The validity of minimally invasive surgery in treatment of lumbar spine degenerative disease

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Abstract

Objectives: To compare patients with lumbar spine degenerative disease treated by minimally invasive surgery using tubular retractor system and conventional surgical method.

Study Design: Cross-sectional study with historical data.

Patients and Methods: The single-institution series included 48 adult patients treated with one of the two surgical methods during a one-year period. The patients were divided between a case group consisting of minimally invasively treated patients and a control group of those operated on by conventional surgery. The research data were the following: age, gender, duration of symptoms, type of spinal pathology, type of surgical method, number of surgical levels treated, neurological status, pain intensity assessed by Visual Analogue Scale, duration of surgery and length of hospital stay. Modified Odom's criteria were used as a primary outcome measure. All data were documented from electronic medical records, statistically analyzed, and correlated between the groups. The level of statistical significance was set at $p<0.001$.

Results: A significant improvement of neurological status after surgery was recorded in all patients (case group, Fisher's exact test, $p=0.002$, control group, Fisher's exact test $p=0.012$). The pain intensity was significantly reduced after surgery in both groups (case group, Wilcoxon test, $p<0.001$, control group, Wilcoxon test, $p<0.001$). A statistically significant difference was observed between the case and the control group in the length of hospital stay (Mann-Whitney U test, $p<0.001$) and in time elapsed from surgery to patient mobilization (Mann-Whitney U test, $p<0.001$). In all other data examined, no statistically significant difference was noted between the case and control groups.

Conclusion: Surgical treatment of lumbar spine degenerative disease results in significant improvement of neurological status and in reduced pain intensity. Minimally invasive surgery using tubular retractors results in shorter length of stay and earlier patient mobilization.

Keywords: lumbar spine, degenerative disease, minimally invasive surgery, management outcome

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Introduction

Degenerative skeletal disorders are common and serious problems worldwide, particularly in aging populations[1]. Degenerative disease of the spine is a common manifestation of the degenerative process, with the earliest spinal lesions thought to occur in the intervertebral discs. Intervertebral disc degeneration typically appears in the second decade of life in males and in the third decade in females, with more than 50% of middle-aged adults showing some evidence of spinal spondylosis[2]. Symptomatic lumbar disc herniation and degenerative lumbar spinal stenosis are two main consequences of degenerative lumbar spine disease requiring surgical treatment.

Minimally invasive procedures are nowadays commonly utilized for the treatment of many spinal pathologies[3]. Currently, most of these minimally invasive procedures involve using progressive dilators to expand through the muscle onto the facet joints at the desired level[4]. Their potential advantages include reduced length of hospital stay, blood loss, and requirement for post-operative analgesia, as well as shorter recovery and earlier return to work[5].

The aim of this retrospective single-institution study is a comparison of clinical outcomes in degenerative lumbar spine patients treated with minimally invasive surgery using a tubular retractor system versus patients treated with a conventional surgical method.

Methods

The study was designed as cross-sectional study of historical data of patients surgically treated for lumbar spine degenerative disease at the university hospital over a one-year period. The study was approved by the hospital institutional review board.

The study included adult patients with degenerative lumbar spine disease (lumbar disc herniation and lumbar spinal stenosis), with no history of previous surgical treatment at the same or different lumbar vertebral segment, aged 18 to 80, who agreed to participate in the study by signing an informed consent. Patients with other types of spinal pathology (neoplastic or infectious), with prior lumbar spine surgeries, younger than 18 or older than 80 years, as well as patients who refused to participate in the study were excluded.

Based on surgical method, the patients were divided in case and control groups. The case group consisted of patients treated with a minimally invasive surgical method using tubular retractors. The control group consisted of patients treated with conventional microscopical lumbar laminectomy and/or discectomy. All procedures were performed by the same team of surgeons during the one-year period.

For all patients, basic demographic data of age and gender were recorded. The following clinical parameters were analyzed: duration of symptoms, type of degenerative disease (lumbar disc herniation versus lumbar spinal stenosis), type of surgery (tubullar retractor versus microdiscectomy), number of surgically treated vertebral segments, neurological assessment before and after surgery, pain intensity before and after surgery assessed by the Visual Analgue Scale (VAS)[6], duration of surgery, surgical complications such as accidental durotomy, length of hospital stay, time to full patient mobilization and surgical treatment outcome according to modified Odom's criteria[7].

