

**SURGICAL INTERVENTIONS IN UNSTABLE FORMS
OF DEGENERATIVE LUMBOSACRAL SPINE****BYVALTSEV V.A.^{1,2,3*}, KALININ A.A.^{1,2}, KHACHIKYAN A.F.⁴, MINASYAN I.S.⁵**

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ABSTRACT

Surgical treatment of degenerative disc diseases is the fastest growing trend in spinal neurosurgery. One of the main clinical symptoms of the degenerative process in the spine is pain, and recurrent pain – the dominant cause of temporary disability with significant economic losses. These diseases affect all ages and social strata of the society, especially in the upward trend of the average life expectancy in developed countries.

Despite the efforts to improve the results of surgical treatment of lumbar degenerative disc disease, changes in the volume of surgical intervention did not lead to a significant effect. Combination of decompression and stabilization interventions was suggested to transform into combo.

Current approach to the patients with degenerative lumbar spine remains debating among the physicians of related specialties.

The article provides an overview of surgical interventions in unstable forms of lumbar spine degenerative diseases for the prevention and treatment of degenerative instability by using fusion methods performed from the anterior, extreme lateral, posterior and transformational lumbar interbody accesses. Determination method of surgical treatment depends on proficiency of the surgeon. According to some authors, neither dorsal nor ventral approaches for the treatment of degenerative spine are universal processes.

Evolution of stabilizing operations on the spine is associated with the development of modern steel structures for spinal fusion, the use of which increases the stability of the operated segment. It is found that anatomically and physiologically correct position of fixed vertebrae directly affects the outcome of the operation.

Improved technologies in spine surgery led to a significant reduction of insufficient results. However, the removal of vertebral neural-conflict recovery is not always accompanied by a dynamic equilibrium in the vertebral column and contributes to the development or progression of the vertebral-motor segment instability in the long term.

Currently in spinal surgery it is topical to investigate the possibility of low-traumatic restoring biomechanical stability of the spine with a full functional recovery as soon as possible. The application of various stabilizing structures, minimally invasive tubular retractors, micro toolkit and percutaneous techniques allows to fix the spine from the anterior, extreme lateral and posterior accesses with preserving supporting elements, less damage to the surrounding soft tissues and less intraoperative blood loss, which reduces the length of hospital stay, the general terms of a temporary loss disability, economic costs for treatment.

KEYWORDS: *degenerative lesions, intervertebral discs, facet joints, segmental instability, spondylolisthesis, lumbar spine.*

Introduction

Surgical treatment of degenerative disc diseases is the fastest growing trend in spinal neurosurgery

[Kaiser M et al., 2002; Drakin A, 2008; Freemont A, 2009; Van den Hauwe L, 2009]. One of the main clinical symptoms of the degenerative process in the spine is pain [Dotsenko V et al., 2004; Kim K et al., 2006], and recurrent pain – the dominant cause of temporary disability with significant economic losses [Slucky A et al., 2006; Krutko A, 2012]. These diseases affect all ages and social strata of

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the society, especially in the upward trend of the average life expectancy in developed countries [Saraph V et al., 2004; Regev G et al., 2009]. Increasing number of patients with degenerative disc diseases promotes intensive introduction of modern high-tech surgical treatment [Fritzell P et al., 2003; Zander T et al., 2003].

In the presence of lumbar and lumbosacral pain, frequency of lesions of intervertebral discs is from 80 to 85% [Panaskov A, 2006; Wurgler-Hauri C et al., 2008; Prodan A et al., 2009], while from 2.2 to 24% vertebrogenic pain associated with the formation of pathological dislocation of vertebra [Lazennec J et al., 2000; Lidsey D et al., 2003; Inamasu J, Guiot B, 2005; Prodan A et al., 2009]. The main role in the pathogenesis of degenerative lumbar spinal column belongs to the intervertebral discs and facet joints [Polikeit A et al., 2003; Bozkus H et al., 2004]. It was found that the emerging pathology of intervertebral joints due to destruction or facet hypertrophy resulted in anterior displacement of a vertebra, while the loss of elements of the intervertebral disc is a shift to the posterior displacement [Tikhodeev S, 2005; Byvaltsev V et al., 2011]. In case of the combination of above-mentioned structures a rotational instability is formed, which is characterized by clinical manifestations of vertebral compression due to neurovascular structures [Moore K et al., 2002; Eliyas J, Karahalios D, 2011].

