Translated by E.V. Trushina

Research Article

https://doi.org/10.23934/2223-9022-2025-14-2-258-267

Immediate Outcomes of Surgical Treatment of Patients with Uncomplicated Fractures of the Thoracic and Lumbar Spine

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RELEVANCE The problem of choosing the optimal treatment method for patients with uncomplicated fractures of the thoracic and lumbar spine remains open.

AIM To present an analysis of the immediate outcomes of various surgical treatment methods: transpedicular fixation (open and percutaneous), spinal canal decompression, anterior and combined spinal fusion.

MATERIALS AND METHODS The study is based on a retrospective analysis of the data of 377 patients operated on in 2009-2022. The average age was 40.5. Radiological parameters (Cobb angle, vertebral height, degree of spinal canal stenosis), complications, duration of hospitalization, and clinical outcomes were evaluated.

RESEARCH RESULTS The results showed that transpedicular fixation (percutaneous or open) demonstrated minimal invasiveness, and reduced the duration of operations and hospitalization. Decompression of the spinal canal increased the degree of restoration of its lumen, but increased intraoperative blood loss and the duration of the intervention. Anterior access was effective for correcting kyphotic deformity; and combined operations were more often used for severe types of injuries. The overall complication rate was 15.5% including somatic and surgical complications. Serious complications were more often observed in complex interventions; and percutaneous fixation tended to decrease them. Improvement was achieved in 93.1% of patients at the time of discharge.

CONCLUSIONS The conclusions of the work indicate the need for an individual approach to the choice of surgical tactics based on the X-ray characteristics of the injury and the patient's condition.

Keywords: uncomplicated compression fractures of the thoracic and lumbar spine, spinal cord injury, conservative therapy for compression fractures of the thoracic and lumbar spine

For citation Grin AA, Talypov AE, Karanadze VA, Kordonskiy AYu, Abdrafiev RI, Lvov IS. Immediate Outcomes of Surgical Treatment of Patients with Uncomplicated Fractures of the Thoracic and Lumbar Spine. *Russian Sklifosovsky Journal of Emergency Medical Care.* 2025;14(2):258–267. https://doi.org/10.23934/2223-9022-2025-14-2-258-267 (in Russ.)

Conflict of interest Authors declare lack of the conflicts of interests

Acknowledgments, sponsorship The study had no sponsorship

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ANR — Association of Neurosurgeons of Russia
AVBH — anterior vertebral body height
CobbaA — Cobb angle
CoT — combined trauma
CT — computed tomography
decTPF — transpedicular fixation with decompression
F-test — two-tailed Fisher's exact test
ISS — Injury Severity Score
i/d — insufficient data
K–W-test — Kruskal–Wallis test
medTPF — transpedicular fixation via medial approach
MSD — mean sagittal diameter
M–W test — Mann–Whitney test
pTPF — percutaneous transpedicular fixation
SC — spinal canal
StSC — degree of spinal canal stenosis
TLS — thoracic and lumbar spine
TPF — transpedicular fixation
VBI — vertebral body index
χ^2-test — chi-square test

INTRODUCTION

Despite a large number of published prospective studies and meta-analyses, the issue of choosing a treatment method for patients with uncomplicated fractures of the thoracic and lumbar spine (TLS) is currently far from being finally resolved. On the one hand, the current recommendation protocol of the Association of Neurosurgeons of Russia (ANR) [1] focuses on decompression and spondylodesis from anterior, posterior or combined approaches, on the other hand, a number of studies have already been published demonstrating the possibility of using other types of treatment. The effectiveness of conservative therapy [2] or short segmental fixation without spondylodesis [3] in such patients is demonstrated by the fact that, by providing adequate immobilization of the injured segment, it is possible to achieve good immediate and remote treatment outcomes. We did not find any studies in the domestic literature devoted to the comparison of various methods of fixation and spondylodesis, or identifying radiological criteria for choosing one or another method of surgical treatment for uncomplicated TLS fractures.

The aim of the work was to analyze the immediate outcomes of using anterior, posterior and combined methods of surgical treatment for uncomplicated TLS fractures, and to determine the radiographic parameters of the most optimal of them.

MATERIAL AND METHODS

General characteristics of patients. This work is a retrospective single-center study. The material was the medical records and computed tomography (CT) data of patients with uncomplicated TLS fractures, operated on from 2009 to 2022.

