie sp. z o.o., Kraków, Poland
ORCID ID: 0000-0002-9856-0553

Rafał Pelczar
Centrum Medyczne w Łańcucie Sp. z o.o., Łańcut, Poland
ORCID ID: 0000-0002-9510-6056

Mikołaj Grodzki
Uniwersytecki Szpital Kliniczny im. Fryderyka Chopina w Rzeszowie, Rzeszów, Poland
ORCID ID: 0009-0003-3368-3119

Weronika Emilia Zubrzycka
5 Wojskowy Szpital Kliniczny z Polikliniką SPZOZ w Krakowie, Kraków, Poland
ORCID ID: 0009-0000-8071-7500

Martyna Biegniewska
Uniwersytet Rzeszowski, Rzeszów, Poland
ORCID ID: 0009-0006-8659-1244

ABSTRACT

Lumbar spine fractures are a clinically significant cause of spinal instability, neurological impairment, and long-term functional disability. While many injuries can be treated conservatively, operative management is frequently required in selected cases. The objective of this narrative review is to summarize and critically analyze current evidence regarding the main surgical strategies used in treatment of lumbar spine fractures, with particular emphasis on indications for surgery, classification systems, and operative techniques.

A narrative review of the literature was performed using the PubMed, Scopus, and Google Scholar databases. Articles published between 2013 and 2024 were screened using predefined keywords related to lumbar spine fractures and operative management. Original research articles, review papers, and clinical guidelines focusing on surgical treatment in adult patients were included.

The reviewed literature indicates that classification systems such as the AO Spine Thoracolumbar Classification and the Thoracolumbar Injury Classification and Severity Score (TLICS) play a big role while guiding the decisions in connection with patient specific factors. Posterior instrumentation remains the most commonly used operative strategy due to its versatility and reliability. Anterior and combined anterior–posterior approaches are reserved for selected complex cases with significant anterior and posterior column compromise, while minimally invasive techniques are increasingly utilized due to decreased complications and morbidity rate.

In conclusion, operative management of lumbar spine fractures should be individualized and guided by fracture morphology, neurological status, and patient-specific factors. Although posterior fixation remains the prime surgical treatment option, evolving techniques continue to refine operative strategies, underscoring the need for further studies.

KEYWORDS

Lumbar Spine Fracture, Surgical Treatment, Spinal Fixation, AO Spine, TLICS

CITATION

Maciej Zachara, Paulina Dybiak, Mateusz Bartoszek, Patryk Harnicki, Erwin Grzegorzak, Oliwia Krawczyk, Jakub Minas, Adrian Morawiec, Paweł Słoma, Rafał Pelczar, Mikołaj Grodzki, Weronika Emilia Zubrzycka, Martyna Biegniewska. (2026) Main Operative Treatment Strategies for Fractures of the Lumbar Spine — a Review of the Current Literature. *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.4683

Introduction:

Lumbar spine fractures today are a significant clinical and socioeconomic problem for clinicians and especially for surgical staff, particularly in the cas of trauma caused by high-energy injuries and the increasing number of pathological fractures among the aging population caused by osteoporosis. These injuries may result from all sorts of vehicle accidents, injuries that are sports related, trauma caused by high falls, or low-energy mechanisms in patients with lowered bone density. Due to the critical role of the spine, especially lumbar spine in load handling and overall mobility, fractures in this region can lead to spinal instability, neurological deficits due to nerve and spinal damage, chronic pain, and long-term disability.

The treatment of lumbar spine fractures remains complex and controversial. While a substantial number of fractures can be treated conservatively using non-operative methods, surgical intervention may be required in some cases if there is a presence of mechanical instability, progressive deformity, neurological damage or possibility of it, or failure of non-operative treatment. Advanced methods in spinal surgery, new imaging methods, and implant technology have significantly expanded the amount of operative strategies available for the treatment of lumbar spine fractures. Nonetheless the topic of optimal surgical strategy in case of lumbar spine fractures is still a subject of multidisciplinary debate and depending on the patient, surgeons experience and availability of technology may differ from case to case.

