



INJURIES TO THE THORACOLUMBAR JUNCTION: BIBLIOMETRIC ANALYSIS OF ENGLISH-LANGUAGE LITERATURE

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Objective. To analyze the 50 most cited articles related to the diagnosis, classification and surgical treatment of injuries of the thoracolumbar junction, which influenced the study of this problem.

Material and Methods. The Web of Science database was searched for keywords to detect articles related to thoracolumbar junction surgery. Articles were selected taking into account the title, abstract and the used methods, and then evaluated by the total number of citations to identify the fifty most cited. Characteristics of publications were analyzed.

Results. The United States of America, Thomas Jefferson University and A.R. Vaccaro were the most productive country, institution and author, respectively, dealing with the subject. The 2000s was the most active decade in terms of the number of publications. The greatest attention of scientists dealing with the problems of thoracolumbar injury was attracted by the article by McLain et al. analyzing the causes of the failures of short-segment transpedicular systems in the early postoperative period. The article by Laursen et al. presenting the results of using recombinant bone morphogenetic protein-7 in combination with metal fixation is at the top of the list in terms of average citation index. Most articles are well-designed randomized studies with the evidence level II.

Conclusion. Citation analysis allowed to identify the most relevant articles, the authors of which have made a significant contribution to the problem of surgery of the thoracolumbar junction. Study of the information field through the prism of the most cited articles allows seeing the mainstream and future development of diagnostics, classification and treatment of the injuries of this localization.

Key Words: spine, thoracolumbar junction, spondylosynthesis, bibliometric analysis, citation.

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The classification of spinal injuries by localization is dominated by those of thoracolumbar junction, which includes the T11–L2 vertebrae [1–5]. Injuries at the level of transition of the rigid thoracic section to the mobile lumbar one are usually accompanied by the formation of kyphotic spinal deformity and compression of the contents of the spinal canal [6, 7]. Surgical treatment of injuries of the thoracolumbar junction requires knowledge of the anatomy and biomechanics of this area, as well as understanding of the entire spectrum of modern methods of metal fixation [8, 9]. Citation analysis is a bibliometric tool [10, 11] that can be used to quantify the impact of an article on the study of the problem in modern reviews of the

medical literature [12]. Considering the general availability of leading medical journals for a reader over the Internet, a literature review is gradually being transformed from a source of detailed information into a brief description of the main trends that define further independent search for the relevant information. At present, the use of a number of publications that is a multiple of fifty is optimal for reviews based on the principle of bibliometric analysis [13–15]. In this case, the primary search is carried out from 1900 to the year of writing the article, and the final list contains articles ranging from the most to the least cited work inclusive.

The objective of the study was to use the electronic Web of Science resource

to select the 50 most cited articles related to the diagnosis, classification and surgical treatment of injuries of the thoracolumbar junction, which influenced the study of this problem.

Material and Methods

After the initial search, 50 articles were selected for inclusion in the final list by the following criteria: papers dedicated to the study of injury or spondylosynthesis of the thoracolumbar junction. Experimental studies on animals were excluded. Articles that discussed surgical aspects of treating injuries to other parts of the spinal column were considered only if the patients with a T12–L2 fracture represented the majority.

Relevant papers were selected from all journals and databases indexed in Web of Science at the time of this analytical study.

Results and Discussion

To create the final list of 50 articles, a two-step query was run on Web of Science platform.

The first stage consisted of a thematic search for the term “thoracolumbar junction fracture”. This search yielded 2430 results, which were subsequently sorted by number of citations. Self-citations were excluded.

The search was limited to years 1900–2018. The initial list consisted of articles published in 1975–2017. The number of articles (Fig. 1) reached its peak in 2017 (205 articles in a year), and the year 2006 was the most productive in terms of the most cited articles (5).

Articles devoted to the problems of thoracolumbar junction surgery were most often published by *Spine* (373 articles, 15.3 % of 2430). It was followed by *European Spine Journal* (229 articles, 9.4 % of 2430) and *Journal of Neurosurgery Spine* (87 articles, 2.6 % of 2430) respectively (Fig. 2). Most of the articles in the list of the most cited ones were also published in *Spine* (19 articles, 38.0 %). The second most popular journal is *Journal of Bone and Joint Surgery American Volume* (6 articles, 12.0 %) and the third place is shared by *European Spine Journal* and *Clinical Orthopaedics and Related Research* (4 articles each, 8.0 %).

Most publications (828 articles, 34.0 % of 2430) were written by authors residing in the United States. Authors from Germany (332 articles, 13.7 %) and PRC (252 articles, 10.4 %) occupy the 2nd and 3rd places. The first ten countries by the number of the published articles are shown in Fig. 3.

Fig. 4 shows the first ten institutions by the number of published articles from the full list. The most productive institutions are the Thomas Jefferson University (91 articles), the University of California (88 articles), and the Rothman Institute (67 articles).

At stage 2, the 50 most cited articles were selected for final inclusion in the list (see Table at the end of the article). Subjects of the articles included classification of injuries, transthoracic and retroperitoneal access to the thoracolumbar junction, transpedicular fixation, anterior spinal fusion, decompression intervention, biomechanical features of the injured and instrumented spine.

These 50 articles were published in 1983–2013.

The following information was extracted from each article in the final list: authors, title, year of publication, abstract, total number of citations, average number of citations (sum of the number of citations divided by the number of results found), type of research and level of evidence. The articles represented the following types of research: clinical or experimental. Study design: from randomized controlled trial to clinical cases.

The level of evidence (from I to V) was determined only for clinical studies:

I: evidence obtained from a meta-analysis of a large number of well-planned randomized studies and randomized studies with a low level of false positive and false negative errors;

II: evidence is based on the results of at least one well-designed randomized trial and randomized trials with a high, relative to level I clinical studies, rate of false positive and false negative errors;

III: evidence is based on the results of well-planned non-randomized controlled studies with one group of patients, studies with a group of historical control;

IV: evidence obtained from non-randomized studies, indirect comparative studies, descriptive studies;

V: evidence is based on clinical cases and examples.

