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Endoscopic and Percutaneous Denervation of Facet Joints in the Treatment of Patients with Degenerative Lumbar Deformities: Comparative Analysis

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Abstract

Background. At present, degenerative lumbar scoliosis is considered as the severest form of degenerative diseases of the spine. As a rule, it occurs at the final stage of the disease development. Advanced age of the patients, high comorbidity and poor bone tissue quality increase risk of complications development at any stage of the treatment. All things considered, the majority of specialists continue their search for minimally invasive surgeries able to improve the life quality of patients with such pathology.

Aim of the study — comparative analysis of the surgical treatment results of patients with degenerative lumbar deformities operated using percutaneous and endoscopic denervation techniques.

Methods. The study enrolled 58 patients: 42 (72.4%) women and 16 (27.6%) men. Median age accounted for 64 (60-69) years, minimum follow-up period — 2 years. In 28 cases, we performed endoscopic denervation of the lumbar facet joints at the apex of the deformity on both sides (group A), in 30 cases — percutaneous radiofrequency denervation in the appropriate volume (group B). Evaluation of the treatment effectiveness was based on the dynamics of pain syndrome (VAS), patients' quality of life (ODI), as well as on the frequency of complications and repeated surgical interventions.

Results. Mean operative duration and radiation exposure were significantly higher in endoscopic intervention ($p<0.001$). Group A showed an earlier reduction in back pain syndrome compared to group B ($p<0.001$). Assessment of patients' life quality by ODI showed a high degree of correlation with the level of back pain syndrome. Significant complications of the surgical treatment were not revealed in any patient of both groups. Repeated denervation was performed during the two-year follow-up period in 18 patients (60%) of group B and in 2 patients (7.1%) of group A ($p<0.001$). Analysis of the factors associated with the efficacy of percutaneous denervation showed the significance of deformation magnitude in the frontal plane. Efficiency of percutaneous treatment decreased at the deformity value of 30° and more with a sensitivity of 77% and specificity of 67%.

Conclusions. A more pronounced decrease in the intensity of back pain syndrome with preservation of the effect during the whole period of follow-up was noted in patients after endoscopic denervation. However, this was accompanied by a longer duration of intervention and radiation load. According to our data, low efficacy of percutaneous denervation is due to the use of this technique in patients with severe deformity of the lumbar spine.

Key words: degenerative scoliosis, minimally invasive surgeries, endoscopic denervation, percutaneous denervation.

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Сравнительный анализ эффективности пункционной и эндоскопической денервации дугоотростчатых суставов в лечении пациентов с дегенеративными деформациями поясничного отдела позвоночника

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Реферат

Введение. Дегенеративный сколиоз поясничного отдела является наиболее тяжелой формой дегенеративно-дистрофической патологии позвоночника. Значительный возраст пациентов данного профиля, а также высокая коморбидность и низкое качество костной ткани повышают риски развития осложнений на любом этапе лечения. Принимая во внимание данные обстоятельства, специалисты продолжают поиск минимально инвазивных технических решений, способных повышать качество жизни пациентов.

Цель исследования — сравнительный анализ результатов хирургического лечения пациентов с дегенеративными деформациями поясничного отдела позвоночника, оперированных по методикам пункционной и эндоскопической денервации.

Материал и методы. В исследование вошли 58 пациентов: 42 (72,4%) женщины и 16 (27,6%) мужчин. Медиана возраста — 64 (60–69) года, минимальный период наблюдения — 2 года. В 28 случаях выполнена эндоскопическая денервация дугоотростчатых суставов поясничного отдела на вершине деформации с обеих сторон (группа А), в 30 случаях — пункционная радиочастотная денервация в соответствующем объеме (группа Б). Эффективность лечения была оценена на основании динамики болевого синдрома (шкала ВАШ), качества жизни пациентов (опросник ODI), а также частоты осложнений и повторных хирургических вмешательств.