Statistical analysis was performed using STATISTICA 13 software (StatSoft, Tulsa, OK, USA). Categorical variables were presented with absolute and relative frequencies. Numerical data were presented with median and interquartile range. Distribution of the variables was tested using the Shapiro-Wilk test. A difference between numerical variables of two independent samples was tested using the Mann-Whitney U-test and the Wilcoxon test for related samples. Differences between categorical variables were tested using the chi-square test and the Fisher's exact test. All p values are two-sided. Statistical significance level was set at alpha=0.05.

Results

The study included a total of 48 patients, 21 in the case group and 27 in the control group. There were 21 (43.75%) male patients and 27 (56.25%) female patients, with median age of 50.5 years. No statistically

significant difference was observed in gender distribution (chi-square test, p=0.387). Demographic data are presented in Table 1.

Table 1. **Demographic data**

	Case group	Control group
Age	52.38 (± 17.12)	49.74 (± 14.15)
Gender Female Male	 11 (52.4%) 10 (47.6%)	 16 (59.26%) 11 (40.74%)

No statistically significant difference was observed in gender distribution (chi-square test, p=0.771) or age between the case and control group (Mann-Whitney U test, p=0.678). The mean duration of symptoms was 6.63 months, ranging from 1 to 48 months. In the case group, mean symptom duration was 8.15 months, and in control group it was 5.4 months. No statistically significant difference in duration of symptoms was noted between the groups (Student t-test, p=0.305).

According to type of degenerative lumbar spine disease, 39 (81.3%) of the patients had lubar disc herniation, while 9 (18.7%) patients had degenerative lumbar spinal stenosis. Distribution of the patients according to the type of degenerative lumbar spine disease is presented in Table 2. No statistically significant difference was observed between the case and control group in respect to degenerative lumbar spine disease type (chi square test, p=0.623).

Table 2. **Distribution of patients according to lumbar spine degenerative disease type**

	Case group	Control group	Total
Lumbar disc herniation	17	22	39
Lumbar spinal stenosis	4	5	9
Total	21	27	48

In 40 (83.3%) of the patients, single-level surgery was performed. In 7 (14.6%) of the patients two levels were operated on, and in one patient (2.1%) three-level surgery was performed. Distribution of the patients according to number of surgically vertebral segments is shown in Table 3. No statistically significant difference was observed between the case and control group in number of surgically treated segments (chi-square test, p=0.436).

Table 3. **Distribution of the patients according to number of surgically treated lumbar segments**

	Case group	Control group	Total
1 segment	19	21	40
2 segments	2	5	7
3 segments	0	1	1
Total	21	27	48

Regarding neurological status before surgery, in the case group normal neurological examination was noted in 9 (42.8%) of the patients. Radicular sensory symptoms were observed in 6 (28.6%) patients and motor symptoms in additional 6 (28.6%) patients. In the control group, normal neurological examination was noted in 14 (51.9%) of the patients. Radicular sensory symptoms were observed in 7 (25.9%) patients and motor symptoms in additional 6 (22.2%) patients. No patients had the cauda equina syndrome. No statistically significant difference was established in preoperative neurological status between the case and control group (chi-square test, p=0.810, Table 4.).

Table 4. **Preoperative and postoperative neurological assessment**

	Case group	Control group	p
Neurological examination before surgery	Normal 9 (42.8%) Sensory 6 (28.6%) Motor 6 (28.6%) Cauda equina 0 (0.0%)	Normal 14 (51.9%) Sensory 7 (25.9%) Motor 6 (22.2%) Cauda equina 0 (0.0%)	0.810
Neurological examination after surgery	Normal 17 (81.0%) Sensory 4 (19.0%) Motor 0 (0.0%) Cauda equina 0 (0.0%)	Normal 25 (92.6%) Sensory 2 (7.4%) Motor 0 (0.0%) Cauda equina 0 (0.0%)	0.383
p	0.002	0.012	

After surgery, normal neurological examination was noted in 17 (81.0%) patients in the case group, while 4 (19.0%) patients had residual radicular sensory symptoms. In the control group, 25 (92.6%) had normal neurological examination after surgery, and residual radic-

ular sensory symptoms were noted in 2 (7.4%) of the patients. No patients in either the case or control group had motor deficits or the cauda equina syndrome after surgery. No statistically significant difference was found in the postoperative neurological status between the case and control group (chi-square test, p=0.383, Table 4.). In both groups, a statistically significant difference was observed between preoperative and postoperative neurological examination (Fisher's exact test, p=0.002 and p=0.012, for the case and control group respectively).