The most cited authors who published articles in this field of study are Vaccaro (78 articles, 3.21 % of 2430), Oner (53 articles, 2.181 %) and Kandziora (41 articles, 1.687 %). Vaccaro is also the most cited author among the authors of the 50 most cited articles (3 articles) and he is followed by McAfee, Dai, Kaneda, Knop and Oner (2 articles each). The

remaining 44 authors published one article each.

The most discussed topic (13 publications in the final list) is the short-segment (bisegmental) transpedicular fixation [13, 16–27]. Seven papers [28–34] present the results of surgical treatment of patients with burst fractures of the thoracolumbar junction using decompression and fixation from the anterior approach, and five [35–39] deal with the classification of injuries of the thoracolumbar junction.

The most cited article on the analysis of results of surgical treatment of the thoracolumbar junction is the study by McLain et al. [22] discussing cases of short-segment transpedicular systems instability in injuries of T11–L2 vertebrae. The highest average number of citations (31.69) belong to the paper by Laursen et al. [40] devoted to the non-encouraging preliminary results of administration of recombinant bone morphogenetic protein-7 (BMP-7) into the body of the affected vertebra in combination with transpedicular fixation.

The article by a group of authors from the Syracuse Medical Center (USA), which is ranked 3rd in the total number of citations, demonstrates the superiority of CT in determining the method of spondylosynthesis based on the structure of the injury using the example of 100 patients with potentially unstable fractures and dislocation fractures of the thoracolumbar junction [36].

The study by Vaccaro et al., which was published in 2013, is ranked 18th and describes AOSpine thoracolumbar spine injury classification system developed by the authors based on data from 40 patients with a trauma to the thoracolumbar junction. Each spinal injury was assessed from the point of the fracture structure, the patient's neurological status, the integrity of the capsule-ligament apparatus and the nature of the accompanying pathology. The classification system was approved by surgeons involved in the study, who confirmed its reliability, accuracy and good reproducibility [38].

The distribution of the 50 most cited articles by year of publication demonstrates several trends. There were 9 such articles published in 1983–1990, 19 in

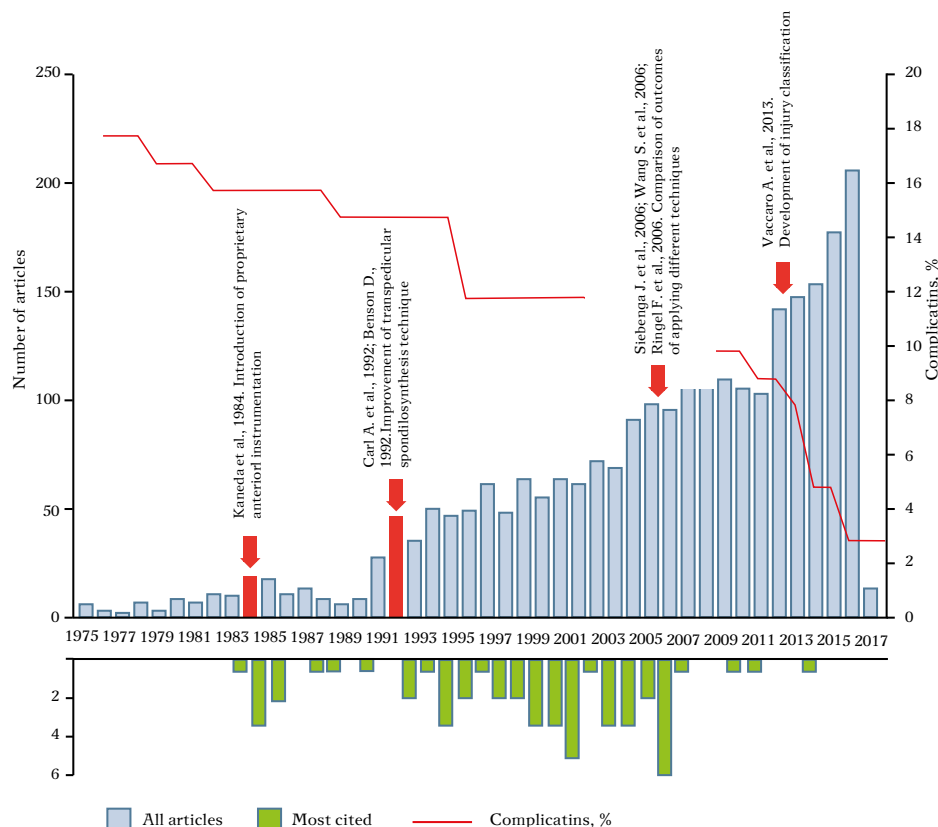


Fig. 1

Distribution of all articles on the thoracolumbar junction surgery and the 50 most cited articles by year of publication; dynamics of regression of the number of complications

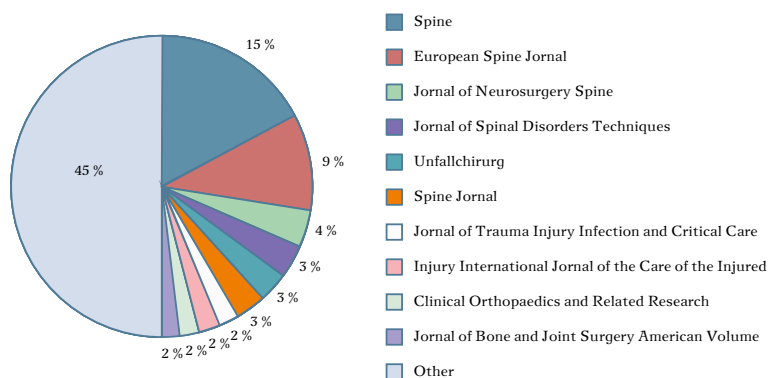


Fig. 2

The journals that published most of the articles (55.02 %) devoted to issues of the thoracolumbar junction surgery

1991–2000, 21 in 2001–2010, and only one published from 2001 to the present. Thus, the 2000s can be considered the most productive decade. There were no such articles published in 1986, 1989, 1991, 2008, 2011, 2012, as well as in the period from 2014 to the present. The drop observed in the 2010s can be attributed both to a short period of time since the publication which was insufficient to accumulate large number of citations and to overall stagnation in the study of this problem.

