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Risk factors of recurrence lumbar disc herniation after primary endoscopic transforaminal discectomy. Part 2

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Recurrence of lumbar disc herniation (LDH) after primary endoscopic transforaminal discectomy (PETD) is diagnosed in 3.8–15 % of cases. Objective. To study preoperative radiographic and MRI signs that potentiate LDH recurrence after PETD. Methods The study material consisted of articles identifying radiographic and MRI risk factors for recurrent LDH after PETD between 2015 and 2025 in the PubMed, Google Scholar, and Medline databases. The study method was a systematic review of relevant literature sources. Results. The level of LDH does not influence the incidence of rLDH, although some authors consider the presence of a disc herniation in the upper lumbar spine as a risk factor for recurrence. rLDH is significantly more frequently recorded with primary disc protrusion; in cases of migrated disc herniation, the risk of rLDH significantly increases with large intracanal displacement of disc material extending beyond the inferior margin of the superior or inferior vertebral pedicle. The use of PETD for resection of central disc herniations most often results in recurrent LDH (compared to foraminal, extraforaminal, and migratory) due to technical errors. A study of disc height index dynamics in the pre- and postoperative periods and the degree of Modic type endplate degeneration showed that the less severe the degenerative processes in the prolapsed intervertebral disc, the higher the risk of herniation recurrence after PETD. Conclusions. Recurrence disc herniation after PETD is significantly more common in cases of primary protrusion and significantly increases with large annular defects (≥ 6 mm). rLDH is significantly more common in discs with moderate degenerative changes, with a disc height index of approximately 0.37 ± 0.09 and Modic type 1.

Рецидив грижі міжхребцевого диска (ГМД) поперекового відділу хребта (ПВХ) після первинної ендоскопічної трансфораміналної дискектомії (ПЕТД) діагностується в 3,8–15 % випадків. Мета. Вивчити на передопераційному етапі рентгенологічні та МРТ-ознаки, які потенціюють рецидив ГМД ПВХ після ПЕТД. Методи. Проаналізовано статті, які містять визначення рентгенологічних і МРТ-факторів ризику рецидиву грижі міжхребцевого диска (рГМД) ПВХ після ПЕТД, за період 2015–2025 р. у базах даних PubMed, Google Scholar, Medline. Здійснено систематичний огляд релевантних джерел літератури. Результати. Рівень грижі міжхребцевого диска ПВХ не впливає на частоту рГМД, хоча окремі автори розглядають її наявність у верхньопоперековому відділі як ризик рецидивування. Значущо частіше рГМД реєструється в разі первинної протрузії диска; у разі грижі, яка мігрувала, ризик рГМД достовірно зростає за умов значного інтраканального зміщення матеріалу диска, який виходить за межі нижнього краю верхньої або нижньої ніжки хребця. Використання ПЕТД для резекції центральних гриж дисків найчастіше призводить до рГМД через технічні помилки. Вивчення динаміки індексу висоти диска в перед- та післяопераційному періодах та ступеня дегенерації замикальних пластинок диска за типом Modic показало, що чим менш виражені дегенеративні процеси, тим вище ризик рецидиву грижі після ПЕТД. Висновки. рГМД після ПЕТД достовірно частіше реєструється в разі первинної протрузії і достовірно зростає за умов значних дефектів фіброзного кільця. Значимо частіше ГМД рецидивує в дисках із помірно вираженими дегенеративними змінами з індексом висоти диска приблизно 0,37 ± 0,09 та типом Modic 1. Ключові слова. Первинна ендоскопічна трансфораміналь дискектомія, рецидив грижі міжхребцевого диска поперекового відділу хребта, фактори ризику, морфометрія поперекового сегмента, дегенеративні зміни міжхребцевих дисків поперекового відділу хребта.

Keywords. Primary endoscopic transforaminal discectomy, recurrent lumbar disc herniation, risk factors, lumbar segment morphometry, degenerative changes in lumbar intervertebral disc

Introduction

Percutaneous transforaminal endoscopic discectomy (PTED) is one of the most widely used and successful modern methods of minimally invasive surgical treatment for lumbar intervertebral disc herniation (LDH). The advantages of PTED include minimal tissue trauma, reduced blood loss, a clean surgical field [1], the possibility of preserving the posterior ligamentous complex and other biomechanical structures [2], the ability to perform surgery in some cases under local anesthesia [3], relatively low surgical costs [4], and high patient satisfaction rates [5].

