


REVIEW

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The future of minimally invasive spine surgery in low-income Latin American countries

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Abstract

Treatment of spinal disorders can be managed conservatively or surgically. With the trend toward minimalistic approaches, minimally invasive spinal surgery (MISS) has gained much more importance over the last decade. Its use along with the required training has tremendously increased in developed countries. However, the availability of MISS today is uneven in different regions due to the development and availability of technology, as well as the level of training and qualifications of surgeons who are able to perform such operations on the spine. The purpose of this article is to analyze the prospects for minimally invasive spine surgery in Latin America in comparison with higher income countries.

Keywords Minimally invasive spine surgery, Latin America, Herniated disc, MISS, Low-income

Introduction

Lower back pain (LBP) is one of the most common complaints among patients seeking medical advice. Different population groups are subject to the occurrence of LBP and a direct correlation of pain with decreased labor productivity and overall quality of life has been revealed [1]. Up to 80% of adults experience LBP at least once in their lifetime, most often in their third decade. Lumbar pain is also characteristic during adolescence due

to active growth, but in adults herniated intervertebral discs are the most pathological finding [2]. The occurrence of lumbar pain has a negative impact on the overall level of a person's ability to work, and is also the cause of a decrease in the quality of life. According to analytical data in the United States, this problem annually leads to financial losses staggering up to \$100 million [3].

A herniated disc is a displacement of disc tissue beyond the boundaries of the intervertebral disc space. The diagnosis must be confirmed by radiological examination. At the same time, the formation of a hernia is directly accompanied by structural changes in the intervertebral discs [4]. The characteristic symptoms that accompany this degenerative process are radicular pain, weakness in the muscles, restrictions in flexion, and pain distributing to the legs during motion [4].

Disc herniations can be managed conservatively or surgically, however, it is surgical treatment that provides faster relief and is indicated for the above symptoms after a confirmed diagnosis. However, there are various surgical treatment modalities as well. One of these options is minimally invasive spinal surgery (MISS), which appeared at the beginning of the twenty-first century

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and is becoming more relevant and actively used by spine surgeons. A minimally invasive approach involves less traumatic intervention and reduced recovery time after surgical intervention. These approaches require less dissection of healthy muscles and bones, lower costs for emergency care, and reduced length of stay in the hospital, but they are also accompanied by long-term training of surgeons [5].

Today, the market for minimally invasive surgery is estimated at \$6.31 billion. According to forecasts, the market will continue to grow, and in the next decade it will probably reach \$10.5 billion [6]. However, the availability of minimally invasive spine surgery today is uneven in different regions due to the development and availability of technology, as well as the level of training and qualifications of surgeons who are able to perform such operations on the spine. The purpose of this article is to analyze the prospects for MISS in Latin America in comparison with higher income countries.

Indications and use

Intervertebral hernia belongs to the category of degenerative-dystrophic diseases of the spine, characterized by multifactorial, chronic and recurrent characteristics [7]. In particular, degenerative stenosis of the spinal canal is understood as a pathological narrowing of the central spinal canal, lateral recess or intervertebral foramen due to the invasion of bone structures, soft tissues or cartilage into spaces, which is manifested by clinical symptoms of compression and ischemia of the nerve roots and (or) spinal cord [8]. Table 1 shows the classification of degenerative changes in the intervertebral disc.

Within the framework of this article, the greatest attention is paid to the lumbar region, in connection with which, Schizas' Classification of Lumbar Spinal Stenosis [10] has been used. The classification distinguishes stenosis into 7 categories, each of which has its own characteristics regarding the distribution of cerebrospinal fluid, epidural fat, the location of the root, and the concentration of nerve roots.

As noted earlier, the effectiveness of surgical treatment seems to be higher compared to conservative methods. The effectiveness of the surgical option has been confirmed by various studies conducted over a long period of observation [11].

Advantages of MISS

During the past, operations on the lumbar spine were one of the most destructive types of surgical intervention for the vertebral structure, despite the ultimate goal of their restoration. For decompression of the nerves or removal of a hernia, a wide dissection of the muscle tissue lying in the region of the disturbed vertebrae was required. As a result, the patient could get a violation of the integrity and functionality of the ligaments and tendons, as well as to the formation of scars in large volumes. In addition, violations of the integrity of the ligaments or their concomitant removal leads to a weakening of the spine and a decrease in its functions. These methods of surgical intervention are relevant today solely for complex cases where other methods will be ineffective. However, destructive approaches are increasingly being replaced by minimally invasive techniques that are less traumatic for patients.