Several classification systems, such as the AO Spine classification and the Thoracolumbar Injury Classification and Severity Score (TLICS), have been developed and can be used as guidelines in deciding on the optimal method and to make the choice between operative and conservative approach. These methods consist of assessing patients by few key clinical elements including neurological status, fracture pattern, and integrity of the posterior ligamentous complex. Nevertheless, there is still a variability in clinical practice, reflecting differences in interpretation of classification systems, institutional protocols, and evolving evidence.

Operative treatment strategies for lumbar spine fractures include techniques such as anterior reconstruction, posterior instrumentation, combined anterior–posterior approaches, and minimally invasive surgical techniques. Each strategy offers distinctive advantages with respect to biomechanical stability, neural decompression, surgical invasiveness, complication rates, and functional outcomes but each also has its own limitations. Because of that in order to optimize the treatment for patients and to mitigate positive and negative treatment outcomes and morbidity it is crucial to have a comprehensive understanding of these approaches.

The aim of this narrative review is to summarize and analyze the current literature regarding the main operative strategies used to treat the fractures of lumbar spine. Main attention is given to indications for surgery, commonly employed surgical techniques, and reported outcomes, the objective of this approach is to provide an up-to-date overview, to support clinical decision-making and highlight areas requiring further research.

Methodology:

Design of the study: This study was conducted as a narrative review of the literature focusing on operative treatment strategies for lumbar spine fractures. The review aimed to compile current evidence regarding surgical indications, techniques, and outcomes reported in recent publications.

Search Strategy: Data collection was performed by literature search using electronic databases including PubMed, Google Scholar and Scopus. The articles included in the search were published between January 2013 and March 2024. The search was concluded using following keywords and their combinations: *lumbar vertebral fracture*, *thoracolumbar fracture*, *surgical treatment*, *lumbar spine fracture*, *operative management*,, *posterior instrumentation*, *anterior approach*, *spinal fixation* and *minimally invasive spine surgery*. Some publications were also picked manually to identify additional useful studies.

Eligibility Criteria: Studies included were picked to meet the following criteria: (1) original research articles, systematic reviews, narrative reviews, or clinical guidelines; (2) publications written in English; (3) studies involving adult patients with traumatic fractures of the lumbar spine; and (4) articles addressing operative management strategies. Exclusion criteria used while conducting the study (1) case reports, (2) conference abstracts, (3) biomechanical or cadaveric studies without clinical relevance, (4) studies focusing exclusively on conservative treatment strategies, and (5) publications addressing thoracic spine fractures without separate analysis of the lumbar region.

Study Selection and Data Extraction: Titles and abstracts found through the search strategy were screened for relevance. Full-text articles were reviewed to determine if they met the eligibility criteria and could be included. From each of the included studies, data extraction was performed regarding fracture classification, indications for surgery, surgical approach and technique, reported outcomes, and complications.