Despite the ongoing development and improvement of the endoscopic discectomy technique for LDH [6, 7], there are reports of unfavorable treatment outcomes [8–11]. One of the most common complications of PTED is recurrent lumbar disc herniation (rLDH), with the incidence varying significantly in the literature: 3.8–7.4 % [12], 1.4–11.4 % [13], 5–15 % [14]. It is the most frequent cause of reoperation, with an overall rate of 5.2–19 %, increasing with the length of follow-up [13, 15]. Reoperations are more commonly performed earlier in older patients [16]. Although re-surgery remains effective, it is often associated with worse functional outcomes, increases the likelihood of further reoperations, and is frequently complicated by the formation of epidural scar tissue [17, 18], which raises the risk of dural tears or nerve damage [19, 20]. Additionally, the removal of the posterior vertebral structure may increase the risk of segmental instability [21]. Both reoperation and the clinical symptoms associated with rLDH have a negative psychological impact [22] and substantial economic burden on patients [23]. Therefore, identifying risk factors for rLDH after PTED is of significant clinical importance for developing surgical protocols, selecting patients appropriately, and improving the effectiveness of endoscopic transforaminal discectomy.

Risk factors for rLDH after primary transforaminal discectomy have been reported in numerous studies, often with conflicting results [22, 24–28]. In our previous literature review on clinical risk factors for rLDH, the most likely factors identified were age > 50 years, body mass index > 25 kg/m², and the time from initial discectomy > 8 weeks after the clinical manifestation [29].

Purpose: To study the radiological and MRI signs that may predispose to recurrent lumbar disc herniation after percutaneous transforaminal endoscopic discectomy.

Material and Methods

The study material includes professional articles that define radiological and MRI signs considered as risk factors for recurrent lumbar disc herniation after primary PTED, published between 2015 and 2024, sourced from PubMed, Google Scholar, and Medline databases. These studies were selected using medical subject headings and keywords such as “recurrent lumbar disc herniation”, “minimally invasive lumbar spine surgery”, “percutaneous endoscopic lumbar discectomy”, “percutaneous endoscopic transforaminal discectomy”, “reoperation”, “re-discectomy”, “radiological risk factors for recurrent lumbar disc herniation”, “lumbar vertebral segment morphometry”, and “MRI signs of intervertebral disc degeneration”.

Recurrent lumbar disc herniation was defined as a confirmed, symptomatic recurrence of LDH at the level of the initial discectomy, detected by imaging methods (radiography/CT/MRI), with radiculalgia ipsilateral to the preoperative symptoms, leading to a repeat surgery [12].

Inclusion criteria: articles that address the results of identifying radiological and MRI risk factors for recurrent mono-segmental LDH after primary PTED.

Exclusion criteria: publications on the outcomes of open surgical treatment for LDH, open and endoscopic discectomy for polysegmental and recurrent LDH in the lumbar spine.

Research method: systematic review of relevant literature sources.

Results and discussion

Level of intervertebral disc herniation

The prevailing view in the literature is that there is no significant correlation between the level of LDH and the frequency of recurrence [22, 30–32]. More intense preoperative radiculalgia and relatively prolonged (up to 1 month) postoperative pain syndrome in patients with extraforaminal and foraminal hernias of L_{IV}–L_V discs are associated with compression or irritation of the ganglion of the posterior nerve roots by the disc material [30, 33]. Some authors consider the location of the disc herniation in the upper lumbar region as a risk factor for rLDH [34].

Type of intervertebral disc herniation:

Recurrent LDH is significantly more frequent in cases of primary disc protrusion, where the defect in the annulus fibrosus (AF) has a wider diameter due to the broad neck of the hernia [35]. Primary extrusion of the intervertebral disc, both transligamentous and subligamentous, does not increase the risk of rLDH [36]. In cases of migrated hernias, the risk increases significantly when there is considerable in-

tracanalar displacement of the disc material beyond the lower edge of the upper or lower vertebral facet [37–39].

When using traditional transforaminal access, complete resection of migrated disc material is complicated by technical difficulties in grasping the distal fragment of the disc [40]. Recently, modified surgical techniques have been proposed for such cases, including targeted puncture and foraminotomy [38], suprapedicular retrocorporeal access [41], and mobile "outside-in" techniques [42]. Most of these methods are considered more appropriate for PTED of migrating hernias of the lower lumbar intervertebral discs [38, 43]. Endoscopic discectomy for LDH in the upper lumbar segments is more often performed through an interlaminar approach [39, 44].

