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Comparison of long-term clinical results of compression fractures treatment of the thoracolumbar spine: Open *vs* percutaneous transpedicular stabilization

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Abstract

Study Design: This is a retrospective questionnaire-based case series analysis.

Objectives: Comparison of long-term clinical results of open vs percutaneous technique of transpedicular stabilization in thoracolumbar fractures.

Background data: Most of the available studies concerning short-term observation show that percutaneous technique is better tolerated. However, the meta-analysis by Liu shows that percutaneous stabilization produces lesser improvement in the change of Cobb angle.

Methods: 85 questionnaires were sent to patients who underwent a transpedicular stabilization for treatment of injury-induced Th10-L2 fractures at our center between 2008 and 2019. Apart from basic patient information, the questionnaires included VAS for back pain, Oswestry Disability Index, Euro-QoL 5Q3 and Health Condition Scale. We compared the results in relation to method of treatment, post-discharge time span, age and BMI.

Results: Return rate of 70,6% enabled us to analyze 60 surveys containing functional status of the patients. The open method group had better results in every analyzed clinical aspect, reaching statistical significance for ODI (20.47 vs 32.05 p=0.02). Moreover, patients with longer timespan from surgery, higher BMI and older age presented a tendency towards better clinical results in open transpedicular stabilization. However, these results were statistically insignificant (p>0.05).

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Conclusion: Our results demonstrate that a long-term follow-up may prove the advantages of the open method over the percutaneous one. Potentially, this may result from the open method offering a better intraoperative correction feasibility and lesser construct stiffness in maintenance of the achieved correction in the percutaneous method. Nevertheless, our findings warrant radiological study comparing sagittal balance and correction degree in these patients and such a study is currently in progress.

Introduction

A comprehensive treatment of spine fractures is one of the biggest challenges in spine surgery [1]. There is a worldwide unparalleled increase in the percentage of cases treated operatively, which stimulates competing biomedical companies to develop new implants and surgical techniques. Although some basic principles of treatment are known and widely applied, there are still doubts about the optimal solutions [2]. In recent years, we have observed an increase in the frequency of percutaneous operations which are gradually replacing open methods in many centers [3,4].

In our department, as in many places, the period 2009-2019 was the time of transition in operation techniques in thoracolumbar fractures. As the number of percutaneous procedures was systematically on the rise, the number of the open ones decreased. Despite the fact that recently substantially more percutaneous stabilizations have been performed in compression fractures, the experience gained with open procedures in proper correction and screw placement cannot be underestimated.

Epidemiological studies indicate that the incidence of spinal injuries amounts to 64 per 100,000 people. Their consequences may be associated with paralysis, pain and deformity, and in the long term, their negative impact on the patients' economic and social status is also possible [5]. More than half of them concern men in the 20-50 age group, while women are in minority and fall in two age groups: 20-50 and 60-80. Approximately 60% of the injuries are located in the thoracic-lumbar region (Th10-L3). Most fractures (54.8%) occur in the compression mechanism - type A, according to the AO classification, rotational fractures of type C constitute 18.5%, of the injuries and flexion fractures of type B amount to 16.9% [6,7].

Among the most common etiologies of injuries in this location there are motor vehicle accidents, high-energy falls from significant heights, pedestrian struck, and also trauma injuries of low energy related to concomitant diseases [8, 9]. Associated injuries were recorded in about 55% of the patients, the most frequent of which included head injuries, chest injuries, upper and lower limb fractures [10-13].

Over the years, the open method of stabilization with a posterior approach was the most common operative procedure. However, it was associated with a substantial blood loss and a risk of infection, a substantial paraspinal muscles injury, and, last but not least, a long surgery, hospitalization and recovery [14].

In recent years, the minimally invasive surgical method of percutaneous stabilization has become increasingly important in the treatment of compression fractures of the spine. Percutaneous transpedicular placement of implants in the vertebrae under the control of neuronavigation systems or X-ray enables minimal incisions in the skin, causes less soft tissue damage and blood loss, it decreases postoperative morbidity and complications as well as hospitalization duration and, according to some studies, it also reduces the length of use of analgesics by 31% and the total dose of the drugs by 42% [15,16].