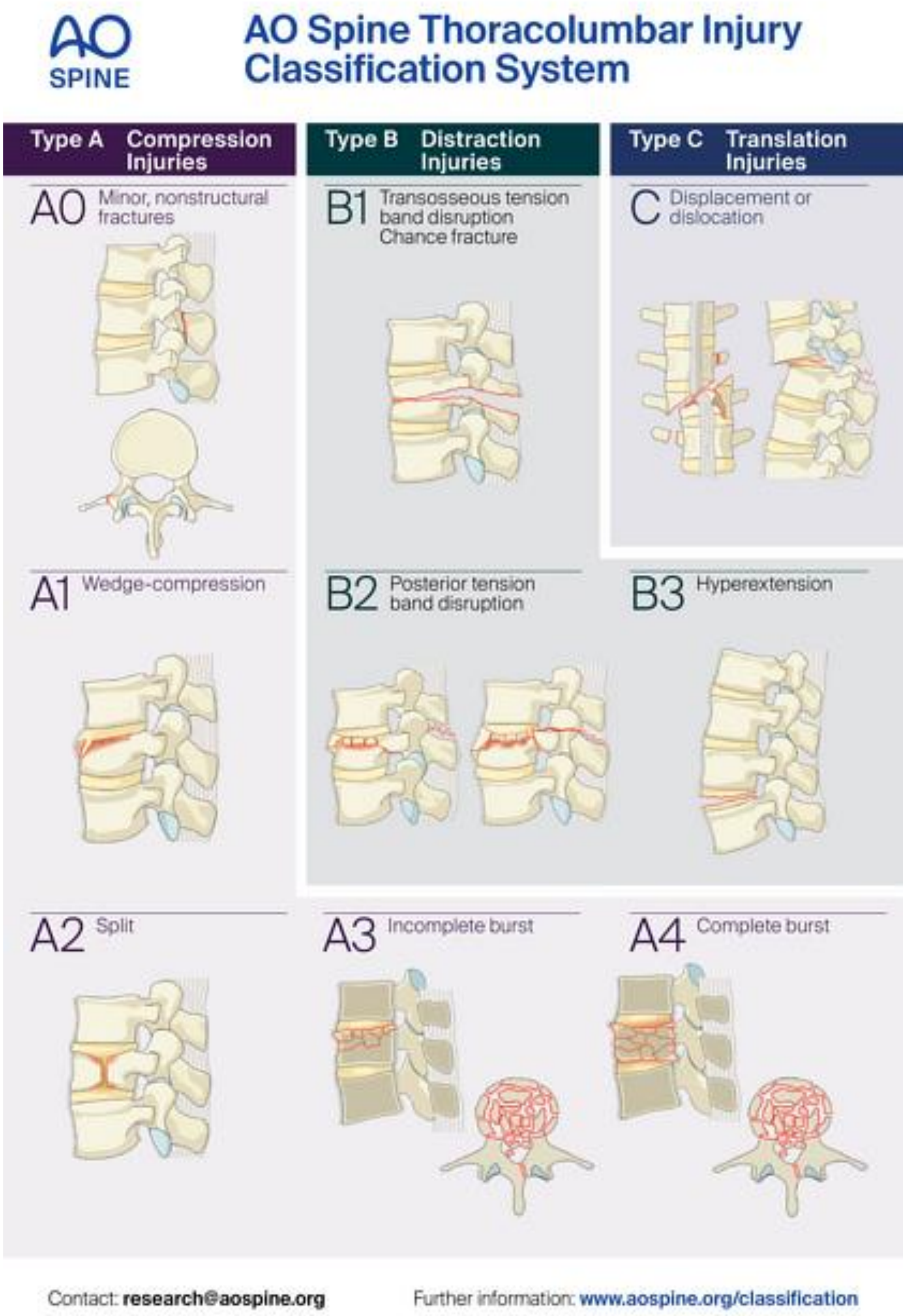
Data combining and analysis: Due to the difference between study designs, sample sizes, populational differences, and outcome measures, literature was synthesized. The findings were organized with emphasis on used operative strategies, their indications, and reported advantages and limitations. Quantitative meta-analysis was not undertaken.

Ethics: As this study was based exclusively on previously published data, ethical approval and informed consent were not required.

Results:

Classification of Lumbar Spine Fractures: According to data collected the proper classification of lumbar spine fractures is essential to assessing injuries and their severity, based in part on the stability of the spine, both dose factors help guide the decision making between choosing operative and non-operative strategies of treatment. There are several classification systems proposed with 2 main ones emerging as most widely used. The aforementioned classifications are: (1) the AO Spine Thoracolumbar Classification and (2) Thoracolumbar Injury Classification and Severity Score (TLICS). This wide spread use makes those 2 classifications as most relevant.