Neuroimaging methods are often verified by a multi-level nature of degenerative changes in intervertebral discs in the lumbar-sacral level [Wurgler-Hauri C et al., 2008; Rameshvili T et al., 2011]. The clinically significant form of degenerative changes in the intervertebral disc is resulted in hernia [Dotsenko V et al., 2004; Arrestov S et al., 2011; Byvaltsev V et al., 2012], and pathological mobility of vertebral-motor segment is defined by spondylolisthesis [Tikhodeev S, 2005; Byvaltsev V et al., 2010; 2011].

Pathological changes in anatomical structures within the vertebral-motor segment are reflected through the natural degenerative process and can be found in the group of people, who don't have vertebral symptoms [Tikhodeev S, 2005; Byvaltsev V et al., 2011]. In this regard, to judge for the presence of pathological changes requiring surgical correction is necessary only if there are clinically

significant violations of vertebral-motor segment [Wurgler-Hauri C et al., 2008; Sink E et al., 2012].

The clinical picture of degenerative processes of the lumbar-sacral spine is formed of vertebral symptoms (disturbance of biomechanics of the lumbar spine) and neurological signs associated with compression of neural structures (sensory, motor and autonomic fibers), as well as vascular lesions (arteries, veins) [Mayer H, 2006].

In the overall structure of the surgical interventions on vertebral spine the number of decompressive-stabilizing operations is about 2-3% [Simonovic A, 2005; Rohlmann A et al., 2007]. This is due to the lack of unique tactics, choice of clinically significant levels of destruction and clarified scope of surgery, as well as the lack of diagnostic events of segmental instability during the preoperative stage.

Minimization of manipulation in the area of surgery reduces the risk of iatrogenic damage of the nerve structures and the severity of scarry-adhesive epiduritis. In 3-20% of cases [Tikhodeev S, 2005; Prodan A et al., 2009] the syndrome of "failed back surgery" is formed, which is characterized by the resumption of post-operative pain in the lower back and/or foot, functional impairment, reduced work capacity and life quality of the patients. The causes of recurrence of neurological symptoms, in most cases, are postoperative segmental instability and recurrent disc herniation [Wurgler-Hauri C et al., 2008; Prodan A et al., 2009]. Clinical severity, duration of the disease and degree of biomechanical disorders are the main reasons for significantly reduction of operation results [Vetrile S et al., 2004; Simonovic A, 2005; Prodan A et al., 2009]. Tactics of the clinical management of patients with spinal osteochondritis, particularly combined with segmental instability are not well defined among physicians of related different specialties. The opinions of reserved mixed reviews on conservative and operative treatment methods are not overcome in the selection of the optimum methods for surgical treatment of degenerative disc disease [Bozkus H et al., 2004; Simonovic A, 2005; Panaskov A, 2006; Wurgler-Hauri C et al., 2008; Shchadranok V et al., 2011].

Conservative tactics are indicated for all patients at the initial stage of the disease, except in cases requiring emergency surgery (patients

with rapidly progressive neurological deficit, caudal syndrome, etc.). In case of the ineffectiveness of this approach raises the question of a planned surgical treatment.

From modern positions of vertebrology, the differentiated approach to surgical interventions in unstable forms of degenerative spinal segments of lumbar-sacral spine remains poorly studied. There is a neuro-orthopedic concept based on the elimination of compression of neurovascular structures (discoradicular conflict) and the prevention of instability of vertebral-motor segment [Prodan A et al., 2009; Shchadranok V et al., 2011; Krutko A 2012]. But for the implementation of tasks an unresolved question remains in the volume decompression of neural structures and the method of fixation of the operated vertebral-motor segment [Bozkus H et al., 2004; Aryan H et al., 2008; Drakin A, 2008; Byvaltsev V et al., 2010; Krutko A, 2012]. Only the basic principle of intervention is determined – primarily decompression, and if necessary – stabilization [Benglis D et al., 2008; Prodan A et al., 2009].

Historical background: Spine surgery was developed in the early XX century. Experience of various decompressive and stabilizing operating stages is very important for retrospective analysis of surgical treatment results, evaluation of the spinal surgery effectiveness and validity.

Identification of the reasons contributing the development of the spinal degenerative process and the study of approaches to the patients' treatment with dorsalgia are implementing for a long time. For the first time a decompressive surgery with the aim to remove a herniated disc was performed in 1909 with the compression of spinal roots by "chordoma". In 1933 American scientists revealed degenerative origin of intra-vertebral formations and suggested to use laminectomy and transdural access to the spine. Analysis of the further results of the use of laminectomy by removing disc herniation was not encouraging: more than half of the patients' relapsed pain and worsening of neurological symptoms [Simonovic A, 2005; Prodan A et al., 2009; Rameshvili T et al., 2011]. To minimize aggression against the compact bone the hemi-laminectomy method was proposed, partial removal of the lamina without breaking the arc and the method for removing disc herniation through

ventral slot developed in 1941. It was found that the decrease in aggression surgery has improved the postoperative neurologic results while maintaining the stability of the operated spinal segment [Sorokovikov V, 2003; Panaskov A, 2006]. However, the impossibility of total removal of herniated disc in the back method was the cause of symptoms and relapse revision of surgery.