The aforementioned perioperative and early postoperative advantages do not raise any doubts, there are, however, scarce data for long-term results which, on the other hand, depend solely on the ability of the stabilization construct to maintain a fracture correction [17-19]. This is especially important in the first few post-operative months.

Material and methods

This is a questionnaire retrospective study designed to compare clinical results of patients with compressive fractures of thoracolumbar spine treated with either open or percutaneous navigation-assisted transpedicular stabilization.

We selected patients aged between 18 and 65 years who had sustained a significant trauma with a resulting fracture of the thoracolumbar spine, without any pathological fractures. We limited our study to the patients with the fracture levels of the spine with similar biomechanical properties, namely Th10-L3 [26]. All patients with fractures requiring decompression were excluded, as were the patients with any neurological deficit and/or poly-trauma.

We also excluded patients treated less than 30 months before the questionnaires were sent and patients treated more than 72 hours after the trauma. The study included patients treated between 2008 and 2019, with 2012 being the year of transition from open to percutaneous navigation-assisted procedures in our department.

85 questionnaires were sent to the patients of Neurosurgery Center University Hospital in Zielona Góra. 60 fully completed questionnaires were received (70.6% return rate).

The questionnaire was designed to include the following data: BMI, chronic diseases (hypertension, diabetes, osteoporosis and rheumatologic diseases), smoking and information about professional life (active, active with difficulty, retired for fracture related worker's compensation or for another reason). We also chose the following tools to measure pain and functional status: VAS and Oswestry Disability Index and we also included a generic scale to measure general health status - EuroQoL 5Q3 [27].

We compared the results in relation to the method of treatment, open vs percutaneous navigation-assisted ones, timespan since discharge, age, BMI and concomitant diseases.

Operation techniques

Percutaneous pedicle screw fixation group (PPSF)

Following the introduction of general anesthesia, a patient was placed in a prone decubitus position. In the first stage of the surgery a neuronavigation frame was attached to a selected lumbar spinal process. Then a CT scan was performed and the

data was transferred to a neuronavigation system, in our case, StealthStation S7 (Medtronic Minneapolis, USA).

A neuronavigation-compatible Jamshidi needle was used. The skin incision as well as the pedicle entry-point and the pedicle passage trajectory were determined under the control of neuronavigation. K-wire was placed inside the vertebral body through a Jamshidi needle. A cannulated and navigated tap was used before a screw placement. A titanium alloy CD Horizon Longitude (Medtronic Minneapolis, USA) poly-axial screws were used in every PPSF case. A control CT scan was routinely performed to assess screws placement with their reposition in case of a pedicle breach. Then two pre-measured and pre-contoured 5.5-mm titanium alloy rods were inserted through a separate skin incision paying special attention to avoid any excessive force applied to bring down the rods into screws heads.

Open pedicle screw fixation group (OPSF)

Following the general anesthesia and patient positioning as in PPSF method, a skin incision was made in the midline over the fractured vertebra and according to planned length of stabilization. Paraspinal muscles were detached to expose facet joints and medial parts of transverse processes. Next, every step of the procedure was performed under the control of C-arm. Entry points to pedicles were marked and fluoro-checked followed by a passage through the pedicles. Tap was routinely used and screws were placed in a standard fashion. After placement of all screws, a well-fitted titanium alloy 5.5-mm rod was attached to screws heads. Poly-axial titanium alloy CD Horizon Legacy (Medtronic Minneapolis, USA) screws were used.

Neither in PPSF nor in OPSF any bone union substances, body augmentation such as kyphoplasty or vertebroplasty were used.

Independently of the operation method applied, the stabilization construct consisted of 6 screws (3-level stabilization). The screw placement in the fractured vertebra depended on the condition of the pedicle and the vertebral body. When the severity of the fracture did not allow for index screw implantation, the fracture level was omitted and the level above was incorporated into the construct [20-25].

In both surgical techniques intraoperative radiological confirmation of satisfactory correction of fractures was used - CT reformatted sagittal and coronal projections for percutaneous method, and lateral and AP X-ray views for open method.