Median preoperative pain intensity assessed by VAS was 6 in both groups (interquartile range 5-7). Median postoperative pain intensity was 0 (interquartile range 0-1) in the case group, and 1 (interquartile range 0-1) in the control group. No statistically significant difference in preoperative or postoperative pain intensity was observed between the groups (Mann-Whitney U test, p=0.795, p=0.876, preoperatively and postoperatively, respectively). A statistically significant difference was noted in the case and control group in preoperative and postoperative pain intensity (Wilcoxon test, p<0.001 for both groups) (Table 5.).

Table 5. **Distribution of patients according to preoperative and postoperative pain intensity assessed by Visual Analogue Scale (VAS)**

	Case group	Control group	p
VAS preoperatively	6 (5-7)	6 (5-7)	0.795
VAS postoperatively	0 (0-1)	1 (0-1)	0.876
p	<0.001	<0.001	

Median duration of surgery in the case group was 107.5 (interquartile range 87.5 – 120) minutes, and in the control group it was 120 (interquartile range 100 – 150) minutes. No statistically significant difference was observed in surgery duration between the case and control group (Mann-Whitney U-test, p=0.069).

Median hospital stay was 2 (interquartile range 2 – 3) days in the case group, and 5 (interquartile range 2 – 7) days in the control group. A statistically significant difference was observed in length of hospital stay between the case and control group (Mann-Whitney U-test, p<0.001, Table 6.).

Table 6. **Comparison of hospital length of stay and time with patient mobilization between case and control group**

	Case group	Control group	p
Length of stay (days)	2 (2 – 3)	5 (2 – 7)	<0.001
Time to mobilization (days)	1 (0 – 1)	2 (2 – 2)	<0.001

Medain time to patient mobilization was 1 (interquartile range 0 – 1) day in the case group, and 2 (interquartile range 2 – 2) days in the control group. A statistically significant difference was noted between the case and control group (Mann-Whitney U-test, p<0.001) (Table 6.).

Accidental durotomy was observed in 4 (19.0%) patients in the case group and 4 (14.8%) patients in the control group. No statistically significant difference in durotomy incidence was noted between the groups (chi-square test p=0.742).

According to modified Odom's criteria for surgical outcome assessment, in all case group patients an excellent outcome was noted. In the control group, an excellent outcome was noted in 22 (81.84%) patients, while good outcome was noted in additional 5 (18.52%) patients. No statistically significant difference was observed in treatment outcomes assessed by modified Odom's criteria between the case and control group (chi-square test, p=0.059, Table 7.).

Table 7. **Surgical treatment outcome according to modified Odom's criteria**

	Case group	Control group	p
Treatment outcome (modified Odom's criteria)	Excellent 21 (100%) Good 0 (0%) Slight improvement 0 (0%) Unchanged 0 (0%)	Excellent 22 (81.48%) Good 5 (18.52%) Slight improvement 0 (0%) Unchanged 0 (0%)	0.059

Discussion

This retrospective cross-sectional study analyses treatment outcomes between comparable groups of patients treated with either minimally invasive or conventional surgery for lumbar spine degenerative disease.

Considering demographic patients' characteristics, female predominance and peak incidence in the fifth to sixth decade of life correspond with literature data[8]. Patients in the case group were in general older than control group patients, though the difference was not statistically significant. It is worth noting that some authors advocate the use of minimally invasive surgical methods in elderly patients in particular[9].

A mean duration of the symptoms of 6.63 months before surgical treatment was considered expectedly long. In all patients, a trial of conservative treatment (bed rest, analgesics, and physical therapy) was recommended. A period of six to eight weeks of conservative treatment is normally suggested[10].

Our research found similar duration of surgery between the case and control group. This contrasts with some previous studies, who consider tubular retractor minimally invasive surgery to last considerably longer, bearing in mind the narrowness of the operative field resulting in reduced visualization and preparation of anatomical structures. However, they emphasize that despite increased surgery duration, tissue trauma is reduced and treatment outcomes are improved, predominantly in postoperative pain reduction and use of analgesics[11].