In a minimally invasive approach, the spine is accessed through a small incision. Using fluoroscopic guidance, a tubular retractor is placed on the lamina-facet junction of the affected level. A microendoscope is then connected to the tubular retractor. At this stage a curette, chisel or a drill can be used to remove any necessary bony components. This allows for the clear visualization of ligamentum flavum. Using Kerrison rongeurs, the superior and articular processes can be thinned allowing for neural decompression. Via this pathway, the intervertebral disc can be also reached and prepared for interbody fusion. Finally, under fluoroscopic guidance can be used to successfully place percutaneous pedicle screws [12]. A demonstration of an example of access to the spine is shown in Fig. 1.

Table 1 Classification of degenerative changes in the intervertebral disc [9]

Stage	Disc structure	Signal intensity (MRI T2W)	Distinction of annulus from pulposus	Height of the disc
I	Homogeneous	Hyperintense (white)	Clear border	Normal
II	Inhomogeneous	Hyperintense (white)	Clear border	Normal
III	Inhomogeneous	Isointense (gray)	Fuzzy	Normal or slightly reduced
IV	Inhomogeneous	Isointense to hypointense (gray–black)	Absent	The border is normal or moderately reduced
V	Inhomogeneous	Hypointense (black)	Absent	The border is sharply lowered

Worldwide trends

The number of minimally invasive surgeries performed in the world is increasing annually due to the development and expansion of the availability of technologies. The reduction in iatrogenic trauma and surgical pain, coupled with the tendency of simple lumbar decompression surgeries into more cost-effective outpatient settings, have led to a significant increase in lumbar spine surgery [13].

The use of minimally invasive surgical techniques is becoming more readily available to patients [14]. It has also become the choice of patients due to fewer post-operative complications, as well as problems associated with anesthesia, decreased hospital stay and decrease use of postoperative medications [15]. Minimally invasive operations can be performed in some cases under local anesthesia in a medical center with the necessary infrastructure and equipment [16].

We have analyzed a number of works that examined the approaches of surgeons to surgical treatment of the lumbar spine. In particular interest, a large-scale survey based study [17] was conducted from five regions of the world: Africa, Middle East, Asia, Europe, North America and South America. The survey involved 586 surgeons who regularly performed operations on the lumbar spine. According to the results of the study, it was found that 59.9% of respondents perform spinal endoscopy, which is the most commonly used method in the world among minimally invasive techniques. This is followed by mini-open approaches—55.1%, as well as the use of tubular retractors—41.8% (Fig. 2). The most preferred endoscopic approach to the spine was the transforaminal method, which was chosen by 56.2% of the surveyed surgeons, interlaminar—41.8% of the respondents, full endoscopic—35.3% and over the top MISS method—13.7% (Fig. 3).

Regional differences

Separately, the authors considered the issues of regional differences in the adoption and use of various minimally

invasive methods of spinal surgery and their impact on the decision-making process in the treatment of patients with lumbar stenosis. Minimally invasive techniques were found to be used by surgeons in all five regions, with representatives from Africa and the Middle East indicating that the perceived prevalence of MISS in the region is higher than its actual use. The largest gap in this perception was demonstrated by surgeons from North America. Another important finding was that endoscopy is the preferred method, despite the fact that the literature indicates greater availability of tubular retraction systems.

The key finding for this study is that minimally invasive techniques are most widely used by South American and Asian surgeons in the survey, while European physicians are more conservative in their choice of techniques. However, the use of minimally invasive surgery in low-income Latin American countries depends on many factors.

Latin America

One of the key disadvantages of minimally invasive methods today is their cost. In particular, the cost of minimally invasive spinal surgery varies depending on the type and severity of the disease. Also, the price is directly influenced by the chosen technique of the operation, the equipment used, the level of the medical organization and the qualifications of the surgeon. The initial average cost for some transactions is summarized in Fig. 4.

From Fig. 4 it becomes clear that Dominican Republic and Mexico, which belong to Latin America, have the least cost when using MISS modalities. However, the very possibilities of MISS in this region, both from medical institutions and from patients are limited.