Results

60 patients underwent a spinal stabilization surgery. They were operated on by 6 neurosurgeons in one institution in the period from January 2008 to December 2019. 43 patients underwent a percutaneous stabilization and the remaining 17 patients underwent an open pedicle screw fixation. Male group was comprised of 36 patients and females comprised 24 patients. Their age ranged from 19 to 86 years (median, 59 yrs). Table 1 presents patients' demographic and clinical characteristics in both treatment groups.

Table 1: Patient information by type of procedure.

Type of procedure	n (%)	
	Percutaneous	Open
Procedure	43 (72%)	17 (28%)
Sex (male)	26 (60.4%)	10 (58.8%)
Age (y) median (range)	51 (19-86)	64 (38-72)
BMI median (range)	25,48 (17,03-37,04)	25,86 (21,31-39,68)
Overweight	16 (37.2%)	9 (47.3%)
Obese	7 (16.2%)	3 (17.6%)
Tobacco user (smoker)	11 (25.6%)	4 (23,5%)
Comorbidities		
Hypertension	15 (34.9%)	5 (29%4%)
Diabetes	5 (11.6%)	3 (17.6%)
Osteoporosis	3 (7%)	1 (5.9%)
Rheumatic diseases	5 (11.6%)	2 (11.7%)

Distant results of treatment of patients are presented in Table 2. The patients after the open pedicle screw fixation stabilization showed statistically significantly better ODI results than patients after percutaneous surgery under the control of neuronavigation (20.47 vs. 32.05 p=0.02).

Similarly, on the EQ scale, better results, approaching statistical significance, were observed in patients operated on with the open method than in those after the neuronavigation method (18.24 vs. 30.93 p=0.08).

Table 2: Distant results of treatment by type of procedure.

	Percutaneous	Open	p-value
VAS	4.68; n=43	3.65; n=17	**0.16**
ODI	32.05; n=43	20.47; n=17	**0.02**
Euro-Qol 5Q3	30.93; n=43	18.24; n=17	**0.08**
Health condition scale	59.81; n=43	67.47; n=17	**0.22**

Table 3 presents distant results of treatment with regard to post-surgery period. Better results in all of the scales in the questionnaire were recorded in the patients who had been operated on more than 6,63 years / 79 months (median value) prior to our research However, these results are not statistically significant (p>0.05) and only show a tendency towards better outcomes in patients with a longer post-procedure period.

Table 3: Distant results of treatment with regard to post-surgery period.

	Longer time (>6,63y/79m after procedure)	Shorter time (<6,63y/79m after procedure)	p-value
VAS	3.98; n=30	4.65; n=30	0,27
ODI	26.2; n=30	31.33; n=30	0,37
Euro-Qol 5Q3	22.33; n=30	32.33; n=30	0,13
Health condition scale	63.97; n=30	60; n=30	0,49

The tendency towards better outcomes in older patients (median age of 59.23 yrs) and with higher BMI (median value of 25.71) can be seen respectively in Table 4 and Table 5. Better ODI and Euro-Qol 5Q3 results were recorded in these patients but the values were also statistically insignificant (p>0.05).

Table 4: Distant results of treatment by the age of the patient.

	Age >59.23 yrs	Age <59.23 yrs	p-value
ODI	25.6; n=30	31.93; n=30	0.27
Euro-Qol 5Q3	22.67; n=30	32; n=30	0.16

Table 5: Distant results of treatment by BMI of the patient.

	BMI >25.71	BMI <25.71	p-value
ODI	26.62; 19-35; n=29	30.77; 22-39; n=31	0.47
Euro-Qol 5Q3	25.86; 15-36; n=29	28.7; 20-37; n=31	0.67

Discussion

The main focus of our study was to investigate the potential difference between long-term results of open in comparison to navigation-guided percutaneous transpedicular stabilization of thoracolumbar spine. The introduction of percutaneous instrumentations in spine surgery has dramatically changed everyday practice in most departments managing spinal fractures, including ours [28]. In fact, since 2012 in our institution most fractures requiring transpedicular stabilization have been treated with the application of percutaneous navigation-guided transpedicular screws. Intuitive advantages of this technique such as a less traumatic muscle dissection, diminished blood loss and shorter hospitalization have already been confirmed in numerous studies [29].