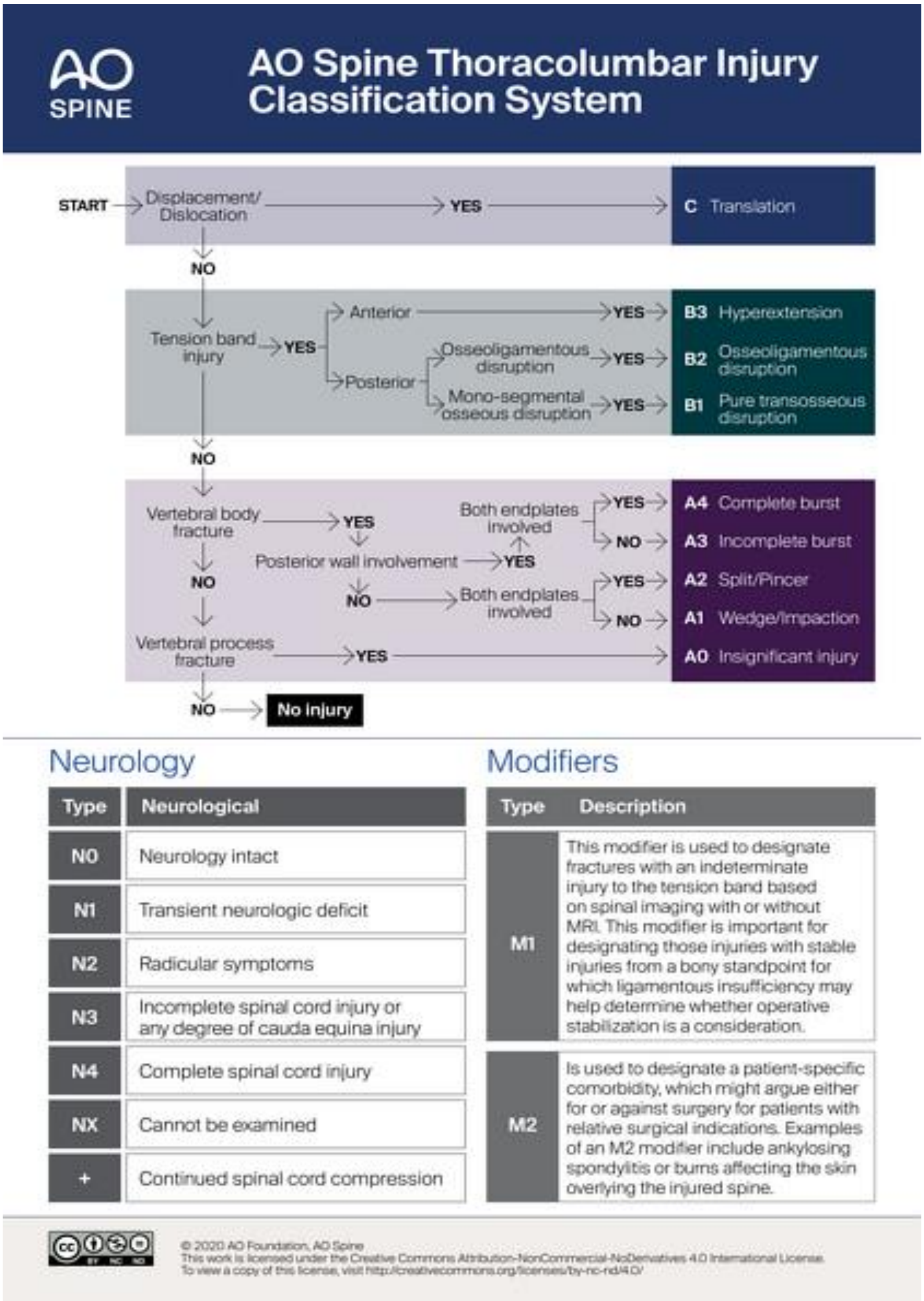
AO Spine Thoracolumbar Classification: The AO Spine Thoracolumbar Classification system uses morphology of an injury with its primary mechanism of spinal column failure for classification. Injuries are divided by 3 main types (A, B, C): type A (compression injuries), type B (tension band injuries), and type C (translational injuries). The table showing the aforementioned categories can be seen below:



