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Hyperplasia of the mediopatellar plica of the knee joint in patients with chronic pain syndrome

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The morphology of the mediopatellar plica of the knee joint in patients with knee pain syndrome is of significant importance, as age-related changes of the plica, its hypertrophy, and trauma may increase the risk of damage to the articular cartilage of the femur and lead to chronic pain. The aim. To study the histological features of the mediopatellar plica of the knee joint in patients with pain syndrome and to identify factors influencing its morphology. Methods. A histological study of 12 mediopatellar plicae harvested from patients aged (42,3 ± 9,8) years (10 men and 2 women) was performed. The relative density of blood vessels, fibrous tissue, and adipose tissue within the plicae was assessed. The association between plica morphology and factors contributing to pain syndrome was analyzed. Results. Histological study demonstrated that the mediopatellar plica is composed of fibrous connective tissue, vascularized, with severe fibrosis with signs of hyalinosis observed in 41,6 % of cases. A morphological difference was identified between the paracapsular and marginal zones of the plica. The marginal zone lacked adipose tissue and consisted predominantly of dense connective tissue. Age and hyalinosis were found to be significant determinants of plica morphology, whereas trauma, type of occupation, and sex were not significant predictors of morphological changes in the mediopatellar plica. Conclusions. Dense connective tissue with features of fibrosis is more characteristic of the marginal zone of the plica, while the presence of adipose tissue beneath the synovial membrane distinguishes the paracapsular zone. Plica thickness significantly increases in the presence of hyalinosis; however, the relationship between plica morphology and clinical factors requires further investigation.

Питання морфології медіопателярної складки колінного суглоба в пацієнтів із больовим синдромом цієї локалізації важливе, оскільки вікові зміни складки, її гіпертрофія і травмування мають ризик ушкодження суглобового хряща стегнової кістки та хронічного болю. Мета. Дослідити гістологічні особливості медіопателярної складки колінного суглоба у хворих із больовим синдромом і чинники, які впливають на її морфологію. Методи. Проведено гістологічне дослідження 12 медіопателярних складок пацієнтів віком (42,3 ± 9,8) років, 10 чоловіків та 2 жінки. Проаналізовано питому щільність судин, фіброзної і жирової тканин у складках. Досліджено зв'язок морфології складки з факторами виникнення больового синдрому. Результати. За допомогою гістологічного дослідження виявлено, що медіопателярна складка сформована волокнистою сполучною тканиною, васкуляризована в 41,6 % випадках із вираженим фіброзом і ознаками гіалінозу. Встановлено відмінність морфології складки між паракапсулярною та крайовою зоною, де остання позбавлена жирової тканини і містить здебільшого лише щільну сполучну тканину. Доведено, що вік і гіаліноз є достовірними чинниками, які визначають морфологію складки, тоді як травма, тип роботи та стать не були достовірними предикторами її змін. Висновки. Щільна сполучна тканина з ознаками фіброзу більш характерна для крайової зони складки, тоді як відмінністю паракапсулярної є жирова тканина під синовіальною мембраною. Товщина складки достовірно зростає через гіаліноз, але залежність морфології складки від клінічних факторів потребує подальших досліджень. Ключові слова. Медіопателярна складка, колінний суглоб, хронічний біль, патогістологічне дослідження.

Keywords. Mediopatellar plica, knee joint, chronic pain, histopathological study

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Introduction

Chronic knee pain is one of the leading causes of long-term disability and reduced physical activity across different age groups. Despite significant advances in arthroscopy and in the treatment of chronic knee pain, the pathogenetic mechanisms underlying pain in a substantial proportion of patients remain incompletely understood [1, 2].

A special role in pain generation has been attributed to synovial plicae of the knee joint, primarily the medial patellar plica (MPP) and the suprapatellar plica (SPP) [3, 4]. For a long time, these anatomical structures were regarded as embryonic remnants with minimal clinical significance. However, modern arthroscopic techniques have demonstrated that pathologically altered synovial plicae may represent an independent source of chronic pain due to mechanical contact and damage to the articular cartilage [5]. At the same time, existing evidence regarding the relationship between morphological alterations of the plicae and clinical manifestations remains contradictory, indicating that current understanding of their pathophysiological role is still incomplete [6].

