Surgical Treatment Options for Degenerative Lumbosacral Spinal Stenosis

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Abstract

Degenerative spinal stenosis is the most common type of degenerative and dystrophic spine disease. The clinical picture of stenosis, which may include axial pain syndrome, leg pain, intermittent claudication syndrome, weakness and loss of sensitivity in the legs, and impaired pelvic functions, can significantly worsen patients' quality of life and reduce their ability to work and lead an active lifestyle.

Degenerative spinal stenosis mostly affects the elderly. Therapeutic and neurological communities have stereotypes about spine surgery being too traumatic and invasive, and, therefore, they believe that their use should be contraindicated to and limited in elderly patients. However, surgeons are increasingly giving preference to minimally invasive interventions with high efficacy and safety together with a low risk of complications.

*We **aimed** at reviewing current treatment methods for degenerative lumbosacral spinal stenosis with an emphasis on surgical treatment methods.*

Keywords: *degenerative spinal canal stenosis; spinal canal decompression methods; endoscopic decompression*

Source of funding. This study was not supported by any external sources of funding.

Conflict of interest. The authors declare no apparent or potential conflicts of interest related to the publication of this article.

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For citation: Yusupova A.R., Gushcha A.O., Arestov S.O., Petrosyan D.V., Kartavykh R.A., Simonyan A.S., Kiselev A.A. Surgical treatment options for degenerative lumbosacral spinal stenosis. *Annals of Clinical and Experimental Neurology*. 2024;18(1):79–87. (In Russ.)

DOI: https://doi.org/10.54101/ACEN.2024.1.9

Received 17.11.2022 / Accepted 19.12.2022 / Published 25.03.2024

Варианты хирургического лечения дегенеративных стенозов пояснично-крестцового отдела позвоночника

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Аннотация

Стеноз позвоночного канала дегенеративной природы является самой распространённой нозологией среди дегенеративно-дистрофических поражений позвоночника. Клиническая картина стеноза, которая может включать аксиальный болевой синдром и боль в ногах, синдром перемежающейся хромоты, слабость и нарушение чувствительности в ногах, нарушение тазовых функций, существенно снижает качество жизни пациентов и приводит к потере ими трудоспособности и возможности вести активный образ жизни.

Дегенеративный стеноз позвоночника – это в основном болезнь пожилых людей. В терапевтическом и неврологическом сообществах сложился стереотип о чрезмерной травматичности и инвазивности хирургических вмешательств на позвоночнике и, следовательно, о противопоказаниях и ограничениях использования опций хирургического лечения у пациентов пожилого возраста. Однако в настоящее время хирурги всё чаще отдают предпочтение малоинвазивным вмешательствам, имеющим высокую эффективность и безопасность и характеризующимся низкими рисками осложнений.

***Целью** данной работы является обзор современных методов лечения дегенеративных стенозов пояснично-крестцового отдела позвоночника с акцентом на хирургических вариантах лечения данной патологии.*

***Ключевые слова**: дегенеративный стеноз позвоночного канала; способы декомпрессии позвоночного канала; эндоскопическая декомпрессия*

Источник финансирования. Авторы заявляют об отсутствии внешних источников финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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Для цитирования: Юсупова А.Р., Гуща А.О., Арестов С.О., Петросян Д.В., Картавых Р.А., Симонян А.С., Киселев А.А. Варианты хирургического лечения дегенеративных стенозов пояснично-крестцового отдела позвоночника. *Анналы клинической и экспериментальной неврологии.* 2024;18(1):79–87.

DOI: https://doi.org/10.54101/ACEN.2024.1.9

Поступила 17.11.2022 / Принята в печать 19.12.2022 / Опубликована 25.03.2024

Introduction

Spinal canal (SC) stenosis is defined as a diffuse or limited abnormal narrowing of the SC that results in compression of neurovascular structures such as the spinal cord, spinal roots, ganglia, arteries, and veins [1–3]. This concept is based on a multifactorial pathological mechanism that involves compression of intracanal neurovascular structures. The clinical picture of lumbar spinal stenosis was first described by H. Verbiest in 1954 [4, 5]. D. Onel et al. defined stenosis as any narrowing of the central spinal canal or intervertebral foramen [6]. Stenosis classifications were described in details by L.E. Antipko [2]. By its ethiology, SC stenosis can be primary (congenital), secondary (acquired), or combined. Congenital SC stenosis is developed as a result of congenital anomalies or postnatal developmental defects. Acquired SC stenosis can be caused by degeneration, infection, traumas, or post-operative changes.