A total of 898 patients with TLS fractures underwent surgery in the Department of Emergency Neurosurgery of the N.V. Sklifosovsky Research Institute for Emergency Medicine during the specified period. Of these, 377 patients (42.0%) had uncomplicated fractures and met the inclusion criteria for the study. There were 210 men (55.7%) and 167 women (44.3%). The mean patient age was 40.5±14.3 years. The main causes of injury were catatrauma (51.9%), falls from height (18.3%), and road traffic accidents (16.8%). Combined trauma (CoT) was diagnosed in 165 patients (43.8%). The structure of CoT was dominated by damage to the rib cage and chest organs (55.8% of patients with CoT), fractures of the limb bones (45.5%), and mild to moderate traumatic brain injury (32.1%). The

average Injury Severity Score (ISS) for patients with CoT was 16.9±7.6.

The inclusion criteria for the study were as follows: patient age from 18 to 65 years, fracture at the level of Th1–L5 vertebrae, absence of symptoms of compression of the spinal cord or its roots. Patients with stable injuries, verified osteoporosis, vertebral density less than 100 HU according to computed tomography (CT), previous spinal surgeries, and malignant neoplasms of any localization were excluded from the study.

Classification of uncomplicated TLS fractures. In this article, due to biomechanical and anatomical features [4], we used the following division of the TLS: thoracic region (Th1–Th10), lumbar spine (L3–L5), and thoracolumbar junction (Th11–L2).

All fractures were divided into three types according to the AOSpine classification [5]. Type A (compression injuries) included four subtypes depending on the degree of vertebral involvement in the injury: from a fracture in the area of one endplate (A1) to unstable compression-comminuted injury in the area of both endplates with compression of the lumen of the spinal canal (SC) (A4). Due to the stable nature of the injury, patients with A1 fractures were excluded from the present study. Type B includes distraction damage predominantly in the area of the posterior structures of the vertebrae (B1 and B2) or in the area of the anterior sections (B3). Type C (translational injury) is represented by displacement in the area of the spinal motion segment in the form of a dislocation or fracture-dislocation.

Surgical treatment methods. We divided all the operations performed into six groups depending on the access and the fact of decompression: isolated transpedicular fixation via medial approach (medTPF); percutaneous TPF (pTPF); TPF with SC decompression in the form of laminectomy with or without removal of bone fragments of the vertebral body (decTPF); anterior decompression and spondylodesis using plates; combined intervention (TPF and anterior spondylodesis using various grafts) with or without intervention in the SC lumen (Fig. 1).

Fig. 1. Intraoperative photographs (A, B), CT-reformations (C, E), and a radiograph (D) demonstrating the surgical treatment methods compared in the study. A — transpedicular fixation from the medial approach (medTPF); B — percutaneous transpedicular fixation (pTPF); C — transpedicular fixation with decompression (decTPF), resection of the facet joint, pedicle of the vertebra, and removal of body fragments; D — anterior spondylodesis using allograft bone and plate; E — combined spondylodesis using decTPF and a lift prosthesis

Analysis of radiographic parameters. CT data were analyzed using the RadiAnt DICOM Viewer 2024.1 program. In the multiplanar reconstruction mode, the bisegmental Cobb angle (CobbA) was measured, as well as the height of the anterior and posterior contours of the vertebra, and the SC area at the level of the fracture and in the adjacent segments.

After the measurements, the following indicators were calculated:

1) VBI= A0: P0, where VBI is the vertebral body index, A0 is the height of the vertebral body along the anterior contour in mm, P0 is the height of the vertebral body along the posterior contour in mm;

2) $AVBH=(A_0:(A_1+A_2):2)\times100\%$,

where AVBH is the relative height of a vertebral body along its anterior edge, of the vertebral body along the anterior contour; A0 – height of the anterior edge of the body of the fractured vertebra in mm; A1 and A2 – height of the anterior edge of the body of the overlying and underlying vertebrae in mm;

3) $StSC = (1 - (S_{SC0}: (S_{SC1} + S_{SC2}): 2) \times 100\%$,

where StSC is the degree of SC stenosis, S_{SC0} is the area of the SC at the fracture level in cm^2; S_{SC1} and $S_{SC}2$ are the area of the SC at the upper and lower levels in cm^2;

4) $CobbA_{corr} = ((CobbA_0 - CobbA_1):CobbA_0) \times 100\%$,

where $CobbA_{corr}$ is the degree of correction of the Cobb angle; $CobbA_1$ is the Cobb angle after surgery, $CobbA_0$ is the Cobb angle before surgery;

5) The degree of AVBH restoration, the dynamics of VBI, and the degree of StSC correction were calculated as the difference in indicators before and after the intervention.

Evaluation of immediate treatment outcomes. Treatment outcomes were assessed at the time of discharge from hospital. All complications were classified based on the F. Ibañez classification [6], according to which grade I was assigned to complications that were resolved with conservative therapy, grade II – to those that required surgical treatment, and grade III – to those that required treatment of the patient in the intensive care unit after the development of this complication.