AO Spine Thoracolumbar Classification graph 1, https://doi.org/10.53347/rID-92655

Type A fractures consist of the fractures where the anterior column undergoes failure and A category includes minor, nonstructural fractures, wedge compression, split and burst fractures. Type B injuries are characterized by disruption of the transosseous or posterior tension band disruption and hyperextension, these types of injuries typically are a result of flexion–distraction mechanisms. Type C injuries are considered the most severe category involving injuries in mechanism of displacement or dislocation of one vertebral segment relative to another, often associated with multidirectional instability.

The AO spine classification includes not only the morphological classification but also assessment of neurological status and modifiers. Those criteria are listed in the graphic below.



AO Spine Thoracolumbar Classification graph 2, https://doi.org/10.53347/rID-92655

This comprehensive approach enhances its clinical applicability and relevance while considering surgical and non-invasive treatment options. In the context of this study the injuries that are part of type B and C categories, as well as selected unstable type A fractures, are more likely to require surgical stabilization.

Thoracolumbar Injury Classification and Severity Score (TLICS): The TLICS system is based on assigning numerical scores based on 3 classification parameters adhering to 3 injury characteristics: (1) fracture morphology, (2) integrity of posterior ligament complex, (3) neurological status. This system, like AO spine classification, is widely used as part of decision making in lumbar spine injury treatment. There is a point value assigned to each component, and the combined score is used to recommend treatment options.A score of 3 or less generally favors non-operative management, a score of 5 or more supports surgical intervention. A score of 4 represents an intermediate zone in which treatment decisions should be individualized. Below is a simplified version of the point system and resulting treatment recommendations:

TLICS	**3 independent predictors**			
1	**Morphology** immediate stability	- Compression - Burst - Translation/rotation - Distraction	1 2 3 4	- Radiographs - CT
2	**Integrity of PLC** longterm stability	- Intact - Suspected - Injured	0 2 3	- MRI
3	**Neurological status**	- Intact - Nerve root - Complete cord - Incomplete cord - Cauda equina	0 2 2 3 3	- Physical examination
Predicts		- **Need for surgery**	0 – 3 4 > 4	- nonsurgical - surgeon's choice - surgical

TILCS system graph 1 https://radiologyassistant.nl/neuroradiology/spine/tlics-classification

The main argument for using the TLICS system in the decision making process is the fact that it emphasises neurological status and soft tissue integrity which are good prognostics in assessing spinal stability and prognosis. In lumbar spine fractures, high TLICS scores are commonly associated with burst fractures with neurological compromise or flexion–distraction injuries, in those situations we often see a necessity for invasive treatment.

Indications for surgical treatment: The decision of pursuing surgical treatment in patients with lumbar spine fractures guided primarily by the factors that were included in systems listed above which are: spinal instability, neurological impairment, progressive deformity and loss of alignment, failure of noninvasive methods, and the clinical condition of the patient. The algorithms of treatment used today mostly focus on the individual approach to patients using those factors. Therefore it is vital to understand the reasoning and the characteristics of them.

Instability of a spine is one of the most important factors that are considered when making the decision to pursue a surgical treatment. This complex factor relies on accessing the type of the fractures, examples of which are shown in the previous paragraph but also on anterior column support and the state of the posterior ligamentous complex. According to this factor Flexion–distraction injuries and translational injuries that are considered as unstable are most of the times used as absolute indication for operative treatment. This is highly important because failure to restore stability may result in progressive deformity, chronic pain, and delayed neurological deterioration.

