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Presentation, Diagnosis, and Management of Lower Back Pain Associated with Spinal Stenosis: A Narrative Review

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Lower back pain (LBP) is an extremely common symptom experienced by people of all ages and is also one of the most frequent causes of disability worldwide. This article aims to review the presentation, diagnosis, and management of lower back pain associated with spinal stenosis. The paper we prepared was classified as a "literature narrative review." Nonetheless, when searching for manuscripts included in our work and reviewing them critically, we concentrated on the keywords: "lower back pain", "lumbar spine stenosis", "diagnostic", "rehabilitation", "neurosurgery", "spine", and "elderly". The incidence of chronic lower back pain (CLBP) increases linearly starting with the third decade of life until 60 years old, and it more often affects women. The course of non-specific LBP above all depends on factors not connected with the spine, which include psychological, behavioral, and social factors, determined by the way the condition is perceived by the patient the environment. Lumbar spine stenosis (LSS) is an age-related process of degeneration of the intervertebral discs, ligamentum flavum, and facet joints, which results in narrowing of the space around the neurovascular structures of the spine. Diagnosis of spinal pain syndromes includes radiography (RTG), computed tomography (CT), and magnetic resonance imaging (MRI). Based on the results of imaging studies, neurological examination, and the severity of the disease, treatment can consist of analgesics and rehabilitation, or, when conservative methods are insufficient, surgical treatment is indicated.

Keywords: Constriction, Pathologic • Low Back Pain • Musculoskeletal Pain • Radiography

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Background

Lower back pain (LBP) is an extremely common symptom, which is experienced by people of all ages and is also one of the most frequent reasons for disability in the world [1,2]. The most noticeable increase in disabilities connected with LBP has been in countries where per capita income is low or average, such as Asia, Africa, and the Middle East, where the health and social care systems are significantly burdened and underfinanced, and their main priority is combating infectious diseases [1-3]. The growing incidence of LBP creates an economic burden because it is connected with employee absence and decreased company productivity [4]. For most patients, it is impossible to precisely define the source of LBP [4]. Nonspecific LBP constitutes about 90-95% of all cases [4]. In approximately three-fourths of LBP patients, an improvement in their condition is measured in an increase in pain and the degree of disability seen within 1 month, but LBP is a chronic condition in about 25% of cases [4].

The incidence of chronic lower back pain (CLBP) increases linearly starting with the third decade of life until 60 years old, and it more often affects women [5,6]. The course of non-specific LBP above all depends on factors not connected with the spine, including psychological, behavioral, and social factors, determined by the way the condition is perceived by the patient and the surroundings [5,6].

Lumbar spine stenosis (LSS) is an age-related process of degeneration of the intervertebral discs, ligamentum flavum, and facet joints, which results in narrowing of the space around the neurovascular structures of the spine [7]. It is estimated that in the United States of America (USA) LSS occurs in more than 200 000 people and is the most common reason for neurosurgical spine surgeries of the lumbar region for people 65 years old and older [7].

The paper we prepared was classified as a "literature narrative review", and we concentrated on the keywords: "lower back pain", "lumbar spine stenosis", "diagnostic", "rehabilitation", "neurosurgery", "spine", and "elderly". Therefore, this article aims to review the presentation, diagnosis, and management of lower back pain associated with spinal stenosis.

Causes of Pain Syndromes of the Lumbar Spine

Imaging and clinical condition tests often cannot determine the exact reason for the pain syndromes of the lumbar spine region [8]. For example, Boden et al found that even though imaging diagnosis showed degenerative changes of the spine, the study subjects did not have any painful conditions of the lumbar spine [9]. On the other hand, Żytkowski found that only 15% of the diagnoses regarding spinal pain were then confirmed by intraoperative tests and autopsy [10].

The available literature shows that pain syndromes are caused by mechanical factors in about 90% of cases, while specific and non-specific inflammation, rheumatic processes, oncologic diseases, and pathologies of the nerve roots are the causes in the remaining 10% [11-13]. **Table 1** shows the causes of pain in the lumbar region of the spine. On the other hand, using the location of pain and the type of pathology as the criteria for division, we can distinguish 4 categories of spinal pain, as shown in **Table 2** [14]. However, when taking into account structures, which may be the potential source of back pain, we can distinguish 5 origins of pain in the lumbar region of the spine, as shown in **Table 3** [15].