A review of the literature shows that most studies focus on anatomical variants of synovial plicae, their impingement against the medial femoral condyle, arthroscopic assessment, and surgical resection. In contrast, pathological and histomorphological features have been investigated only in isolated reports and are predominantly descriptive in nature [7–9]. The topography and degree of fibrotic and age-related changes, as well as alterations associated with knee injuries and varying levels of physical activity, including occupational load and intensity of work, remain insufficiently studied.

Previous research [10] suggested that knee pain is mainly associated with changes in the medial patellar plica, whereas the suprapatellar plica plays a secondary role. In contrast, the infrapatellar and lateral plicae were traditionally not regarded as potential pain generators. However, the mechanism of pain development remains unclear, and therefore research into the relationship between morphological changes of the medial patellar plica and factors contributing to knee pain continues.

Aim: to investigate the histological features of the medial patellar plica in patients with knee pain syndrome and the factors influencing its morphology.

Materials and Methods

The study was approved by the bioethics committee (protocol No. 3 dated 20.04.2026) of the State Institution “National Institute of Traumatology and Orthopaedics of the National Academy of Medical Sciences of Ukraine” in accordance with the ICH GCP guidelines, the Declaration of Helsinki, and the current legislation of Ukraine. All participants were informed about the study design and conditions and provided written informed consent.

Twelve specimens of the medial patellar plica obtained during arthroscopic surgery from patients with chronic knee pain syndrome were analyzed. The mean age of the patients was (42.3 ± 9.8) years; the cohort included 10 men and 2 women. A history of occupational or sports-related knee trauma was reported in 9 patients. The specimens were fixed in 10% formalin, embedded in paraffin, and stained with hematoxylin and eosin, Picrosirius red (PSR), and Weigert’s hematoxylin. Histological evaluation was performed using an Olympus BX51 light microscope, and images were captured using an Olympus C3040ZOOM digital camera with Olympus DP-Soft 3.2 software.

For quantitative assessment of tissue components within the plica samples, entire sections of each specimen were photographed. Using ImageJ 1.46 image analysis software, masks were generated for four histologically distinct regions: (1) areas dominated by fibrosis (dense collagen bundles, hypo- or acellular regions), including hyalinized zones (acellular, weakly stained areas); (2) areas with bundles of oxyphilic collagen fibers of varying thickness resembling relatively intact connective tissue; (3) areas containing newly formed thin-walled blood vessels (angiogenesis); and (4) clusters of adipocytes. The area of each region was measured in pixels, and its relative proportion within the total specimen area was calculated as a percentage, representing tissue density (%).

Statistical analysis was performed using StatPlus software (version 7.0). Data are presented as median with lower and upper quartiles (Me [Q1; Q3]). The normality of distribution was assessed using the Shapiro–Wilk test. Differences between plica regions were evaluated using the Mann–Whitney U test. Associations between structural components of the plica were examined using non-parametric Spearman correlation analysis. The influence of factors such as sex, age, occupational type, and history of knee trauma on plica structure was analyzed using linear, logistic, or binomial regression models. A p-value ≤ 0.05 was considered statistically significant.

Results

According to histological analysis, the structural elements of the MPP (thickness 2.7 [1.7; 2.9] mm)

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were heterogeneous and demonstrated marked morphological variability. The plica consisted of a fibrous core with dense, wavy bundles of collagen fibers, while its surface was covered by synovial cells.

Two distinct regions were identified: marginal (facing the joint cavity) and paracapsular. The marginal region demonstrated greater variability than the paracapsular region. In some areas, synovial cells formed a thin lining, whereas in others hyperplasia and signs of productive inflammation were observed (Figs. 1, 2).

In specimens showing signs of ligamentous injury (presumably trauma-related), active regeneration was observed, characterized by newly formed connective tissue and neovascularization, along with local inflammatory infiltration. Within the fibrous core, nearly acellular areas with a high density of collagen bundles or homogeneous oxyphilic masses resembling hyalinization were identified. In samples with hyalinization features (n = 5; 41.6 %), plica thickness was significantly greater (β = 1.67; SE = 0.62; p = 0.02). At the same time, factors such as trauma history, occupational type, and sex were not significant predictors of the observed structural changes in this cohort (Table 1).

