SHORT VS LONG POSTERIOR FIXATION OF THORACOLUMBAR SPINE INJURIES

KRATKA NASUPROT DUGOJ POSTERIORNOJ FIKSACIJI POVREDA TORAKOLUMBALNE KIČME

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Summary

Introduction. More than a quarter of total number of posterior fixations of thoracolumbar spine is unsuccessful. Material and methods. The aim is to compare short and long fixation of thoracolumbar spine injuries. During the period of 2006 to 2015 we examined 99 patients at the Department of Orthopedic Surgery and Traumatology of Clinical Center of Vojvodina. Short fixation was performed in 63 cases and long fixation in 36 cases. All patients underwent clinical, radiographic and neurological evaluation. Mean age in the short fixation group was 47 (18-66) and in the long fixation group it was 43 (17-70). Mean follow-up time was 4.5 years. Results. Implants were extracted in 14 cases of short and in 4 cases of long fixation. Collapse of anterior part of vertebral body developed in 28.45% in the short fixation group and in 22.43% in the long fixation group whereas angulation value was 10.20, 12.30 respectively. Mean low back outcome scale value was 61 points in the short fixation group and 50 in the long fixation group. There were 22 patients with neurological deficit. Full recovery was recorded in 8 patients (36.4%) of the short fixation group and in 17 patients (22.7%) of the long fixation group. Complications developed in 15 patients (23.8%) of the short fixation group and 11 (30.6%) of the long fixation group. Conclusion. Short fixation is biomechanically weaker but provides a better functional recovery than long fixation.

Key words: Lumbar Vertebrae; Thoracic Vertebrae; Spinal Fractures; Orthopedic Fixation Devices; Treatment Outcome; Fracture Fixation, Internal

Sažetak


Ključne reči: lumbalni pršljenovi; grudni pršljenovi; prelom

Introduction

Spine injuries are frequent. The outcome of the treatment of unstable thoracolumbar spine injuries is often uncertain and depends on many factors, mainly on final neurological status of the patient, pain severity, degree of correction of traumatic spine deformity and complications. Surgical approach and ways of fixation of these injuries are still controversial [1]. Posterior transpedicular fixation has become increasingly popular during the past several years. The short posterior fixation [2] is stabilization of the injured vertebra together with the adjacent upper and lower vertebrae and the long posterior fixation is stabilization of the injured vertebrae together with two adjacent upper and two lower vertebrae. About a quarter of total number of posterior fixations turns out to be a failure regarding the degree of deformity correction, stability of construction and related complications [3]. The short fixation leads to lesser muscle trauma and lesser number of “stiffened” segments of the spine which should lead to a better functional result but it is shown over a long period of time that this weaker construction leads to a recurrent deformity [4]. Therefore it is necessary to compare long and short fixation from several aspects so that a surgeon can decide which way of stabilization should be used in individual cases.

The aim of this study is to analyze functional, radiographic and neurological results of posterior
**Abbreviations**

SF – short fixation
LF – long fixation
t – t test
ADin – angular deformity initially
ADk – angular deformity control
B in % – the collapse of the anterior wall of the vertebral body initially
B k % – the collapse of the anterior wall of the vertebral body control
LBOS – low back outcome scale
χ² – Chi-square test
χ² > χ²a – the ratio of the value of the Chi-square test for short and long fixation

fixation of these injuries and to compare short and long fixation.

**Material and Methods**

During the period from 2006 to 2015 at the Department of Orthopedic Surgery and Traumatology, and at the Emergency Department of the Clinical Centre of Vojvodina 175 patients with spinal injury were operated. There were 147 patients with thoracolumbar spine injury, 18 of them died, 30 of them did not come to checkups so we analyzed 99 of them. Short fixation was performed in 63 cases of unstable thoracolumbar spine injury and long posterior transpedicular stabilization was performed in 36 patients.

There were 74 (75%) male and 25 (25%) female participants. Mean age was 47 years (ranging from 18 to 66) and 43 years (ranging from 17 to 70) in the group with short fixation and in the group with long fixation, respectively. The oldest and the youngest patient was 70 and 17 years old, respectively. The patients underwent clinical, radiographic and neurological examination. Standard native radiographies and computed tomography (CT) were used.