Improvement was considered to be the development of positive dynamics in the patient's condition at the time of discharge with regression of pain syndrome and other complaints, and the possibility of activating the patient within the department. If the patient's complaints or condition remained at the preoperative level, and against this background there were difficulties in activating the patient in the postoperative period, the condition was assessed as "unchanged". Deterioration was considered to be the development of neurological symptoms requiring additional monitoring and treatment after discharge from hospital.

Statistical analysis. Statistical data were analyzed using PC STATISTICA (Version 10) (StatSoft@ Inc., USA).

Normality of data distribution was determined using the Shapiro–Wilk test. Comparison of continuous data with non-normal distribution was performed using the unpaired Mann–Whitney U test (M–W test) or the Kruskal–Wallis test (K–W test). Comparison of categorical and dichotomous characteristics between the groups was performed using the chi-square test or two-tailed Fisher's exact test (F-test). Statistical hypotheses were tested at a critical significance level of $p<0.05$.

RESULTS

Every third patient with an uncomplicated unstable TLS fracture had damage at the level of the L1 vertebra (Fig. 2). In 65.3% of cases (246 patients) a single TLS fracture was detected. In 60 patients (15.9%), the spinal injury was multiple, in 31 cases (8.2%) it was multilevel, and in 40 patients (10.6%) it was multiple multilevel.

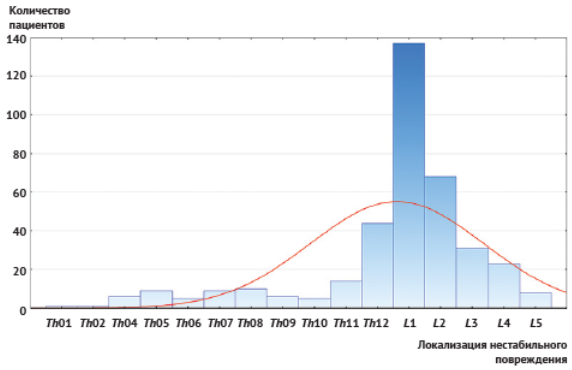

Fig. 2. Distribution of patients depending on the localization of unstable injury

According to the AOSpine classification, 83.2% of patients were diagnosed with compression injury (type A) (Fig. 3). In 11.6% of cases, the injury mechanism was distraction (type B), and in 5.2% of patients, dislocation (type C) was detected in the damaged segment.

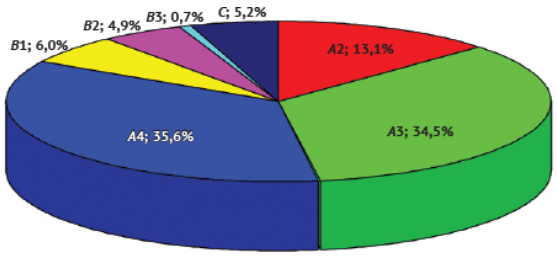

Fig. 3. Distribution of patients according to the AOSpine classification

Features of surgical interventions

The distribution of patients depending on the method of surgical treatment was as follows: medTPF, n=56 (14.9%); pTPF, n=46 (12.2%); decTPF, n=84 (22.3%); spondylodesis from anterior approach, n=123 (32.6%); combined spondylodesis with and without SC decompression, n=30 (7.9%) and n=38 (10.1%), respectively. When comparing the radiographic parameters of fractures on admission depending on the level and type of intervention performed, no statistically significant differences were found (Table 1).

Table 1

Comparison of median values and interquartile range of radiographic parameters of patient groups depending on the level of damage and the method of surgical intervention