Statistical analysis of the relative density of tissue components in the MPP was performed. Four main tissue elements were identified: vascular structures;

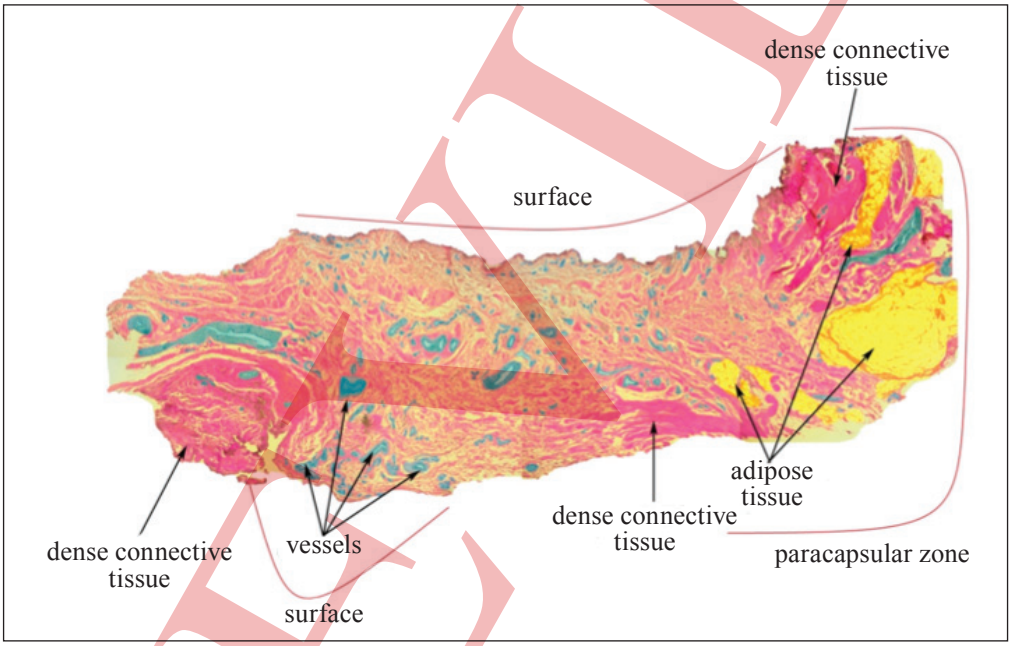


Fig. 1. Schematic representation of the structural elements of the MPP based on a histological micropreparation: yellow — adipose tissue; blue — vessels; pink — connective tissue.

