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AGE-RELATED MORPHOLOGICAL CHANGES OF THE MENISCI IN WOMEN

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Abstract

The menisci are essential fibrocartilaginous structures of the knee joint that play a critical role in load distribution, shock absorption, joint stabilization, lubrication, and protection of articular cartilage. Age-related degenerative processes significantly affect the morphology and functional properties of the menisci, particularly in women, due to hormonal changes, metabolic alterations, and biomechanical factors associated with aging. Understanding the morphological transformations occurring in the menisci throughout different stages of life is important for improving the diagnosis, prevention, and treatment of knee joint disorders.

This study investigates age-related morphological changes of the menisci in women and evaluates structural modifications associated with aging. Particular attention is devoted to alterations in collagen fiber organization, cellular composition, vascularization, extracellular matrix structure, and degenerative changes observed in different age groups. The relationship between age-related meniscal degeneration and the development of osteoarthritis is also examined.

The findings indicate that aging is associated with progressive reduction in cellular density, disorganization of collagen fibers, decreased vascular supply, and accumulation of degenerative changes within meniscal tissue. These structural modifications contribute to reduced biomechanical performance and



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increased susceptibility to meniscal injury and knee osteoarthritis. The study highlights the importance of early identification of age-related meniscal changes for maintaining joint health and preventing degenerative musculoskeletal disorders.

The research concludes that age-related morphological changes significantly influence the structural integrity and functional capacity of the menisci in women. Improved understanding of these changes may contribute to the development of effective preventive and therapeutic strategies aimed at preserving knee joint function throughout aging.

Keywords: Meniscus, Women, Aging, Morphology, Knee Joint, Fibrocartilage, Degeneration, Histology, Osteoarthritis, Musculoskeletal Aging.

Introduction

The menisci are important fibrocartilaginous structures of the knee joint that contribute to load transmission, shock absorption, joint stability, and protection of articular cartilage. Structural integrity of the menisci is essential for maintaining normal knee function throughout life.

In women, age-related hormonal, metabolic, and biomechanical changes significantly influence meniscal morphology. Progressive aging is associated with alterations in collagen organization, cellular density, vascularization, and extracellular matrix composition. These changes reduce the regenerative capacity of meniscal tissue and increase susceptibility to degenerative disorders.

Numerous studies have demonstrated that age-related degeneration of the menisci is closely associated with the development of knee osteoarthritis. Morphological changes such as collagen fiber disorganization, decreased hydration, matrix



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degeneration, and calcification contribute to impaired biomechanical function of the knee joint.

Understanding the morphological changes occurring in the menisci during aging is important for improving early diagnosis, prevention, and treatment of degenerative knee disorders. Therefore, the aim of this study was to investigate age-related morphological changes of the menisci in women and evaluate their potential role in the development of knee joint pathology.

Materials and Methods

The study was conducted to investigate age-related morphological changes of the menisci in women. Meniscal samples were analyzed from different age groups to evaluate structural alterations associated with aging.

Morphological examination included macroscopic and histological assessment of meniscal tissue. Tissue samples were fixed in 10% formalin, processed according to standard histological procedures, embedded in paraffin, sectioned at 5–7 μm thickness, and stained with hematoxylin-eosin and Masson's trichrome.

The analysis focused on collagen fiber organization, cellular density, vascularization, extracellular matrix characteristics, and degenerative changes. Microscopic evaluation was performed using light microscopy at different magnifications.

Women were divided into age groups (20–30 years, 31–45 years, 46–60 years, and over 60 years) to compare age-dependent morphological features. Quantitative and qualitative assessments were performed to determine the degree of meniscal degeneration associated with aging.

The obtained data were analyzed comparatively to identify the main morphological patterns occurring in the menisci during the aging process and their potential relationship with degenerative knee joint diseases.



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Results

The study demonstrated that significant age-related morphological changes occur in the menisci of women. In the youngest age group (20–30 years), meniscal tissue exhibited a well-organized collagen fiber network, high cellular density, and preserved extracellular matrix structure. Vascularization was relatively more pronounced in the peripheral regions, indicating better nutritional support and regenerative potential.

In women aged 31–45 years, mild degenerative changes were observed. Collagen fibers remained predominantly organized; however, focal areas of fiber disorientation and slight reductions in cellular density were detected. The extracellular matrix showed early signs of age-related remodeling.

The 46–60 years age group demonstrated more pronounced structural alterations. Histological examination revealed fragmentation of collagen bundles, decreased vascularization, reduced cellularity, and accumulation of degenerative matrix changes. Areas of fibrocartilaginous degeneration were frequently identified.