Parameter	medTPF	pTPF	decTPF +	Anterior approach	Combined approach		p*
					without decompression	with decompression	
Cobb angle, °							
Th1–Th10	24.1 (21.0–25.9)	16.5 (9.9–29.7)	20.1 (16.2–20.1)	12.0 (8.9–21.1)	16.0 (9.4–22.5)	i/d	0.032
Th11–L2	17.2 (11.2–21.5)	16.8 (11.1–20.0)	9.9 (4.1–14.9)	11.3 (7.0–16.1)	9.3 (6.6–12.5)	17.3 (5.7–21.7)	0.470
L3–L5	–34.9 (–40.1, –28.9)	–0.8 (–7.4–5.9)	–16.1 (–24.1–8.7)	–11.6 (–17.8–4.2)	i/d	–16.5(–30.7, 1.0)	0.351
AVBH, %							
Th1–Th10	54.1 (53.1–61.5)	60.3 (48.8–77.3)	67.3 (54.8–100.0)	56.4 (44.7–87.2)	74.1 (48.2–100.0)	i/d	0.965
Th11–L2	66.5 (56.6–75.9)	64.3 (60.4–83.7)	65.5 (59.3–72.6)	65.9 (58.3–70.8)	64.2 (51.0–80.4)	62.9 (56.6–65.9)	0.771
L3–L5	83.1 (72.6–93.6)	69.9 (66.8–73.0)	68.1 (64.1–75.7)	8.1 (58.9–89.4)	i/d	80.0 (69.1–94.5)	0.723
VBI							
Th1–Th10	0.60 (0.60–0.67)	0.61 (0.46–0.77)	0.65 (0.52–1.13)	0.59 (0.50–0.85)	0.92 (0.51–1.33)	i/d	0.968
Th11–L2	0.70 (0.62–0.73)	0.73 (0.63–0.78)	0.75 (0.64–0.82)	0.68 (0.62–0.78)	0.61 (0.56–0.85)	0.73 (0.69-0.79)	0.533
L3–L5	0.92 (0.90–0.95)	0.72 (0.70–0.74)	0.91 (0.72–1.08)	0.90 (0.71–1.05)	i/d	0.90 (0.73–1.0)	0.791
SC stenosis, %							
Th1–Th10	6.4 (0–25.7)	12.6 (3.3–27.0)	22.7 (11.2–39.1)	6.9 (0–10.2)	0	i/d	0.390
Th11–L2	25.2 (4.5–33.6}	25.9 (19.8–40.2}	36.7 (20.0–51.8}	28.0 (20.0–37.5}	27.0 (16.8–31.3}	33.3 (25.7–60.6}	0.646
L3–L5	4.7 (0–9.3)	18.0 (0–36.0)	45.0 (32.7–61.5)	25.2 (5.5–41.6)	i/d	31.7 (14.5–50.7)	0.169

Notes: * — comparison of radiographic parameters of patient groups depending on the intervention method using the Kruskal–Wallis test; i/d – insufficient data; SC – spinal canal; pTPF – percutaneous transpedicular fixation; medTPF –transpedicular fixation from the median approach; AVBH – anterior vertebral body height; VBI – vertebral body index

Comparative analysis of the operative time and the volume of intraoperative blood loss (Table 2) demonstrated the advantage of standard TPF performed openly or minimally invasively (K–W-test, p<0.0001). Comparison of pre- and postoperative radiographic parameters yielded the following results. $CobbA_{corr}$ was statistically significantly lower in interventions from the anterior approach compared to different TPF options (K–W test, p=0.001). The percutaneous TPF method was not inferior to other methods of medTPF and combined approaches without decompression in the degree of AVBH restoration (K–WW test, p=0.656) or indirect SC decompression (M–W test, p=0.480). Interventions from an exclusively anterior approach were statistically not inferior in the degree of SC restoration to the methods of circular decompression in posterior or combined interventions (K–W test, p=0.212).

The analysis of surgical treatment details demonstrated the following results. After different variants of TPF, in 155 cases (66.8%) only fixation of the segments adjacent to the fracture was performed (short TPF), and in 77 cases (33.2%) — more than 2 segments (extended TPF). Statistical analysis showed that regardless of the intervention method (decTPF, medTPF or pTPF), lengthening the fixation system did not statistically significantly affect either CobbAcorr (M–W test, p=0.295, 0.791, and 0.321) or AVBH (M–W test, p=0.629, 0.104, and 0.863). At the same time, the use of extended TPF statistically significantly prolonged the duration of operation in all the groups (M–W test, p=0.007, 0.001, and 0.005), and significantly increased blood loss during medTPF (M–W test, p=0.021).

In 32.9% of cases, laminectomy after TPF was accompanied by additional resection of facet joints on one or both sides. On the one hand, this allowed an additional increase in S_{SC0} (M–W test, p<0.001), and on the other hand, it was accompanied by an increase in the duration of operation (M–W test, p=0.001) and blood loss (M–W test, p=0.003). Facet joint resection did not have a significant effect on other radiographic parameters ($CobbA_{corr}$, AVBH restoration, and VBI dynamics) (M–W test, p=0.270, 0.602, and 0.802). It should be noted that the StSC on admission in patients with decTPF and pTPF did not differ statistically significantly (34.9% (21.9–54.5), and 23.4% (16.3–36.0), p=0.447), while between decTPF and medTPF the difference was statistically significant (34.9% (21.9–54.5), and 13.6 (1.2–32.8), p=0.007).