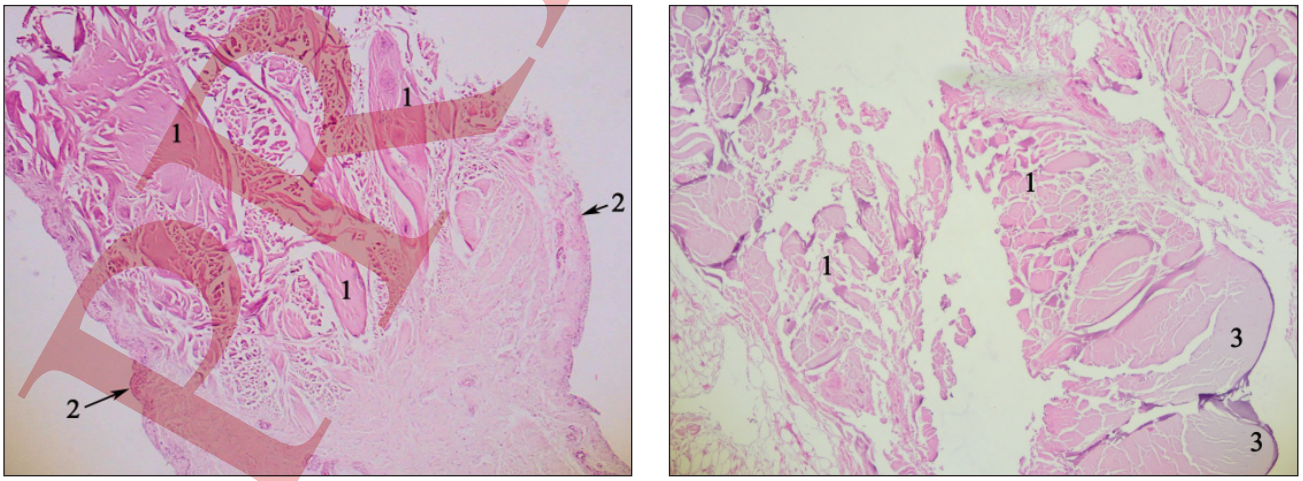


Fig. 2. Medial patellar plica of the synovial membrane of the knee joint: 1 — area of fibrosis; 2 — synovial membrane; 3 — area of fibrosis with signs of hyalinization. Staining: H&E. Magnification ×40.

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adipose tissue foci; connective tissue of varying density without fibrotic features or with dense collagen bundles; and poorly cellular or acellular homogeneous fibrotic tissue with features of hyalinization (Table 2). Overall, connective tissue accounted for approximately 91.4 (80.9; 95.1)% of the examined samples.

Despite pronounced morphological variability, a common finding was the difference between marginal and paracapsular regions in the proportion of fibrous connective tissue. The marginal region contained approximately 1.7 times more fibrous tissue ($p < 0.001$), whereas adipose tissue was observed mainly in the paracapsular region, which is explained by its anatomical continuity with the joint capsule. The relative density of non-altered connective tissue and vascular elements did not differ between the two regions. The morphological variability of both zones is likely driven by local tissue distribution patterns, as confirmed by correlation analysis (Table 3). A strong positive Spearman correlation was identified between vascular density in the plica and its thickness.

The potential association between MPP morphology and clinical parameters (age, sex, trauma history, and occupational type) was also evaluated. Spearman analysis demonstrated a correlation between vascular density and age (rho = 0.57; $p = 0.05$), which was further supported by linear regression analysis ($\beta = 0.12$; $p = 0.03$) (Table 4). A significant association was also

Table 1

Association of fibrotic changes in the MPP with patients' social factors using a binary logistic regression model

Variables in the regression model		Regression coefficient		
independent	dependent	β	SE	p-value
Fibrosis with signs of hyalinization	Injury (yes/no)	–0.47	1.40	0.74
	Male sex	12.24	876.10	0.99
	Type of work (heavy/light)	1.32	1.24	0.29

Table 2

Results of the analysis of differences in the distribution of tissue components between the paracapsular and marginal zones of the MPP of the knee joint

Plica zone	Tissue components in the plica, %			
	connective tissue		vascular	adipose tissue
	signs of fibrosis and hyalinization	without signs of fibrosis		
Entire plica	56.4 (37.3;64.2)	32.6 (24.5;42.2)	4.29 (2.95;5.22)	0[0;8.6] ; 11.8(6.3;20.8)*
Paracapsular zone	37.3 (22.4;46.8)	36.4 (27.9;43.8)	4.2 (3.3;5.0)	12.2 (3.1;37.8)
Marginal zone	62.7 (51.0;72.6)	31.8 (23.1;37.2)	4.3 (2.7;5.6)	0.0 (0;0.29)
Mann–Whitney U test	< 0.001	0.14	0.44	< 0.001

Note. * — linear regression.

Table 3

Correlation between tissue structures in the MPP of the knee joint

Plica zone	Tissue components in the plica, %			
	connective tissue		vascular	adipose tissue
	signs of fibrosis and hyalinization	without signs of fibrosis		
Connective tissue (fibrosis)	–0.65 (0.02)*	—	—	—
Vessels	–0.291 (0.35)*	0.17 (0.60)*	—	—
Adipose tissue	–0.75 (< 0.001)*	0.25 (0.44)*	–0.10 (0.75)*	—
Plica thickness	–0.31 (0.32)*	0.01 (0.97)*	0.80 (< 0.001)*	0.10 (0.75)*

Note. * p — statistical significance at $p \leq 0.05$.