The risk of rLDH significantly increases in cases of large defects in the annulus fibrosus (≥ 6 mm) [45, 46], with irritation of the nerve root causing clinically significant postoperative radiculalgia [47]. Additionally, through defects in the annulus fibrosus, inflammatory mediators can come into contact with the nerve roots, potentially leading to chemical radiculitis [48].

To prevent recurrent disc material protrusion, aggressive discectomy is performed to remove as much of the gelatinous nucleus as possible [49]. However, the drawbacks of this approach include a more rapid decrease in intervertebral disc height and accelerated degeneration of the disc [48, 50].

Localization of the intervertebral disc herniation

Recurrent LDH after PTED most commonly occurs after resection of central disc herniations, with the primary cause of this complication being technical errors [51, 52]. In the past, the presence of a central disc herniation was considered a contraindication for PTED due to the location of the working zone near the posterior midline, making it difficult to position the endoscope at the correct angle and differentiate the soft tissues visually [51]. This could lead to nerve root injury and incomplete removal of the disc material [42, 51]. Over time, with the advancement of PTED techniques, resection of central disc herniations has been performed using foraminoplasty. In this case, the newly created expanded intervertebral foramen provides a full view of the central disc herniation, the adjacent compromised nerve root, and, if necessary, the contralateral spinal nerve root, following the principle of "unilateral access, bilateral decompression" [51]. The presence of intervertebral disc herniation at other locations (foraminal, extraforaminal) or migrated hernias does not affect the recurrence rate after PTED [38, 43, 53, 54].

Intervertebral disc height

The height of the intervertebral disc (IDH) is determined by both absolute and relative measurements. The absolute height is the arithmetic mean of the height of the disc in the anterior and posterior sections, or the anterior, middle, and posterior parts of the disc [55].

As a predictor for rLDH, the dynamic change in IDH during the pre- and postoperative periods is important. The IDH typically decreases by approximately 0.8 mm after disc tissue is removed during discectomy [56]. A lower IDH in the early postoperative period (compared to preoperative values) indicates a more aggressive discectomy [55]. The frequency of rLDH after limited discectomy is twice as high as that following aggressive discectomy [57, 58]. It is important to note that the optimal amount of disc herniation that should be removed for the best clinical outcomes remains unclear [55]. A decrease in IDH over time [29, 47] is often accompanied by inclination and later hyperplasia of the articular processes and their facets, which may lead to clinically significant spondyloarthrosis in the long-term postoperative period [59].

The relative measurement of IDH is the intervertebral disc height index (IDHI), which is calculated as the ratio of the disc height to the height or width of the adjacent vertebra [55]. Regardless of the calculation method, higher IDHI values at the level of surgical intervention are significantly correlated with an increased frequency of rLDH after PTED [25, 35, 36, 55]. For example, at 48 months post-surgery, the average IDHI was 0.37 ± 0.09 in the group with recurrent disc herniation and 0.29 ± 0.09 in patients without rLDH [25]; and 0.35 ± 0.007 and 0.26 ± 0.002, respectively [55]. In other words, the less pronounced the degenerative processes in the prolapsed intervertebral disc, the higher the risk of recurrent herniation after PTED.

Higher IDHI values correspond to moderate degenerative changes in the intervertebral disc. A hypointense signal from the prolapsed nucleus pulposus on T2-weighted MRI images [60] indicates the preservation of some amount of hydrophilic glycosaminoglycans in the extracellular matrix of the nucleus pulposus [61], and undamaged collagen, predominantly in the anterior part of the annulus fibrosus [62]. The structural-functional properties of the intervertebral disc are partially preserved; its tissues are capable of maintaining some oncotic pressure [63]. However, the presence of a structural defect in the disc leads to a reduction in its mechanical stiffness, resulting in excessive segmental mobility.

Discectomy in such a "latent unstable segment" [55] ("segment with micron instability" [64]) accelerates degeneration of the disc, leading to persistent chronic pain syndrome [56], rLDH [25, 35, 36, 55], and potential instability of the operated segment [65, 66].