Stabilizing interventions in the form of spondylosis has been used in 1911 that is introduction of a bone autograft in the splitting of spinous processes and in 1912 and 1917, with the fixation of not only spinous processes, but also the handles with intervertebral joints. Inferiority of callus formation and the tendency to resorption of the graft stimulated to develop modifications to the posterior interspinous fusion with bone graft and steel wire, and the compression of fusion metal ties according to Tsivyan-Ramikh. The most commonly used method of degenerative disc disease treatment was the posterior interbody spinal fusion [Sorokovikov V, 2003; Prodan A et al., 2009]. Some of the advantages are inability to adequately fix several segments, anatomical lumbar lordosis hindering the tight fit preventing graft, lack of proper load on the vertebral arch and the associated lack of consolidation and lysis of bone, defined the limited use of this method.

Based on the position of the radical discectomy W. Muller (1906) put into the practice a fundamentally new method of spinal fusion of the anterior transperitoneal access. The intervention techniques and the results of the discectomy from the anterior access are presented in the works of V.D. Chaklin (1931) and B.H. Bums (1933) [Sorokovikov V, 2003]. However, this method of spinal fusion has not got a wide popularity [Dotsenko V et al., 2004] and was used mainly for the treatment of tuberculous spondylitis and spondylolisthesis [Bono C, Lee C, 2004; Dotsenko V et al., 2004].

Despite the efforts to improve the results of surgical treatment of lumbar degenerative disc disease, changes in the volume of surgical intervention did not lead to a significant effect. Combination of decompression and stabilization interventions was suggested to transform into combo. Two areas were defined: complement of the usual removal of herniated disc by scraping the cavity and execution of posterior interspinous or interbody

spinal fusion in the affected level after the standard decompression. In 1946 it was suggested to use interbody corporodesis with the help of bone grafts through a posterior access. However, unsatisfactory results of the combined interventions resulted in reducing the number of surgical operations.

Current situation of the issue: Current approach to the patients with degenerative lumbar spine remains debating among the physicians of related specialties [Bozkus H et al., 2004; Aryan H et al., 2008; Prodan A et al., 2009]. Pathogenesis treatment of degenerative disc disease is to eliminate the discoradicular conflict and if the situation is stabilized – to the indicative implementation of operated segment [Dotsenko V et al., 2004; Panaskov A, 2006; Benglis D et al., 2008], as etiotropic treatment of already formed degenerative process of the spine does not show encouraging results [Vetrile S et al., 2004; Simonovic A, 2005; Rameshvili T et al., 2011].

Different views regarding the volume of required decompression with preservation of stability of support elements are the cause for debates in the modern spine science. Many authors consider unreasonable to perform interventions on clinically insignificant intervertebral discs, despite the expression of their degeneration, arguing that the additional manipulation of the spinal canal and nerve structures lead to the formation of epidural fibrosis, spondylitis and discitis. Thus, according to W. Caspar, in 94% of cases the operation is performed at the same level of lesions [Freemont A, 2009; Arrestov S et al., 2011]. This is due to the need for a full decompression of neurovascular structures of the spinal canal and the preservation of the operated spine stability.

It was found that iatrogenic instability often results from a laminectomy followed by discectomy and foramina decompression (facetectomy). It is considered that the preservation of intervertebral joint on one side of the spine supports the stability [Tikhodeev S, 2005; Prodan A et al., 2009; Lutsyk A et al., 2010; Krutko A, 2012]. Several biomechanical studies have shown that instability of vertebral-motor segment may occur in case of completely removal of the intervertebral joint from one side, but the implementation of unilateral or bilateral medial facetectomy on vertebral stability is not reflected. It has been shown that the removal of

more than 50% of each of the intervertebral joint at the same level results in a considerable segmental instability, while in case of extra discectomy a rough destabilization of vertebral segment is observed [Dotsenko V et al., 2004; Marotta N et al., 2006; Nachanakian A et al., 2013].

In the study of postoperative segmental instability, it was found that the composition of the back decompression without stabilization among 73% of patients with a low preoperative spondylolisthesis causes its progression. The study of biomechanics of operated vertebral-motor segment showed minimal impact of facetectomy during flexion. At the same time, during the rotation, especially with the dual axial load, the instability of the vertebral segments objectively increases [Zdeblick T, David S, 2000; Tikhodeev S, 2005; Leone A et al., 2007].