Результаты. Средняя продолжительность операции и лучевая нагрузка были значимо выше при эндоскопическом вмешательстве (p<0,001). В группе А было выявлено более раннее снижение болевого синдрома в спине по сравнению с группой Б (p<0,001). Оценка качества жизни пациентов по ODI показала высокую степень корреляции с уровнем болевого синдрома. Значимых осложнений оперативного лечения не было выявлено ни у одного из пациентов обеих групп. Повторная денервация проводилась на протяжении двухлетнего периода наблюдения у 18 пациентов (60%) группы Б и у 2 пациентов (7,1%) группы А (p<0,001). Анализ факторов, ассоциированных с эффективностью пункционной денервации, показал значимость величины деформации во фронтальной плоскости. Эффективность пункционного лечения снижалась при величине деформации 30° и более с чувствительностью 77% и специфичностью 67%.

Заключение. Более выраженное снижение интенсивности болевого синдрома в спине с сохранением эффекта на протяжении всего периода наблюдения было отмечено у пациентов после эндоскопической денервации, что, однако, сопровождалось большими продолжительностью вмешательства и лучевой нагрузкой. Низкая эффективность пункционной денервации обусловлена применением данной методики у пациентов с выраженной деформацией поясничного отдела позвоночника.

Ключевые слова: дегенеративный сколиоз, минимально инвазивное лечение, эндоскопическая денервация, пункционная денервация.

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INTRODUCTION

Degenerative lumbar scoliosis is currently considered as the most severe form of degenerative spinal pathology, typically manifesting in the final stages of its progression. Surgical intervention in patients with degenerative scoliosis, following orthopedic approaches to correct deformity and restore the physiological profile of the spine, is often associated with a significant number of complications, both intra- and postoperative [1, 2, 3, 4]. The advanced age of such patients, combined with a high comorbidity and poor bone quality, increases the risk of complications at all stages of treatment [5, 6, 7, 8]. Furthermore, the high incidence of complications, particularly in the long-term, necessitates repeated operation with more extensive fixation, accompanied by increased risks of infection [7, 9, 10]. Given these circumstances, many specialists continue to search for minimally invasive techniques that can improve the quality of life for these patients [11, 12, 13, 14, 15]. Notably, pain is one of the most significant factors associated with reduced quality of life in patients with degenerative spinal deformities. Thus, interventional treatment targeting one of the sources of pain may significantly improve the quality of life for patients with degenerative scoliosis, while avoiding the high risk of complications typical for highly invasive surgical treatment [16]. Additionally, minimally invasive treatment aimed at reducing pain, even with temporary effect, allow for the implementation of anti-osteoporotic therapy, reducing the risk of serious complications following extensive decompressive stabilizing interventions [5, 6, 7, 8, 16].

In recent years, percutaneous denervation of the facet joints has become the gold standard for treating spondyloarthrosis [17, 18, 19]. A recent meta-analysis has demonstrated that radiofrequency denervation is effective for up to 12 months in reducing back pain caused by overload and inflammation of the facet joints [20]. Endoscopic rhizotomy represents an advancement of percutaneous puncture denervation [21]. This technique allows for direct visualization of anatomical structures and provides stable and prolonged pain relief through more complete and extensive denervation of the dorsal branch [22]. The advantage of directly visualizing the facet joint and dorsal nerve branch may be particularly crucial for patients with pathological changes in the posterior spinal structures due to degenerative deformity.

The aim of the study is to compare the outcomes of surgical treatment in patients with degenerative deformities of the lumbar spine following either puncture or endoscopic denervation of the facet joints.

METHODS

Study design

This retrospective study evaluated the surgical outcomes of 58 patients who underwent surgical treatment between 2018 and 2022.

The cohort consisted of 42 (72.4%) women and 16 (27.6%) men, with a median age of 64 years (range: 60-69).

Inclusion criteria: presence of degenerative deformity of the lumbar spine in the frontal plane exceeding 10°, surgical treatment involving facet joint denervation, and a follow-up period of no less than two years.

Exclusion criteria: presence of severe scoliotic deformities requiring decompressive stabilizing interventions, malignant tumors, spinal infections, or prior surgery for this pathology.