The most frequently injured vertebra was L1 (34 cases) followed by Th12 (25 cases), L2 (14 patients) and Th11 (11 cases). The lower lumbar spine, levels L3-L5, was injured in 8 cases and the medial and upper thoracic spine, levels Th1-Th10 in 7 cases. The most frequent injuries were unstable burst fractures Magier type “A3” [5] in 69 cases, type “A2” in 12 cases, “B1” in 10 cases and types “B2” and “C” in 4 cases each.

Radiographic analysis consisted of angle measurement of local angulation using Cobb’s method and calculation of percentage of collapse of the anterior side of vertebral body at the checkup [6]. We took mean value of anterior height of two adjacent vertebrae as the initial value of the vertebral height before the injury (Scheme 1).

Neurological evaluation and follow-up were performed using Frankel’s score system [7]. Neurological impairment was observed in 39 patients (39.4%), i.e. in 17 patients (47.2%) from the group with long fixation and in 22 patients (34.9%) from the group with short fixation. Complete paralysis (Frankel “A”) was noted in 5 (7.9%) cases in the group with short fixation and in 4 (11.1%) cases in the group with long fixation while an incomplete neurological deficit (Frankel “B” – “D”) was noted in 17 (27%) cases in the group with short fixation and in 13 (36.1%) cases in the group with long fixation.

The surgical procedure consisted of transpedicular stabilization of the injured level together with adjacent upper and lower vertebral levels. We displayed the posterior part of vertebrae to the transversal processes by using a standard posterior approach. Then we opened pedicles of the injured and the adjacent vertebrae through the known projection points on the small vertebral joints. We placed poliaxial screws through these openings. In cases with neurological deficit we performed posterior decompression – partial or complete laminectomy and extraction of bony fragments from the spinal canal until dural sac was completely free. Then we placed modified rods to the grooves at the screw’ heads. We manipulated the rods to gain distraction and derotation along with the hyperextension of the injured level which led to the correction of deformity and indirect decompression of the spinal canal at the level of fracture and stenosis. Short fixation consisted of stabilization of the injured level together with one adjacent upper and lower levels and long fixation consisted of stabilization together with two adjacent upper and lower levels. Early postoperative mobilization of patients started the next day and consisted of turning to sides and performing active exercises for body and extremities. In cases with neurological deficit it consisted of turning to sides, gradual verticalization, breathing exercises and positioning of the legs in order to prevent flexion contractures of the joints.

Functional examination at checkups was performed by means of Low Back Outcome Scale (LBOS) score system [8]. Maximum result was 75 points. Functional result was graded as “excellent” (65-75 points), “good” (50-64 points), “satisfactory” (30-49 points) and “poor” (0-29 points). We also included pain intensity felt by the patient at the end of the treatment and it was evaluated by the pain intensity scale – 0 points – no pain, 3 points – weak pain, 6 points – medium pain, 9 points – severe pain. After discharge from the hospital the physical treatment was performed at some of the specialized rehabilitation centers. Mean follow-up time was 4.5 years (2-8).

**Results**

Average final collapse of the anterior part of vertebral body was 42.25% in cases with short fixation and 32.45% with long fixation, that being statistically significant (t=2.35 p<0.05) while final angulation was 10.2° in the group with short fixation and 12.3° in the group with long fixation (t=0.77 p<0.05).

Average value of LBOS – the scale of functional capacity was 61 points (good) in cases with short fixation and 50 points (good) in cases with long fixation. Zero hypothesis is that distributions of frequencies of LBOS points of short and long fixations χ² i χ²a are equal. Xsr long=1.77, xsr short=1.07; χ² =48.75 ; r= 3;
In this study we noticed a higher percentage of implant fracture and migration in the group with short fixation (24% compared to 20% in the other group) as well as a higher percentage of the need for implant extraction (22% compared to 11% in the group with long fixation). Farrokhi et al. [9] compared complications caused by transpedicular implants in short fixation. The results showed that these complications occurred in 21.4% of cases in the group with bridging of the fracture level and in only 5.26% in the group where the broken vertebra was included into the instrumentation. In most cases in our study we performed vertebral fixation with bridging the injured vertebra, those are the “A3” types of injuries with fracture of the base or the pedicle itself within crushing the vertebra so our results are similar to the results of the “bridging” subgroup in Farrokhi’s study. Jutte and Castelein [10] noticed complications related to implants in more than 50% of the cases of total of 105 transpedicular instruments. They

### Discussion

Pneumonia was noted in 4 patients (6.32%) in the group with short fixation and in 3 patients (8.34%) in the group with long fixation. Deep wound infection occurred in one patient (1.58%) from the group with short fixation and in 2 patients (5.6%) in the group with long fixation. Infection was treated by local tissue debridement, irrigation and antibiotics with the removal of the implants (Graph 1).