Degeneration and dystrophic processes in the spine are irreversible and begin in humans around the age of 20. They are caused by the Kirkaldy–Willis cascade, which includes three stages: dysfunction, relative instability, and restabilization [7].

Prevalence of symptomatic degenerative spinal stenosis is 11% and 25% in the total population and in outpatient settings, respectively [8]. The need for surgical care for degenerative stenosis is 50 procedures per 100,000 population[1], which corresponds to 20% of patients seeking medical help for spinal stenosis. Prophylactic measures are important in preventing the development of any disease, which is also true for degenerative SC stenosis. However, in the case of stenosis, the aim is not to prevent it as such but rather to slow down degeneration and dystrophic processes with preserving maximal functionality of the spine, paravertebral muscles, and nervous structures such as the spinal cord and roots. Conservative treatment and rehabilitation are initiated if spinal stenosis becomes symptomatic [9]. And only if these treatment options turn out to be ineffective, the patient can proceed to radical surgery.

Clinical findings

Neurogenic (caudogenic) intermittent claudication is the most typical syndrome of SC stenosis; it includes the following symptoms:

- back pain occurs when walking and irradiates to legs;
- leg pain and paresthesia in specific spine positions. Symptoms become worse during extension, walking (especially down stairs), prolonged standing, i.e. in body positions with SC being narrowed yet more;
- pain decreases or disappears when sitting, bending, or squatting. There is no pain when walking up the stairs or riding a bicycle;
- bending or standing does not increase symptoms, unlike discogenic pain;
- pain increases in lying position;
- neurological symptoms (i.e. muscle weakness, loss or decreased reflexes, sensory disorders) are related to exercise;
- Lasegue's sign is more often negative.

Neurogenic claudication should be differentiated from true (vascular) intermittent claudication associated with occlusive disease.

In patients with SC stenosis, other complaints include pelvic dysfunction, which is manifested by bladder disturbances and impotence of various degree.

Neurological examination shows minimal to no abnormalities [10].

Magnetic resonance imaging (MRI) is a method of choice for diagnosing degenerative spinal stenosis. Fig. 1 shows

[1] Progress Report for 2020 by V.V. Krylov, Head External Neurosurgery Expert of the Ministry of Health of Russia. URL: https://static-0.minzdrav.gov.ru/system/attachments/attaches/000/056/647/original/Отчет_за_2020_год_Крылов.pdf

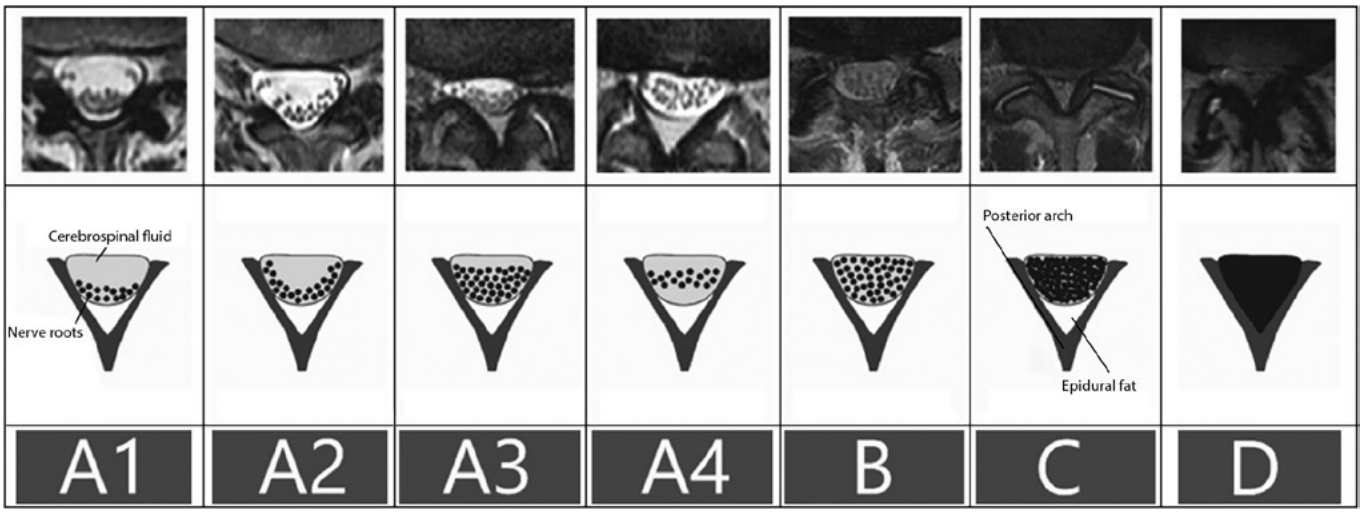


Fig. 1. Visual grading of stenosis according to C. Schizas [11].