In the group of patients, two types of interventions were performed after the anterior approach. In 83 cases (67.5%), corpectomy was performed, and in 40 cases (32.5%), discectomy was performed, supplemented, if necessary, by removal of adjacent fragments. Vertebral body removal

Table 2

Comparison of median values and interquartile range of intraoperative parameters and radiographic indicators of patient groups depending on the method of surgical intervention

Parameter	medTPF	pTPF	decTPF +	Anterior approach	Combined approach		*p**
					without decompression	with decompression	
Operation time, minutes	172 (100–150)	130 (110–200)	220 (180–280)	240 (190–285)	190 (127–270)	270 (212.5–316.5)	<0.001
Blood loss, ml	200 (100–300)	100 (50–100)	700 (500–800)	300 (180–600)	400 (200–1300)	700 (600–1500)	<0.001
$CobbA_{corr}$, %	43.1 (25.1–81.8)	58.2 (40.0–86.9)	65.8 (23.4–100)	35.2 (19.1–61.6)	56.6 (23.2–91.4)	46.4 (20.0–100.0)	0.001
AVBH Recovery, %	4.9 (–2.3–13.9)	7.3 (3.7–17.6)	3.2 (–7.7–22.7)	–	–	–	0.656
VBI Dynamics	0.09 (0.02–0.24)	0.08 (0.05–0.16)	0.13 (–0.04–0.22)	–	–	–	0.789
Direct correction of the StSC, %	–	–	14.3 (–5.1–38.5)	12.6 (2.1–26.0)	–	15.1 (0–45.3)	0.212
Indirect correction of the StSC, %	0 (0–8.3)	0 (–2.6–3.5)	–	–	0 (–2.7–3.6)	–	0.480

Notes: * - comparison of radiographic parameters of patient groups depending on the intervention method using the Kruskal-Wallis test; SC – spinal canal; pTPF – percutaneous transpedicular fixation; medTPF –transpedicular fixation from the median approach; AVBH – anterior vertebral body height; CobbA – the Cobb angle; MSD – mean sagittal diameter; VBI – vertebral body index

compared to discectomy was accompanied by slightly increased blood loss (400.0 ml (200.0–600.0), and 200.0 ml (100.0–500.0)), and a better degree of kyphotic deformity restoration (45.3% (24.1–59.1) and 29.1% (18.6–67.7)), but this was statistically insignificant (M–W test, p=0.129, and p=0.336). After corpectomy, distraction prostheses were used in 48 cases (57.8%), auto- or allobone – in 30 cases (36.1%), and other types of implants in 5 cases (6.1%). The use of distraction cages did not statistically significantly reduce the duration of operation (M–W test, p=0.468), and did not affect the degree of CobbA correction (M–W test, p=0.340). Nevertheless, when using distraction prostheses, a statistically significant postoperative StSC decrease was noted (M–W test, p=0.016).

Patients with type A2 fractures predominantly underwent anterior interventions, with type A3 injuries — anterior and decTPF, with A4 injuries — combined and decTPF (χ^2-test, p=0.001, statistically significant). For distraction fractures (type B), medTPF and pTPF were predominantly used, while for translation fractures (type C), decTPF and combined interventions were used (χ^2 test, p=0.001, statistically significant).

Analysis of immediate treatment outcomes. The overall incidence of somatic complications was 15.5%. The structure of these complications was dominated by grade Ib according to the F. Ibañez classification — pneumonia (31.8% of all patients with complications), and deep vein thrombosis of the lower extremities (29.5%). Grades IIIa and IIIb were detected in 4 patients. In 2 observations they were represented by acute cerebrovascular accident, in 1 case — pulmonary embolism, and in 1 case — perforated gastric ulcer. General somatic complications developed statistically significantly more often in patients with CoT (F-test, p=0.011). However, in the group of patients with CoT, no statistically significant relationship was found between the ISS and the fact of developing a somatic complication (M–W test, p = 0.264). Blood loss did not significantly affect the development of somatic complications (M–W test, p=0.448), but longer surgeries statistically significantly more often provoked their development (M–W test, p=0.047). Among patients without CoT, a strong trend towards a lower likelihood of complications after pTPF compared with anterior and combined approaches was noted, but it did not have statistical significance (F-test, p=0.082, and 0.055, respectively).

Minor surgical complications (grades Ia and Ib according to the F. Ibañez classification) were detected in 5.9% of patients. Among them, the most common were supra-aponeurotic suppuration of the postoperative wound (1.7%), and wound edge failure (1.3%). Among other complications, residual pneumothorax in the transthoracic access area, malposition of the vertebral body prosthesis or plate screw that did not require reoperation, and wound liquorrhea were observed in isolated cases. One patient developed lower paraparesis up to 3 points after posterior decompression-stabilization intervention, and one patient developed hip hypoesthesia after retroperitoneal access to L3–L4–L5 vertebrae. There was no statistically significant relationship between the method of surgical treatment and the development of F. Ibañez grade Ia and Ib complications (χ^2-test, p=0.376).