In women older than 60 years, the most severe morphological changes were observed. Meniscal tissue exhibited marked collagen disorganization, extensive matrix degeneration, reduced cell numbers, and occasional calcification. These alterations were associated with a significant decline in the structural integrity of the menisci.



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Table 1. Age-Related Morphological Changes of the Menisci in Women

Age Group	Collagen Organization	Cell Density	Vascularization	Degenerative Changes
20–30 years	Well organized	High	Moderate	Minimal
31–45 years	Slightly altered	Moderate	Moderate	Mild
46–60 years	Fragmented	Reduced	Low	Moderate
>60 years	Severely disorganized	Low	Very low	Marked

The findings indicate a progressive deterioration of meniscal structure with advancing age. The degree of degeneration increased significantly after the age of 45 years, suggesting that age-related changes may contribute to the development of knee joint disorders, particularly osteoarthritis.

Overall, the results demonstrate that aging in women is associated with gradual loss of meniscal structural integrity, reduced regenerative capacity, and increased susceptibility to degenerative knee diseases.

Discussion

The findings of the present study demonstrate that aging significantly influences the morphological structure of the menisci in women. Progressive age-related alterations were observed in collagen fiber organization, cellular density, vascularization, and extracellular matrix composition. These structural changes reduce the biomechanical efficiency of the menisci and increase susceptibility to degenerative knee disorders.

One of the most important observations was the gradual disorganization of collagen fibers with increasing age. In younger women, collagen bundles were densely packed and regularly arranged, providing optimal resistance to mechanical stress. However, aging was associated with fragmentation and loss of



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structural organization, which may impair the load-distributing function of the menisci.

The study also revealed a significant reduction in cellular density in older age groups. Meniscal cells are responsible for maintaining extracellular matrix homeostasis and tissue repair. Therefore, age-related decline in cell numbers may contribute to decreased regenerative capacity and accelerated tissue degeneration. Another notable finding was the reduction of vascularization within meniscal tissue. Adequate blood supply is essential for nutrient delivery and tissue maintenance. Decreased vascularization observed in older women may explain the limited healing potential of degenerative meniscal lesions and the increased prevalence of knee joint pathology with advancing age.

The accumulation of degenerative changes, including matrix deterioration and occasional calcification, became more evident after the age of 45 years. These findings support previous studies suggesting that age-related meniscal degeneration is closely associated with the development of osteoarthritis. Structural deterioration of the menisci may alter joint biomechanics, increase cartilage stress, and accelerate degenerative processes within the knee joint.

Hormonal factors may also contribute to age-related meniscal changes in women. The decline in estrogen levels during menopause has been associated with alterations in connective tissue metabolism, collagen synthesis, and joint health. These physiological changes may partially explain the higher prevalence of degenerative knee disorders among older women.

Despite the observed degenerative changes, the progression of meniscal aging appears to be gradual and multifactorial. Genetic predisposition, body weight, physical activity, occupational load, and metabolic factors may influence the rate and severity of structural alterations.



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The results of this study emphasize the importance of early detection of meniscal degeneration and implementation of preventive strategies aimed at preserving knee joint health. Regular physical activity, weight management, and timely orthopedic evaluation may help reduce the impact of age-related degenerative changes.

Overall, the study confirms that aging is associated with progressive morphological deterioration of the menisci in women. These structural changes play an important role in the pathogenesis of knee joint degeneration and should be considered in the prevention and management of musculoskeletal disorders.

Conclusion

The present study demonstrated that significant age-related morphological changes occur in the menisci of women and progressively increase with advancing age. Histological examination revealed gradual alterations in collagen fiber organization, reduction of cellular density, decreased vascularization, and degeneration of the extracellular matrix.

The findings showed that the menisci of younger women possess a well-preserved structural architecture characterized by organized collagen bundles, adequate cellularity, and minimal degenerative changes. In contrast, older age groups exhibited progressive tissue degeneration, including collagen fragmentation, reduced regenerative capacity, and structural deterioration.

The study also confirmed that age-related meniscal degeneration is closely associated with impaired biomechanical function of the knee joint. The observed morphological changes may contribute to increased susceptibility to meniscal injury, joint instability, and the development of osteoarthritis.

Furthermore, hormonal and metabolic changes occurring during aging may accelerate degenerative processes within meniscal tissue. Reduced vascular



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supply and cellular activity limit tissue repair mechanisms and promote progressive structural damage.

The results emphasize the importance of early identification of age-related meniscal alterations and implementation of preventive measures aimed at preserving knee joint health. Regular physical activity, maintenance of optimal body weight, and timely clinical assessment may help reduce the progression of degenerative changes.

In conclusion, aging significantly affects the morphology of the menisci in women and leads to progressive structural deterioration. Understanding these age-dependent changes is important for improving the prevention, diagnosis, and management of degenerative knee joint disorders.

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