Neurological deficit is another indicator used in the decision making process and neurological impairment is considered strong evidence for the need of surgical treatment. Neurological deficits with or without progression related to spinal canal compromise, retropulsed bone fragments, or hematoma often necessitate operative decompression and stabilization. Role of surgery in patients with spine canal compromise without neurological impairment is still debated but many authors advocate performing surgery if the deterioration is imminent or the radiological findings are compliant with clinical symptoms.

Progressive deformity and loss of alignment are additional indications for surgery. Their presence directly negatively affects the functional outcomes and spinal biomechanics. The goal of surgical treatment is to restore the alignment and progression of deformity allowing patients earlier mobilisation and are shown to reduce the risk of long-term disability.

Surgical management may also be considered in cases where non-operative treatments fail in achieving their goals such as: inadequate pain control, not achieving stability, or prolonged time for functional recovery. Persistent mechanical pain, progression of deformity, or delayed neurological symptoms during conservative treatment are signs to reevaluate previous strategy and consider surgical intervention.

Finally it is crucial to consider all the factors relating to the patient such as age, bone density, and chronic diseases. Examples of that may be the need for augmented methods of stabilization in patients with osteoporosis or need for quick mobilization and rehabilitation in polytrauma cases as well as considering risks associated with surgery that may be heightened by chronic diseases.

In summary, indications for operative management of lumbar spine fractures arise from a combination of mechanical, neurological, and clinical considerations. A thorough evaluation using classification systems, in connection with clinical judgment, is essential in decision making between operative and nonoperative methods and choosing optimal surgical treatment options.

At this point it is necessary for us to get into the surgical strategies that may be used to treat lumbar spine fractures. As we previously mentioned the main purpose of operational strategies in lumbar spine fractures is to restore stability, decompress neural elements, fix the alignment. All those factors must be achieved in order for the patient to regain best possible functionality and to start the rehabilitation process if needed. The strategy is based on many factors included in scales listed above and besides deciding if to operate they also can help surgeons in picking appropriate methods of surgery. Contemporary operative strategies can be categorized into few categories such as posterior approaches, anterior approaches, combined anterior–posterior procedures, and minimally invasive techniques.

Posterior approach is performed using pedicle screws and is the most common strategy in stabilization of lumbar spine fractures. This method is considered reliable in achieving stabilization and indirect decompression by using diffraction and also allows to correct the deformity. We need to mention that this operative method allows for different length stabilization with short-segment fixation used commonly in less severe injuries and long-segment fixation used in patients with more severe injuries and lowered bone density. Another advantage of posterior fixation is shorter operative time and reduced number of complications when comparing witch anterior and anterior-posterior approaches altho there are still concerns regarding loss of correction and implant failure in selected cases.

Anterior approaches are mostly used in severe cases associated with severe vertebral body comminution, significant anterior column compromise, or persistent spinal canal encroachment where use of posterior approach may not be sufficient. This approach is viable in this situation because it allows decompression of neural elements directly contrary to indirect decompression in the posterior approach but also allows to reconstruct the natural vertebral body high using cages and structural grafts. Despite these advantages the demanding nature of the approach risks complications and higher mobility limits the use of this method to selected patients.

Combined anterior–posterior stabilization is generally performed in the most complex cases and unstable spine fractures including translational fractures and fractures with substantial damage to both posterior and anterior column. With this strategy it is possible to achieve comprehensive decompression and deformity correction with superior biomechanical stability. Unfortunately as with anterior approaches this type of approach comes with increased invasiveness, longer operation times, increased risk of complications and morbidity, because of that it is strictly reserved for a selective group of patients. In recent years there has been more restriction on this method because of advancements in posterior fixation techniques.

Minimally invasive surgical (MIS) techniques have gained increasing popularity in the treatment of lumbar spine fractures. The aim of these approaches is to reduce the soft tissue damage, pain and blood loss thus decreasing the amount of post operative complications while achieving the same standard of stabilization as classic techniques. Percutaneous pedicle screw fixation and minimally invasive decompression techniques are commonly employed, mostly in cases with neurological intact, and polytrauma patients due to reduced operation times. Although MIS techniques offer several advantages, their applicability may be limited in complex fracture patterns requiring extensive decompression or deformity correction.