visual grading of stenosis according to C. Schizas [11]. Significant stenotic changes on computed tomography or MRI in healthy people without complaints is a challenge related to imaging [12]. Therefore, significance of any imaging results in patients with SC stenosis is defined by their clinical findings.

Treatment methods

Conservative treatment

According to clinical guidelines, conservative stenosis treatment includes medication and non-medication methods [9, 13]. Medication treatment includes non-steroidal anti-inflammatory drugs (NSAIDs), opioid analgesics, muscle relaxants, antidepressants, and anticonvulsants [1, 9, 14–17]. Medication methods aim to reduce the intensity of chronic back pain. No NSAIDs were shown to be superior over the other ones in their analgetic activity. Long-term use of NSAIDs is associated with an increased risk of adverse effects, primarily gastrointestinal and cardiovascular disorders. Therefore, NSAIDs should be administered for a short period, i.e. for 5 to 10 days (according to European guidelines for the management of chronic nonspecific low back pain, treatment with NSAIDs should last not more than 3 months) [13].

In case of inadequate treatment response to NSAIDs or contraindications to their use, weak opioids are recommended to reduce pain intensity.

Their most common side effects include drug dependence, constipation, dizziness, increased sweating, and decreased potency [9]. The use of potent opioids is limited to transdermal therapeutic systems with gradual sustained release of the active ingredient. For mild chronic back pain, muscle relaxants can be used as an alternative to NSAIDs to reduce pain intensity; for severe pain, a combination of muscle relaxants with NSAIDs or other analgesics can be administered. Medications that aim to eliminate the neuropathic component of pain (antidepressants and anticonvulsants) can be used in the treatment of chronic back pain.

Psychological factors become more important as chronic back pain persists. According to the current concept, cognitive behavioral therapy can be used for management of chronic pain because pain and disability are caused not only by anatomical or physical abnormalities but also by psychological factors. Inclusion of cognitive behavioral therapy in multidisciplinary programs significantly increased treatment efficacy and decreased the number of lost workdays vs. standard care (evidence level A) [18].

Despite minimal risks associated with conservative treatment and apparent comparability of its efficacy with surgical treatment, conservative treatment is a symptomatic solution for stenosis, while anatomically, compression of the neurovascular structures still persists and can be completely eliminated only by decompression surgery in the degenerative SC segment.

A review (2016) to evaluate optimal non-surgical and surgical treatment options for SC stenosis had very little confidence to conclude whether surgical treatment or a conservative approach was better for lumbar spinal stenosis and could provide no new recommendations to guide clinical practice. However, the authors noted that no side effects were reported for any conservative treatment, and the rate of side effects ranged from 10% to 24% in surgical cases. No other differences were found between non-surgical and surgical treatment methods. The authors noted that clinicians should be very careful in informing patients about possible treatment options, especially given that conservative treatment options have resulted in no reported side effects.

There are no standard protocols for non-surgical treatment, which is challenging. Despite the availability of international and national clinical guidelines, treatment protocols are rarely followed in real-world clinical practice. This may suggest an individual approach to each clinical case (although guidelines usually indicate alternative treatment options if the patient has contraindications to a particular group of medications) or inadequate communication between surgeons and medical professionals who prescribe conservative treatment. In any case, the lack of standardization does not allow evaluating and further comparing treatment outcomes with various methods using the evidence-based approach. The authors stated that the concepts for comparing the methods were incorrect by default, and it would be more illustrative and effective to compare one type of surgical approach versus a specific physical exercise program or versus a defined medication protocol [19]. No clear protocols for non-surgery treatment and poor methodology of the studies that compared conservative and surgical methods were also mentioned by other authors [20, 21].