Due to its fragmented structure and rather high levels of inequality of the health care systems in Latin American countries, large-scale changes and a rapid transition to minimally invasive procedures are difficult. The prevalence of health insurance among the population is quite low, and the availability of quality medical care decreases with distance from large cities, and is practically

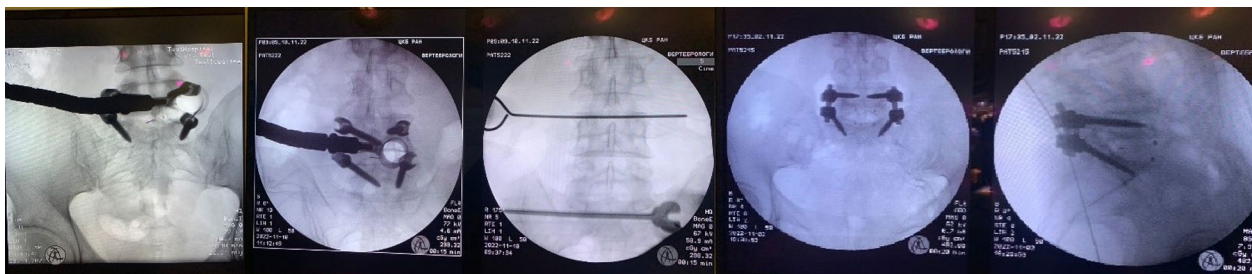


Fig. 1 Fluoroscopic images of a bilateral L5-S1 fusion

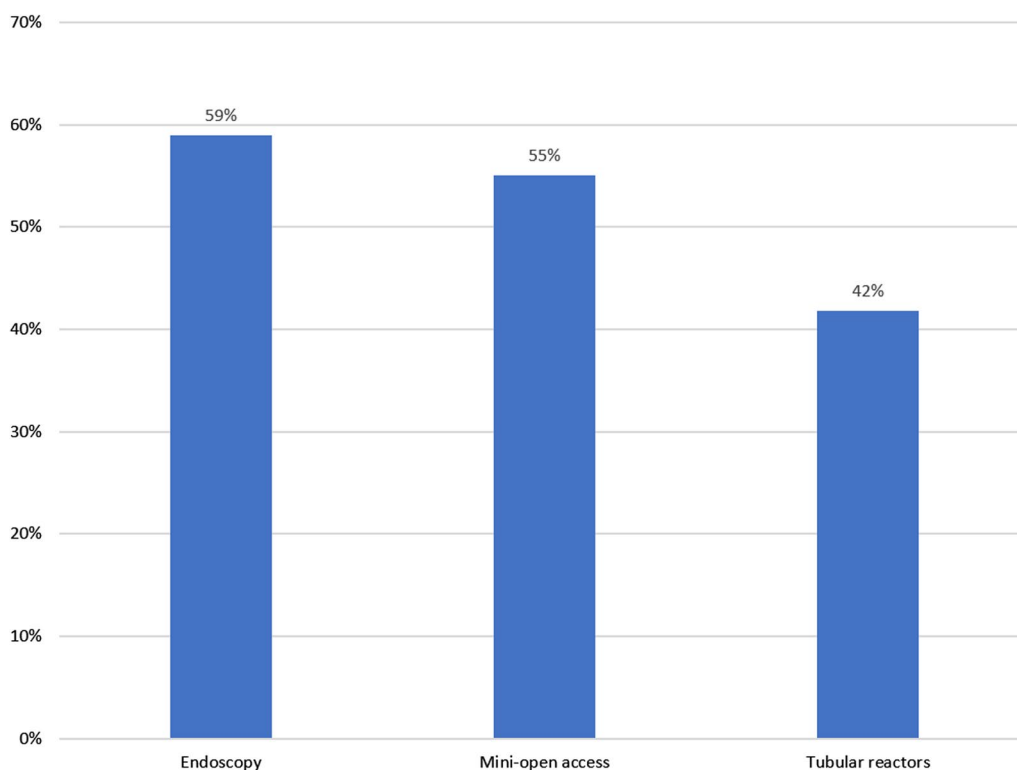


Fig. 2 The most commonly used minimally invasive techniques in the world [4]

inaccessible to the rural population and various indigenous peoples and Afro-Latin descendants [18].

In addition, there is no established system of intercultural approach in relation to indigenous people, which would take into account linguistic, cultural and traditional differences when assessing the possibility of receiving assistance within the framework of minimally invasive techniques.