In order to minimize the destabilizing effect, alternative ways of decompression laminectomy were offered in the 70s-80s of the last century: limited, osteoplastic laminectomy (laminoplasty), subarticular fenestration, laminectomy, selective decompression [Zdeblick T, David S, 2000; Leone A et al., 2007]. The use of these methods allows to avoid the progression of instability, but their field of application is limited to single-level defeat of vertebral-motor segment [Rohmann A et al., 2007; Rameshvili T et al., 2011].

For a long time microsurgical discectomy with the use of a surgical microscope has taken leading place on the frequency of the use and results of treatment in degenerative changes of lumbar spine. This method is least traumatic and provides adequate visualization of interbody intervals, thereby allowing to improve the results of treatment as compared to traditional open procedure [Chertkov A, 2005; Simonovic A, 2005; Lutsyk A et al., 2010; Shchadranok V et al., 2011]. Continued research for effective ways of discectomy in 1997 led to the development of technique of micro-endoscopic discectomy and in 1999 – endoscopic method for treating discoradicular conflict [Panaskov A, 2006; Byvaltsev V et al., 2010, Arrestov S et al., 2011]. According to some authors, the results of the use of operating microscope and endoscope are comparable [Sorokovikov V, 2003; Panaskov A, 2006; Byvaltsev V et al., 2010]. Due to the limited visualization of interbody periods and impossibility to

carry out the necessary stabilization there is available data for conflicting views on their use in unstable forms of degenerative lesions in spinal motion segments of lumbar spine [Chertkov A, 2005; Shchadranok V et al., 2011].

Surgical fixation of the operable part of the spine from the modern operable spine is based on the establishment of a fixed fusion and dynamic stabilization. It is the formation of a bone block between the vertebrae with the lack of movement between them and a reduction in abnormal movements with minimal changes in biomechanics of the operated spine.

Mixed views on the need to stabilize the operated segment led to a series of studies to analyze the results of surgical interventions with and without installing fixing devices. It was found that in 74% of lumbar stenosis without the presence of preoperative instability, a significant improvement was achieved in decompression only when initially available hypermobility of vertebral-motor segments, biomechanical results of arthrodesis were more effective than the use of poly-rigid pedicular fixation system (Dynesys) [Quintero S, Manusov E, 2012]. Some researchers [Saraph V et al., 2004; Yang J et al., 2008; Tjardes T et al., 2010; Rameshvili T et al., 2011; Taher F et al., 2012] have not found the differences in the results of decompressive-stabilizing and decompressive surgery without prior segmental instability. At the same time, the existing signs of abnormal excessive mobility, considering its postoperative aggravation by resection of the supporting elements are undoubtedly indication for installing fixing devices.

Today, for prevention and treatment of degenerative instability by using fusion methods performed from the anterior, extreme lateral, posterior and transformational lumbar interbody accesses. Determination method of surgical treatment depends on the proficiency of the surgeon. According to some authors, neither dorsal nor ventral approaches for the treatment of degenerative spine are universal processes [Brau S, 2002; Bono C, Lee C, 2004; Dotsenko V et al., 2004; Markin S et al., 2007; Prodan A et al., 2009; Shchadranok V et al., 2011].

Evolution of stabilizing operations on the spine is associated with the development of modern steel structures for fusion [Lieberman I et al.,

2000]. It is found that its use increases the stability of the operated segment [Wilmink J, 1999]. J. Lazennec and co-authors indicated that anatomically and physiologically correct position of fixed vertebrae directly affects the outcome of the operation [Lee K et al., 2004].

Anterior stabilizing interventions: Traumatism and significant amount of intraabdominal postoperative complications of the classical approach to vertebral column have led T. Iwahara (1944) to develop less aggressive techniques – retroperitoneal approach [Markin S et al., 2007]. The application of anterior spondylodesis technique for the surgical treatment of degenerative lumbar discs was justified [Rohlmann A et al., 2007]. For corporodesis auto-bone was originally used, and later in 1992 the cylindrical implant was firstly used, which was placed in the bone chips. Currently, a variety of interbody cages are presented: cylindrical and rectangular titanium, ceramic, synthetic fibers, porous titanium nickelide, polyacidoxygental and polyaromatic polymers [Brau S, 2002; Marchi L et al., 2012].

Changing of biomechanics of operating level and accelerating of degeneration adjacent segments led to the development of mobile prosthesis [Shustin V et al., 2006]. Comparative analysis of the use of structurally different systems showed that the use of mobile intervertebral disk allows to achieve more successful and satisfying postoperative rehabilitation results than using the fixed one [Madan S, Boeree N, 2003; Dotsenko V et al., 2004; Benglis D et al., 2008]. It was found that using anterior lumbar interbody fusion techniques increases the number of levels impairing the quality of ankylosis due to which this method is preferred for the operation on one spinal motion segment [Lowe T et al., 2002; Bono C, Lee C, 2004; Dotsenko V et al., 2004].