Thus, we can identify 13 articles, which deserve more detailed consideration in the context of bibliometric research.

The review of the most cited articles in each of the decades revealed the following. In the 1980s the most cited arti-

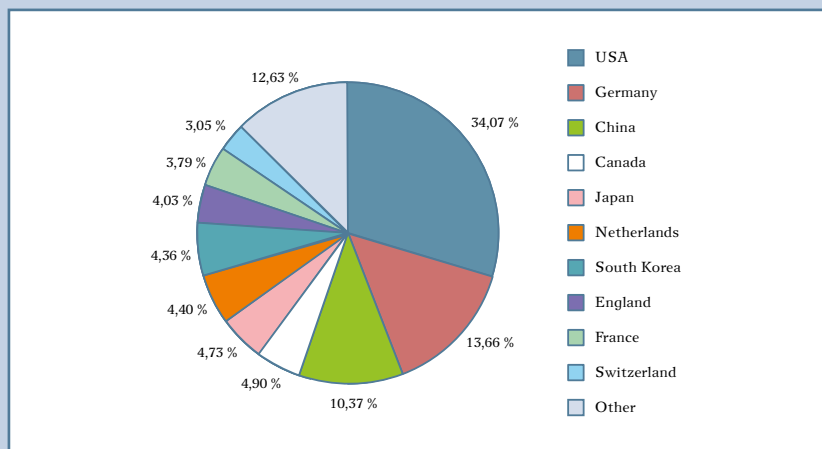


Fig. 3

Countries that have published most of the articles (55.02 %) devoted to issues of the thoracolumbar junction surgery

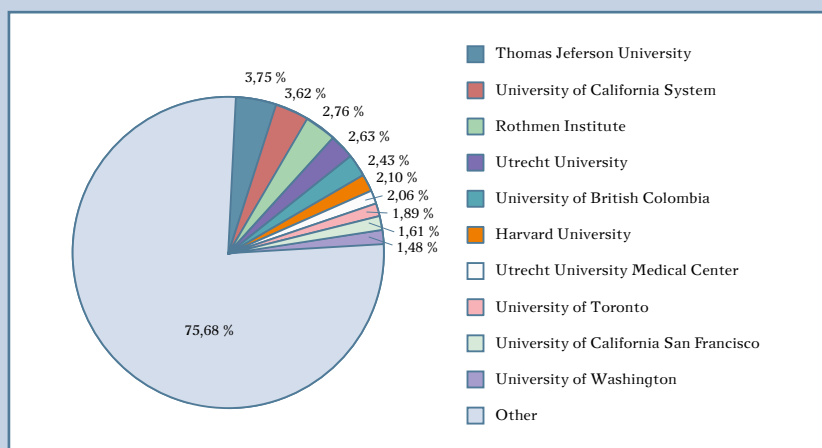


Fig. 4

Institutions whose staff have published the highest number of articles on issues of the thoracolumbar junction surgery

cle was the study by a group of authors of the Department of Orthopedics of the Syracuse Medical Center (USA), which reflects the technological leap in many branches of medicine associated with the invention X-ray computer tomography in 1970s. The key role of CT data in determining the choice of tactics for treatment of fractures of the thoracolumbar junction has been demonstrated [36]. In the last decade of the XX century, the article by McLain et al. [22], analyzing the

failure of short-segment transpedicular systems in the early postoperative period attracted the most attention of scientists working in the field of thoracolumbar injuries. This article is also the most cited one in the top 50 list. In the 1990s, the total and relative increase in the number of surgical interventions with the use of immersion metal structures for spinal injuries led to many unsatisfactory results. A significant portion of the clinical studies and literature reviews of the time [4,

41–44] is devoted to search for and analysis of predictors of such complications.

By the 2000s, the need for a classification system allowing standardization of the algorithm for choosing treatment tactics for patients with spinal fractures became obvious. Previously existing classifications were no longer compatible with the increased capabilities of spinal surgery [45]. Vaccaro et al. [39] proposed the TLICS classification, which allows determining the type of damage and selecting the appropriate conservative or surgical treatment based on CT data on the fracture structure, MRI data on the dorsal ligamentous complex, as well as on the patient's neurological status [46, 47].

The second decade of the XXI century is the period of review and analysis of the colossal amount of data accumulated over previous years about spinal cord injury and methods of its treatment [3]. While continuing his work on the classification of thoracolumbar injuries, Vaccaro et al. [38] devoted special attention to availability of the developed instrument to the practical surgeons. The statistically similar results of determining the type of injury according to the AOSpine TL Injury Classification System in one group of patients by different independent experts allow recommending this classification for widespread use. This fact, apparently, defined the status of this publication as the most cited one in the 2010s.

The important role of evolution of algorithmic approach to choosing the type of spondylosynthesis depending on the nature of the injury should be noted. In our opinion, this factor, along with the development of minimally invasive techniques, is responsible for the significant reduction in the incidence of complications of surgical treatment of injuries of the thoracolumbar junction in the 2000s.

Ranking based on the average number citations puts one of the first articles describing the results of administration of BMP-7 in combination with metal fixation [40] at the top of the list. The second-ranked paper in the average number of citations is devoted to one of the controversial aspects in the choice of treat-

ment tactics for patients with thoracolumbar junction injuries: comparing the functional outcomes of uncomplicated comminuted fractures after surgical and conservative approach [48]. Remarkably, the conclusions about similar results of conservative and surgical treatment of uncomplicated injuries [26, 49] coexist in the final list of the articles with publications demonstrating the unequivocal superiority of active surgical tactics [11, 13, 40, 44]. It should be noted, however, that the number of the latter prevails.

