SEGMENTAL SPINAL INSTABILITY: UNSOLVED PROBLEMS

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An analytical review of the literature on the problem of segmental spinal instability is presented. The relevance of the investigated field of spine surgery is beyond doubt. At present, a number of issues related to the definition of the concept of instability, its biomechanical basis, diagnostic criteria and treatment tactics remain debatable. The paper highlights the views of the world's leading researchers on the understanding of various aspects of this pathology in spine surgery. The research materials were abstracts from the PubMed and Scopus databases, papers published in *The Spine Journal, Spine, European Spine Journal*, and in periodicals of Ukraine and Russia.
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In 1985, Kirkaldy-Willis [27] formulated the questions "What does instability mean?", "How to diagnose instability?", "How to treat instability?" to the scientific audience at the symposium on the lumbar spine instability. Instability is the condition of the system characterized by heterogeneity and time diversity of each process and all changes in general. It is the form of observable relationships and causality of all phenomena that is opposed to stability. Therefore, the term "instability" is given as the antithesis to "stability", i.e. the lack of stability [8], the state of decreased stability of a system [9]. Although this definition is valid from the standpoint of legitimate logic, it is not acceptable from a clinical point of view.

For the first time, the term "spinal instability" was used by Ferguson in 1934 to describe the clinical concept that refers to the state of the lumbosacral junction, wherein its supporting function is not possible without excessive tension of the corresponding muscles and ligaments.

There are a lot of definitions of "spinal instability" in the literature and the definition itself evolved with the development of vertebrology and accumulation of knowledge in this area.

The definition suggested by White and Panjabi [59], which is considered as classical one, is as follows: "the loss of the spine's ability to maintain its patterns of displacement under physiologic loads so there is no initial or additional neurologic deficit, no major deformity, and no incapacitating pain". This definition reflects biomechanical and anatomical changes in the segment and their relationship with clinical manifestations.

In the literature, there is a categorical opinion that the spine is a mechanical structure and so biomechanical and physical concepts, rather than clinical criteria, are the most important in determining its instability, and only these interpretation will enable selecting the correct treatment [11]. However, most authors, formulating their own instability concept, believe that it is a reliable assessment of clinical criteria that provides the basis for the choice of treatment tactics [13, 60].

Kirkaldy-Willis and Farfan [25] determined instability as a situation, where the clinical condition of the patient having problems in the lumbar spine worsens due to minimal movements, provoking enhancement of clinical symptoms. That is, they emphasized the clinical component of the syndrome. Interestingly, these authors suggested inclusion of the latest stage of a degenerative disease, presenting with limited mobility of the segment, into the unstable state category. When considering the "instability" concept in terms of technical definition, this suggestion is incorrect, since the system with limited mobility cannot become unstable. The statement seems to be logical in terms of the aforementioned definition. The same view is shared by other authors. Dupuis et al. [8] wrote: "A lumbar motion segment is considered to be unstable when it exhibits abnormal movement. This movement can be abnormal in quality (abnormal coupling patterns) or in quantity (abnormal increased motion)". Olsson et al. [39] and Schneider et al. [51] showed that instability is not always associated with increase in the motion range in the segment, but it may present with abnormal movement direction, for instance in the sagittal plane, or rotation center displacement, as exemplified by assessment of motions in patients with spondylolisthesis.

Currently, the most comprehensive definition of instability in the Russian medical literature includes three essential components: biomechanical instability substrate, i.e. lack of spinal segment capability of supporting physiological movements of the vertebrae with respect to each other; disturbed physiological displacement of the vertebrae with respect to each other; the presence of typical symptom complex and its main element, the dependence between pain intensity and load. The final definition is as follows: spinal instability is a pathological condition, arising for various reasons and characterized by insufficient supporting ability of the spine that manifests under the action of excessive load, presenting with excessive deformation, pathological displacement, or progressive destruction of the elements of the spinal segment, as a major symptom [1].

Farfan et al. [10] gave the following definition: "instability is that (symptomatic) condition where, in the absence of new injury, a physiologic load induces abnormally large deformations at the intervertebral joint". That is, this formulation emphasizes the role and status of the facet joints.