Another significant problem is the dependence of the Latin American region on the import of medicines, technologies and equipment for minimally invasive operations. Despite the fact that Latin American market has a great potential for manufacturers and sellers of equipment for minimally invasive operations, there is an acute problem of a shortage of qualified specialists in the field of MISS [19].

This is due in particular to the shortcomings of the established norms for MISS, since many decisions in minimally invasive spine surgery do not depend on fixed norms, but on the individual experience of a highly qualified surgeon. However, the standard curriculum in many medical schools in Latin America do not include training in MISS. Therefore, to perform such operations the surgeon is required to undergo additional training, most often abroad, which requires financial investments from medical institutions that may lack material resources.

The lack of infrastructure today is also one of the problems [20]. The only full-scale hospital that is internationally certified and performs minimally invasive operations is in Tijuana, Mexico. Its peculiarity lies in individual accompaniment by managers from the USA. Minimally invasive surgeries are also performed in other clinics in large cities of Latin America, including the Dominican Republic, however as noted earlier, it is important for patients to conduct a detailed analysis of the clinic's capabilities and the qualifications of doctors.

We also analyzed a publication in which authors for Latin America assessed the key barriers that spinal neurosurgeons face when performing MISS [21]. The high cost of MISS implantation and limited access to navigation technology, percutaneous screws and operating microscopes were cited as major barriers [22].

Conclusion

In conclusion, it is important to emphasize the development of the minimally invasive MISS-TLIF and PLIF procedures, which provide a viable substitute for standard surgical methods to avoid significant risks of iatrogenic damage. The skill along with the experience of the surgeons and their familiarity with surgical instruments will allow the procedures to yield positive results. Thus training with MISS is vital during residency and even

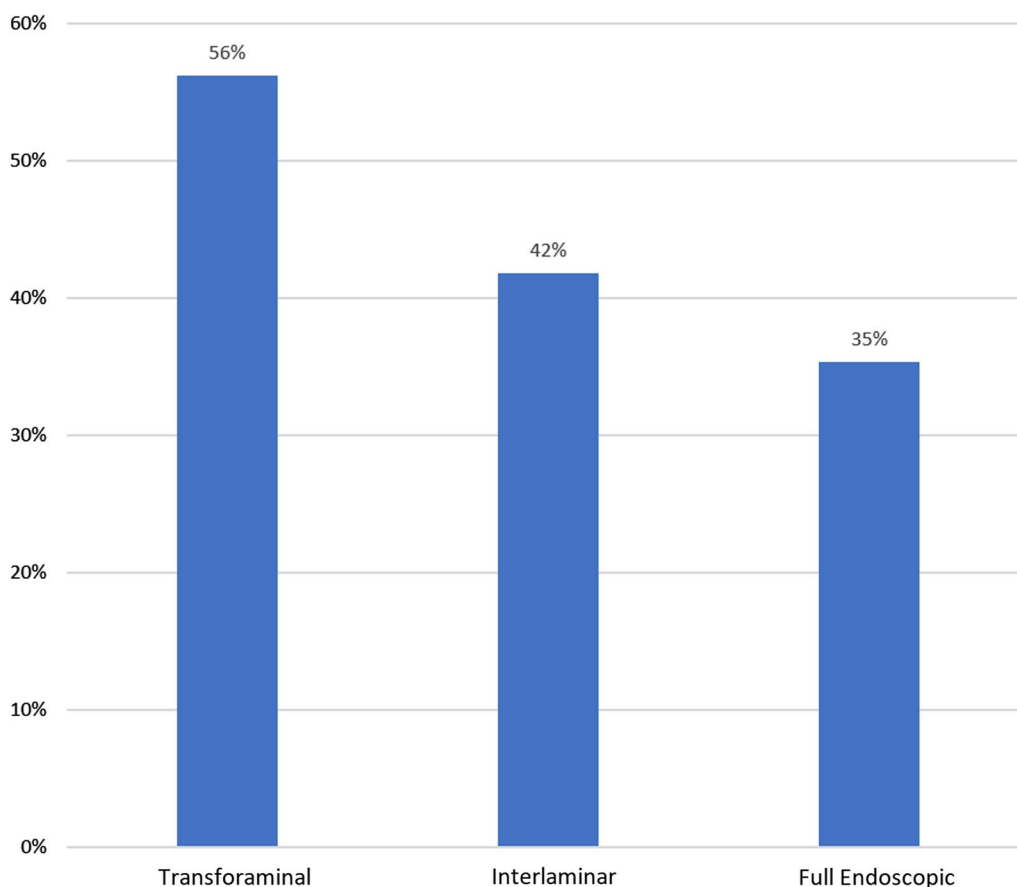


Fig. 3 Most preferred endoscopic techniques among surgeons [10]