Surgical treatment

Currently there is an increasing number of surgical interventions performed for lumbar spinal stenosis. This is related to the fact that average life expectancy is increasing, and incidence of back pain increases with age. An increasing need for surgical treatment for back pain and increasing number of elderly patients necessitates searching for more effective and safe techniques and approaches.

Fig. 2 shows an algorithm for management of patients with lumbar spinal stenosis.

Open decompression and stabilization

Spinal column decompression is a conventional surgical procedure for lumbar stenosis; it can be performed with or without instrumental stabilization (interbody fusion, transpedicular fixation). SC decompression can be performed by open technique or through minimally invasive tubular

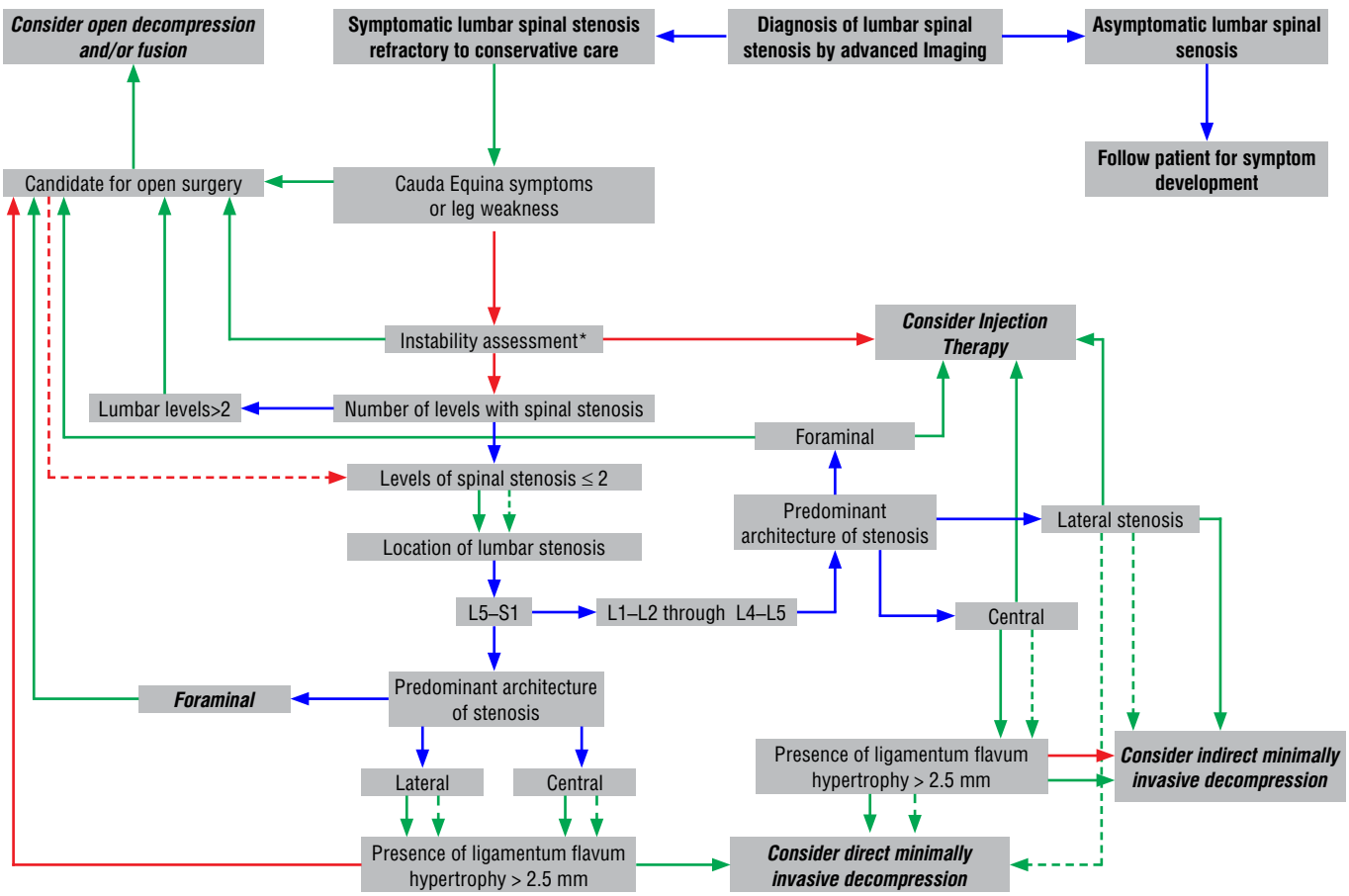


Fig. 2. Surgery treatment algorithm for degenerative stenosis according to T.R. Deer et al. [22].
Blue arrows, option chosen; green arrows, yes; dotted green lines, instability, hypertrophy of the ligamentum flavum, the patient is not a candidate for open surgery with or without stabilization; red arrows, no; dotted red lines, instability, no hypertrophy of the ligamentum flavum, the patient is not a candidate for open surgery with or without stabilization.
*In this algorithm, instability is defined as spondylolisthesis of grade 2 or more.