Patients were divided into two groups based on the type of operation performed.

Group A: endoscopic rhizotomy of the dorsal branch for facet joint denervation.

The surgical procedures in this group were performed using Joimax endoscopic instruments. After preliminary radiographic marking, a skin incision of up to 0.7 cm was made at the base of the transverse process. The subcutaneous fat tissue and fascia were then incised. Under radiographic control, guides of increasing diameters were sequentially inserted into the base of the transverse process, followed by the introduction of the endoscope tube. Under visual control, the denervation of the facet joint at the base of the transverse process was carried out using an endoscopic electrocautery, raspatory, and scissors by directly rhizotomizing the dorsal branch of the spinal nerve. If necessary, access to adjacent facet joints was achieved by inclining the tube caudally or cranially at an average angle of 45-60°.

Group B: puncture denervation of the facet joints via radiofrequency ablation of the dorsal branch.

In this group, surgery was performed using Cosman 4G radiofrequency generator. Under radiographic control, 20G guide cannulas with a tip of 5 mm were placed at the levels of interest so that the tip of the cannula was positioned at the center of the transverse process base. Next, a radiofrequency ablation electrode was inserted into each cannula for sensory and motor testing to confirm the correct positioning. If necessary, the position of the guide cannulas was adjusted under radiographic control (Figure 1).

In both groups, preoperative parameters such as the magnitude of the main deformity curve in the frontal plane (measured using Cobb's method) and the degree of sagittal imbalance relative to the sagittal vertical axis (SVA) were assessed.

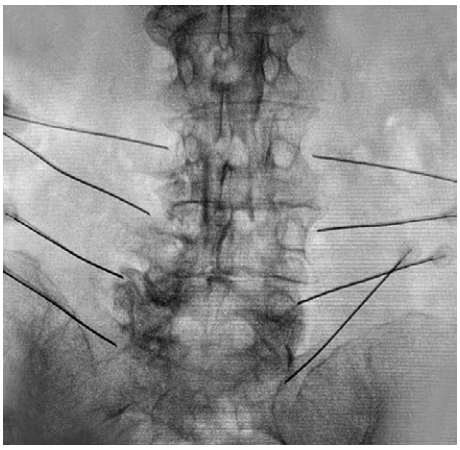

Figure 1. Percutaneous radiofrequency denervation of facet joints. Radiological intraoperative control of the position of the guiding cannulae

Outcome assessment

Treatment outcomes were assessed based on changes in the intensity of back pain (according to the Visual Analog Scale (VAS)) and the quality of life (using the Oswestry Disability Index (ODI)). Data were analyzed based on patient-completed assessment scales during follow-up visits in the first two years post-surgery.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics v. 23 software. Numerical data were presented as median (Me) [Q1; Q3]. Normality of distribution was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Comparative analysis of independent variables between groups was carried out using the Mann-Whitney U test. Binary and categorical data were evaluated using Pearson's chi-square test and Fisher's exact test. The statistical significance of factors and their impact on treatment efficacy were assessed via logistic regression analysis. Differences were considered statistically significant at $p<0.05$.

RESULTS

The comparability of the study groups was assessed based on the distribution of patients by gender, age, mean body mass index (BMI), degree of scoliotic curve deformation, sagittal balance disturbance, and preoperative back pain levels. Additionally, the number of denervation levels was evaluated (Table 1).

Table 1

Characteristics of patients in the study groups

Parameter	Total (n=58)	Group A (n=28)	Group B (n=30)	p
Gender:				
male	16 (100%)	6 (38%)	10 (62%)	0.319*
female	42 (100%)	22 (52%)	20 (48%)	
Age, years	64 (60-69)	65.5 (63.0-71.5)	62.5 (59.8-68.0)	0.107**
BMI	29 (26.8-31.0)	29 (27.0-30.8)	29 (26-31)	0.814**
Magnitude of the main deformity curve, deg.	29.5 (20.8-36.0)	27 (20.3-36.0)	32 (20.8-36.0)	0.553**
Sagittal vertical axis, (SVA) deviation	58.5 (45-85)	57.5 (45.0-88.8)	58.5 (48.8-81.3)	0.932**
Pain syndrome (VAS)	6 (5-7)	6 (5-7)	6.5 (5-7)	0.717**
Number of denervation levels	5 (4-5)	5 (4-5)	5 (4-6)	0.363**

* – Pearson's chi-square test; ** – using the Mann-Whitney U test.