Traditionally for each skin incision the approaches of the median, suprapubic and adrectal are used. All of them include a retroperitoneal approach to the intervertebral disc with the mobilization of iliac vessels [Rohlmann A et al., 2007; Scheufler K et al., 2007; José-Antonio S et al., 2011]. Anatomical effectiveness of the p anterior lumbar interbody fusion procedure includes restoring disc height and lumbar lordosis, as well as reducing the voltage of posterior ligamentous ap-

paratus [Zuckerman J et al., 2003; Rohlmann A et al., 2007]. Through this access, it is possible to apply the total discectomy with the formation of full and limiting scarry-adhesive process in the spinal canal due to the lack of instrumental manipulations [Markin S et al., 2007; Marchi L et al., 2012]. Constraints of using this method are the inability to eliminate foraminal stenosis and removal of sequestered disc herniation [Markin S et al., 2007]. Emerging complications: bowel obstruction, damage to abdominal organs [Fuchs P et al., 2005], postoperative ventral hernia, retrograde ejaculation [Zuckerman J et al., 2003; Freemont A, 2009], most often are directly related to the projection access.

According to several authors, the method of surgical treatment leads to positive clinical results from 73% to 85% of cases [Brau S, 2002; Dotsenko V et al., 2004]. But, according to some researchers, in most cases, the bone block is not formed and radicular pain syndromes are stored, and the frequency of early postoperative complications is about 15-30%. In the long-term analysis the results revealed that only 42% of the patients are returned to their previous work and 23% required repeating surgery [Bono C, Lee C, 2004; Markin S et al., 2007].

Anterior lumbar interbody fusion procedure has undergone in its three stages: open, mini-open and laparoscopic. The results of the comparative analysis of surgical treatment of lumbar osteochondrosis with various techniques of ventral access are controversial. The technique of laparoscopic anterior fusion, proposed by T.G. Obenchain in 1991, required appropriate skills for surgeon, accompanied by a significant number of complications (wound of internal organs and major blood vessels), as well as by the increase of surgical treatment time [Markin S et al., 2007]. T.A. Zdeblick and S.M. David [Zuckerman J et al., 2003] while studying the methodology of open and laparoscopic anterior lumbar interbody fusion showed 4% and 20% complications, respectively. M.G. Kaiser and co-authors [Kanayama M et al., 2007] have not defined benefits between laparoscopic and mini open anterior lumbar interbody fusion. Thus, among the most actively used anterior lumbar interbody fusion procedure (in fewer complications) is the mini-open access. According to S.A.

Brau [Coe J, 2004], complications encountered during such access in the form of vascular damage were 1.6%, retrograde ejaculation – 0.1%, ileus lasting more than 3 days – 0.6%, superficial wound infection – 0.4%.

In order to improve the performance of radiological fusion, the technique uniting front corpectomy and pedicle fixation method had appeared. This combination has been recommended for patients with a high risk of pseudarthrosis formation: during the second intervention, smokers and patients with diabetes mellitus. K.R. Moore and co-authors reported the successful arthrodesis from 95% to 86% successful outcomes in patients with chronic pain syndromes in back on the background of ineffective conservative treatment [Nachanikian A et al., 2013]. The assessment of late postoperative results revealed that pseudarthrosis is originated in 19% of cases, and degeneration adjacent segment is occurred in 14% [Szpalski M et al., 2007].

Lateral stabilizing interventions: Improved additional use of laparoscopic techniques of anterior lumbar interbody fusion procedure is widely used [Lowe T et al., 2002] regardless of the number of complications like bleeding, damage to internal organs, sexual dysfunction [José-Antonio S et al., 2011], which became as a motivation to develop less traumatic methods and approaches fusions like extreme lateral and direct lateral interbody fusion. These extreme lateral approaches to the spine are carried out through retroperitoneal fat and lumbar muscle and are relatively new trend in the spine. The techniques of operative access provided by L. Pimenta (2001) were a modification of the ventral and retroperitoneal approach [Park Y et al., 2011]. Its main advantages include posterior muscle-tendon complex and anterior longitudinal ligament, as well as the absence of traction spinal root. Complications associated with the procedure of extreme lateral and direct lateral interbody fusion take place at the stage of access or are not available, and the risk of the destabilizing effect of the intervention is minimal [Korovesiss P et al., 2004; Park Y et al., 2011]. Limited field during the operation makes it impossible to use this technique in the multi-level degeneration of the intervertebral discs with prolapse of disc material combined

with segmental instability (spondylolisthesis II-V stage). Anatomically determined limitations of manipulations on intervertebral discs LI-LII, LV-SI (due to the lower edges of the vertical stroke and high standing of the wing of ilium) and inability to perform the central decompression of the spinal canal are also deterrents to widespread use of this technique.