dilators, with or without microscopic or endoscopic assistance. Decompression includes laminectomy, hemilaminectomy, facetectomy, foraminotomy, which can be either unilateral or bilateral depending on the patient's clinical picture. Previously, open decompression was performed for SC stenosis; now more and more clinics can perform microscope-assisted decompression, which implies not only microsurgical visualization of the surgical wound but also use of microsurgical instruments for more precise and accurate procedures.

A.J. Caputy et al. [23] believed that stabilization should be used in the cases when laminectomy is performed together with discectomy and facetectomy, which lead to spine destabilization. Spine stabilization includes interbody fusion (installation of an implant [cage] in place of the intervertebral disc after its removal) and transpedicular fixation (installation of metal structures [screws] into the bodies of adjacent vertebrae through their pedicles and connection of the screws using a rod system). Decompressive and stabilizing interventions can be performed from the posterior, transforaminar (through the intervertebral foramen), lateral, anterior, and extralateral approaches (PLIF, TLIF, OLIF, ALIF, and XLIF, respectively; Fig. 3). TLIF and PLIF are used in most cases [24]. Recently, the KLIF abbreviation has appeared to designate Kambin's triangle for lumbar interbody fusion (Fig. 4).

Despite an increasing popularity of minimally invasive approaches, instability signs in the spinal motion segment that is involved in the degenerative process are an indication for stabilizing surgery.

Degenerative spondylolisthesis has always been considered a sign of instability, although no consensus on the definition of instability has been achieved yet. Several studies suggested that spondylolisthesis is iatrogenic in its nature and the degree of existing spondylolisthesis increases after surgical decompression [24–26]. Other studies supported a wide use of stabilization surgeries both for patients with or without spondylolisthesis [27]. A.R. Vaccaro et al., C.R. Martin et al. [28, 29], the authors of publications that were contested afterwards, advocated simultaneous decompression and stabilization to prevent restenosis or postoperative instability.

A. Goel believed that instability is the basis of any clinical problem with spine degeneration (whether cervical or lumbar), and, therefore, stabilization is the only possible approach and treatment method [30]. He explained this by the fact that compression cannot be primary but is a consequence of instability; therefore, decompression alone without stabilization cannot be a complete treatment.

The instability issue, like many other issues in medicine, is controversial and ambiguous and is unlikely to have a

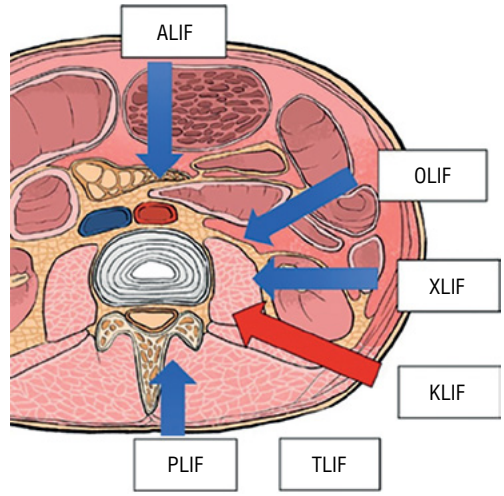


Fig. 3. Access types for interbody fusion.
ALIF, anterior lumbar interbody fusion; OLIF, oblique lumbar interbody fusion; XLIF, extralateral lumbar interbody fusion; KLIF, Kambin's triangle for lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion, PLIF, posterior lumbar interbody fusion.
Source: Morimoto M., Sairyo K. Full-endoscopic trans-Kambin's triangle lumbar interbody fusion (Fullendo-KLIF). In: Sairyo K. (eds.) Transforaminal full-endoscopic lumbar surgery under the local anesthesia. Singapore Springer; 2021.
DOI: 10.1007/978-981-15-7023-0_13