The primary analysis of the preoperative distribution of the studied parameters did not reveal statistically significant differences between the groups, allowing for a comparative analysis of treatment outcomes.

Statistically significant differences were identified in the duration of surgery and intraoperative radiation exposure. The mean duration of the inpatient postoperative phase did not show statistically significant differences between the groups (Table 2).

Analysis of the dynamics of back pain levels revealed a statistically significant reduction in pain intensity one month after endoscopic intervention (Group A) and three months after treatment in both groups ($p<0.001$). Analysis of later outcomes (3 months and beyond) demonstrated a lower mean pain intensity in Group A ($p<0.001$) (Figure 2).

Furthermore, during the first three months post-intervention, no reduction in pain levels was observed in 8 (26.7%) patients after percutaneous radiofrequency (RF) denervation. A slight reduction in pain intensity (no more than 1 point on the VAS) was noted in 10 (33.3%) patients following percutaneous RF denervation. In contrast, in Group A, only 2 (7.1%) patients reported a slight reduction in pain during the first three months.

The average disability index (according to ODI) also showed a significant tendency to decrease from the first month postoperatively in Group A and from the third month in Group B ($p<0.001$). However, in Group B, there was a tendency for quality of life to worsen one year after surgery ($p<0.001$) (Figure 3).

Table 2

Analysis of the main intraoperative indicators and the average length of hospital stay

Parameter	Group A (n=28)	Group B (n=30)	p*
Surgery duration, minutes	70 (60-80)	40 (30-40)	<0.001
Radiation exposure, mSv	1 (1-1)	3 (3-4)	<0.001
Inpatient postoperative phase, days	1 (1.0-1.8)	1 (1-1)	0,056

* – using the Mann-Whitney U test.

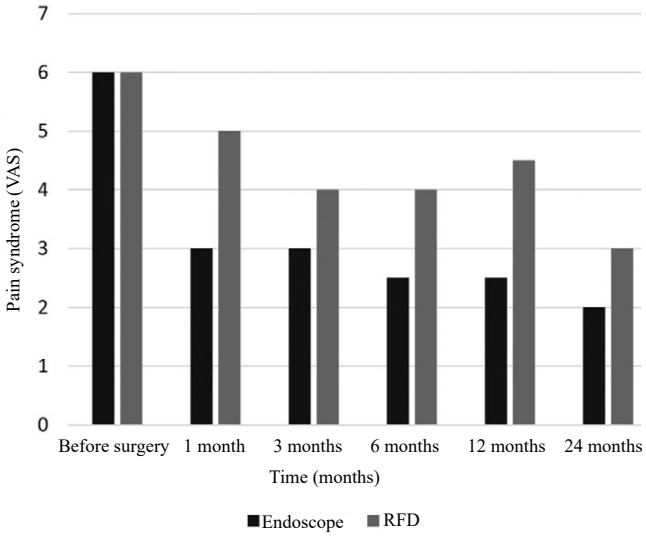

Figure 2. Dynamics of back pain syndrome after surgical treatment

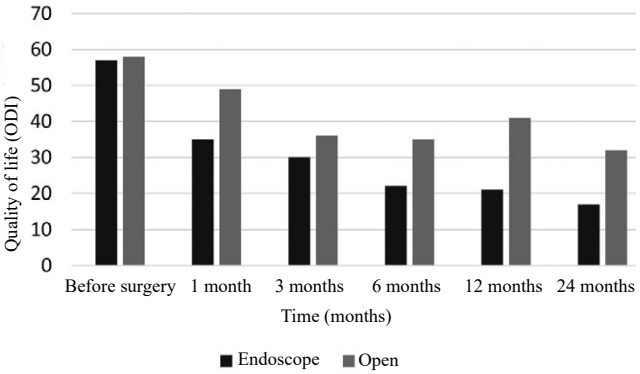

Figure 3. Dynamics of patients' quality of life after surgical treatment

A correlation analysis revealed a strong inverse relationship (p = -0.762) between the intensity of back pain and the disability index (Table 3).