Biomechanical definition of instability was extended to include the concept of "altered neutral zone", which emphasizes the fact that the excessive movement amplitude is not the only indicator of pathology. Abnormal response of the spinal motion segment and impaired movement pattern usually reflect the failure of passive and active stabilizers [6]. Therefore, spinal instability is a condition, when it is impossible to preserve stable spatial relationship between the elements of the multielement kinematic chain of the spine under the external load.

Degenerative disc disease is one of the major causes of segmental instability [64] and for this reason the term "discogenic instability" is sometimes used [28]. However, disturbed stability undoubtedly presents with failure of all the structures of the spinal motion segment. It is not always possible to identify major or primary component. This factor is of limited importance for the treatment strategy. When the authors mention discogenic instability, they possibly oppose it to instability types associated with changes in the primary bone structure, for example, after fracture, posttraumatic, or after resection of the supporting structures, iatrogenic, in the case of some diseases, such as spondylolisthesis [28].

There are conflicting views on the instability concept both from the clinical viewpoint and from the perspective of its precise diagnosis and objectification [36]. Diagnosis of instability is still a disputable issue and challenge for practitioners, which in turn determines the ambiguity of approaches to its treatment. It is difficult to identify objective diagnostic criteria of clinically significant symptoms due to the multifactorial nature of instability [6]. In practice, it is very difficult to apply direct load to the vertebral structures in order to directly measure the level of segment mobility [17, 39, 61], and therefore indirect signs are mostly used for assessment.

Spine is a three-dimensional structure characterized by complicated structural relationship between the elements of its biomechanical chain. Due to this fact, the displacement of the spinal motion segment in one direction results in displacement of all structures, including adjacent ones, in different directions (in three dimensions). For the first time, this was emphasized by White and Panjabi [59], who suggested the "coupling" concept and defined it as a conjugated, interrelated motions, i.e. movements, where translation or rotation of a rigid body about one axis causes corresponding rotational or translational shift of the same body about the other axis. This factor complicates accurate assessment of displacement of the structures during motion due to the fact that related movements of adjacent structures can be very significant, since the spinal motion segment can be stable, for example, when assessing the translational displacement, but lack rotational stability. Therefore, it is quite difficult to describe even normal kinematics of the spinal segment, and the task is even more complicated, when it is a pathological movement.

Spinal stability is determined by the structures (ligaments, muscles, and other soft tissue structures), which ensure its balance under conditions of gravity. Several concepts were developed in order to characterize the motions of the segment. ROM (range of motion) represents the numerical value of the distance between two points in the extreme positions of physiological translational or rotational displacement of the vertebra, i.e. it is a quantitative characteristic of the amplitude of movements, showing maximum segment deformation [62]. On the average, ROM value measured by stereo-radiography in healthy young individuals is about 14° at most levels during flexion-extensions [62], about -4° during lateral body bending, -1.5° during axial rotation. The L5—S1 segment has smaller range of motion in all directions compared to other segments. The term "quality of motion" refers to the characteristic features of motion and is determined by the structure, type of movement, and its configuration. When flexion-extension motions occur in the segment, load-induces displacement curve has typical sigmoidal shape with its concavity directed along the load axis (when the movement involves muscular component, curves tend to linearity). This form of the curve reflects the properties of the disc and ligamentous apparatus of the segment: these structures have low resistance with respect to low load and enable some free oscillation, while increased load increases their rigidity. This mechanism provides elasticity and flexibility of the segment under low loads and its stiffness, rigidity under high loads.

The pattern of movements is characterized by two parameters: neutral zone and rigidity in the high flexibility zone. Neutral zone is the difference between the maximum and minimum deformation without load on the hysteresis curve (phase lag in one of two interrelated processes or events). It is calculated as the difference between the segmental angle at a zero bending moment in degrees [62]. High flexibility zone is the area around the neutral zone, within which bone and ligamentous structures of the segment can be displaced with low resistance. The terms "neutral zone" and "rigidity in the high flexibility zone" qualitatively characterize motions of the segment during lateral bending and axial rotation. These values are important since they change under the influence of compression load or due to disc degeneration.

The fact that the correct study of segment biomechanics is impossible without taking into account the action of muscle strength was repeatedly emphasized. The effect of muscle strength is usually simulated by application of load along certain vectors and evaluation in the experiments on intact blocks. The studies of Panjabi et al. [42] and Wilke et al. [62] led to the conclusion that the effect of intersegmental muscle strength supports normal range of motion or reduces it after simulated injury, except for ROM during flexion. Neutral zone is better indicator for evaluation of segment instability than ROM. This parameter is believed to be more sensitive criterion of instability than the range of motions and translation, especially in the case of disc degeneration and traumatic injuries, but it can be assessed only *in vitro* [41, 42, 44].