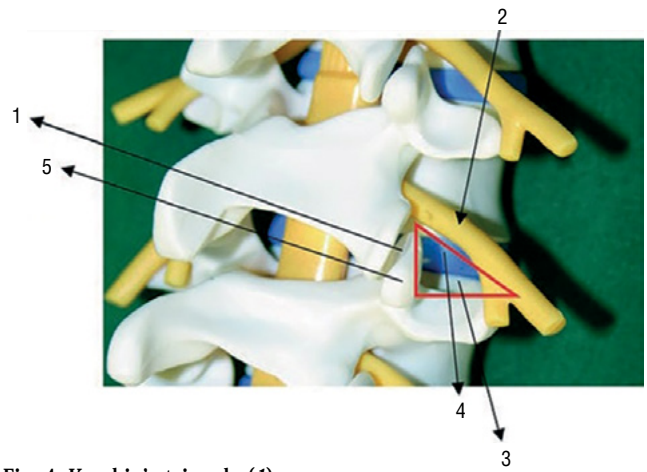


Fig. 4. Kambin's triangle (*1*).
2, nerve root forms the anterior border of the working area; 3, proximal plate; 4, intervertebral disc; 5 superior articular process.

universal solution that would work for all patients and satisfy all medical professionals [31–35]. Thus, it is most fair to believe that there is no one correct answer to the question whether stabilization is needed, and the decision should be made in each individual case in order to achieve most effective treatment outcomes and restore patients' functional status.

Endoscopic methods

In recent years, the surgical community has increasingly discussed the use of endoscopic approaches in lumbar stenosis surgery. This is explained by both a global trend

towards reducing the aggression of surgical interventions and expected better clinical outcomes such as improvement in symptoms, hospitalization duration, financial burden, rapid restoration of functional status, and ability to work. Endoscopy is particularly relevant in surgery for elderly and comorbid patients due to less intraoperative trauma to surrounding tissues, shorter surgery duration, no need to install implants, and rapid postoperative rehabilitation and recovery.

Endoscopy was introduced into the practice of spinal surgeons relatively recently (in the 1990s), when K.T. Foley et al. presented a tubular retractor system for endoscopic spine surgery. Endoscopic methods were gradually introduced in the practice of intervertebral disc decompression and removal of herniated intervertebral discs [36–39].

By their invasiveness, endoscopic methods are classified into percutaneous endoscopy (full-endoscopic methods) and tubular endoscopy (microendoscopy). Technically, percutaneous endoscopic approaches are classified as intralaminar, transforaminar, and posterolateral (Fig. 5) [1].

For surgical treatment of central stenosis formed by hypertrophic joints and the yellow ligament and stenosis of the lateral recess, there are percutaneous endoscopic systems with a 10-mm port, which allow adequate decompression even with severe compression of the nerve structures. Through unilateral access, decompression is carried out on one side of the SC and on the opposite side using the over-the-top technique (Fig. 6, 7).

A pilot, multicenter, randomized, double-blind study (2020) compared two minimally invasive approaches in the treatment of lumbar spinal stenosis: uniportal full-endoscopic interlaminar and tubular approaches [40]. The only significant difference found was a better improvement in Oswestry Disability Index (ODI) (i.e. in functional status) at 6 months in endoscopic group. All patients underwent MRI before and after surgery. Between-group differences were not statistically significant. Finally, clinical improvement was shown to be independent of the degree of increase in the cross-sectional area of the SC or dural sac. There were statistically significant between-group differences in intraoperative blood loss (lower in endoscopic group), while number of complications was similar in both groups (2 in each group).

Many studies showed advantages of endoscopy over microsurgery [41, 42]. When both techniques are compared, considering highly qualification and broad experience of operating surgeons, endoscopy would be superior to microsurgery since minimal intraoperative tissue trauma leads to faster patients' recovery and high efficacy of surgical treatment. We can say that such

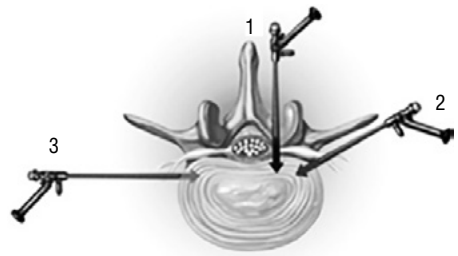


Fig. 5. Percutaneous endoscopic methods: intralaminar (1), posterolateral (2) and transforaminal (3).