These findings may suggest a high dependence of quality of life in patients with degenerative spinal deformities on the severity of back pain.

No significant complications were identified that affected the length of hospital stay or required reoperation or prolonged specific conservative treatment. However, an analysis of the frequency and structure of reoperations during the two-year follow-up period revealed significant differences between the study groups (Table 4).

Table 3

A correlation analysis of the factors

Factors		Pain syndrome level	Quality of life
Pain syndrome level	Pearson correlation	1	-0.762
	Significance (two-tailed)	-	< 0.001
Quality of life	Pearson correlation	-0.762	1
	Significance (two-tailed)	< 0.001	-

Table 4

Analysis of the structure and frequency of reoperations during 24 months

Reoperation	Group A (n=30)	Group B (n=30)	p*
Denervation:	2 (7.1%)	18 (60%)	< 0.001
- endoscopic	2 (100%)	12 (66.7%)	< 0.001
- ercutaneous RFD	0 (0%)	6 (33.3%)	< 0.001
Decompression	3 (10.7%)	3 (10%)	0.929
Stabilization	1 (3.6%)	2 (6.7%)	0.598

* – using the Mann-Whitney U test.

Re-denervation due to primary surgery failure or reinnervation of the facet joints was performed in 60% of patients in Group B, which is 8.5 times higher than in Group A. The frequency of decompressive and decompressive stabilizing operations during the two-year follow-up period did not significantly differ between the groups.

Given the high number of unsatisfactory outcomes in Group B, we conducted an assessment of factors that may influence the effectiveness of percutaneous radiofrequency denervation of the facet joints in this patient cohort.

The analysis included the following factors: gender, age, BMI, degree of frontal plane deformity, sagittal imbalance, number of denervation levels, and preoperative pain level.

Logistic regression analysis of these factors revealed a significant effect of frontal plane deformity on the effectiveness of this surgical technique (Table 5).

The analysis confirmed the influence of frontal plane deformity on the effectiveness of percutaneous RF denervation of the facet joints. An increase of 1° in Cobb angle increases the risk of RF denervation failure by 1.11 times (or 11%) (p = 0.004; OR 1.11; 95% CI 1.01–1.24).

Table 5

A logistic regression analysis of the factors affecting the effectiveness of percutaneous RFD

Factor	p-value	OR	95% CI
Gender	0.949	0.99	0.65–1.50
Age	0.398	0.99	0.97–1.01
BMI	0.412	1.64	1.58–1.72
Deformity magnitude	0.004	1.11	1.01–1.24
SVA	0.363	0.65	0.61–0.82
Number of RFD levels	0.420	0.84	0.55–1.28
Preoperative pain level	0.211	0.29	0.11–0.37

OR – odds ratio; SVA – sagittal vertical axis deviation.

The threshold value of the deformity, at which a significant reduction in RF denervation effectiveness was observed, was determined based on ROC curve analysis with a significant p-value of <0.001 and an area under the curve (AUC) of 0.770 (95% CI 0.650–0.889) (Figure 4).

The threshold deformity value, beyond which the effectiveness of facet joint RF denervation significantly declines, is 29.5°, with a sensitivity of 77% and specificity of 67%.