Kettler et al. [24] examined 203 segments and correlated degeneration level with the range of motion and neutral zone. The lumbar segments have different elasticity at different levels, which increases when combining the segments. Statistical model was suggested to reduce this effect and large material was taken (database over 10 years) to improve reliability. The data obtained showed decrease in the movement amplitude with increase in disc degeneration level during flexion-extension and lateral bending. On the contrary, rotational motions tended to increase in amplitude with degeneration progression and early stages of degeneration were not always accompanied by rotational instability. Apparently, this is due to the following changes: during rotation, disc is subjected to shearing load and the disc having cracks and breaks cannot resist them to the same extent as the intact structure; in the case of axial load during extension-flexion and lateral bending, disc is exposed to compression and elastic stretching forces, to which these defects are more resistant. The second reason may be related to facet joints, which are known to limit the rotation of the segment to varying degrees, depending on its position: the more kyphotic is the segment, the later restricting function of facet joints occur during axial rotation. For this reason, for example, increase in axial rotation is expectable in the case of degenerative changes and kyphotization of the segment [11]. Degradation of the articular cartilage of the facets can also alter their normal functioning and contribute to the strengthening of the axial rotation [20].

Seligman et al. [15, 52] assessed the rotation center displacement during flexion and extension and showed that movement of degenerative segment results in downward migration of the rotation center and its eccentrical displacement, which is not coordinated with the displacement of the rotation center of intact segment. For example, both anterior and posterior translations are possible during flexion. The study of Schneider et al. [51] showed that normal amplitude of movements was accompanied by displacement of rotation centers in patients with spondylolytic spondylolisthesis. In both of the above papers, the authors concluded that evaluation of rotation center displacement is a highly sensitive method (94 %), especially compared to functional radiographs (25 %), to identify non-physiological motions in the segment and can be used to evaluate instability and indirectly assess the severity of degenerative changes.

In the current research, high priority is given to investigation of the rotation center and new techniques are being developed to study it, since only a comprehensive assessment of segment movement quality will enable selecting pathogenetically justified treatment with load redistribution in the segment, which provides maximum recovery of the physiological pattern [50].

Cadaver studies are optimal for studying instability. Mathematical models can be used to explain the experimental results, predict outcomes, but simulation capabilities are limited by information about the properties of biological tissues [4]. These studies have rational component, but they require certain limitations when using the results in clinical practice, since they are based only on a series of measurements of cadaver units and are based on some assumptions in the experiment. Taylor and Twomey [56] compared the range of motion in the cadaver blocks and patients and found no significant differences in these data, thus proving the importance and significance of cadaver studies. However, the validity of these data should be clearly understood and they should be correctly placed against in vivo studies.

In clinical practice, diagnosis of instability is usually based on standard imaging techniques. In most clinical studies, lateral radiographs in the maximum flexion and extension position are used to diagnose segmental instability [8, 26]. Some original authorial research techniques, such as traction-compression [12, 47], and complex techniques, assessing rotational instability [61], have been developed. However, none of them is widely used in practice.

Segmental sagittal, frontal angulational, and (or) translational hypermobility, vacuum phenomenon, traction spurs, "black" disc, Modic changes in the endplates and red bone marrow of the adjacent vertebral bodies, changes in the facet joints, tri-axial deformation of the segment, degenerative spondylolisthesis, *de novo* scoliosis, central spinal stenosis, and facet joint degeneration can be attributed to radiological signs of instability [5, 16].

Although flexion-extension radiography is the most common method, its diagnostic value is often in doubt and it detects only indirect signs of instability. There are studies, questioning their diagnostic value: for example, functional radiographs detect angulation of 7—14° and translation of more than 4 mm in 20 % of subjects without clinical symptoms of lumbar spine diseases [19]; in patients with back pain and radicular symptoms, range of motion in the low-lumbar section is limited, conjugated coupled motions (rotation, translation) are impaired [45]; in patients with degenerative instability diagnosed based on the clinical and radiographic studies, decrease in disc height, sclerosis of facet joints etc., angulational and translational displacement during flexion and extension of the lumbar spine show no expected deviations from normal values [53].