General Characteristics of Degenerative Stenosis of the Lumbar Region of the Spine

The spinal canal (according to Spivak) is divided sagittally into 3 regions: 1) the central zone; 2) the intermediate zone (more appropriately paracentral) of the lateral recess, and 3) the zone of the pedicle of the vertebral arch [16]. Another division is the transversal one, also into 3 anatomic regions: 1) pedicle level; 2) intermediate level (vertebral body), and 3) disc level [17,18].

Degenerative stenosis of the lumbar spine is almost always connected with hypertrophy and the creation of osteophytes in the area of the intervertebral joints [19,20]. Degeneration of the intervertebral joints is causes instability and impaired mobility [19-21].

Overloading and micro-injuries lead to hypertrophy of the spinal joints, significantly contributing to narrowing of the spinal canal [22]. This process involves both the anterior and posterior edges of the joint, as well as the non-joint part and the posterior joint surface [22]. In addition, it also involves the joint capsule, the yellow ligament, and the supraspinous ligament [22]. Over time, the intervertebral disc undergoes degeneration and there is a disappearance of segmental mobility and a narrowing of the intervertebral space, which causes shortening of the spinal canal [22]. There is a protrusion of the intervertebral disc, which eventually undergoes calcification and osteophytes, which cover the intervertebral disc [22]. As a result of the narrowing of intervertebral space, during the shortening of the spinal canal, the yellow ligaments are bent in the direction of the spinal canal, and they undergo hypertrophy and calcification [22].

Pathomechanism of Pain Syndromes of the Spine

An important work in understanding the etiopathogenesis of pain syndromes of the lumbar region of the spine was published

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Table 1. Causes of pain in the lumbar region of the spine.

Causes	Examples
Degenerative disease	Degenerative disc disease; degenerative vertebral body disease causing pressure on the nerve roots; degenerative disease in the intervertebral joints
Inflammatory changes	Ankylosing spondylitis; rheumatoid arthritis; infections (tuberculosis, brucellosis, typhuses, staphylococcus, fungal infections); other infectious spondylopathies
Cancers	Primary bone cancers (plasmocytoma, osteoma, chondro-osteoma); cancers of the nervous system (glioma, fibroma molluscum, meningioma); metastases from the breast gland, prostate gland, lungs, and kidneys)
Metabolic diseases	Osteoporosis; osteomalacia; Paget's disease; calcium pyrophosphate deposition; ochronosis; hyperactivity of the parathyroid glands
Injuries	Acute and chronic overloads; intervertebral joint subluxation; spondyloses; vertebral body compression fractures; transverse process fractures of the lumbar vertebrae
Other congenital and acquired disorders of the statics of the spine	Lordoses and kyphoses; scoliosis; spondylolistheses; L5 sacralization; S1 lumbarization; cleft spine
Diseases outside the spine causing pain in the area of the L-S spine	Pain in the lumbar region of the spine caused by a duodenal ulcer, diseases (especially cancers) of the pancreas, kidneys, lymph nodes, abdominal cavity, shingles, thoracic aortic aneurysm; pain in the sacral region due to: diseases (especially cancers) of the uterus, rectum, prostate gland, ovaries, and pelvic lymph nodes

Table 2. Categories of spinal pain according to the location of pain and the type of pathology.

Category	Cause of pain
Static-muscular pain	Resulting from long-term or inappropriate pressure on the spine connected with the overburdening and extending of its structures
Reflex muscular pain	Occurring as a consequence of reflex muscle contraction caused by irritation of the nerve roots
Dural pain	Generally acute in its character and occurring with vertebrae damage or osteoporosis
Vegetative pain	Resulting from irritation of the sympathetic nerves

Table 3. Categories of spinal pain according to the structures, which may be the potential source of back pain.