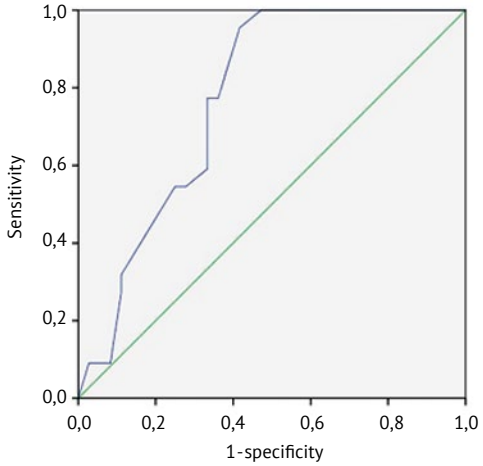

Figure 4. ROC-curve for the deformity value

DISCUSSION

Degenerative lumbar scoliosis is typically characterized by severe pain, which intensifies with minimal axial load. The incidence of lumbar pain in patients with degenerative scoliosis reaches up to 90% [9, 13, 23]. A notable feature of this pain is its polyetiological nature and resistance to conservative treatment. The primary causes of back pain in patients with degenerative scoliotic deformities include inflammatory degenerative processes affecting the lumbar facet joints and intervertebral disci, instability of spinal motion segments, as well as disruption of the global spinal balance, which engages compensatory mechanisms that eventually become exhausted. Each of these pathological conditions leads to facet joint overload and, consequently, an increase in back pain [24].

Percutaneous puncture denervation of the facet joints is currently the widely accepted minimally invasive treatment method for back pain caused by spondyloarthrosis [19, 20]. However, there is limited literature on the effectiveness of this method in patients with degenerative spinal deformities.

Our study demonstrated that the intensity of back pain decreases more rapidly after endoscopic intervention, and the beneficial effects of the endoscopic treatment were maintained throughout the two-year follow-up period. In contrast, percutaneous RF denervation of the facet joints showed either no effect or only a minor reduction in back pain in 60% (18 patients) of cases. Additionally, patients in this group exhibited negative dynamics, with an increase in average back pain scores within 12 months post-surgery. This could be attributed to the reinnervation of facet joints, leading to the recurrence of pain.

Several authors also link the temporary effects of RF denervation to the regeneration of the medial branch after the procedure [20, 25, 26]. Furthermore, anatomical studies have demonstrated various pathways of the medial branch, as well as ossification of the mamillo-accessory ligament (lig. mamillo-accessorium – MAL), which, combined with altered facet joint anatomy in patients with degenerative spinal deformities, may reduce the effectiveness of radiofrequency ablation [27, 28]. In such cases, better treatment outcomes may be achieved through endoscopic denervation. A retrospective study by A.M. Meredji et al., involving 33 patients with facet syndrome, reported 97.4% excellent, good, and satisfactory results following endoscopic denervation [22]. However, to date, there is no comprehensive data on the effectiveness of facet joint denervation, either percutaneous or endoscopic, in patients with degenerative lumbar scoliosis.

In this study, patients' quality of life showed a strong correlation with back pain and mirrored this tendency throughout the two-year follow-up period. Additionally, repeated denervation of the facet joints after percutaneous procedures was performed 8.5 times more frequently than after endoscopic interventions.

The analysis of the causes of unsatisfactory treatment outcomes following percutaneous denervation revealed a statistically significant impact of frontal plane deformity on the effectiveness of this method. A threshold deformity value of 29.5° was identified, beyond which the effectiveness of percutaneous RF denervation significantly decreased. This dependency is likely due to the technical challenges in placing guides caused by vertebral rotation, as well as pronounced deformity and hypertrophy of the facet joints.

CONCLUSIONS

Given the significant correlation between the quality of life and back pain, minimally invasive techniques aimed at reducing pain intensity can be considered a promising approach in the comprehensive treatment of patients with degenerative spinal deformities. However, the effectiveness of standard percutaneous radiofrequency denervation is substantially lower than endoscopic interventions in cases where lumbar deformity exceeds 30°.

DISCLAIMERS

Author contribution

Ptashnikov D.A. — study concept and design.

Masevnin S.V. — study concept, data analysis and interpretation, statistical data processing, drafting and editing the manuscript.

Lim E.N. — literature search and review, statistical data processing, drafting and editing the manuscript.

Normatov S.G. — iterature search and review, statistical data processing, drafting and editing the manuscript.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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Ethics approval. Not applicable.

Consent for publication. The authors obtained written consent from patients to participate in the study and publish the results.

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