The article that ranks 3rd in the average number of citations is an experimental study on cadaveric material, confirming the unstable nature of burst fractures of the thoracolumbar junction. It has been established that the damaged spine is the least resistant to rotational loads. This biomechanical study [50] and others like it [44] can be considered as a step towards the development of a modern complex of indications for a stabilizing intervention.

Four literature reviews [1, 10, 39, 52] included in the final list occupy a special place among the most cited articles.

Boerger et al. [10] published an analysis of data from 275 articles on the surgical treatment of burst fractures of the thoracolumbar localization, which allows concluding that there is no correlation between the completeness of decompression and postoperative regression of neurological deficit. Verlaan et al. [1] analyzed the evolution of surgical techniques for reconstruction of the thoracolumbar junction in 1970–2001. A team of authors headed by Vaccaro [39] conducted an analysis of the literature to determine predictors of instability of injuries of the thoracolumbar localization in a 2005. The mechanism of injury (based on the morphology of damage), the integrity of the posterior ligamentous complex and the neurological status are important for determining the choice of spondylosynthesis technique. The Vaccaro's classification is based on the findings of this review. Dai et al. [52] search in PubMed

for articles devoted to treatment of injuries of the thoracolumbar junction, suggest the superiority of surgical techniques over conservative one. Thus, the listed literature reviews can be considered a reflection of the key trends in spinal surgery over the past two decades.

The most productive country, institution and author based on the analysis of the 50 most cited articles are the USA, the Thomas Jefferson University and Vaccaro, respectively. However, as can be seen from Fig. 3 and 4, the overall vision of the problem has been developed by the multinational and multi-institutional academic community.

The distribution of articles included in the final list by level of evidence is as follows: level I, 5 papers, level II, 15, level III and IV, 11 papers each; there are no studies with level of evidence V (clinical cases) among the articles with a high number of citations. In addition to the original articles, there are studies that are not ranked in the level of evidence: one discussion of the developed classification, four literature reviews and three experimental *in vitro* studies.

Limitations of the study. The authors are aware of some of the limitations of the study conducted by the means of bibliometric analysis. Citation analysis is, by definition, a biased assessment tool. Citing does not always demonstrate the direct influence of the literary source on the research that refers to it. Often, the authors provide a vast array of literature references in the "Relevance of the study" section, citing related articles or papers, the content of which has not been analyzed thoroughly. Another important limitation is the factor of self-citation, that is, quoting one's own works. Self-citations artificially increase the total number of citations of the article, which may cause an incorrect assessment of the impact of the publication in the relevant field. After we removed self-citations the total number of citations decreased, on average, by 9 per article. Another limitation is associated with the date of publica-

tion; an earlier study has more chances to accumulate citations than a more recent one. The use of average number of citations allows circumventing this limitation. The structure of the list of most cited articles reflects this phenomenon: the article ranked 3rd was published in 1983, whereas the 2013 paper, devoted to the most relevant issue of the classification of spinal injuries, ranks only 18th.

The average number of citations is also not a perfect tool for assessing the significance of the article. The more time has passed since publication, the higher the denominator is in the equation for calculating this value. This, in fact, dilutes the total number of citations of this article.

One must assume that only a comprehensive assessment of such indicators as the total number of citations and the average number of citations provides an objective picture of the significance of the published study for analyzing the state of affairs in any subject field in general and in surgery of the thoracolumbar junction in particular.

Conclusion

We used Web of Science service to identify 50 most cited articles devoted to the study of traumatic injuries to the thoracolumbar junction. Diagnosis, classification and surgical treatment of this pathology remain a subject of debate even today. There is a notable shift in the interests of scientists from particular aspects of surgical tactics in 1980–1990 to the problems of classifications, algorithmic approaches and analysis of accumulated information in 2000–2010. The higher number of studies with a level of evidence II–V compared to level I studies confirms the advisability of further work in this field.

The study did not have sponsorship. The authors declare no conflict of interest.

Table

The 50 most cited articles on injuries of the thoracolumbar junction published in 1983–2013 (data retrieved from Web of Science)

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
1	McLain RF, Sparling E, Benson DR	J Bone Joint Surg Am. 1993;75:162–167	Early failure of short-segment pedicle instrumentation for thoracolumbar fractures. A preliminary report	The results of short-segment transpedicular fixation of burst fractures of the thoracolumbar localization are presented. Based on the analysis of 10 cases of metal fixation instability in 19 patients operated on using this technique, the author calls for caution in using this arrangement without ventral spinal fusion	Retrospective non-randomized clinical trial	IV	293	22.98
2	Vaccaro AR, Lehman RA Jr, Hurlbert RJ, Anderson PA, Harris M, Hedlund R, Harrop J, Dvorak M, Wood K, Fehlings MG, Fisher C, Zeiller SC, Anderson DG, Bono CM, Stock GH, Brown AK, Kuklo T, Oner FC	Spine. 2005;30:2325–2333	A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status	A classification of injuries of the thoracic and lumbar regions, considering the morphology of the damage, involvement of the posterior ligamentous complex and the patient's neurological status, is proposed.	Analysis of the reliability and validity of the classification	—	264	8.50
3	McAfee PC, Yuan HA, Fredrickson BE, Lubicky JP	J Bone Joint Surg Am. 1983;65:461–473	The value of computed tomography in thoracolumbar fractures. An analysis of one hundred consecutive cases and a new classification	The example of 100 patients with potentially unstable fractures and fractures of the thoracolumbar localization (50 were operated on) was used to demonstrate the superiority of CT in determining the spondylosynthesis technique based on the structure of the injury.	Prospective non-randomized clinical trial	III	245	22.43
4	Wood K, Buttermann G, Mehbod A, Garvey T, Jhanjee R, Sechriest V	J Bone Joint Surg Am. 2003;85:773–781	Operative compared with nonoperative treatment of a thoracolumbar burst fracture without neurological deficit. A prospective, randomized study	Comparison of long-term results of surgical (23) and conservative (24) treatment of patients with stable fractures of thoracolumbar junction. No significant benefits of the surgical approach have been identified.	Prospective randomized clinical trial	II	232	15.78
5	Kaneda K, Taneichi H, Abumi K, Hashimoto T, Satoh S, Fujiya M	J Bone Joint Surg Am. 1997;79:69–83	Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits	150 patients with complicated burst fractures of the thoracolumbar localization were operated on using anterior decompression, fusion and fixation with Kaneda device. Good radiographic and functional results were obtained.	Prospective non-randomized clinical trial	III	215	18.73