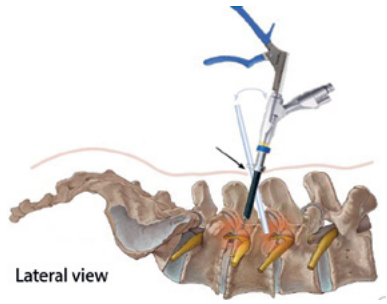


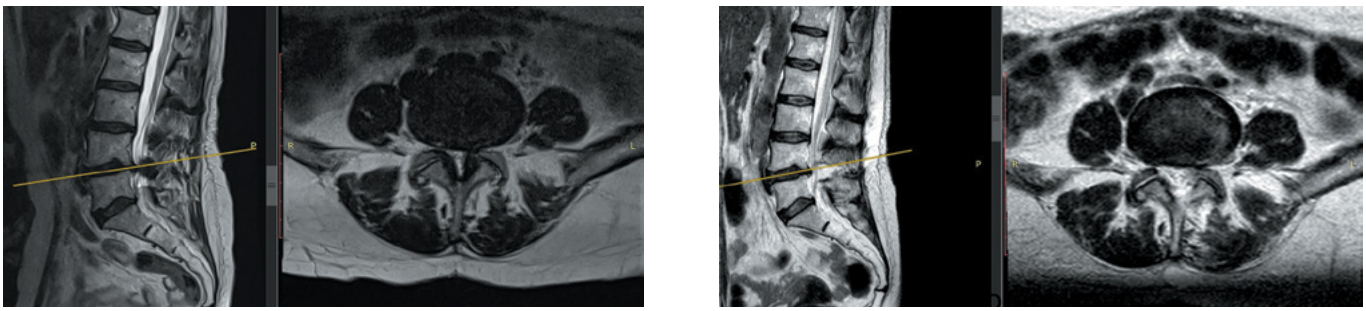
Fig. 6. System for percutaneous endoscopic surgery for degenerative spinal stenosis.
Arrow, one access for decompression at two levels.

promising results were expected and obvious. Efficacy and safety of endoscopy was also showed by H.S. Kim et al. [42–44].

Ralf Wagner (Germany) is a leading expert in endoscopic spinal neurosurgery. He has a broad experience in minimally invasive interventions and is actively involved in training specialists and international collaborative studies to investigate the efficacy of minimally invasive methods. For instance, he developed indications and contraindications for fully-endoscopic intralaminar lumbar decompression and described a step-by-step technique for performing this intervention [45]. R. Wagner is an author of several publications with technical notes about different spine endoscopies [45–48]. He conducted a randomized clinical trial together with surgeons from Spain and Argentina [40].

Several publications of C.J. Siepe et al. described full-endoscopic procedures for lumbar disc herniations and lumbar spinal stenosis [49, 50]. They mentioned a learning curve for new minimally invasive methods, which is one of the main and significant disadvantages of endoscopic interventions. However, benefits of endoscopic procedures can be seen not only in young patients but also in the elderly with comorbidities [51].

Therefore, many authors noted faster restoration of patients' functional status after endoscopic interventions, a long period of time needed to train in minimally invasive



A *B*

Fig. 7. MRI of a patient with central degenerative stenosis at L4–L5 level.
A, before surgery; *B*, after endoscopic decompressoin with DeltaJoimax.

methods, and heterogeneity of parameters used to compare conservative and surgical treatment methods [52, 53].

Conclusion

The microsurgical technique remains the gold standard in the surgical treatment of degeneration and dystrophic spine disease; it is clearer and has been tried and tested by more surgeons. Microsurgical decompression with stabilization is a treatment of choice for severe stenosis. However, surgery is evolving towards reduced invasiveness, and endoscopic methods, if performed by highly skilled specialists, are very effective, so operating surgeons can further develop their skills and improve clinical outcomes.

Compared with traditional decompression and stabilization procedures, endoscopic surgery is associated with a minimal risk of complications and allows patients to quickly restore their functional status and ability to work. This is relevant for patients without signs of obvious instability of the spinal motion segment, elderly patients with comorbidities, which can be relative contraindications for open traumatic surgery and complicate the postoperative recovery period.

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DOI: 10.1097/BRS.0000000000003478

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