Considering all that, we see that there is no universally applicable strategy and the choice of the right one for the patient must be performed according to patient specific factors, surgical expertise and the equipment availability.

Discussion:

This narrative review summarizes current knowledge regarding operative strategies for lumbar spine fractures and highlights the multifactorial nature of the decision-making behind it. The reviewed literature underscores that no single operative approach is universally superior; rather, optimal outcomes depend on appropriate patient selection, accurate fracture classification, and individualized treatment planning.

Classification systems such as the AO Spine Thoracolumbar Classification and the TLICS score play a central role in making clinical decisions. Their creation and widespread use are proof that there is a need for a standardized approach. Nevertheless, variability still exists in this field, this is mostly noticeable in patients with intermediate severity of injuries where fever amount of restricting factors allow for less definitive recommendations. This fact suggests that critical judgement is and still should be the main motor of clinical judgement but we also see evidence that these classifications are a useful helping tool in making this judgement.

Posterior instrumentation remains the cornerstone of operative treatment for most lumbar spine fractures, owing to its versatility, effectiveness, and favorable risk factors. Advances in pedicle screw design and fixation techniques made it so this technique is used in cases previously reserved for more complex approaches. However, concerns regarding loss of correction and implant failure are still topics of discussion.

Anterior and combined anterior–posterior approaches offer its own advantages, particularly in fractures involving severe anterior and posterior column compromise or persistent canal encroachment. Despite these benefits, their increased surgical invasiveness and higher complication rates have led to a more selective application. The trend toward limiting combined approaches reflects both technological advancements in posterior fixation and a growing emphasis on minimizing surgical morbidity.

Minimally invasive surgical techniques represent a new direction in the field of surgical management of lumbar spine fractures. That is constantly evolving and being perfected.The reviewed studies suggest that MIS approaches may reduce patient morbidity and give a chance for early mobilization. However, evidence regarding long-term outcomes and their applicability in complex fracture patterns remains limited, highlighting the need for further studies.

Several limitations within the existing literature must be acknowledged. Many studies are retrospective in nature, involve heterogeneous patient populations, and utilize varying outcome measures, which complicates direct comparison between them. Additionally, there is a relative scarcity of randomized controlled trials focusing specifically on lumbar spine fractures, as many investigations combine thoracic and lumbar injuries. These limitations emphasize the necessity for standardized reporting and future prospective research.

In summary, operative management of lumbar spine fractures requires a balanced consideration of biomechanical stability, neurological preservation, and patient-related factors. While current evidence supports a patient specific approach guided by classification systems and surgical principles, further advances in surgical techniques and implant technology continue to expand treatment strategies. Further research is essential to clarify optimal indications and long-term outcomes for the operative approaches.

Conclusions:

Topic of management of lumbar spine fractures requires careful assessment and individualized approach. The surgical treatment plays a significant role in this topic especially in cases with complications connected to fracture itself. Based on literature there is strong evidence suggesting that decision making processes should be guided using established classification systems, such as the AO Spine Thoracolumbar Classification and the TLICS score in unison with clinical evaluation.

Posterior instrumentation remains the most commonly employed and versatile operative strategy, while anterior and combined approaches remain relevant in some cases but with further technical improvements are more restricted. Minimally invasive techniques continue to gain relevance, offering potential benefits in selected patients. Overall conclusion is that, there is no universally applicable strategy and the choice of the right one for the patient must be performed according to patient specific factors, surgical expertise and the equipment availability.

Further high-quality prospective studies are needed to more precisely determine surgical indications, compare operative strategies, and clarify long-term outcomes in patients with lumbar spine fractures treated with different methods.

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