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
6	Verlaan JJ, Diekerhof CH, Buskens E, van der Tweel I, Verbout AJ, Dhert WJA, Oner FC	Spine. 2004;29:803–814	Surgical treatment of traumatic fractures of the thoracic and lumbar spine: a systematic review of the literature on techniques, complications, and outcome	A total of 132 articles from 1970–2001 were analyzed. The main surgical techniques used in patients with fractures of the thoracic and lumbar vertebrae have been identified and classified.	Literature review	–	195	14.55
7	Denis F, Armstrong GW, Searls K, Matta L	Clin Orthop Relat Res. 1984;(189):142–149	Acute thoracolumbar burst fractures in the absence of neurologic deficit. A comparison between operative and non-operative treatment	Analysis of the long-term outcomes of treatment of 104 patients with unstable fractures of the thoracolumbar localization; 75 % of the operated patients fully returned to their previous work, while 25 % of those treated conservatively only returned on a part-time basis	Retrospective randomized clinical trial	II	190	25.07
8	Parker JW, Lane JR, Karakovic EE, Gaines RW	Spine. 2000;25:1157–1170	Successful short-segment instrumentation and fusion for thoracolumbar spine fractures: a consecutive 4 1/2-year series	46 patients with fractures of the thoracolumbar localization were operated on using short-segment fixation (transpedicular systems) or ventral stabilizing systems); algorithmic approach to determining indications for short-segment fixation, depending on the severity of the vertebral injury, from anterior or posterior access allowed for good treatment outcome	Retrospective non-randomized clinical trial	IV	180	17.99
9	McAfee PC, Bohlman HH, Yuan HA	J Bone Joint Surg Am. 1985;67:89–104	Anterior decompression of traumatic thoracolumbar fractures with incomplete neurologic deficit using a retroperitoneal approach	Analysis of the results of decompression and stabilization performed from the retroperitoneal approach in 70 patients with complicated T11–L2 vertebral fractures. Good clinical and radiological outcomes allow the authors to recommend performing decompression and stabilization operations for injuries of the thoracolumbar localization using extrapleural retroperitoneal access described by the authors	Retrospective non-randomized clinical trial	III	168	28.60
10	Kaneda K, Abumi K, Fujiya M	Spine. 1984;9:788–795	Burst fractures with neurologic deficits of the thoracolumbar-lumbar spine. Results of anterior decompression and stabilization with anterior instrumentation	A total of 27 patients with burst complicated fractures of the thoracolumbar localization; decompression, correction and fixation from the anterior access is performed; 15 patients operated on using Kaneda device showed the best functional results	Prospective randomized clinical trial	II	161	28.23

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
11	Alanay A, Acaroglu E, Yazici M, Oznur A, Surar A	Spine. 2001;26:213–217	Short-segment pedicle instrumentation of thoracolumbar burst fractures: does transpedicular intracorporeal grafting prevent early failure?	of T10–L3 vertebrae. Comparison of the results of surgical treatment using short-segment transpedicular fixation and in combination with transpedicular insertion of bone graft (10 patients). No advantages of the combined technique were identified	randomized clinical trial	II	151	16.65
12	Shen WJ, Liu TJ, Shen YS	Spine. 2001;26:1038–1045	Nonoperative treatment versus posterior fixation for thoracolumbar junction burst fractures without neurologic deficit	80 patients with uncomplicated burst fractures of the T11–L2 vertebrae: 47 received conservative treatment, 33 underwent short-segment transpedicular fixation. Surgical treatment allows to correct post-traumatic deformity and provide an early analgic effect. Long-term outcomes are comparable	Prospective randomized clinical trial	II	130	17.15
13	Bradford DS, McBride GG	Clin Orthop Relat Res. 1987;218:201–216	Surgical management of thoracolumbar spine fractures with incomplete neurologic deficits	Long-term outcomes of surgical treatment of 59 patients with complicated fractures of the thoracolumbar localization. Anterior decompression of the contents of the spinal canal (20 patients) provides better regression of the neurological deficit than posterior decompression (39 patients)	Retrospective randomized clinical trial	II	126	23.43
14	Knop C, Fabian HF, Bastian L, Blauth M	Spine. 2001;26:88–99	Late results of thoracolumbar fractures after posterior instrumentation and transpedicular bone grafting	Analysis of late clinical and radiological results of surgical treatment of fractures of the thoracolumbar junction: 76 patients underwent transpedicular fixation in combination with anterior corporeal transpedicular bone graft. The research results do not allow to recommend this technique for widespread use.	Retrospective randomized clinical trial	II	120	18.12