Category	Cause of pain
Skeletal	Occurs as a result of irritation of receptors of perivascular blood vessels of the cancellated bone of intervertebral bodies and arches, as a consequence of mechanical damage, eg, fractures of intervertebral bodies in osteoporosis, osteomalacia, injuries, or cancers
Musculo-articular, fascial, and ligament	As a consequence of chemical or mechanical irritation of nociceptive receptors of such perispinal structures as joint capsules, tendons, aponeuroses, ligaments
Vascular	As a result of mechanical irritation (due to venous stasis and vein distention caused by elevated venous pressure in the area of the abdomen and the chest) of nerve endings located in the walls of the vertebral venous plexuses
Neurological	Meaning secondary pain occurring as a result of the dysfunction of nerves connecting the spinal cord with the peripheral system of receptors of perispinal tissues
Dural	Connected with pressure on the front part of the dura mater

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Table 4. Sources of pain in degenerative spine disease.

Tissue	Number of patients	Pain significance (%)	Location of pain
Lumbar fascia	193	0.50	Back
Paraspinal muscles	193	0.00	Back
Supraspinous ligament	193	0.00	Back
Interspinous ligament	157	0.50	Back
Spinous process	193	0.00	
Joint capsule	192	2.50	Back, buttock
Synovial membrane of the joint	186	0.00	
Yellow ligament	167	0.00	
Epidural fat	193	0.00	
Back part of the dura mater	92	6.00	Buttock, leg
Front part of the dura mater	64	5.00	Back, buttock
Compressed nerve root	167	90.00	Whole lower limb
Uncompressed nerve root	55	9.00	Buttock, leg
Central part of the fibrous ring	183	15.00	Back
Centro-lateral part of the fibrous ring	144	30.00	Back
Vertebral pulp	176	0.00	
Endplate	109	9.00	Back

by Kuslich et al, who described 193 cases of procedures performed on the lumbar region of the spine due to intervertebral disc (IVD) herniation or stenosis or the co-occurrence of both causes. Prior to administering anesthesia, each of the uncovered structures was stimulated and measured, and the pain response was noted [23], as shown in **Table 4**. In the summary section, the authors concluded that muscle tension is not a cause of pain in the lumbar region of the spine, but rather is an impulse reaction to pain [23]. This study undermined the observations made by Wyke, who believed that IVD is not a source of pain, since it does not contain nerve endings [24]. The findings of Ksulish et al [23] were later confirmed by subsequent research, which showed penetration of the free nerve endings into the damaged IVD after its mechanical damage, as well as the invasion of free nerve endings into the separated free part of the IVD (sequestrum) [25].

Sensory dysfunctions, paresthesias, lack of tendon reflexes, weakening of muscle strength, and sphincter dysfunctions are syndromes of irritation of the root nerves or the cauda equina [26,27].

They may occur together with the pain or each may be isolated. They are present at an advanced stage of the disease and they generally accompany a massive narrowing of the spinal canal or the intervertebral openings [28,29]. These symptoms are radicular in nature, but in the case of multi-layer changes or a high degree of central narrowing, they may not be obvious. Dysfunctions of the sphincters are a very rare symptom of extreme narrowing of the lumbar region, always connected with other symptoms [29,30]. The incidence of radicular pain or "neurological" symptoms allows for the determination of a potential level of damage to the cauda equina or part of the root nerve. The incidence of local pain in the lumbar spine, which is potentially somatically radiating, makes any attempts to determine the level of damage impossible [28-30].

Clinical Symptoms for Patients with Stenosis of the Lumbar Region of the Spine

Symptoms for patients with congenital stenosis of the lumbar region of the spine manifest quite early, often at the age of 30 or 40 years old, while acquired stenoses manifest themselves as radiculopathy and claudication, usually after the age of 50 [31-33]. Symptoms often appear on one side, and then later affect both sides. Typically, neurogenic claudication begins bilaterally and is characterized by pain in the lower limbs, numbness, tingling, and reduced muscle strength [31-33]. Neurogenic claudication increases while standing and walking and decreases while sitting and lying down. Although patients cannot walk properly, they can travel relatively comfortably while seated [31-33]. Patients with central stenosis and those with lateral recess stenosis have resting pain and night pain, as well as pain while sneezing [31,33].

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Central stenosis is often accompanied by lateral recess stenosis. In a neurological study, 60% of the patients with central stenosis and 43% with mixed stenosis exhibited Lasegue's syndrome and a reverse Lasegue's syndrome [33]. The mechanics, motor activity, reactions, and sensation most often reflect the level or levels of pathology. However, many patients either do not experience neurological symptoms or these symptoms are very slight. However, a common symptom of stenosis of the lumbar region of the spine is chronic dysfunction of the urinary bladder [34].