What quantitative criteria of the displacement of the vertebrae are indicative of segmental instability? Lysell [30] showed that translational displacement of more than 4 mm is non-physiological. Importantly, these results were obtained for the cervical spine. Penning and Blickman [46] measured adjacent segment in patients with spondylolytic spondylolisthesis and found that angulation of more than 10° is pathological. Wood et al. [63] used the following criteria when assessing instability of spondylolisthesis: angulation higher than 8°, translation of more than 8 %. Friberg [12] believes that translation of more than 5 mm is pathological. Ochia et al. [38] suggested angulation of more than 4° and translation of more than 6 mm as instability criteria.

It is highly important to assess the range of motion in all planes, keeping in mind the component of pathological rotation described by White and Panjabi [60] as a coupled motion.

In clinical practice, instability is in most cases diagnosed based on the functional radiographs (flexion-extensions), but the technique of this examination is not standardized and has limited reproducibility, while diagnostic criteria and radiographic signs of instability remain controversial and do not preclude the presence of measurement errors. All this complicates multicenter clinical trials.

Spondyloarthritis is considered as a significant symptom reflecting the presence of segmental instability [16]. Pitkannen et al. [48] determined it as a predictor of the anterior and posterior translational instability. At the same time, spondyloarthritis precedes all other radiological signs of segmental motor dysfunction in 20 % of cases.

Some authors consider morphological changes in the red bone marrow of the adjacent vertebral bodies described by Modic et al. [33] as a sign of segmental instability. Segmental hypermobility, which was determined as a translation of the vertebrae on the flexion-extension spondylograms by more than 3 mm, was detected in 70 % of cases with type I changes and only in 16 % of cases with type II changes [33]. It was noted that spinal fusion is more often required in patients with chronic pain in the lumbar spine and type I Modic changes compared to type II changes. Hayashi et al. [18] evaluated the data of the kinematic MRT of 450 patients and found significant positive correlation between Modic changes and Pfirrmann grade of intervertebral disc degeneration, as well as translation-angulation changes in the spinal motion segment. They found that the highest mobility of the segment is observed in the case of type I Modic changes and the highest translation is observed in the case of type II changes.

Relationship between Modic I changes and segmental instability is mainly supported by indirect evidence resulting from the fusion in the lumbar spine [7, 9, 58]. Chataigner et al. [7] conducted anterior interbody fusion in 56 patients and found more favorable clinical outcomes in patients with type I changes compared to those in the case of isolated disc degeneration and type II changes. Esposito et al. [9] conducted instrumented spinal fusion in 60 patients with severe chronic pain in the lumbar spine and single-level pathological process and noted excellent results in patients with type I changes compared to the data observed in the group with type II changes. Based on this fact, the authors concluded that spinal fusion accelerates type I Modic changes by correction of mechanical instability, which can be indistinguishable on radiographs.

Functional CT is more sensitive for detection of abnormal mobility of the segment. As for the specific types of instability, such as rotational one, it is almost impossible to assess it using functional radiographs, meaningful data can be obtained only using three-plane CT [38]. MRI can evaluate condition of soft tissues, whose changes also contribute to abnormal motion in the segment. At the same time, there is no unique specific sign or combination of signs that clearly determine “normal” and “unstable” state of the segment and therefore the development of the algorithm and the list of additional examination methods, which are necessary and sufficient for the diagnosis of instability, is an extremely important issue.

It should be noted that stability parameters are not the same for different segments and organisms. For example, displacement values associated with motion of stable segments differ significantly in young and elderly individuals [56]. It is interesting to consider another biological factor. Age-related changes occur in the proprioceptive system, and this may lead to the situation when anomalous range of motion is observed as a nociceptive impulse. Therefore, instability may be determined not only by the range of motion of the segment but also by the variance of perception of this movement by the nervous system, which, in turn, can be modified in the cerebral cortex, creating a relationship between biomechanical instability and psychological aspects of instability evaluation [23].

Apparently, only a combination of several techniques for complex objective evaluation will provide sufficient data for accurate diagnosis of instability. The development of application standards for external load or range of motion to assess the level of structure displacement on the X-ray and algorithm for clinical and radiological diagnosis of segmental instability would possibly be useful for practitioners.