At later stages of degeneration, structural changes in the disc tissue with herniation are characterized by an increase in the number of fibrous-cartilage and hypertrophic cells in the nucleus pulposus matrix, significant loss of disc volume, an increase in the overall thickness of the endplates, and degeneration of the annulus fibrosus layers [67]. This is visualized on MRI as a "gray/black disc" appearance [68]. As the intervertebral disc undergoes fibrotization, the segment gradually loses its motor function. Restabilization of the segment occurs when the disc collapses with a reduction in its height of more than 50 %, which correlates with an IDHI of approximately 0.15 [55]. Therefore, the relationship between IDHI and rLDH is determined by the interdependence of the processes of structural degradation in the disc tissue and their biomechanical consequences.

MRI signs of intervertebral disc degeneration

The degree of intervertebral disc degeneration is determined on MRI scans using the Modic classification [69] and the Pfirrmann classification [70]. Modic changes reflect alterations in the endplates and bone marrow of the vertebral bodies adjacent to the intervertebral disc, detected through changes in signal intensity on T1- and T2-weighted tomography scans, and correlate with histological findings [36] and disc degeneration [71].

Modic type 1 changes are associated with splitting, microfractures in the endplates, and edema in the bone marrow; type 2 indicates fatty degeneration of the bone marrow [69]; and type 3 involves sclerosis of the endplates and subchondral bone [72]. There is a consensus in the literature regarding the significant correlation between the higher frequency of rLDH and the presence of Modic type 1 changes [12, 22, 27, 36, 37, 73, 74]. This is thought to be due to the damage to the endplates and the bone marrow edema, which leads to an increase in intraosseous pressure in the vertebral body [75], resulting in increased oncotic pressure in the disc. This promotes the migration of the nucleus pulposus through the cracks in the annulus fibrosus and the endplates, thereby increasing the risk of forming rLDH [76].

The MRI classification for assessing the degree of intervertebral disc degeneration according to Pfirrmann on sagittal T2-weighted tomograms includes the following qualitative parameters: the signal intensity from the nucleus pulposus and the homogeneity of its structure; the differentiation between the images of the nucleus pulposus and the annulus fibrosus; and the height of the intervertebral disc. The classification consists of 5 stages of degeneration, where Stage I represents normal disc MRI images, and Stage V corresponds to the late stages of degeneration with a loss of structure and disc collapse [70]. The relationship between the frequency of rLDH after PTED and the degree of disc degeneration according to the Pfirrmann classification in the literature is debated. Some authors have found no significant correlation between these parameters [36, 43], while others have established a significant connection when degeneration reaches Pfirrmann Stage ≥ IV [22, 77, 78], Stage III [75], or ≥ Stage III [79]. In other words, in most reports, the frequency of rLDH, according to the Pfirrmann classification, is significantly higher in discs with advanced degeneration, while disc height, IDHI, and Modic type correlate with rLDH frequency in cases of moderate degeneration of the disc tissue. These contradictory results may be explained by the insufficient discreteness of the Pfirrmann criteria [80, 81] and their incomplete correspondence with morphological, particularly involutional, features [82, 83], which were noted by the authors of the classification themselves [70].

J. F. Griffith and colleagues developed a modified Pfirrmann classification that contains 8 stages based on the interpretation of sagittal T2-weighted tomograms using three main criteria: signal intensity from the nucleus pulposus and the internal fibers of the annulus fibrosus (Stages 1–3); differentiation between the internal and external fibers of the annulus fibrosus at the posterior edge of the disc (Stages 4 and 5); and reduction in disc height (Stages 6–8) [80]. Although the Griffith classification for disc degeneration is more detailed, it has not gained widespread use.

Conclusions

Recurrent disc herniation after PTED is significantly more frequent in cases of primary disc protrusion and increases with significant defects in the annulus fibrosus (≥ 6 mm). Most disc herniation recurrences occur after resection of central disc hernias due to technical errors. The level of disc herniation does not influence the frequency of recurrence.

rLDH after PTED is significantly more frequent in discs with moderate degenerative changes, with an IDHI of approximately 0.37 ± 0.09 and Modic type 1 changes. The data on the relationship between rLDH frequency and the degree of disc degeneration according to the Pfirrmann classification remain contradictory.

Conflict of Interest. The authors declare that there is no conflict of interest.

Future research prospects. Currently, it is important to analyze the literature regarding the impact of radiological, including radiometric, indicators on the frequency of recurrent lumbar disc herniations.

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RISK FACTORS OF RECURRENCE LUMBAR DISC HERNIATION AFTER PRIMARY ENDOSCOPIC TRANSFORAMINAL DISCECTOMY. PART 2

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