In studies done on animals, it was concluded that constant pressure applied to the nerve elements causes neurological degradation and loss of potential induced in the lower limbs [34]. This is followed by atrophy and demyelination caused by direct pressure onto the nerve roots and the shrinking and decrease of flow in the vessels that supply the nerve roots [34].

Radiculopathy and neurogenic claudication connected with stenosis of the vertebral canal are attributed both to direct and indirect pressure as a result of vascular insufficiency, which leads to ischemia of the nerve elements [35]. Standing and walking temporarily increases spine lordosis, causing stenosis by yellow ligaments bulging out into the central canal and lateral recesses, which increases the symptoms [36]. On the other hand, sitting and lying down decreases lordosis, opening up the vertebral canal, and increasing blood flow, as a result of which symptoms decrease [35,36]. The anthropoid position is characteristic of patients with neurogenic claudication, leaning forwards, decreases lumbar lordosis, and the pressure on the yellow ligaments and joint surfaces [35,36].

Differentiation in Degenerative Stenosis of the Lumbar Spine

Lumbar stenosis manifests itself with neurogenic claudication, which should be differentiated from vascular claudication [37]. Neurogenic claudication is a lateral or bilateral pain of the buttocks, hips, and thighs, especially while standing and sitting (strongly variable), while the pain decreases when the position is changed to sitting or lying down [37], and relief comes very quickly. In vascular claudication, limb pain is connected with muscular ischemia as a result of arteriosclerosis [37]. As opposed to vascular claudication, neurogenic claudication is induced by ischemia of the spinal nerve root, whose vessels are compressed by the surrounding structures [37]. Neurogenic claudication is very specific for lumbar stenosis [38].

Symptoms of trochanteric bursitis are similar to the symptoms of lumbar stenosis [39]. They generally include intermittent pain in the lateral part of the hip, which radiates to the lateral or dorsal part of the thigh [39]. Similarly to neurogenic claudication, it is experienced while standing and sitting, but the pain on the affected side does not recede while lying down [39]. The pain increases while moving in the area of the hip joint, especially in external rotation (positive Patrick test) [40]. Treating trochanteric bursitis is based on using non-steroid anti-inflammatory drugs, local steroid injections, and anesthetic drugs, using manual therapy (muscle stretching), as well as using ice compresses [40]. Prolapse of the nucleus pulposus often accompanies degenerative stenosis of the lumbar spine, and spondylolisthesis [40]. Mediolateral prolapse causes pressure on the dural sac and the nerve roots found within. Lateral prolapse causes a narrowing of the lateral recess and direct pressure on the nerve root [40]. Lateral hernia of the nucleus pulposus occurs in 7-12% of all disc hernias. Far-lateral prolapse of the nucleus pulpous causes pressure on the nerve root in the area of the pedicle of the arch [41,42].

The lumbar region of the spine, especially on the L4/L5 level, is predisposed to spondylolisthesis (the joint surfaces are placed more sagittally than coronally) [43]. The advancing dislocation leads to constriction of the cauda equina and nerve roots [43]. The disease most often affects middle-aged women at an average age of approximately 67 years [43]. Degenerative spondylolisthesis most often occurs on level L4/L5 and then on levels L3/L4, L2/L3, and L5/S1 [43].

Patients with diffuse back or lower-limb pain may suffer from cervical spinal stenosis or thoracic spinal stenosis [44]. However, in elderly patients with stenosis, neurological examination can determine that the symptoms are cephalic [44].

Synovial cyst is a rare pathology, clinically described in 1968, and its etiology is unknown [45]. It develops from the elements of the intervertebral joint, or less commonly the yellow ligament. Surgical treatment is the most common treatment [45]. Ossification of the yellow ligament can be a significant factor in the development of lumbar stenosis. Due to growth factors, the yellow ligament is induced to proliferate and it undergoes hypertrophy and then calcium saturation, and as a result, ossification [44]. Amyloidosis may also contribute to lumbar stenosis, as amyloid deposits were found in a hypertrophied yellow ligament [45].