Posterior stabilizing interventions: In the history of the posterior stabilizing operating technique are acknowledged the periods from 1931 to 1982 – implementation of non-functional designs for the restoration of the statics of the vertebral spine [Sorokovikov V, 2003; Nazarenko G et al., 2008] and the establishment of functional prosthesis while maintaining static and dynamic functions [Prodan A et al., 2009; Shchadranok V et al., 2011].

A wide bony decompression and maximum removal of disk material was offered in 1988. Subsequently, the disc was placed in the cavity of the osteoconductive or osteoinductive material [Fuchs P et al., 2005]. The use of autologous bone interbody fusion with a tendency to the formation of pseudarthrosis or lysis was a prerequisite for the development of threaded cages, which made it possible to provide a secure fit of the vertebral segment to increase the effectiveness of treatment and reduce the time of postoperative bed rest [Bozkus H et al., 2004]. Today implants for trans-body fixing are made of various materials (metals, ceramics, carbon), widespread cages of porous titanium nickel alloy. Constructions of metal with a shape of memory effect, as a promising trend in spine surgery have not been widely spread, since insufficient fixing function. The expandable design (X-tenz, DePuy Acromed; Synex, Synthes; VBR, Ulrich; B-Twin) with the original small size can reduce the amount of resection of bone structures. Complications associated with posterior lumbar interbody fusion technique are similar and presented with dural sac damage with worsening neurological symptoms, traction and wound roots and the development of epidural fibrosis.

According to the research, the posterior approach decompression and interbody corporodesis are more traumatic than the ventral intervention and are associated with recurrent hernias of intervertebral discs, development of scar adhe-

sions, fibrosis in 7-27% of cases [Isaev N, Dralyuk M, 2010; Rameshvili T et al., 2011]. This method allows to manipulate more intervertebral discs involved in the pathological process and does not have anatomical limitations to perform the interventions [Braun S, 2002; Vetrile S et al., 2004; Prodan A et al., 2009].

The tendency to strengthen the posterior support structures after wide decompression initiated the development of dorsal spinal fusion – pedicle fixation, the basis of which is incorporated by holding special screws through the roots of the arcs of the vertebrae. Bone resorption around a set of screws and related instability in the structure, as well as fractures and deformation of its elements are the main shortcomings of the existing pedicle structures [Vetrile S et al., 2004; Lutsyk A et al., 2010]. Study of the possible reduction of surgical aggression against pedicle fixation stimulated the emergence of percutaneous pedicle screws while minimizing trauma of the access and reduction of postoperative pain [Schleicher P et al., 2008; Parker S et al., 2011; Rameshvili T et al., 2011].

The outcomes of posterior interbody stabilization are ambiguous. It was shown that the isolated transpedicular fixation is not conducive to an adequate lumbar fusion and results in recompression neural structures through the growing instability [Prodan A et al., 2009; Lutsyk A et al., 2010]. This improper conduct of retaining elements contributes to the damage of nervous structures [Okuda S et al., 2004; Rubinstein S et al., 2012]. In this regard, the transpedicular fixation combining with posterior lumbar interbody fusion technique [Okuda S et al., 2004; Prodan A et al., 2009; Quintero S, Manusov E, 2012] significantly increases the stability (90% arose bone block) and the number of good treatment results (67%).

It is established that interbody fusion is not combined with additional pedicle fixation in 26% leads to the formation of pseudarthrosis with recurrent pain and decreases the labor rehabilitation [Lidsey D et al., 2003; Lee K et al., 2004; Marotta N et al., 2006; Sink E et al., 2012]. Prospective randomized studies of several authors have confirmed the benefits of the combination of techniques for successful employment rehabilitation – 75% compared with their isolated applications,

where only 1/3 of the patients returned to their previous work, but the stabilization characteristics of both techniques were comparable [Marotta N et al., 2006; Boos N, Aebi M, 2008].

H.G. Blume (1985) developed less traumatic transforaminal access, which is one-sided approach to the vertebral column [Moore K et al., 2002]. In the future, the operation was called transforaminal lumbar interbody fusion, and it began to be combined with interlaminar spondylosyndesis, single- or double-sided pedicle fixation [Cramer G et al., 2010; Ibarz E et al., 2013]. This procedure has become an alternative of posterior lumbar interbody fusion with minimal traumatization of soft tissues and bone structures and fewer injuries of the dura mater [Fuchs P et al., 2005; Krutko A, 2012].

