

REVIEW

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A Brief Review of the Degenerative Intervertebral Disc Disease

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ABSTRACT

Introduction: The degenerative processes of the intervertebral disc represent an important cause of morbidity in everyday clinical practice, exerting burden on patients and clinicians treating them. Numerous factors may initiate degenerative processes, which most commonly affect the nucleus pulposus and ultimately influence the biomechanics of the whole spine.

Aim: This paper provides an overview from the literature about the process, causes and mechanisms of disc degeneration and the associated factors. **Methods:** The scientific literature was reviewed through PubMed, Medline and Science Direct. The articles were chosen in correlation with the study objective and their scientific relevance. **Results:** Many mechanical factors, such as mechanical, traumatic, genetic and nutritional, may affect the integrity of the intervertebral disc. The degenerative processes involve the structural damage of the intervertebral disc and the changes in number and composition of cells. The main factor in the degeneration of the intervertebral disc is the loss of proteoglycans. Degenerative changes of the disc are connected to damage of adjacent structures, leading to functional changes, higher susceptibility to injuries and clinical signs and symptoms. **Conclusions:** Degenerative disease of the intervertebral disc remains a significant health problem. Besides standard conservative and surgical treatment, techniques of regenerative therapy are becoming very promising, although still in the experimental phase.

Keywords: intervertebral disc, fibrous annulus, nucleus pulposus, degenerative disease, spine.

1. INTRODUCTION

The degenerative disease of the intervertebral disc and back pain are chronic conditions that are caused by several factors and represent an important cause of morbidity and mortality in everyday clinical practice (1).

During the clinical examination, the disease may present as axial back pain, spinal stenosis, myelopathy or radiculopathy. The consequences of the degenerative disease of the intervertebral disc are among the main initiative factors for chronic instability of the diseased segments of the spine and for functional disability among both sexes, which significantly affects living quality, especially in young and active population (1-3).

2. AIM

This paper provides an overview from the literature about the processes, causes and mechanisms of disc degeneration.

The associated factors are briefly described, as well as the epidemiology and clinical symptoms.

3. METHODS

Literature search was conducted for this review. The data about intervertebral disc structure, degeneration and its consequences was collected from various sources. These included electronic databases PubMed, Medline and Science Direct. The search was performed using a combination of the following terms: intervertebral disc, degenerative disc disease, fibrous annulus, nucleus pulposus, degenerative disease and lumbar spine. The articles were selected in correlation with the study objective and their scientific relevance.

4. RESULTS AND DISCUSSION

4.1. EPIDEMIOLOGICAL CIRCUMSTANCES

The incidence of low back pain varies widely among different reports. It is the fifth most common cause for the visit to the doctor and affects 7.6 to 37% of patients (1-3). Long lasting pain and movement difficulties are experienced by 10% of patients (1). The degeneration of intervertebral disc tissue starts sooner than the degeneration of other muscular and skeletal tissues and is in many cases asymptomatic. It has been reported

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that the initial degeneration of intervertebral disc may be present as early as in the adolescence, when 20% of young people have mild signs of the disease (4, 5). With age, the incidence rises. It affects 10% of male population at the age of 50 years and up to 50% at the age of 70 years. In some reports, the degenerative disease of the intervertebral disc may be present in 90% of people; many of them have no signs of the disease (2, 3, 6, 7).

Low back pain is strongly connected to the degenerative process of the intervertebral disc. The height of the intervertebral disc gradually falls and the consequence is changed dynamics in the affected segment of the spine. This accelerates the degeneration of other, nearby segments as well as other spinal structures, such as ligaments, joints and muscles. In the long term, this leads to narrowing of the spinal canal with the compression of neural tissues due to spinal stenosis, which is the main cause of pain, especially among the elders. With increase of elderly population, this problem is gaining significance (4, 5).

4.2. THE PROCESS OF THE INTERVERTEBRAL DISC DEGENERATION

The intervertebral disc is composed of three layers: I) fibrous annulus with its outer and inner part, II) central pulpous nucleus and III) terminal plates (4, 5). The disc is avascular, structure, made of fibrous tissue and cartilage. Microscopically, it is composed of scarce fibroblast-like cells, located in the extracellular matrix, accounting for the most of the disc structure. Both cells and matrix are fundamental for normal function of the intervertebral disc (4).

Many mechanical factors, depending on duration, severity, type and position of load, affects the state of the intervertebral disc and thus the biological response to these factors (4, 8, 9). The border between the annulus of the intervertebral disc and its nucleus becomes more and more pronounced during the organism growth. The degenerative processes encompass the structural damage of the intervertebral disc and the changes in number and composition of cells. With aging and advancing degeneration, the nucleus is primarily affected. It becomes more fibrous and less elastic. Tiny concentric breaks emerge in the outer part of the disc from where they extend into the nucleus.

The amount of fibrous tissue rises, composition and quantity of proteoglycans changes and number of cells changes due to apoptosis. Different factors such as mechanical, traumatic, genetic and nutritional play an important role in the degenerative process (7-9). The fibres in the fibrous annulus become increasingly disoriented and the network made of elastin and collagen fibres gradually deteriorates. Cells in the nucleus are affected by apoptosis and later on by necrosis, on the other hand they tend to proliferate excessively. These degenerative cascades are frequent and in an adult intervertebral disc, up to 50% of cells may be necrotic (10, 11).