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
15	Farcy JP, Weidenbaum M, Glassman SD	Spine. 1990;15:958–965	Sagittal index in management of thoracolumbar burst fractures	Analysis of the results of surgical treatment of 62 patients with kyphotic deformity due to burst fractures of T12–L2 vertebrae. In the course of preoperative planning, the sagittal index used to simulate the rods of dorsal combination system (laminar hooks – transpedicular screws) was determined based on X-ray data. The technique allowed to achieve encouraging radiological and clinical results.	Prospective non-randomized clinical trial	III	119	18.50
16	Siebenka J, Leferink VJM, Segers MJM, Elzinga MJ, Bakker FC, Haarman HJ, Rommens PM, ten Duis HJ, Patka P	Spine. 2006;31:2881–2890	Treatment of traumatic thoracolumbar spine fractures: a multicenter prospective randomized study of operative versus nonsurgical treatment	34 patients with type A fractures of T11–L2 according to AO: 18 were operated on, 16 received conservative treatment. Analysis of radiological and functional outcomes allows recommending ventral spondylosynthesis in case of A3 fractures according to AO classification.	Multicenter prospective randomized trial	I	119	9.72
17	Vaccaro AR, Oner C, Kepler CK, Dvorak M, Schnake K, Bellabarba C, Reinhold M, Aarabi B, Kandziora F, Chapman J, Shanmuganathan R, Fehlings M, Vialle L	Spine. 2013;38:2028–2037	AOSpine Thoracolumbar Injury Classification System: Fracture Description, Neurological Status, and Key Modifiers	AOSpine Thoracolumbar injury classification system was developed. Data from 40 patients with thoracolumbar trauma were analyzed in the framework of this classification by a group of specialists. The system was highly approved, and its reliability and accuracy were confirmed.	The study of the reliability of the classification system based on retrospective data	II	109	2.37
18	Hashimoto T, Kaneda K, Abumi K	Spine. 1988;13:1268–1272	Relationship between traumatic spinal canal stenosis and neurologic deficits in thoracolumbar burst fractures	The relationship between the severity of deficit of the spinal canal lumen in damage to T11–L2 vertebrae and the risk of neurological deficit was identified	Retrospective non-randomized clinical trial	III	109	19.28
19	Cho DY, Lee WY, Sheu PC	Neurosurgery. 2003;53:1354–1361	Treatment of thoracolumbar burst fractures with polymethyl methacrylate vertebroplasty and short-segment pedicle screw fixation	Analysis of the results of surgical treatment of 70 patients with burst fractures of the thoracolumbar localizations: 50 of them underwent short-segment transpedicular fixation, in 20 patients it was supplemented with polymethylmethacrylate vertebroplasty. The combined method allows to achieve a better analgesic effect and reduces the risk of metal structure instability.	Prospective randomized clinical trial	II	108	14.72

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
20	Dick W, Kluger P, Magerl F, Woerdorfer O, Zach G.	Paraplegia. 1985;23:225–232	A new device for internal fixation of thoracolumbar and lumbar spine fractures: the «fixateur interne»	The use of a transpedicular system with increased repositioning opportunities in 45 patients with T12–L2 vertebrae fractures	Prospective non-randomized clinical trial	IV	107	23.30
21	Hauser CJ, Visvikis G, Hinrichs C, Eber CD, Cho K, Lavery RF, Livingston DH.	J Trauma. 2003;55:228–235	Prospective validation of computed tomographic screening of the thoracolumbar spine in trauma	The advantage of CT scan over X-rays in the diagnosis of injuries of the thoracolumbar junction, including in case of combined trauma is demonstrated	Prospective non-randomized clinical trial	III	107	14.30
22	Wang ST, Ma HL, Liu CL, Yu WK, Chang MC, Chen TH	Spine. 2006;31:2646–2652	Is fusion necessary for surgically treated burst fractures of the thoracolumbar and lumbar spine?: a prospective, randomized study	58 patients with burst fractures of the thoracolumbar localization were operated on using transpedicular fixation: 30 of them underwent a posterior spinal fusion with autograft, 28, had no spinal fusion. No advantage of combining transpedicular fixation with posterior spinal fusion before transpedicular fixation has been identified.	Prospective randomized clinical trial	II	105	9.71
23	Mermelstein LE, McLain RF, Yerby SA	Spine. 1998;23:664–670	Reinforcement of thoracolumbar burst fractures with calcium phosphate cement. A biomechanical study	Short-segment transpedicular fixation with additional stabilization of the anterior column of the damaged vertebra with calcium phosphate cement demonstrates greater stability compared to standard transpedicular fixation	Experimental – biomechanical research	–	101	31.69
24	Benson DR, Burkus JK, Montesano PX, Sutherland TB, McLain RF	J Spinal Disord. 1992;5:335–343	Unstable thoracolumbar and lumbar burst fractures treated with the AO fixateur interne	25 patients with unstable T10–L2 vertebral fractures were operated on using transpedicular fixation. Good outcomes have been achieved in terms of post-traumatic kyphosis correction and spinal canal remodeling	Prospective non-randomized clinical trial	III	99	34.80
25	Vaccaro AR, Zeiller SC, Hulbert RJ, Anderson PA, Harris M, Hedlund R, Harrop J, Dvorak M, Wood K, Fehlings MG, Fisher C, Lehman RA Jr, Anderson DG, Bono CM, Kuklo T, Oner FC	J Spinal Disord Tech. 2005;18:209–215	The thoracolumbar injury severity score: a proposed treatment algorithm	Literature review to determine predictors of instability of injuries of the thoracolumbar localization. The following factors are significant for determining the choice of spondylosynthesis tactics: injury mechanism (based on the morphology of the damage), integrity of the posterior ligamentous complex, neurological status	Literature review	–	99	15.89