### Table 2. Neurological evaluation

<table>
<thead>
<tr>
<th>Frankel Initially</th>
<th>Frankel final - short fixation</th>
<th>Frankel final - long fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frankel Početno</td>
<td>Frenkel finalno - kratka fiksacija</td>
<td>Frenkel finalno - duga fiksacija</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
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<td>B</td>
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<td>E</td>
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</table>

### Table 1. Radiographic and functional parameters and complications caused by the implants

<table>
<thead>
<tr>
<th>AD&lt;sup&gt;0&lt;/sup&gt; in AD&lt;sup&gt;0&lt;/sup&gt;</th>
<th>t</th>
<th>B&lt;sub&gt;k&lt;/sub&gt; in %</th>
<th>B&lt;sub&gt;k&lt;/sub&gt; K%</th>
<th>t</th>
<th>LBOS point/ bod</th>
<th>χ&lt;sup&gt;2&lt;/sup&gt;</th>
<th>χ&lt;sup&gt;2&lt;/sup&gt; &gt; χ&lt;sup&gt;2&lt;/sup&gt;&lt;sub&gt;α&lt;/sub&gt;</th>
<th>Implant migration</th>
<th>Implant extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF</td>
<td>18,6</td>
<td>10,2</td>
<td>0,77</td>
<td>51,4</td>
<td>42,2</td>
<td>2,4</td>
<td>61</td>
<td>48,75</td>
<td>24</td>
</tr>
<tr>
<td>LF</td>
<td>21,7</td>
<td>12,3</td>
<td>(p&gt;0,05)</td>
<td>54,8</td>
<td>32,5</td>
<td>(p&lt;0,05)</td>
<td>50</td>
<td>3,841</td>
<td>(p&lt;0,05)</td>
</tr>
</tbody>
</table>

Legend:
- SF - short fixation/kratka fiksacija, LF - long fixation/duga fiksacija, t - t test, AD<sup>0</sup>in - angular deformity initially/ lokalna angulacija inicijalno, AD<sup>0</sup>k - angular deformity control/lokalna angulacija kontrola, B<sub>k</sub> in % - the collapse of the anterior wall of the vertebral body initially/kolaps prednjeg dela tela pršljena inicijalno, B<sub>k</sub> K % - the collapse of the anterior wall of the vertebral body control/kolaps prednjeg dela tela pršljena kontrola, LBOS - low back outcome scale/ishoda skala donjeg dela leđa, χ<sup>2</sup> - Chi-square test/Hi-kvadrat test, χ<sup>2</sup> > χ<sup>2</sup><sub>α</sub> - the ratio of the value of the Chi-square test for short and long fixation/odnos hi-kvadrat testova kratke i duge fiksacije

As χ<sup>2</sup> > χ<sup>2</sup><sub>α</sub>, we reject the zero hypothesis with the risk α and conclude that the differences between frequencies distribution are significant.

Implant fracture and migration was noted at checkups in 29 cases (46%) in the group with short fixation and in 11 cases (30.5%) in the group with long fixation. There was a statistical significance between the groups regarding this parameter (p<0,05). Implants were removed in 14 cases (22.2%) with short fixation and in 4 cases (11.1%) with long fixation. Radiographic and functional results as well as complications related to implants are displayed in Table 1.

Eight (36.4%) out of 22 patients from the group with short fixation and 7 out of 17 patients from the group with long fixation (41.1%) recovered from neurological deficit. Neurological recovery was observed only in subgroups with partial neurological deficit (“B”, “C”, “D”). Eight (44%) out of 17 patients in the group with short fixation and 7 (53.9%) of 13 patients from the group with long fixation with initial neurological status Frankel “B”, “C” and “D” recovered from partial neurological deficit. Neurological status of patients is given in Table 2.