Patients with diabetic neuropathy, diabetic amyotrophy, or angiopathy may be insufficiently diagnosed and undergo lumbar stenosis surgery [46]. Clinically, a patient with diabetes differs from a patient with lumbar stenosis due to the sudden appearance of pain, especially at night, a burning sensation when urinating, and no improvement as the body position changes [46]. Those suffering from diabetes with lumbar stenosis who have undergone decompression surgery are often less pleased after the surgery, while post-surgical treatment is longer [46].

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Tumors in the cervical, thoracic, or lumbar region (especially the cauda equina and conus medullaris) may cause symptoms similar to the symptoms of lumbar stenosis [47,48].

Radiological Diagnosis of Patients with Degenerative Lumbar Stenosis of the Spine

Most studies are based on the criteria published by Verbiest in 1975 [49], who classified a narrowing of the canal below 12 mm as relative stenosis, while a narrowing of less than 10 mm was classified as absolute stenosis [49]. The system based on measuring the diameter of the lumbar canal was from its inception criticized for ignoring the shape and surface area of the lumber canal [50]. It was also shown that the parameter that best correlates with claudication distance is the surface area of the transverse cross-section of the lumbar canal [50]. Experimental studies suggested it is "rather improbable" that symptoms of lumbar canal narrowing would when the surface area of the transverse cross-section was greater than 80 mm^2 [51]. However, later studies found a correlation between lumbar canal surface area and the distance of neurogenic claudication when the boundary value of the narrowing was 100 mm^2 [52]. Nevertheless, there is no agreement on the definition of the narrowing by determining the minimal surface area of the transverse intersection of the lumbar canal, with various studies reporting <75 mm^2 [50],<100 mm^2 [52], <130 mm^2 [53], and <145 mm^2 [54].

In 2010, a classification of the narrowing of the lumbar canal in the lumbar region was developed taking into account the shape of the dural sac [55]. The classification distinguished 4 shapes (A-D) of the dural sac corresponding to the individual stages of the narrowing: A) round shape – lack of narrowing; B) oval shape – moderate narrowing; C) triangular shape – severe narrowing; D) needle shape – extreme narrowing [55]. While such differentiation is radiologically significant, clinically it means absolutely nothing, and the 4 divisions based on severity have a lower degree of correlation when it comes to pain and neurogenic claudication [55].

Narrowing of intervertebral openings is considered a cause of pain in the course of degenerative disease of the lumbar spine [56]. A width of the opening smaller than 3 mm is considered to cause absolute stenosis, but there is no universal agreement as to the appropriate value [57].

In evaluating the surface area of the narrowed intervertebral opening, authors give values between 40 and 160 mm^2 [57,58]. It has been proven that in patients with coexisting scoliosis, the surface area of the intervertebral openings is greater on the convex side and lesser on the concave side [59,60]. A significant problem is the variable geometry of the vertebral opening, which is different for each level and for the right and left sides [57,58,60].

A significant problem in the evaluation and classification of narrowing of the spinal canal is the methodology of conducting the imaging tests: magnetic resonance imaging (MRI) and computed tomography (CT) [61]. This phenomenon is connected with the mapping of three-dimensional space on a flat surface [61]. In the radiological literature, there is a lack of a clear definition of the narrowing of the spinal canal and intervertebral openings [61].

Radiography

With the aid of radiography (RTG), the outline of the vertebra and the lumbar spine, as well as its curvature, may be determined [62,63]. Dynamic X-ray testing allows us to determine the hypermobility and instability, which manifests itself in a more than 4 mm dislocation and more than 10 to 12 degrees of the angular fold [62,63]. X-ray imaging does not provide any significant information about lumbar stenosis [62,63]. Plain film in anterior-posterior (AP) and lateral projections may be useful, especially when spondylolisthesis is suspected [62,63]. Spot film X-rays of the lumbar spine in a lateral projection allow for an initial estimate of the degree of narrowing of the intervertebral space, facet arthrosis, spine stability, or narrowing of the intervertebral openings [62,63]. It is also possible to diagnose the hypertrophic process, especially pathological fracture. Currently, X-rays in an AP and lateral projections of the whole spine along with the hip joints are predominantly used for evaluation of frontal and sagittal balance [64].

Myelography

Myelography can show constrictions of the contrast medium, with partial or complete blocking of the flow [65]. This test may be difficult to conduct due to low flow of cerebrospinal fluid and a thick bundle of nerve roots. Myelography is performed in a very few selected cases [65].