However, as this is too often the case in spinal surgery research, long-term results are scarcely reported. In the meta-analysis by Phan K. both percutaneous and open stabilizations led to early postoperative improvement of VAS scores, however, it was the percutaneous method that produced significantly better results (p=0,001) [4]. The meta-analysis also showed no difference in terms of postoperative Cobb angle [30,31]. In contrast, the meta-analysis by Liu showed that the percutaneous stabilization provided less improvement in the change of Cobb angle. Furthermore, the long-term follow-up revealed no clear advantage of this technique either [32,33].

Our study did not include radiological measurements but provided some insight into long-term clinical results in terms of pain and functional status. Better results were found in the patients operated on with the open technique, and in the case of ODI the difference reached a statistical significance. Moreover, a clear tendency towards better results was also observed when every other clinical results assessment tool was applied. We believe that this may result from a worse initial correction as well as insufficient rigidity to sustain the achieved correction over a period of time required to establish a proper healing of the fractured vertebral body.

One may argue that better results in the group treated with the open technique may be a consequence of the mean time interval from the operation being longer in comparison to the percutaneous group. However, it seems reasonable to assume that after two years, which we included in the design of this study, there should not be a substantial change of clinical results in comparison to even longer time periods. Nevertheless, to investigate this issue we have already designed an extension study to compare late preservation of proper correction in both groups. The study will measure the maintenance of complete sagittal balance of the spine in both groups of patients and a potential advantage of one of the groups [34].

There still seems to be an open question whether the transpedicular stabilization is actually maintaining its function in a much longer time setting – over 2-3 years. Arguably, there is no need for that as the transpedicular stabilization should only be applied as an internal fixation device which must be removed after a certain amount of time, usually within 12 months. Nevertheless, this is not a widespread consensus and in practice many centers do not routinely remove transpedicular stabilizations [35,36].

Our study also indicated that slightly worse outcomes characterized younger patients rather than the older ones. This tendency may be explained by potentially more high-energy traumas recorded in younger people. Moreover, we observed a positive correlation between higher BMI values and lower disability index in our survey. However, it is not consistent with the research on short segment fixation by M. Formica who claimed that BMI>30 was associated with a higher risk of segmental correction loss [37].

Our results demonstrated that a long-term follow-up may prove the advantages of the open method over the percutaneous one. Potentially, this may result from the open method offering a better intraoperative correction feasibility and lesser construct stiffness in maintenance of the achieved correction in the percutaneous method. Although minimally invasive spine surgery should be developed, our analysis implies that percutaneous techniques and implants should always be carefully considered in order to allow for a better correction of the fracture and its more efficient maintenance, optimally with minimal heathy segment incorporation, and thus without further need of the implant removal. [38]. Nevertheless, our findings warrant radiological study comparing sagittal balance and correction degree in these patients and such a study is currently in progress.

Study limitations

The study has a number of limitations. First of all, it is a retrospective study based on questionnaires filled out by patients. The built-in subjectivity in the design of such studies has to be taken into consideration. The sample size is relatively small and there is a substantial difference in the observation time between groups and their sizes. However, this disadvantage is a consequence of the change of operative practice.

Conclusion

Although minimally invasive spine surgery should be developed, our analysis implies that percutaneous techniques and implants should always be carefully considered in order to allow for a better fracture correction and its more efficient maintenance, without incorporation of healthy and further need of the implant removal.

Declarations

Conflict of interest: The authors declare no conflict of interest.

Approvals: The study protocol has been reviewed and accepted by the Bioethical Committee of the District Medical Chamber in Zielona Góra, Poland. All procedures performed in this study were performed in accordance with the ethical standards of the Bioethical Committee of the District Medical Chamber in Zielona Góra and with the 1964 Helsinki declaration as amended. The informed consent was obtained from all individual participants included in the study.

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