Complications were present in 15 patients (23.8%) in the group with short fixation and in 11 patients in the group with long fixation (30.6%). The most frequent complication was urinary infection with positive bacterial culture during the observation period and it was noted in 12 patients (12%) from the group with short fixation and 8 patients (22.2%) from the group with long fixation. All patients had severe neurological deficit (Frenkel “B”, “C” and “D”). Pneumonia was noted in 4 patients (6.32%) in the group with short fixation and in 3 patients (8.34%) in the group with long fixation. Deep wound infection occurred in one patient (1.58%) from the group with short fixation and in 2 patients (5.6%) in the group with long fixation. Infection was treated by local tissue debridement, irrigation and antibiotics with the removal of the implants (Graph 1).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tr>
<td>5</td>
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considered a complication every position of the implant which was not the ideal position. They noticed an implant fracture in 12.4% of the cases, which was less than in our study. The same authors removed the instrumentation in 10% of the case, that being half of the frequency in our study. We presume that one of the reasons of our poorer results compared to Jutte’s study is that we often performed the instrumentation with technical inaccuracy.

We also noticed that the final collapse of the body of the injured vertebra in patients treated with short stabilization (25%) was 10% larger compared to treatment with long fixation (32.34%). Vertebral body collapse occurred regularly after burst fractures. In those cases, due to crushing of the vertebral body there was no anterior part of the vertebra so the patient’s weight bent the implant during the process of verticalization [11]. We, as well as other authors [12], have noticed that when the patient’s weight above the fracture level is transferred to only one pair of transpedicular screws without the support of the anterior part of the vertebral body, the instrumentation suffers much larger load than in cases when the weight is distributed to more screws which are placed proximally. The difference between the groups of patients can be explained to a certain extent by the difference in age. The Patients from the short fixation group were 4 years older on average than in the long fixation group. In older patients bones are weaker so the fixation of transpedicular screws is weaker [13]. Guven et al. [14] noticed the collapse of the fractured thoracolumbar vertebrae treated with short and long transpedicular fixation in 16.4% and 10.6%, respectively and Tezeren [15] in 15% and 8%, respectively. Our results are significantly poorer (42.2% and 32%) although according to this parameter in our study the long fixation is significantly more efficient than the short fixation. A reason of this significant deviation of results may be that in our study we surgically treated so-called “A3” bursting fractures without grafting the anterior column of the vertebra in most cases while the aforementioned authors did not use this technique in

\[
\alpha = \text{angle of local angulation/ugao lokalne angulacije}
\]

\[
B_0 = \text{anteriort height of the vertebral body prior to fracture/prednja visina tela pre povređivanja}
\]

\[
B_1 = \text{measured anterior height of the fracture vertebral body/izmerena visina prednjeg dela tela prelomljenog pršljenja}
\]

\[
B_2 = \text{percentage of reduction of the anterior part of fractured vertebra, } B_2 = \frac{(B_0 - B_1)}{B_0} \times 100\%
\]

\[
A_x = \text{anterior height of the upper adjacent vertebral body/prednja visina tela susednog višeg pršljenja}
\]

\[
C_x = \text{anterior height of the lower adjacent vertebral body/prednja visina tela susednog nižeg pršljenja}
\]

\[
D = \text{translation/translacija}
\]

Scheme 1. Calculation of radiographic parameters on an X-ray

**Sema 1.** Merenje i izračunavanje radiografskih parametara na rendgenskom snimku

\[
\alpha = \text{angle of local angulation/ugao lokalne angulacije}
\]

\[
B_0 = \text{anteriort height of the vertebral body prior to fracture/prednja visina tela pre povređivanja}
\]

\[
B_1 = \text{measured anterior height of the fracture vertebral body/izmerena visina prednjeg dela tela prelomljenog pršljenja}
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\]

\[
D = \text{translation/translacija}
\]

A. Short fixation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Short Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surg wound inf</td>
<td>2%</td>
</tr>
<tr>
<td>Gastrointest</td>
<td>0%</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>19%</td>
</tr>
<tr>
<td>Urinary Inf</td>
<td>6%</td>
</tr>
<tr>
<td>Cardiovasc</td>
<td>5%</td>
</tr>
</tbody>
</table>