Computed tomography

Computed tomography (CT) shows the characteristic shape of the spinal canal, which resembles a 3-leaf clover. CT allows for evaluation of the A-P dimension of the spina canal, hypertrophic yellow ligaments, and intervertebral joints, as well as protrusions of the intervertebral discs [66]. CT of the spine supplemented with 2 and 3-dimensional reconstructions allows for an exact diagnosis of recurrent stenosis, dislocation of the nucleus pulposus, fracture, and ossification of the posterior longitudinal ligament and yellow ligament [66]. Three-dimensional CT or CT myelography produce images of each axis of the spinal canal, and evaluation of the lateral and far-lateral regions

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[66]. Radiological computed tomography is especially useful in the diagnosis of skeletal changes as a supplementary test in the case of diagnostic ambiguities [67].

Magnetic Resonance

Magnetic resonance imaging (MRI) is a test that better displays the soft tissue and enables the differentiation between scar and disc, while also showing tumors, demyelinating diseases, and infections [68]. An MRI shows pressure on the nerve element and a loss of signal of the cerebrospinal fluid [68]. An MRI also allows imaging of the soft tissues of the spinal canal, especially the nerve structures, and shows damage to the discs and intervertebral joints, yellow ligament hypertrophy, and presence of synovial cysts [68], which is why it is highly recommended for diagnosis of spinal canal narrowing and intervertebral openings [68,69]. MRI should always be carried out in case of suspicion of cancerous and inflammatory changes [70].

Pharmacotherapy, Rehabilitation, and Surgical Treatment of Patients with Degenerative Lumbar Spine Stenosis

Pharmacotherapy Treatment of Patients with Degenerative Lumbar Spine Stenosis

The introduction of non-steroid anti-inflammatory drugs brings relief to pain caused by inflammation of the spinal joints [71]. On the other hand, in the case of symptomatic central lumbar stenosis, using non-steroid anti-inflammatory drugs, opioids, or non-opioid painkillers, myorelaxants, antidepressants, or tranquilizers yields little benefit in reducing the symptoms of cauda equina claudication [71]. Steroids administered orally or in epidural injections are effective, but they can only be taken for a limited amount of time [71,72].

In the treatment of chronic and neuropathic pain, anticonvulsants such as gabapentin and carbamazepine have had a positive effect [73]. Their multi-factor functioning mechanism includes reducing the experience of pain, increasing the pain threshold, and improving sleep [73]. These drugs should not be used in treating acute pain [73]. Tricyclic antidepressants (eg, amitriptyline) are also used in treating neuropathic pain; however, adverse effects limit their use. Currently, the most often used drug is gabapentin [73].

Opioid drugs are very strong painkillers. Tramadol in combination with paracetamol is most commonly used [74]. Using other strong opioid drugs to treat pain in degenerative spine disease is very limited and are commonly used in treatment of post-surgical pain [74].

Myorelaxants are often used to increase the painkilling activity of non-steroidal anti-inflammatory drugs or painkillers [75]. Typically, they are administered before going to sleep, taking advantage of their slight sedative effect [75].

Selective blocking of spinal structures with the use of painkillers (lidocaine or bupivacaine) and long-acting steroid drugs are used in pain treatment, especially for patients who should not be surgically treated [76]. Injections may be used to treat pain from the facet joints, sacroiliac joints, or intervertebral discs [76]. Furthermore, it is possible to block the nerve roots or perform injections into the epidural space [76]. The effectiveness of the above-mentioned method is estimated at 52-100%, with the highest effectiveness (75-100% in limiting pain in the facet joints [77].

Rehabilitation Treatment of Patients with Degenerative Lumbar Spine Stenosis

Physical therapy methods such as massage, ultrasound, percutaneous electric stimulations, girdles, acupuncture, biofeedback, heat and cold treatment, traction, and spinal manipulation may bring relief from root pain in lumbar spine [78]. Unfortunately, many patients with central stenosis and symptoms of claudication of the cauda equina, as well as root pain caused by stenosis of the root openings, do not achieve any significant improvement after such treatment [78,79].

Patients with lumbar spine pain should not wear a lumbar girdle for more than 6 months, as it may reduce pain but is not recommended for people who work [80].