The incidence of surgical complications leading to reoperation (F. Ibañez grade IIb and IIIb) was 7.1%. Suppuration in the implant area occurred in 3.4% of patients and was significantly less common in patients after the anterior approach (F-test, p = 0.041). The method of TPF performing did not statistically significantly affect the development of suppuration (χ^2-test, p=0.439). The incidence of clinically significant implant malpositions was 1.7%. Intergroup comparison demonstrated that the pTPF method did not statistically significantly differ from other TPF methods in the incidence of this complication (χ^2-test, p=0.752). Single observations included arterial bleeding into the pleural cavity, which required revision surgery, and wound liquorrhea, the resolution of which required additional sealing of the dura mater and installation of lumbar drainage. In general, in the structure of complications, grade IIb was statistically significantly more common after combined intervention, while IIIb was more common after decTPF (χ^2-test, p=0.043).

The median length of hospital stay for patients without CoT was 16 bed-days (12–24), and with CoT — 25 bed-days (18–39) (M–W test, p<0.0001). Among patients without CoT, the shortest hospital stay was in patients after pTPF (11 hospital stays (9–14), K–W test, p=0.009), while for other surgical treatment methods the median bed-days ranged from 16 to 17, and did not differ significantly from each other (K–W test, p=0.908).

Improvement was achieved in 93.1% of patients. In 6.1% of cases, the patients' condition at discharge was interpreted as "unchanged". Deterioration was noted in 2 patients (0.5%). One patient died (0.3%) due to perforated gastric ulcer, peritonitis and multiple organ failure. There was no statistically significant difference in the outcomes between the studied surgical treatment methods (χ^2-test, p=0.772).

DISCUSSION

The issue of choosing a method of surgical treatment of uncomplicated TLS fractures has not lost its relevance to this day, as evidenced by the continuing high rate of publications in the literature of both clinical studies, systematic reviews and meta-analyses [7]. In our opinion, this is due to the fact that most of the basic concepts and approaches to the treatment of this type of injury have been significantly revised. Thus, 10 years ago, the ANR published a recommended treatment protocol for acute spinal trauma in adults [1]. In relation to uncomplicated TLS fractures, a clear treatment concept was formulated in it, based on a specific fracture type according to the AOSpine classification system. The sample of patients presented in this article was treated mainly in accordance with the above recommendation, and is in fact a reflection of the results of its application. Namely, in patients with type A2 fractures, anterior spondylodesis was statistically significantly more often used, A3 – anterior interventions and decTPF, A4 and C – combined operations and decTPF, B1–B2 – medTPF and pTPF.

With regard to the features of surgical treatment, one of the most controversial aspects at present is the need to perform decompression of the anterior femoral structures in case of uncomplicated TLS fractures. As an indication for its performance, the ANR protocol specifies only compression of the SC structures without specific percentages. In our study, anterior decompression was performed mainly in patients with type A2 fractures, decTPF — A3 and A4. It should be noted that the median increase in the SC lumen, regardless of the performance method, was small, and its median did not exceed 15.1%. In addition, decompression was accompanied by a statistically significant increase in the duration of the operation and blood loss, and did not provide any advantages in the degree of correction of post-traumatic deformity. Moreover, prolonged operative time was a statistically significant trigger for the development of postoperative somatic complications, and in the structure of surgical complications, the most severe of them were observed with decTPF. In none of the observations in patients without SC decompression was there an increase in neurological deficit, and the immediate outcomes of their treatment did not statistically significantly differ from the outcomes after the other methods. Initially, decTPF was performed in patients with higher StSC, as evidenced by the statistical significance of the difference in this indicator between medTPF and decTPF (p = 0.007). Since 2018, the Clinic has been using the percutaneous TPF method more actively and widely. Based on our own clinical experience and publications in the literature on the effectiveness of TPF without decompression [8–10], indications for laminectomy began to be limited, as clearly demonstrated by the lack of statistical significance in the StSC upon admission between decTPF and pTPF (p=0.447).

During laminectomy, a number of patients underwent resection of the facet joints on one or both sides. It is believed that this helps prevent spinal cord or root injury, facilitate visualization and removal of fragments. It should be noted that degeneration of intervertebral joints and their subsequent ankylosis can be of significant importance in the formation of reliable spondylodesis between the vertebrae [11], and their preservation in some patients may help avoid anterior spondylodesis or serve as an additional strength factor. Our study demonstrated that anterior and posterior decompression can be performed safely, provided that the facet joints are preserved. Moreover, the only increase in neurological deficit after TPF was in the patient with resection of the facet joints.

The length of the TPF in patients with uncomplicated TLS fractures has also been repeatedly discussed in the literature. The latest meta-analysis [12] shows the advantages of extended TPF in the correction of kyphotic deformity and a lower number of implant-associated complications. Another systematic review [3] did not reveal any significant difference between short and extended TPF in the immediate and remote treatment outcomes. In our study, lengthening the TPF led to a significant increase in the duration of the operation

and blood loss, while no statistically significant effect on the dynamics of radiographic parameters (reduction of kyphosis, AVBH restoration), or on complications, was found.