B. Long fixation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Long Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surg wound inf</td>
<td>7%</td>
</tr>
<tr>
<td>Gastrointest</td>
<td>4%</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>11%</td>
</tr>
<tr>
<td>Urinary Inf</td>
<td>28%</td>
</tr>
<tr>
<td>Cardiovasc</td>
<td>11%</td>
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treatment of Magerl “A3” types of fractures. Besides, we cannot hide our technical errors during the instrumentation placement in some cases which is significant because instrumentation which is not done perfectly leads to vertebral body collapse as shown by some authors [16].

Guven et al. [14] noticed mean angulation of 8° and 7.2° in the groups with short and long fixation, respectively while we noticed 10.2° and 12.3°, respectively, in other words somewhat lower mean values and poorer result in the group with long fixation. The reason for this is that the starting values of angular deformity in the group with long fixation in our study were significantly higher than in the group with short fixation (18.6° short and 21.7° long fixation). On the other hand, Guven had completely homogenous groups regarding this parameter in his study.

Tezeren et al. [14] noticed mean final values of angulation in 18 patients – 10° and 6° for short and long fixation, respectively so it can be concluded that the results were significantly better with long fixation. It is possible that these results are a consequence of a smaller group compared to our study, which included 99 patients. The loss of correction of the fractured vertebral body treated with transpedicular fixation cannot be avoided. In their earlier studies, Carl et al. [17] noticed recurrent kyphosis and collapse of almost 90% of the accomplished correction of burst fractures of the thoraco-lumbar spine while Louis [18] reported that the injured patients with corrected kyphosis and vertebral diameters developed recurrent deformity which could be up to 50% of the initial deformity. It needs to be stated that Louise used older types of instrumentation – neutralization plates and screws which are not tightly connected with them. Louise plates were widely used in pathology of vertebral column [19]. Alanay [20] examined two groups of patients treated with short transpedicular fixation with transpedicular grafting and without grafting. He managed to get correction of the deformity in about half of examined cases from both groups. These results are similar to ours. In a study done by a group of Korean authors [21], short and long posterior fusion of thoracic and lumbar vertebral fractures were compared after the Cotrel-Dubousset instrumentation. A higher percentage of successful fusion was accomplished in the group with short fusion although final collapse of broken vertebrae was 24% compared to 17% after long fusion. Final local angulation was also bigger in the group with short fusion than with long fusion (the mean difference was 5.7°) but the functional recovery at the end of the study was better.

We can draw a conclusion that short fixation is biomechanically weaker than long fixation.

The functional outcome represented by the LBOS scale in our study is significantly better in the patients treated with short fixation which is similar to the result obtained by Korean authors in their study.

In our study the mean value was 61 points in the group with short fixation and 50 in the group with long fixation. Tezeren [14] also used this scale for comparison of short and long fixation and got mean LBOS scale value of 61 points in the short fixation group and 63 points in the long fixation group. These are functional results which are significantly different in comparison with our study and that may be explained by the fact that we included the patients both without and with neurological deficit and Tezeren included only the patients without neurological deficit. The functional status is also affected by general surgical complications which we noted in significantly higher percentage in the long fixation group which was not the case in Terezen’s study. Besides that, the patients in Terezen’s study were younger (40 years old) while in our study they were 43 and 47 years old in the long and the short fixation group, respectively. It is known that younger patients regenerate their fun-

![Figure 1. Short transpedicular fixation – the collapse of the body](image-url)