Strengthening the paraspinal muscles and the abdominal muscles allows for a decrease in symptoms and prevention of increased stenotic pain [81]. Exercises in a swimming pool or riding a bike are particularly helpful in this regard [81].

Patients with mild lumbar stenosis in a radiological examination may be treated behaviorally [82]. Patients with acute and widespread lumbar stenosis in an imaging examination, even those with neurological deficits, can avoid surgery by using behavioral treatment [82]. In addition, it has been shown that axial loading of the spine, such as while walking, has a beneficial effect on the hydration of intervertebral discs, which in turn changes the pH, contributing to elimination of pain [83,84].

Among kinesitherapeutic methods used in treating patients with spinal pain, a diagnosis and therapy program developed by McKenzie is used more and more often [85,86]. This system is designated for people with mechanical spinal pain caused by long-term static loads, as well as structural problems in the area of the vertebral disc, and pressure to the nerve root or the nerve itself [85,86].

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In the McKenzie therapy, mechanical factors are used that are generated by the patient as well as manual techniques [87]. The rule is that individually selected exercises are used first, and manual therapy is employed only if it is necessary, after excluding contraindications to its use [87].

Manual therapy is a specific form of kinesiotherapy that enables diagnosis of functional disorders of paraspinal structures [88]. By manually removing reversible disorders, the function of the spinal joints is improved, and specific palpatory techniques improve the quality of "joint play" of the spinal joints [88].

A supplement to the comprehensive rehabilitation process is physical therapy, which is one of the oldest methods of analgesic and anti-inflammatory treatment, and it is most effective when combined with kinesiotherapy [89]. However, it is necessary to know all the indications and contraindications of therapies and the range of their effectiveness [89]. Physical therapy methods used for degenerative spinal stenosis include electrotherapy, ultrasonotherapy, cryotherapy, light therapy, laser therapy, magnetic therapy, and hydrotherapy [89].

Surgical Treatment of Patients with Degenerative Lumbar Spine Stenosis

Surgical procedures enable faster alleviation of symptoms than with behavioral treatment and bring more long-term benefits [90]. From a long-term perspective, surgical treatment is also cheaper than behavioral treatment [90].

Surgical procedures used for degenerative disease of the lumbar spine must be divided into procedures that retain motion as well as surgeries with stiffening that lead to spondylodesis [91]. All may be performed as a single-level or multi-level procedure [91].

Surgical treatment of lumbar stenosis is based on decompression of nerve elements. To properly decompress the nerve elements, decompressive laminectomy is used, which removes the vertebral arch and the yellow ligament and broadens the root canal [36]. This type of treatment is highly effective and decreases the pain that is typical for lumbar stenosis [36]. It is not necessary to remove the skeletal abdominal osteophytes or the calcified protrusions of the intervertebral discs [36]. After surgical treatment, physical fitness is restored and pain tolerance while walking and standing is increased [36]. However, laminectomy does not decrease pain connected with inflammation of the spinal joints and instability [36]. When the spinal joints or the disc space are damaged, the pain resulting from inflammation of the intervertebral joints or instability can increase [36].

In addition to decompression, it may sometimes be necessary to remove the prolapsed nucleus pulposus [92]. Many surgeons, apart from performing decompressions, also perform fusions, which yield the worst results among the oldest patients [92]. Sometime after the surgery, there are both back and limb pain, as well as neurological deficits. Second lumbar stenosis yields worse results, and patients have better treatment results after 1 surgery than after 2 [93,94]. The frequency of repeated decompression is 9.3-28%. For every 100 patients, 16 have experienced recurrent stenosis on the operated level or higher [93,94]. The longer the observation time after the original decompressive laminectomy, the higher the percentage of repeated surgeries [93,94]. Posterolateral stabilization is recommended for patients with lumbar stenosis with coexisting spondylolisthesis requiring decompression [94]. Transpedicular stabilization in addition to posterolateral stabilization may be considered in stenosis and spondylolisthesis if there is preoperative instability or kyphosis on the level of the spondylolisthesis or if there is also iatrogenic instability [94]. Stability may strengthen degeneration in neighboring levels and thus is only recommended on the level of the spondylolisthesis [94].

Younger patients who experience instability after surgery require stability [95]. For older patients, stability is often associated with a higher mortality rate and more complications. Instability after lumbar stenosis surgery via laminectomy seldom requires stabilization [95]. Decompressed of more levels is associated with higher risk of slippage [95].