The main factor in the degeneration of the intervertebral disc is the loss of proteoglycans. These large molecules are degraded to smaller fragments that are lost from disc tissue (12,13). The consequence is fall in osmotic pressure in the disc matrix and loss of water mole-

cules, which affects the mechanical properties of the disc (12, 14, 15). As degenerated intervertebral discs contain less water and have therefore inferior capabilities for sustaining pressure, they bulge and lose height. Proteoglycan loss affects also movement of other molecules into and out of the disc matrix. Serum proteins and cytokines diffuse into the matrix, affect the cells and accelerate the process of the degeneration (5, 13, 15).

With the matrix degeneration is connected also the quantity of collagen and its composition. Orientation, location and types of collagen fibres are most affected, total quantity of collagen to a lesser extent, however (5, 6). Old collagen fibres become denatured, although new fibres are being synthesised in early the process of degeneration. Enzyme activity has an important role in the process of collagen, fibronectin and proteoglycan denaturation and breakdown. Matrix metalloproteinases and cathepsins are the most important among others (5, 6, 16).

Degenerative changes of the intervertebral disc are connected to damage of nearby structures, such as ligaments, joints and vertebral muscles. This leads to functional changes and greater susceptibility to injuries. Due to overloading, a degenerated intervertebral disc is lower than normal and apophyseal joints need to bear higher loads (5, 16). The consequence is osteoarthritic degeneration. Strength of yellow ligaments decreases, which leads to their hypertrophy and protrusion of the ligaments into the spinal canal with consequent narrowing and compression of neural structures (17). The causes for pain in the course of the degenerative process are complex and in many cases a fair combination of structural and mechanical deformation as well as activity of inflammatory mediators. Frequently, spinal nerve radices are involved in the degenerative cascade, which causes chronic pain mainly due to their compression and partly due to ingrowths of tiny neural endings into the degenerated disc and their activation due to constant release of inflammatory mediators (5, 17).

4.3. FACTORS INFLUENCING THE INTERVERTEBRAL DISC DEGENERATION

Prolapsed or herniated disc are one of the most frequent reasons for presentation to the orthopaedist or neurosurgeon. Herniation is bulging of the disc due to partial or complete rupture of the outer fibrous annulus. The bulging may involve anterior, posterolateral or posterior direction (18). The last two directions are particularly important as they cause compression of the neural structures in the vertebral canal (18, 19). Occasionally, spontaneous resorption of the disc may occur, leading to improvement or even cessation of lumbar pain. Although disc herniation is most commonly caused due to mechanical injury and consequent rupture of the fibrous annulus, some extent of initial degeneration is necessary in order to allow the pulpous nucleus to herniate through fibrous bands of annulus into the vertebral canal (17-19). For a healthy disc to rupture, an enormous force is necessary. In many cases, the terminal plate of the vertebrae fails sooner than the fibrous belt (11, 20, 21).

4.4. MECHANICAL STRESS

Abnormal mechanical loads and continuous microscopic injuries lead to disc degeneration through faster wear and tear of both cellular and acellular components, involving the processes described above. The most common clinical consequence is chronic pain (22, 23). The most important risk factors include heavy physical labour, smoking (through atherosclerosis of minute vessels that supply the terminal plates), obesity, inappropriate flexed posture and lack of physical activity (13, 22, 24-26).

4.5. GENETIC FACTORS

There is also genetic basis for the degenerative process of the intervertebral disc. Certain genetic polymorphisms for matrix molecules define the integrity of the extracellular matrix and these polymorphisms may also influence the course of the degenerative process (27, 28). Mutations in genes coding for matrix molecules lead to alterations of matrix morphology, consequently affecting the function and biochemical processes of the disc (27, 29). However, genes alone are not the only reasons for disc disease as environmental factors are also involved, showing that intervertebral disc degeneration is probably a multifactorial disease (30-32).

4.6. DISC DEGENERATION DUE TO NUTRITIONAL DISORDERS

For normal function and structure of the disc, the cells need sufficient nutritional supply. One of the important reasons for the degenerative process is, therefore, also nutritional disorder of the intervertebral disc (33). As the disc is an avascular structure, its supply depends mainly on diffusion. Capillaries arising in the vertebral bodies extend only to the subchondral area of the disc terminal plate. This means that gasses and nutrients must diffuse through extracellular matrix in order to reach the cells. A fall in nutritional supply causes a fall in oxygen quantity and a rise in lactate concentration with consequent pH alteration, affecting the cell function and synthesis of extracellular matrix. In long term, this leads to degenerative process (33, 34).

5. CONCLUSIONS

Degenerative disease of the intervertebral disc remains a significant health problem, still not understood and solved sufficiently. Besides standard conservative and surgical treatment, techniques of regenerative therapy are very promising, although at the moment of writing still in the experimental phase. Regenerative therapy aims to restore the degenerated disc matrix by two approaches: with growth factors enhancing extracellular matrix synthesis by the disc cells and with agents inhibiting cytokines that normally cause matrix loss.

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