the early years of professional career. The high cost of technologies and equipment, along with the lack of practical training for highly skilled surgeons who can perform minimally invasive procedures are the main problems affecting the developing minimally invasive surgery sector in Latin America. Despite being among the least expensive in the world, MISS-TLIF and PLIF are still not widely available to the local community due to costs, shortages of surgeons, and necessary equipment. Although minimally invasive techniques are more satisfactory for both the patient and the surgeon, they are more expensive, which is a major concern in low-income countries. Therefore, there are several recommendations for low-cost countries. One of the

first requirements is that the national health service of the nation in question provide options other than the well-established practice of offering medical insurance to cover costs; in this context, this means adding minimally invasive procedures to the list of procedures that are covered. An alternative would be to have the national congress of the concerned country draft a bill that would allow the industry to purchase older but still useful models at a competitive price by means of international trade with developed or high-income nations. Nevertheless, Latin America remains and will likely remain one of the most promising areas for the development of minimally invasive surgery.

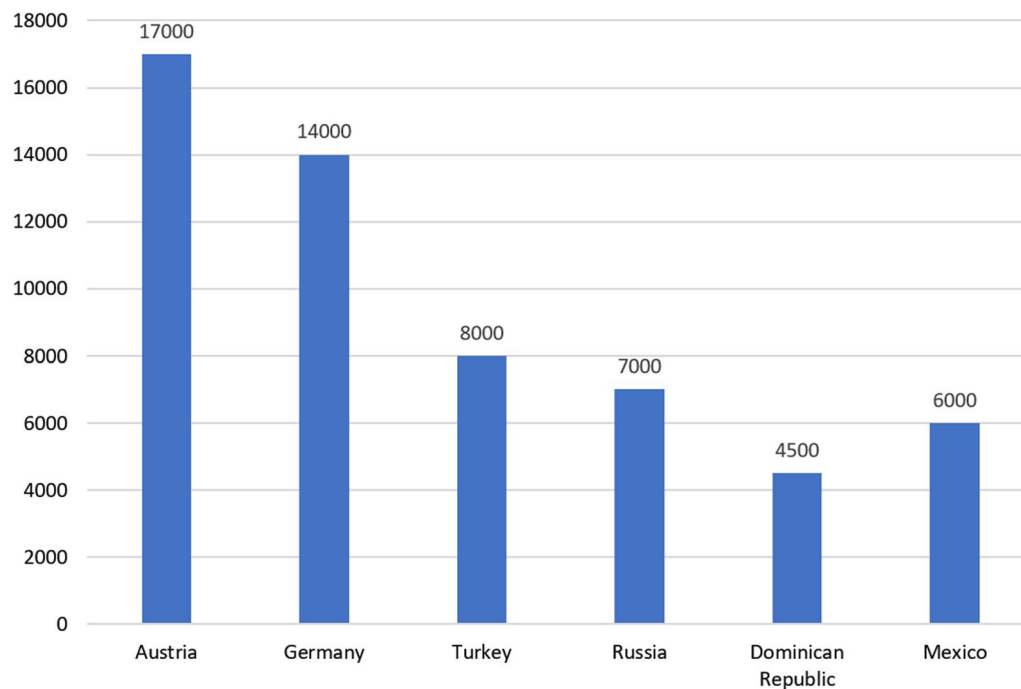


Fig. 4 The cost of MISS for lumbar disc herniations in various countries (USD) [17]

Abbreviations

LBP Lower back pain
MISS Minimally invasive spinal surgery

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Author contributions

IB, DES, AV, GS: conceptualization, methodology, software, writing original draft. ATS, BE, MD: investigation, data curation. EB, PN, TN: formal analysis, investigation, review and editing. RN, GC, BC: supervision, visualization.

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Declarations

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Consent for publication

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Competing interests

The authors have no competing interests related to this study.

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