A: „burst“ fracture of the body L1 (arrow key) / „burst“ prelom tela L1 (strelica)
B: CT of the fracture - retro-pulsion of the fragments and stenosis/CT snmak preloma - retropulzija fragmenta i stenoza
C: Postoperative status - the arrow is pointing restoration of vertebral body dimensions/Postoperativni status – strelica pokazuje restoraciju dimenzija tela pršljena
D: Control anteroposterior and lateral X-ray - there was a collapse of the body to its original dimensions (arrow)/ Kontrolni anteroposteriori i profilni rendgenski snimak – došlo je do kolapsa tela do početnih dimenzija (strelica)
A: comminutive fracture L2 – initial X-ray/rasprskavajući prelom L2 – inicijalni RTG
B: axial CT - the display of size of the vertebral body comminution fracture and bilateral fractures of pedicle base/aksijalni CT – prikaz veličine rasprskavanja tela preloma i prelomi baza oba pedikla
C: postoperative AP and lateral X-ray – transpedicular instrumentation placed to two levels above and two under the fracture/ po
postoperativni prednje-zadnji i bočni RTG – transpedikularna instrumentacija sa fiksacijom dva nivoa iznad i ispod nivoa preloma

Figure 2. Long transpedicular fixation

Slika 2. Duga transpedikularna fiksacija

A: comminutive fracture L2 – initial X-ray/rasprskavajući prelom L2 – inicijalni RTG
B: axial CT - the display of size of the vertebral body comminution fracture and bilateral fractures of pedicle base/aksijalni CT – prikaz veličine rasprskavanja tela preloma i prelomi baza oba pedikla
C: postoperative AP and lateral X-ray – transpedicular instrumentation placed to two levels above and two under the fracture/ po
postoperativni prednje-zadnji i bočni RTG – transpedikularna instrumentacija sa fiksacijom dva nivoa iznad i ispod nivoa preloma

ditional status more easily and more quickly than older patients. Wei et al. [22] also conducted functional research of the patients treated with short and monosegmental fixation of thoracolumbar spine. They found the mean LBOS scale value of 74.9 points in the group with monosegmental fixation, which is much better result than in our study, and 60.2 points in the group with short fixation, which is similar to our result. We can conclude that shorter fixation leads to a better functional recovery of patients. That “saves” more dynamic segments, allows more mobility of the spine which leads to better functional status of the spine as a whole [23]. Alanay [20] also conducted an examination of the functional status and pain. Functional result and pain was expressed by Likert’s scale (pain intensity graded from 0 to 10). The results were similar in both groups of patients – 7.0 points in the group where transpedicular grafting was used and 7.2 in the group where grafting was not used. These results are somewhat poorer than ours.

Deep infection of surgical wound when treating spine trauma was recorded in about 4.7% of the cases in Jutta’s [10] study, which is similar to our results in the long fixation group (5.6%). In the short fixation group of our study a deep wound infection was recorded in just one patient (1.58%). The difference can be explained by shorter surgery time and lesser tissue trauma during the short fixation. Complications of transpedicular fixations of the thoracolumbar spine were examined also by Farrokhi et al [9]. The percentage of deep infection was 5.25% in the “including” group and 9.5% in the “bridging” group. “Including” means that fractured vertebra was also fixated through the pedicles and “bridging” means that that fractured vertebra was skipped. The results of Farrokhi are similar to our results. Guven [14] recorded one case of deep vein thrombosis. In our research the most frequent complication was urinary infection in both groups (in 19% and 28% of the patients from the short and long fixation group, respectively). It was recorded only in the patients who suffered neurological deficit and had a urinary catheter for a long time. Other frequent complications included pneumonia in four cases in the short (6%) and four cases in long fixation group (11%).

Neurological status of patients in both groups was better than the initial one. Better recovery was recorded in the long fixation group (36.4% short and 44% long fixation). The difference of neurological recovery was statistically significant in the subgroups of incomplete lesions (“B”, “C”, “D”), being better in long fixation (in 53.9% and 44% of the patients from the long and short fixation group, respectively). This difference can partially be explained by better and more stable reconstruction of the vertebral column by using long instrumentation which enables more aggressive early rehabilitation and also by a fact that partial neurological deficit was much more frequent in the long instrumentation group (36% long, 27% short). In other words patients with bigger neurological deficits were in the long fixation group. The size of neurological recovery was, on average, in both groups one Frankel grade which has also been reported by other authors [24].

Conclusion

Short fixation of the thoracolumbar spine fractures as biomechanically weaker allows recurrence of the traumatic deformation to a larger extent than long fixation but is is less invasive and provides better functional result with fewer complications.

References

All doctors employed the Department of Orthopedic Surgery and Traumatology
*Svi lekari Klinike za ortopedsku hirurgiju i traumatologiju*