It is estimated that approximately 5% of patients who have undergone laminectomy require stabilization [96]. Lumbar instability after decompressive laminectomy is quite rare (1%) [96]. Fusion is rarely needed in subluxation and degenerative stenosis. Stability is maintained when 50-66% of the intervertebral joint remains and when the disc space remains intact [96]. Younger and more active patients are more susceptible to instability. Post-surgical instability is verified by functional X-ray images of the lumbosacral spine before and after surgery [96].

Posterolateral stabilization is not recommended for patients with lumbar stenosis after decompressive surgery unless there is evident spondylolisthesis and intraoperative facetectomy [97]. Posterolateral stabilization is recommended for patients with lumbar instability, while transpedicular stabilization is not recommended in combination with posterolateral stabilization [97]. **Table 5** summarizes the surgical procedures that allow patients to retain spinal motion on the operated levels or that result in stiffening and spondylodesis [91].

Future Directions

Because of the multifactorial nature of pain and the inability to determine the primary cause of low back pain syndromes based on imaging studies and clinical conditions, including

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Table 5. Surgical procedures that allow patients to retain spinal motion on the operated levels or that result in stiffening and spondylodesis.

Surgical procedures that allow patients to retain spinal motion on the operated levels	Surgical procedures that result in stiffening and spondylodesis
Laminectomy	From the posterior or posterolateral approach
Hemilaminectomy	Posterior lumbar interbody fusion – PLIF
Partial hemilaminectomy – fenestration	Transforaminal lumbar interbody fusion – TILF
Foraminotomy	Posterior transpedicular spondylodesis (classic and percutaneous)
Microdiscectomy	Spinal osteotomies
Implanting an interspinous distraction device	From the anterior approach
Implanting a disc prosthesis or a nucleus pulposus prosthesis	Anterior lumbar interbody fusion
	Anterior spondylodesis with the use of pedicle screws
	Spinal osteotomies
	Lateral lumbar interbody fusion

those in the course of spinal canal stenosis, as well as the physical, psychological, and social consequences of LSS, it is necessary to develop a holistic, multidisciplinary approach to patients and their disease [66]. The diagnostic and therapeutic process should include the performance of imaging studies, a neurological examination, a thorough interview with the patient, and provision of pharmaceutical care, as well as care from a physiotherapist, neurologist, orthopedist, or neurosurgeon/neuro-orthopedist [98]. There is also need for psychological support [98]. Only when specialists in various fields jointly assess the patient's condition is it possible to establish a treatment regimen tailored to each patient, which is part of the trend of personalized medicine [98]. It is also possible that, in addition to the traditionally accepted methods of treatment, the use of "unconventional" methods of treatment, such as acupuncture, herbalism, and folk medicine, should be thoroughly investigated, adding these techniques to the overall arsenal of possibilities [99]. It is also important to establish a registry of patients with LBP or LSS at the local and national, and perhaps international, levels to record and analyze the outcomes of patients at all stages of care, taking into account the various treatment methods, to better assess the effectiveness of various treatment options [100]. An interesting option is to use machine learning to create diagnostic and therapeutic algorithms in patients with LBP or LSS [100].

Conclusions

Back pain is becoming an increasingly common problem, affecting more than just older people. In addition, we live in a time of continuous development in LBP diagnosis and therapy, so it is important to constantly keep up with trends to provide patients with the highest-quality services.

In this literature review, we have turned our attention to the etiopathogenesis of pain accompanying LBP and LSS. The available literature and our own experience indicate that it is impossible to determine the exact reason for the pain syndromes of the lumbar spine region based on imaging and clinical condition tests [8]. Currently, in the neuroimaging diagnosis of LBP and LSS, X-ray imaging is used, which in most cases is the starting point for more advanced imaging studies, such as CT and MRI. MRI, which allows visualization of bony structures and soft tissues, is the criterion standard in diagnosing spinal pain. Finally, treatment should always be tailored to the patient's clinical condition and reported symptoms and their severity, not just changes visualized on imaging studies. This should be guided by the principle that conservative treatment, including pharmacotherapy and rehabilitation, should be used first and, only later, when necessary, surgical treatment. Therefore, this review has assessed the current knowledge and future research directions.

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