Instability of spinal segments is believed to play a significant role in the etiology of back pain. According to some authors [53], over 30% of pain episodes are associated with this cause. In the 1980s, instability was believed to be the main causative aspect of back pain, whose occurrence was explained from the viewpoint of segment biomechanics [12]. However, it is difficult to make clear clinical diagnosis of this condition and the statement that there is direct relationship between pain and segment hypermobility is extremely controversial [31]. When disturbance of segment mobility is detected, this suggests its dysfunction and involvement, but not necessarily it is the causative factor of low back pain in a patient. For example, Panjabi [43] suggested that chronic low back pain may be associated with micro-traumas of ligaments, leading to muscle dysfunction. Other authors [54] observed that formation of instability-induced pain syndrome is to a greater degree caused by long lasting tension of the back muscles than by increase in the range of intersegmental mobility.

N.I. Khvisyuk et al. [3] analyzed the material comprising the data on treatment of several hundred patients with various types of instability and significantly supplemented characteristics of clinical symptoms by determining the main complex of instability symptoms, namely clear correlation between the intensity of pain and vertical load on the spine. It manifests as occurrence and worsening of pain immediately after verticalization of the patient or in 15—20 min, so that the patient is forced to lie down or unload the spine. The pain disappears or considerably decreases in the horizontal position or with an external immobilization; pain is localized in the lumbar spine and radiate into one or both lower extremities. It is often accompanied by paresthesia, antalgic scoliosis, back muscle hypertonia, which also disappear in the horizontal position [3]. In this case, radiography shows narrowed interbody space, asymmetric decrease in the height of the disc space on the functional radiography, disturbed sagittal profile, translation, retrolisthesis, and antelisthesis.

Definition of hypermobility (increased range of motions without clinical symptoms) and instability with corresponding clinical symptoms was given in 1962 at the Conference of the Orthopedics Association in San Francisco. It is very important from the practical viewpoint since pain is not always caused by abnormal segmental motion. Kraemer [28] proposed to classify instability into two forms: with and without severe clinical manifestations. Then the question arises, can we even talk about instability syndrome in the absence of clinical manifestations? We believe that it is more appropriate to refer this situation as radiological signs of segment hypermobility rather than instability syndrome itself.

Kirkaldy-Willis and Farfan [25] described disc degeneration as a process passing through the following stages: temporary dysfunction (with intermittent pain), instability (constant pain syndrome), and stabilization (without pain symptoms), which is consistent with the results of Fujiwara et al. [14], who compare the data from MRI and CT studies with the results of assessment of the range of motion. Murata et al. [34] compared MRI data and functional radiographs in patients with low back pain and showed that increase in angulation and translational motions are typical in patients without signs of disc degeneration or at its initial stages but not in the case of pronounced disc degeneration, when the range of motions in the segment is reduced. In 1998, Kaigle et al. [22] showed that patients with degenerative disc diseases have reduced range of motion in the segment compared to healthy individuals. These studies led to the conclusion that disc degeneration results in reduced rather than increased range of motion in the segment, although the latter option is implied by the term “instability”. Then it turns out that “instability” is a broader concept that includes all abnormal patterns of movement, including its limitation.

Some authors reported instability at the early stages of degeneration [14, 55], while others obtained completely opposite results [29, 32, 40]. This can be due to several reasons. Firstly, the studies were carried out on cadavers and the whole lumbar spine was evaluated en bloc, without isolation of the individual segments. Secondly, the authors used different evaluation criteria (MRI, discography, radiography, microscopy of specimens, etc.).

Abnormal biomechanics of the segment results in accelerated disc degeneration and back pain. In turn, degenerative-dystrophic changes in the intervertebral discs play a major role in the pathogenesis of instability [21, 64], and changes in facet joints, ligaments, and muscles are of great importance [2, 25, 60].

Instability of the spinal motion segment is a clinical and radiological concept, wherein abnormal (usually increased) pattern of motions in the segment with translational component is one of the causes of pain. It was believed that it is abnormal motion that causes pain and therefore spinal fusion is the most pathogenetically justified method of surgical treatment of this segment.

However, the failure to prove that abnormal or increased motion is a specific feature of degenerative disc disease in combination with the fact that more rigid fixation (e.g., transpedicular) did not lead to significant improvement in clinical outcomes have cast doubts on the existing concept of instability. Since all the causative factors and mechanisms of mechanical back pain are not yet determined, the optimal method of its treatment is disputable in spite of the more than 100-year history of this issue.

