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MORPHOLOGICAL STRUCTURE OF THE INTERVERTEBRAL DISC IN HERNIAS IN YOUNG PATIENTS

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Abstract
This study presents a comprehensive analysis of the morphological structure and alterations of intervertebral discs in young patients with intervertebral disc herniations. The structural features of the nucleus pulposus and annulus fibrosus were examined across different spinal regions — cervical, thoracic, and lumbar.It was found that in young individuals, the nucleus pulposus retains high elasticity and hydration, which contributes to the formation of large hernias without pronounced age-related degenerative changes.
Mechanical loads, static tension, and microtraumas were identified as the primary contributing factors, leading to tears of the annulus fibrosus, protrusion of the nucleus pulposus, and development of inflammatory-destructive processes in the surrounding tissues.Morphometric analysis revealed the presence of fibrotic areas, microvascular reactions, and aseptic inflammation, confirming that degenerative processes may begin at a relatively young age.The findings are of great significance for a deeper understanding of the pathogenesis of intervertebral disc herniation, as well as for the early diagnosis, prevention, and development of individualized treatment strategies.

Keywords: Intervertebral disc, disc herniation, morphology, morphometry, nucleus pulposus, annulus fibrosus, young age, spine, degenerative-dystrophic changes.

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Research results

Morphological and morphometric analysis of intervertebral discs in young patients with diagnosed hernias revealed a number of characteristic structural changes that reflect the early stages of the degenerative-dystrophic process.

On visual examination, the intervertebral discs in the area of herniated protrusion had a flattened shape, uneven thickness, and loss of normal elasticity. In most cases, there was a decrease in the height of the intervertebral space and local deformation of the adjacent vertebral bodies. Microscopic examination showed the presence of pronounced disorders in the structure of the fibrous ring — stratification of collagen fibers, focal breaks and disorganization of the orientation of the bundles were observed. In some zones, microfractures were detected, accompanied by penetration of fragments of the pulpous core into the thickness of the ring.

Condition of the pulpous nucleus

At a young age, the nucleus retained a relatively high fluid content (up to 85%), but in the areas of hernial protrusion, partial dehydration, loss of turgor, and the appearance of foci of mucoid degeneration were noted. A number of patients showed initial signs of chondroid degeneration with increased cell matrix density. В парадисковыхSigns of aseptic inflammation were recorded in paradisk tissues: vascular fullness, perivascular edema, and minor lymphocytic infiltration. In some cases, increased angiogenesis was observed, indicating a compensatory response of tissues to chronic mechanical irritation.

Morphometric data

Morphometric analysis confirmed a statistically significant ($p < 0.05$) decrease in the thickness of the fibrous ring by an average of 17-22% compared to the control group. The area of the pulpous nucleus decreased by 14-18%, and the density of collagen fibers increased by almost 25%, which reflects the process of fibrosis. The most pronounced changes were observed in the lumbar spine, where the biomechanical load is maximal. In the cervical region, hernias were characterized

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by smaller sizes, but more often accompanied by reactive inflammation and muscle-tonic syndrome.

Table 1. Morphological and morphometric changes of the intervertebral disc in young patients with hernias

№	Indicator no	. Control group (healthy)	Group with disc herniation	Change (%)	Characteristics of changes
1	Thickness of the fibrous ring (mm)	2,8 ± 0,3	2,2 ± 0,2	−21%	Moderate thinning, focal fiber breaks
2	Area of the pulpous nucleus (mm2)	38,5 ± 3,1	31,8 ± 2,7	−17%	Reduced hydration, partial mucoid degeneration
3	Core water content (%)	85 ± 4	74 ± 5	−13%	Dehydration, turgor loss
4	Collagen fiber density (conl. units)	)100 ± 8	125 ± 10	+25%	Fibrosis, disorganization of fiber orientation
5	Thickness of hyaline cartilage of end plates (microns)	410 ± 35	355 ± 30-13	%	Initial signs of degeneration and compaction
6	Area of the vascular bed in paradisk tissues (mm2)	1260 ± 90	1485 ± 120	+18%	Increased angiogenesis, signs of aseptic inflammation
7	Index of degenerative changes (in points)	0.8 ± 0.2	2.6 ± 0.3	↑ by 3.2 times	Comprehensive assessment of destructive-dystrophic processes

The data presented in the table clearly demonstrate the differences between the indicators of the control group and patients with young intervertebral hernias. Morphometric analysis revealed a regular decrease in the thickness of the fibrous ring and the area of the pulpous nucleus, which reflects the onset of degenerative-dystrophic processes at an early age. The thickness of the fibrous ring decreased by an average of 21% compared to the control group. This is due to mechanical microtraumas and increased axial loads on the spine, leading to thinning and local tears of collagen fibers. The areaof the pulpous nucleus decreased by 17%, and the water content in it decreased by 13%, which indicates a gradual loss of hydrophilicity and turgor of the tissue. These changes are accompanied by the formation of microcracks, stratifications, and foci of mucoid degeneration.
The density of collagen fibers in the fibrous ring, on the contrary, increased by 25%, which reflects the process of fibrosis and compensatory restructuring of the

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structure in response to chronic overload. Such compaction reduces the elasticity of the disc and increases the risk of its rupture in case of minor injuries. The thickness of the hyaline cartilage of the end plates decreased by 13%, which can be considered as the initial stage of degeneration of subchondral structures. This is accompanied by a decrease in the diffusion of nutrients into пульпозноethe nucleus pulposus, exacerbating trophic disorders.

B Paradisk tissues showed an increase in the area of the vascular bed by 18%, which is associated with the development of reactive angiogenesis and aseptic inflammation. This process is compensatory in nature, aimed at improving tissue trophism in conditions of chronic microtraumatization. A comprehensive assessment of changes expressed in terms of the index of degenerative processes showed its increase by more than three times compared to the norm. This emphasizes that even in young patients, morphological signs of intervertebral disc destruction are already pronounced and can be a morphological substrate of pain syndrome.

Thus, the results of the table confirm that in young people, intervertebral hernias are formed not only as a result of acute traumatic impact, but also against the background of initial structural and biochemical changes that reflect the early stage of disc degeneration.

Generalized Conclusions

In young patients, the formation of intervertebral hernias occurs mainly against the background of mechanical factors and microtraumas, with relative preservation of the age-related properties of the tissue. However, even in the early stages, destructive-dystrophic changes are detected, similar to those observed at an older age.

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