Biomechanical study of rigid methods of posterior and transforaminal lumbar interbody fusion showed that in postoperative period the natural biomechanics of the operated segment is changing by flattening the lumbar lordosis [Prodan A et al., 2009; Cramer G et al., 2010]. T.G. Lowe and co-authors have established that after the unilateral transforaminal lumbar interbody fusion combined with transpedicular fixation of fusion was achieved in 90% of cases, whereas the excellent results were observed in 85% of patients [Parker S et al., 2011; Krutko A, 2012].

The continuing number of poor results was the basis for the emergence of minimally invasive techniques of transforaminal lumbar interbody fusion [Madan S, Boeree N, 2003; Shuler T et al., 2004]. The method consists of the installation of pedicle screws only to the side facetectomy followed by pedicle screws through the facet joints on the opposite side. This technique reduces the operation without impairing the rigidity of the system [Schmoelz W et al., 2003]. Biomechanical studies of A.V. Slucky while comparing one-sided, one-sided with the installation of screw contralateral and bilateral pedicle fixation found, that the first method does not provide the optimum stabilization effect, and the second and third are comparable in hardness between each other [Slucky A et al., 2006; Son S, et al., 2012]. Improving postoperative results of the mini-transforaminal lumbar interbody fusion procedures is associated with transcutaneous administration

screws under image intensifier of the paramedian section through tubular retractor [Stevens K et al., 2006; Resnick D et al., 2008; Kettler A et al., 2011]. Comparative analysis of the methods with standard transforaminal lumbar interbody fusion showed complete fusion in 80% and 87%, respectively [Schleicher P et al., 2008; Parker S et al., 2011]. K.J. Stevens and co-authors using MRI confirmed the diagnosis of traumatic lower transcutaneous techniques [Stevens K et al., 2006; Suratwala S et al., 2009]. Comparative analysis of postoperative complications in the groups of open and mini-open transforaminal lumbar interbody fusion received the data on 4.0% and 0.6%, respectively [Pellise F et al., 2007].

Studies of the possibility of using minimally invasive techniques in the lumbosacral transition led to a method of percutaneous axial lumbar interbody fusion, which is used at the level of LV-SI via percutaneous of presacral access. The methods have been described by N. Marotta and co-authors [Marotta N et al., 2006; Martins D et al., 2010]. H.E. Aryan and co-authors reported about 91% of adequate fusion [Battie M et al 2004; Aryan H et al., 2006].

The randomized clinical trials of several authors were conducted by the comparative analysis of three groups – an isolated pedicle fixation, combined with posterior and anterior interbody fusion [Fritzell P et al., 2003]. The complete bone block occurred in 72%, 87% and 91%, respectively. The number of early complications was 6%, 16% and 31%. Long-term complications of treatment groups were detected in 12%, 22% and 40% [Fritzell P et al., 2003]. Biomechanical studies have shown that after the installation of cages, vertebral-motor segment is stable and able to withstand the load in flexion, extension and lateral inclination [Moore K et al., 2002; Rameshvili T et al., 2011; Krutko A, 2012]. In the works of A. Polikeit and co-authors no significant biomechanical differences are revealed between the two cages: mounted from the anterior access and one cage set from the posterior access [Polikeit A et al., 2003; Putzier M et al., 2004].

K. Kim and co-authors in the analysis of three groups isolated the transpedicular fixation and posterior interbody fusion and by their combinations found that good and excellent results were reported in 81%, 88% and 86%, respectively, and

the occurrence of pseudarthrosis was detected in 8%, 5%, 4% [Kim K et al., 2006; Knight R et al., 2009]. The research of a series of authors showed no significant benefit of any stabilization technique [Harris B et al., 2004; Glassman G et al., 2006]. Several authors have reported no significant results between posterior and anterior lumbar interbody fusion [Marchi L et al., 2012; Nachanakian A et al., 2013].

The opinion about the consideration of interbody corporodesis and rigid fixation combination as a basic standard of segmental instability treatment is currently changing [Prodan A et al., 2009; Rubinstein S et al., 2012]. By eliminating the instability of the affected vertebral-motor segment the rigid spinal fusion may lead to functional overload of adjacent segments [Schwender J et al., 2005; Wai E et al., 2006; Rohlmann A et al., 2007]. Using interbody arthrodesis results in significant biomechanics change of the accelerated degeneration of adjacent segment [Whitesides T, 2003; Pezowicz C et al., 2005; Ozgur B et al., 2006; Zagra A et al., 2012] due to the redistribution of the load on endplates and increase of inter-disc pressure [Nockels R, 2005].