As for the anterior approaches, on the one hand, in our sample of patients this method was statistically significantly inferior to TPF in the degree of correction of kyphotic deformity, on the other hand, it was accompanied by a statistically significantly lower incidence of surgical complications of grades IIb and IIIb according to the F. Ibañez classification. It should also be noted that the StSC reduction was statistically significantly higher when using lift prostheses. We explain this by the fact that after corpectomy, distraction by the prosthesis leads to tension of the posterior longitudinal ligament and the removal of the remaining fragments from the spinal canal, which causes additional decompression.

Thus, the conducted study demonstrated that strict adherence to the previously published ANR protocol allows achieving good treatment outcomes in more than 93% of patients with an overall complication rate not exceeding the published values in systematic reviews and meta-analyses [3, 13]. Nevertheless, in the presented sample of patients, regardless of the fracture type according to the AOSpine classification, decTPF anterior and combined approaches did not demonstrate obvious advantages in patients with uncomplicated TLS fractures compared to medTPF and pTPF. The use of percutaneous fixation made it possible to reduce blood loss, duration of surgery, incidence of early postoperative complications, and duration of hospitalization.

If we compare the medians of a number of radiographic parameters on admission in pTPF in our study and the combined parameters of the most recently published meta-analysis [14], then the following features can be found. CobbA and AVBH at the Th10–L2 level, in which pTPF was performed, were similar: 16.80 and 64.3% in the present study, and 15.90 and 65.2% in the meta-analysis. At the same time, the StSC at admission had a significant difference: 25.9 and 43.1%, respectively. In our opinion, this is due to the fact that, according to the ANR protocol, it is the higher degree of the StSC that is an indication for decompression, while in the studies included in the meta-analysis, in the absence of neurological deficit even with larger StSC, indications for laminectomy are limited. Nevertheless, our study demonstrated alike immediate outcomes with systematized works of a similar plan [3, 7, 14]. Such ambiguous results of a simple comparison may be a reason for another revision and updating of the ANR spinal injury treatment protocol.

CONCLUSION

Percutaneous transpedicular fixation may be the preferred method of surgical treatment of patients with uncomplicated fractures of the thoracic and lumbar spine. Further study of the remote outcomes of the presented patient sample should be conducted in the future. Together with meta-analysis data, this will allow us to formulate clear criteria for choosing one or another treatment method in patients with uncomplicated fractures of the thoracic and lumbar spine.

FINDINGS

1. At the level of Th1–Th10 vertebrae, percutaneous transpedicular fixation allows achieving good treatment outcomes with a bisegmental Cobb angle of less than 29.70, relative height of the vertebral body along the anterior contour over 48.8%, vertebral body index over 0.46, and spinal canal stenosis degree under 27%. At the level of the thoracolumbar junction, these indicators were as follows: bisegmental Cobb angle of less than 200, a relative height of a vertebral body along its anterior edge of more than 60.4%, vertebral body index over 0.63, and spinal canal stenosis degree no higher than 40.2%. At the L3–L5 level, good results are achieved with percutaneous transpedicular fixation at a Cobb angle of less than 5.90, a relative height of a vertebral body along its anterior edge exceeding 66.8%, a vertebral body index of more than 0.70, and spinal canal stenosis degree below 36%.

2. Decompressive laminectomy after transpedicular fixation is accompanied by an increase in the duration of the operation (Mann–Whitney test, p=0.001) and the volume of blood loss (Mann–Whitney test, p=0.003), and statistically significantly increases the number of IIIb complications (Chi-square test, p=0.043).

3. The use of distraction cages does not statistically significantly affect the degree of bisegmental Cobb angle correction (Mann–Whitney test, p=0.340). However, this was accompanied by a statistically significant decrease in the degree of spinal canal compression after surgery (Mann–Whitney test, p=0.016).