In 1965, Newman [37] was the first who emphasized the need for stabilization of the lumbar segments in patients with back pain after discectomy as the method aimed at specific elimination of pain. Spinal fusion as a treatment for back pain was used since the early 20th century although none of the studies proved that pain is associated exclusively with abnormal movement. It was believed that the effect of fusion is associated with the fact that exclusion of segment motion reduces irritation from the neural structures. However, unpredictable results of fusion, which did not improve despite the progressive development of rigid fixation techniques, cast doubt on the idea that back pain was associated with movement of the segment and exclusion of movement was a key moment in its treatment. Thus, is it possible that pain is associated with axial load rather than movement?

To date, fusion is considered as the gold standard for the treatment of low back pain. However, analysis of the literature shows that this idea has no scientific background [34]. Fusion surgery was originally proposed in the early 20th century for low back pain associated with congenital abnormalities and conditions after infectious diseases of the spine. Clinical outcomes after spinal fusion for back pain were often unpredictable.

Application of transpedicular stabilization in combination with interbody one significantly increased fusion rate, but it was not 100 % effective. Implementation of dynamic stabilizers, including artificial discs, showed that, despite the preservation of certain range and amplitude of motion due to implant design, clinical results were similar to those with spinal fusion. All this facts drew closer attention to another disc function, which was also fulfilled by these implants, i.e. load transmission function. Great attention was paid to load transmission by the implants, when developing their design and selecting materials. Improper load distribution between the implant and supporting part of the bone explains poor clinical outcomes of some operations. It is possible that lower back pain is associated with incorrect load transmission mechanism rather than with abnormal motion of the segment (instability), which is possible in the case of disc degeneration and results in pain. If we accept the fact that impaired load transmission by the degenerative disc causes low back pain, the treatment should be aimed at restoring this function and does not necessarily lead to formation of fusion. For example, dynamic implants, which do not form fusion, restore load transmission function by limiting only abnormal direction of displacement and can provide good clinical outcomes without segment immobilization.

In the studies published in recent years, the relationship between instability and clinical symptoms is mentioned more cautiously: instability could potentially cause back pain, especially rotational one [38]. Biomechanical studies laid the basis for assumption that back pain is caused by stress concentration in the posterior portions of the annulus fibrosus as a consequence of pathological pattern of motions in the segment with degenerated intervertebral disc rather than by increased range of motion [64]. According to this concept, it can be assumed that load redistribution in the segment using different types of implants, such as dynamic one, rather than rigid fixation, may solve this problem.

From a practical point of view, the diagnosis of the type of instability and its classification in terms of the nature of displacement is important in order to answer the question whether stabilization is required and to apply its particular type with allowance for the distribution of biomechanical loads in the segment.

Frymoyer and Krag [13] identified the following types of instability: rotational, translational, retrolisthesis, and postsurgical, based on the knowledge of the degenerative process patterns and biomechanical properties of the segment. In the absence of treatment, each of these conditions leads to formation of rigid deformity with prevailing clinical symptoms of stenosis. The authors believe that antitorsion facet fixation should be used in the case of rotational instability, interbody stabilization — with translational one, fusion in flexion position — with retrolisthesis. However, these statements are only recommendations, since they were not proven in appropriate studies. However, the idea of differentiated approach to stabilization method with allowance for the type of pathological movement is certainly rational.

In literature, instability is classified based on the types and direction of displacement into the anterior, angular and posterior ones [57]. This classification has no uniform criterion and no practical significance. Therefore, it is important to identify the types of instability, which differ in terms of method of treatment, so that classification of instability into types would determine strategy of their treatment. We have not found such a classification in the literature.

In summary, segmental instability is a complex, integrated, and ambiguous concept, which is difficult to diagnose. It is based on clinical, radiographic, and biomechanical characteristics. Only identification of clinical criteria, development of clear diagnostic system based on the comprehensive objective evaluation using modern diagnostic methods in cooperation with radiologists and specialists in biomechanics, and formulation of reliability criteria of data assessment for each of the methods used, will enable us to identify clinical and radiographic correspondence and approach to the issue of etiopathogenetic treatment. The development of an algorithm of clinical and radiological diagnosis of segmental instability will be useful for practitioners.

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