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
26	Been HD, Bouma GJ	Acta Neurochir (Wien). 1999;141:349–357	Comparison of two types of surgery for thoraco-lumbar burst fractures: combined anterior and posterior stabilisation vs. posterior instrumentation only	Analysis of the results of surgical treatment of 46 patients with complicated trauma of the thoracolumbar junction. The regression of neurological deficit in 27 patients operated on using decompression-stabilizing operations from the anterior approach did not differ from the results obtained for transpedicular spondylosynthesis and decompression obtained through ligamentotaxis	Retrospective randomized clinical trial	II	97	20.96
27	Danisa OA, Shaffrey CI, Jane JA, Whitehill R, Wang GJ, Szabo TA, Hansen CA, Shaffrey ME, Chan DP	J Neurosurg. 1995;83:977–983	Surgical approaches for the correction of unstable thoracolumbar burst fractures: a retrospective analysis of treatment outcomes	Based on the analysis of the results of surgical treatment of 49 patients with unstable and burst fractures of the vertebrae of the thoracolumbar junction operated on from the ventral (16), dorsal (27) and combined approaches. There was no significant difference in the long-term results of surgical treatment, spondylosynthesis from the posterior access was performed faster and with lower blood loss	Retrospective randomized clinical trial	II	97	26.60
28	Lee HM, Kim HS, Kim DJ, Suk KS, Park JO, Kim NH	Spine. 2000;25:2079–2084	Reliability of magnetic resonance imaging in detecting posterior ligament complex injury in thoracolumbar spinal fractures	The integrity of the posterior ligamentous complex in case of an injury to the thoracolumbar junction is best determined by T2-weighted images MRI with fat suppression	Prospective non-randomized clinical trial	III	92	14.04
29	Oner FC, van der Rijt RR, Ramos LM, Dhert WJA, Verbout AJ	J Bone Joint Surg Br. 1998;80:833–839	Changes in the disc space after fractures of the thoracolumbar spine	Analysis of MRI data for intervertebral discs adjacent to the damaged vertebrae of the thoracolumbar junction 18 months after transpedicular fixation. Changes in the discs are caused by the redistribution of disc tissue in the deformed intervertebral space.	Non-randomized study	IV	89	21.74
30	Schnee CL, Ansell LV	J Neurosurg. 1997;86:48–55	Selection criteria and outcome of operative approaches for thoracolumbar burst fractures with and without neurological deficit	An example of satisfactory functional outcomes of surgical treatment of 25 patients with burst fractures of the thoracolumbar localization is used to demonstrate an algorithmic approach to the choice of spondylosynthesis tactics depending on the number of damaged columns, spinal canal lumen deficit, segmental kyphosis, degree of compression, neurological status	Non-randomized prospective clinical trial	III	88	27.79

The rest of the table

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31	Rhyne A 3rd, Banit D, Laxer E, Odum S, Nussman D	J Orthop Trauma. 2004;18:294–299	Kyphoplasty: report of eighty-two thoracolumbar osteoporotic vertebral fractures	52 patients with compression fractures of the thoracolumbar localization and osteoporosis were operated on using balloon kyphoplasty. Good results in terms of correction of the vertebral body, pronounced analgic effect were achieved	Retrospective non-randomized clinical trial	IV	86	29.93
32	Carl AL, Tromanhauser SG, Roger DJ	Spine. 1992;17(8 Suppl):S317–S324	Pedicle screw instrumentation for thoracolumbar burst fractures and fracture-dislocations	Good results were obtained using transpedicular fixation in treatment of 38 patients with burst fractures of the thoracolumbar junction.	Non-randomized prospective study	IV	85	19.71
33	Kraener WJ, Schemitsch EH, Lever J, McBroom RJ, McKee MD, Waddell JP	J Orthop Trauma. 1996;10:541–544	Functional outcome of thoracolumbar burst fractures without neurological deficit	24 patients with fractures of the thoracolumbar junction were observed for two years after injury. Functional capabilities were not related to the magnitude of the residual kyphosis and depended on the pain intensity. No significant difference in functional status depending of treatment tactics has been identified.	Retrospective randomized clinical trial	II	85	31.45
34	Shono Y, McAfee PC, Cunningham BW	Spine. 1994;19:1711–1722	Experimental study of thoracolumbar burst fractures. A radiographic and biomechanical analysis of anterior and posterior instrumentation systems	The superiority of decompression and stabilization operations using Kaneda anterior screw instrumentation system over the posterior instrumentation has been established	Experimental - biomechanical research	–	85	22.7
35	Boerger TO, Limb D, Dickson RA	J Bone Joint Surg Br. 2000;82:629–635	Does «canal clearance» affect neurological outcome after thoracolumbar burst fracture?	Based on the analysis of 275 articles on the surgical treatment of burst fractures of the thoracolumbar localization, the authors conclude that there is no correlation between the completeness of decompression and postoperative regression of the neurological deficit	Literature review	–	84	16.18
36	Ferguson RL, Allen BL Jr	Clin Orthop Relat Res. 1984;(189):77–88	A mechanistic classification of thoracolumbar spine fractures	A classification of fractures of the thoracic and lumbar vertebrae depending on the mechanism of injury is presented.	Clinical cases corresponding to the proposed classification are presented	IV	84	25.20
37	Kramer DL, Rodgers WB, Mansfield FL	J Orthop Trauma. 1995;9:499–506	Transpedicular instrumentation and short-segment fusion of thoracolumbar fractures: a prospective study using a single instrumentation system	Eleven patients with burst fractures of the thoracolumbar junction were operated on using short-segment transpedicular fixation with posterior spinal fusion with autobone. The instability of metal structures in several patients testified to the inadequacy of the intervention volume, however, the patients with stable constructions demonstrate good functional outcomes.	Non-randomized retrospective clinical study	IV	82	30.39