REFERENCES

1. Krylov VV, Grin' AA, Lutsik AA, Parfenov VE, Dulaev AK, Manukovskiy, et al. An advisory protocol for treatment of acute complicated and uncomplicated spinal cord injury in adults (association of neurosurgeons of the Russian Federation). Part 3. *Burdenko's Journal of Neurosurgery*. 2015;79(2):97–110. https://doi.org/10.17116/neiro201579297-110
2. Grin AA, Karanadze VA, Kordonskiy AYu, Talypov AE, Lvov IS, Abdrafiev RI. Efficacy and safety of conservative treatment in patients with neurologically intact thoracolumbar burst fractures: a meta-analysis. *Russian Journal of Spine Surgery (Khirurgiya Pozvonochnika)*. 2024;21(2):27–38. https://doi.org/10.14531/ss2024.2.27-38
3. Grin A, Karanadze V, Lvov I, Kordonskiy A, Talypov A, Smirnov V, et al. Effective method of pedicle screw fixation in patients with neurologically intact thoracolumbar burst fractures: a systematic review of studies published over the last 20 years. *Neurocirugia (Astur: Engl Ed)*. 2024;35(6):299–310. PMID: 39089628 https://doi.org/10.1016/j.neucie.2024.07.009
4. Ramikh EA. Injuries of the thoracic and lumbar spine. *Russian Journal of Spine Surgery (Khirurgiya Pozvonochnika)*. 2008;(1):086–106. (In Russ.) https://doi.org/10.14531/ss2008.1.86-106
5. Vaccaro AR, Oner C, Kepler CK, Dvorak M, Schnake K, Bellabarba C, et al. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. *Spine (Phila Pa 1976)*. 2013;38(23):2028–2037. PMID: 23970107 https://doi.org/10.1097/BRS.0b013e3182a8a381
6. Landriel Ibañez FA, Hem S, Ajler P, Vecchi E, Ciraolo C, Baccanelli M, et al. A new classification of complications in neurosurgery. *World Neurosurg.* 2011;75(5–6):709–715; discussion 604–611. PMID: 21704941 https://doi.org/10.1016/j.wneu.2010.11.010
7. Grin A, Karanadze V, Lvov I, Talypov A, Kordonskiy A, Abdrafiev R. Is anterior fusion still necessary in patients with neurologically intact thoracolumbar burst fractures? A systematic review and meta-analysis. *Neurocirugia (Astur: Engl Ed)*. 2024 Nov 19:S2529-8496(24)00072-8. PMID: 39571681 https://doi.org/10.1016/j.neucie.2024.11.006 Online ahead of print.
8. Wu X, Zhang B, Zhang CL, Wu XT, Zhang QH. Efficacy and safety of minimal pedicle screw fixation for thoracolumbar fractures: a meta-analysis. *Eur Rev Med Pharmacol Sci.* 2018;22(1 Suppl):45–52. PMID: 30004564 https://doi.org/10.26355/eurrev_201807_15362
9. Lan T, Chen Y, Hu SY, Li AL, Yang XJ. Is fusion superior to non-fusion for the treatment of thoracolumbar burst fracture? A systematic review and meta-analysis. *J Orthop Sci*. 2017;22(5):828–833. PMID: 28641907 https://doi.org/10.1016/j.jos.2017.05.014
10. Diniz JM, Botelho RV. Is fusion necessary for thoracolumbar burst fracture treated with spinal fixation? A systematic review and meta-analysis. *J Neurosurg Spine*. 2017;27(5):584–592. PMID: 28777064 https://doi.org/10.3171/2017.1.SPINE161014
11. Izeki M, Fujio K, Ota S, Soga S, Matsuda S. Radiological follow-up of the degenerated facet joints after lateral lumbar interbody fusion with percutaneous pedicle screw fixation: Focus on spontaneous facet joint fusion. *J Orthop Sci*. 2022;27(5):982–989. PMID: 34373146 https://doi.org/10.1016/j.jos.2021.06.018
12. Ituarte F, Wiegers NW, Ruppar T, Goldstein C, Nourbakhsh A. Posterior Thoracolumbar Instrumented Fusion for Burst Fractures: A Meta-analysis. *Clin Spine Surg*. 2019;32(2):57–63. PMID: 30614840 https://doi.org/10.1097/BSD.0000000000000763
13. Hinojosa-Gonzalez DE, Estrada-Mendizabal RJ, Bueno-Gutierrez LC, Roblesgil-Medrano A, Tellez-Garcia E, Galindo-Garza CA, et al. A Network Meta-Analysis on the Surgical Management of Thoracolumbar Burst Fractures: Anterior, Posterior, and Combined. *Spine Surg Relat Res*. 2023;7(3):211–218. PMID: 37309497 https://doi.org/10.22603/ssrr.2022-0196 eCollection 2023 May 27.
14. Grin AA, Talypov AE, Kordonskiy AYu, Karanadze VA, Lvov IS, Smirnov VA, et al. Efficacy and safety of short segment pedicle screw fixation in patients with neurologically intact burst fractures of the lower thoracic and lumbar spine: a meta-analysis of studies published over the last 20 years. *Russian Journal of Spine Surgery (Khirurgiya Pozvonochnika)*. 2024;21(3):14–24. https://doi.org/10.14531/ss2024.3.14-24

Received on 21/01/2025
Review completed on 12/02/2025
Accepted on 24/03/2025