Fundamentally new approaches to solving the problem of surgical treatment of degenerative diseases of the spine are the researches on application of the dynamic fixation of unstable spinal segments [Sorokovikov V, 2003; Bozkus H et al., 2004; Glassman S et al., 2006]. The prerequisites for this were the absence of 100% radiographic evidence of arthrodesis after installing rigid structures, a moderate amount of good and excellent results (60 to 80%) and the formation of 89% of the patients in the five-year postoperative degenerative process adjacent to the interference level [Boos N, Aebi M, 2008].

The ligamentoplastic method and other its methods are based on the use of synthetic materials to replace the ligament apparatus after a rear decompression [Kaner T et al., 2010]. Later, interspinous implants have been developed with synthetic ligaments [Schwender J et al., 2005; Byvaltsev V et al., 2011; Lattig F et al., 2012]. The study of the effects of these systems shows that they do not change inter-disc pressure and the size of foraminal holes related to vertebral-motor segment operation, and act exceptionally locally [Lieberman I et al., 2000; Taher F et al., 2012].

The use of soft dynamic stabilizers more often was not stabilizing to the appropriate level, which was the reason for the development of Graf, Dynesis and Fass systems [Okuda S et al., 2004; Yang J et al., 2008; Siepe C et al., 2012], consisting of pedicle screws and artificial ligaments between the screws allowing to obtain optimistic postoperative outcomes [Sorokovikov V, 2003; Okuda S et al., 2004; Yang J et al., 2008]. Biomechanical, dynamic pedicle fasteners have tighter degree of fixation, loss of range of motion in the frontal and sagittal planes, while the interspinous implant only in the sagittal [Siepe C et al., 2012]. At the same time, the use of dynamic stabilization system results in a slight flattening of lordosis and thus minimizes changes in the biomechanics of the operated spine. Further study of these structures did not reveal the advantages of systems with poly-rigid fixation with rigid [Sorokovikov V, 2003; Lattig F et al., 2012], and the use of soft stabilization led to a large number of negative long-term results and became having narrow range of use [Schwender J et al., 2005; Siepe C et al., 2012]. Studies of A. Rohlmann and co-authors [Rohlmann A et al., 2007; Rubinstein S et al., 2012] found that the dynamic implants are less resistant to axial loads, than the rigid system, and cannot be used in severe segmental instability. The prospective study devoted to the surgical treatment of unstable forms of lumbar osteochondrosis in groups: decompressive laminectomy and rigid, poly-rigid and dynamic pedicle fixation showed no statistically significant differences in terms of postoperative pain and quality of bone block formation between the vertebral bodies [Lattig F et al., 2012].

In order to maintain the flexible-extensive position of vertebral-motor segment, some authors proposed the use of interspinous implant without ligamentoplastic (X-Top) [Zuckerman J et al., 2003]. This has contributed to the emergence of creation of U-shaped form [Lazennec J et al., 2000; Sorokovikov V, 2003]. The use of such interspinous implants allowed to enlarge the spinal canal and the intervertebral foramen by changing the height of posterior and middle parts of interbody space without affecting the anterior ones – thereby creating a kyphosis. It is found out that the distraction of posterior support structures of vertebral-motor segment can lead to vertebral sublux-

ation due to reduction of the contact area of articular facets [Shuler T et al., 2004; Shustin V, 2006; Aryan H et al., 2008; Prodan A et al., 2009]. The analysis of published data shows that the use of soft poly-rigid and soft stabilization does not reduce the number of postoperative complications compared to the rigid one [Lazennec J et al., 2000; Tikhodeev S, 2005; Ozgur B et al., 2006]. Regardless to all advantages of dynamic implants, indications for their installation are not currently formulated [Shuler T et al., 2004; Tikhodeev S, 2005; Ozgur B et al., 2006; Prodan A et al., 2009].

Improved technology in spine surgery led to a significant reduction of insufficient results. Despite this, the removal of vertebral neural-conflict recovery is not always accompanied by a dynamic

equilibrium in the vertebral column and contributes to the development or progression of vertebral-motor segment instability in the long term.

Currently in spinal surgery it is topical to investigate the possibility of low-traumatic restoring biomechanical stability of the spine with a full functional recovery as soon as possible. The application of various stabilizing structures, minimally invasive tubular retractors, micro toolkit and percutaneous techniques allows to fix the spine from the anterior, extreme lateral and posterior accesses with preserving supporting elements, less damage to the surrounding soft tissues and less intraoperative blood loss, which reduces the length of hospital stay, the general terms of a temporary loss disability, economic costs for treatment.

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