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
38	McDonough PW, Davis R, Tribus C, Zdeblick TA	Spine. 2004;29:1901–1908	The management of acute thoracolumbar burst fractures with anterior corpectomy and Z-plate fixation	The corpectomy, fusion and fixation with the extramedullary Z-plate made it possible to achieve good radiological and functional results in 35 patients with burst fractures of the thoracolumbar spine	Non-randomized prospective clinical trial	IV	82	11.75
39	Oner F, Ramos L, Simmermacher R, Kingma P, Diekerhof C, Dhert W, Verbout A	Eur Spine J. 2002;11:235–245	Classification of thoracic and lumbar spine fractures: problems of reproducibility	Comparison of AO and Denis classifications using CT and MRI of 52 patients. The authors propose to increase reproducibility of the AO classification by using MRI	Retrospective non-randomized study	III	82	16.09
40	Sanderson PL, Fraser RD, Hall DJ, Cain CM, Osti OL, Potter GR	Eur Spine J. 1999;8:495–500	Short segment fixation of thoracolumbar burst fractures without fusion	28 patients with burst fractures of the thoracolumbar localization were operated on using short-segment transpedicular fixation. Performing posterior spinal fusion with autobone did not affect the long-term outcome of the intervention.	Retrospective randomized clinical trial	II	82	21.56
41	Dai LY, Jiang SD, Wang XY, Jiang LS	Surg Neurol. 2007;67:221–231	A review of the management of thoracolumbar burst fractures	By analyzing the results of the search for sources devoted to the treatment of injuries of the thoracolumbar junction in PubMed the authors concluded that surgical techniques are superior to conservative treatment	Literature review	–	81	9.30
42	Dai LY, Jiang LS, Jiang SD	J Bone Joint Surg Am. 2009;91:1033–1041	Posterior short-segment fixation with or without fusion for thoracolumbar burst fractures. A five to seven-year prospective randomized study	73 patients with burst fractures of the thoracolumbar junction: 36 were operated on using short-segment transpedicular segmentation, 37, using transpedicular segmentation with posterolateral spinal fusion. No advantages of the combined technique were identified	Prospective randomized study	I	81	4.68
43	Laursen M, Hoy K, Hansen ES, Gelineck J, Christensen FB, Bungert CE	Eur Spine J. 1999;8:485–490	Recombinant bone morphogenetic protein-7 as an intracorporeal bone growth stimulator in unstable thoracolumbar burst fractures in humans: preliminary results	Pilot study of the administration of recombinant bone morphogenetic protein-7 into the vertebral body in combination with transpedicular fixation. No promising results were not obtained in 5 patients with thoracolumbar fractures.	Non-randomized prospective clinical trial	IV	81	41.67
44	Adams MA, Pollintine P, Tobias JH, Wakley GK, Dolan P	J Bone Miner Res. 2006;21:1409–1416	Intervertebral disc degeneration can predispose to anterior vertebral fractures in the thoracolumbar spine	An experimental study based on the determination of effort required to destroy 41 vertebral motor segments of corpses aged 62–94 years. Degenerative changes in the segment reduced the force that causes a vertebral compression fracture.	Non-randomized experimental cadaver study	III	80	14.53

The rest of the table

Nº	Authors	Year of publication, journal, issue, pages	Title of the article	Summary of the article	Type of study	Level of evidence	Total number of citations	Average number of citations
45	Panijati MM, Oxland TR, Lin RM, McCowen TW	Spine. 1994;19:578–585	Thoracolumbar burst fracture. A biomechanical investigation of its multidirectional flexibility	Based on the experiment using cadaveric material, the unstable nature of the burst fractures of the thoracolumbar junction was confirmed. The damaged spine is least resistant to rotational loads	Experimental - biomechanical research	–	79	31.08
46	Reinhold M, Knop C, Beisse R, Audige L, Kandziora F, Pizanis A, Pranzl R, Gercek E, Schultheiss M, Weckbach A, Buhren V, Blauth M	Eur Spine J. 2010;19:1657–1676	Operative treatment of 733 patients with acute thoracolumbar spinal injuries: comprehensive results from the second, prospective, Internet-based multicenter study of the Spine Study Group of the German Association of Trauma Surgery	Analysis of epidemiology of spinal injuries, outcomes of surgical treatment of 733 patients: 47% of the injuries are located in the thoracolumbar junction. The best functional results were achieved for dorsal interventions, the best correction for combined (ventral-dorsal) ones, the use of container vertebral prostheses resulted in a smaller loss of correction than the use of autograft. The long-term neurological outcome did not depend on the type of intervention	Multicenter study	I	77	3.71
47	Knop C, Blauth M, Buhren V, Arand M, Egbers HJ, Hax PM, Northwang J, Oestern HJ, Pizanis A, Roth R, Weckbach A, Wentzensen A	Unfallchirurg. 2001;104:583–600	Operative Behandlung von Verletzungsges thorakolumbalen bergangs - Teil 3: Nachuntersuchung	The long-term (4–61 months) results of surgical treatment of 372 out of 682 patients with unstable vertebral T10-L2 fractures were analyzed. The advantage of circular spondylosynthesis over dorsal in relation to loss of correction is demonstrated.	Prospective randomized multicenter study	I	74	19.12
48	Dickman CA, Yahiyo MA, Lu HT, Melkerson MN	Spine. 1994;19(20 Suppl):2266S–2273S	Surgical treatment alternatives for fixation of unstable fractures of the thoracic and lumbar spine. A meta-analysis	Comparison of the effectiveness of fixation devices for injuries of the thoracolumbar junction	Meta-analysis	I	74	29.00
49	Ringel F, Stoffel M, Stuer C, Meyer B	Neurosurgery. 2006;59(4 Suppl 2):ONS ₃₆ 1-ONS ₃₆ 7	Minimally invasive transmuscular pedicle screw fixation of the thoracic and lumbar spine	104 patients were operated on using transcutaneous transpedicular systems; 87% of screws are installed correctly. Authors recommend transcutaneous transpedicular fixation for widespread use.	Non-randomized prospective clinical trial	IV	70	11.48
50	Sasso RC, Renkens K, Hanson D, Reilly T, McGuire RA Jr, Best NM	J Spinal Disord Tech. 2006;19:242–248	Unstable thoracolumbar burst fractures: anterior-only versus short-segment posterior fixation	53 patients with unstable fractures of the thoracolumbar localization. In 40 cases, anterior spondylosynthesis was performed with resection of the vertebral body, fusion and fixation with a plate. In 13 cases, short-segment transpedicular fixation was performed. Anterior spondylosynthesis demonstrates lower loss of correction in the postoperative period.	Retrospective randomized clinical trial	II	67	8.41

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