It is worth noting that postoperative neurological assessment in our study was performed at the first follow-up after discharge. Long-term follow-ups after surgical treatment of lumbar spine degenerative disease record some degree of symptom recurrence[12], axial pain being more frequent, partly due to devascularization and trauma to paravertebral musculature. This is particularly prominent in patients treated with conventional surgery[13].

Shorter hospital length of stay in patients surgically treated with minimally invasive approach in comparison to controls is one of the main findings of this study. This is in accordance with findings of two recent studies[6, 11].

Surgery for degenerative lumbar spine disease can be performed in one-day surgery settings. However, patients with comorbidities such as diabetes mellitus or arterial hypertension, older patients, and patients with prolonged surgeries are prone to postoperative complications, and longer hospital stay is to be recommended[14].

A further advantage of minimally invasive surgery is early patient mobilization and presumably quicker recovery. A recent study confirmed earlier return to everyday activities in patients who underwent minimally invasive lumbar spine surgery[15].

Limitations of this study stem from a relatively small number of participants and its retrospective nature. Hence, a prospective study with a greater number of patients would be required to corroborate our results.

In conclusion, surgical treatment of lumbar spine degenerative disease results in significant improvement of neurological status and reduction of pain intensity. Minimally invasive surgery using tubular retractors results in shorter length of stay and earlier patient mobilization leading to faster recovery, with comparable treatment outcome and incidence of complications.

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Vrijednost minimalno invazivne kirurške metode u liječenju degeneracijske bolesti slabinske kralježnice

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Sažetak

Cilj: Usporediti skupine bolesnika s degeneracijskom bolešću slabinske kralježnice liječenih minimalno invazivnom kirurgijom uporabom sustava tubularnih retraktora i konvencionalnom kirurškom metodom.

Nacrt studije: Presječna studija s povijesnim podacima.

Ispitanici i metode: U institucijsko istraživanje uključeno je 48 odraslih ispitanika liječenih jednom od dviju kirurških metoda tijekom godine dana. Ispitanici su podijeljeni između ogledne skupine koju su činili oni operirani minimalno invazivnom metodom i kontrolne skupine operiranih konvencionalnom metodom. Ispitivani su pokazatelji: dob, spol, trajanje simptoma bolesti, vrsta spinalne patologije, vrsta primijenjene kirurške metode, broj bolesnih i operiranih dinamičkih segmenata, neurološki status, intenzitet bolnoga sindroma ocijenjen vizualno analognom ljestvicom, trajanje operacije i duljine hospitalizacije. Kao glavna ocjena uspješnosti liječenja primijenjeni su modificirani Odomovi kriteriji. Svi su podaci preuzeti iz elektroničke medicinske dokumentacije, statistički su obrađeni i uspoređivani između skupina. Razina statističke značajnosti postavljena je kao $p < 0,001$.

Rezultati: Zabilježeno je znatno poboljšanje neurološkog statusa nakon operacije u svih ispitanika (ogledna skupina, Fisherov egzaktni test, $p = 0,002$; kontrolna skupina, Fisherov egzaktni test, $p = 0,012$). Intenzitet bolnoga sindroma u svih se ispitanika znatno smanjio nakon operacije (ogledna skupina, Wilcoxonov test, $p < 0,001$; kontrolna skupina, Wilcoxonov test, $p < 0,001$). Utvrđena je statistički značajna razlika između ogledne i kontrolne skupine u duljini hospitalizacije (Mann-Whitneyjev U-test, $p < 0,001$) i vremenu vertikalizacije (Mann-Whitneyjev U-test, $p < 0,001$) nakon operacije. U ostalim istraživanim parametrima nije utvrđena statistički značajna razlika između skupina ispitanika.

Zaključak: Kirurško liječenje degeneracijske bolesti slabinske kralježnice rezultira znatnim poboljšanjem neurološkog statusa i smanjenjem intenziteta bolnog sindroma. Minimalno invazivna kirurgija sustavom tubularnih retraktora u usporedbi s konvencionalnim kirurškim metodama rezultira kraćom duljinom hospitalizacije i kraćim vremenom vertikalizacije.

Ključne riječi: slabinska kralježnica, degeneracijska bolest, minimalno invazivna kirurgija, uspješnost liječenja