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Table 4

Association of histological characteristics of the MPP with patients' social factors using linear or logistic regression models

Regression model factor		Regression coefficient		
незалежний	залежний	β	SE	p–value
Gender (male) *	plica thickness	1.51	0.96	0.15
	fibrosis area, %	–13.7	11.03	0.24
	non-fibrotic area, %	5.10	6.23	0.43
	vessels, %	2.11	1.47	0.18
	adipose tissue, %	5.76	9.12	0.54
Age *	plica thickness	–0.01	0.04	0.86
	fibrosis area, %	–0.66	0.42	0.15
	non-fibrotic area, %	0.53	0.19	0.02
	vessels, %	0.12	0.05	0.03
	adipose tissue, %	–0.09	0.37	0.80
Injury (yes/no) **	plica thickness	–158.6	$1.9 \cdot 10^5$	0.99
	fibrosis area, %	383.5	$3.8 \cdot 10^5$	0.99
	non-fibrotic area, %	456.2	$4.6 \cdot 10^5$	0.99
	vessels, %	284.3	$2.3 \cdot 10^5$	0.99
	adipose tissue, %	409.2	$3.7 \cdot 10^5$	0.99
Type of work (heavy/light) **	plica thickness	–168.4	$8.1 \cdot 10^4$	0.99
	fibrosis area, %	–63.7	$3.3 \cdot 10^4$	0.99
	non-fibrotic area, %	–34.7	$2.1 \cdot 10^4$	0.99
	vessels, %	193.1	$9.0 \cdot 10^4$	0.99
	adipose tissue, %	–28.8	$1.9 \cdot 10^4$	0.99

Notes: * — linear regression; ** — logistic regression.

found between age and the proportion of connective tissue with no clear signs of remodeling or fibrosis.

However, the relatively small sample size, morphological variability, and high dispersion of measured variables represent limitations of this study. These factors contributed to quasi-separation in logistic regression modeling; therefore, analysis of the relationship between hypertrophic plica changes and clinical–lifestyle factors requires further investigation in a larger cohort.

Discussion

Based on the results of the study of the MPP in patients with chronic pain, morphological heterogeneity of the plica was identified, which enabled zonal differentiation for a comprehensive morphometric assessment of its structure. The marginal zone of the MPP (facing the joint cavity) was found to contain a higher proportion of fibrous tissue, likely reflecting active reparative processes. In this study, no statistically significant association was found between pathological transformation of the MPP and a history of trauma, although the potential role of this factor cannot be entirely excluded. In contrast, pathological thickening of the MPP showed a clear relationship with the degree of hyalinization of the fibrous core and patient age. The observed age-related effect is consistent with previously reported data on age-associated hypertrophy of synovial plicae [12], although it should not be considered an independent predictor of plica hypertrophy. The present findings also indicate that the condition of the MPP is not determined by knee trauma, occupational or physical workload, or patient sex. It is therefore likely that the state of synovial plicae is influenced by multiple interacting factors. Accordingly, the relationship between pain syndrome and pathological changes in the MPP requires further investigation with a larger sample size and with specific assessment of neural elements within synovial plicae of the knee joint.

According to the literature, pain syndromes are associated only with certain morphological types of the MPP [11]. Type A (thin synovial fold) and type B (more prominent thin fold) do not interact with the medial femoral condyle and are not considered predictors of pain. In contrast, folds covering

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the medial femoral condyle (non-fenestrated type C and fenestrated type D) are associated with pain, as they tend to become stiffer and thicker with age, leading to entrapment between the patella and the medial femoral condyle. Type D plicae demonstrate greater clinical significance and more frequently trigger pain symptoms compared with type C. With aging, plica morphology changes independently of trauma history; elasticity decreases, and increased tension and mechanical pressure on the medial femoral condyle or the medial articular surface of the patella contribute to pain development [12]. In the present study, age-related changes were also observed, including an increase in MPP thickness accompanied by increased microvascularization. Other studies have reported neoangiogenesis in the context of fibrosis and inflammation [7], while hypertrophied plicae may partially transform into hyalin-like tissue and even undergo calcification [3, 4]. Some of these changes were also identified in the studied MPP samples, including increased thickness of the marginal zone due to hyalinization and pronounced remodeling of the fibrous core. However, no signs of calcification were detected. A limitation of this study is that the morphological type of the plicae was not considered, although fenestrated and non-fenestrated forms may have distinct structural characteristics.

Literature data also indicate that persistent contact between the plica and articular cartilage may lead to chondromalacia and cartilage erosion [13, 14]. This aspect was not addressed in the present study and will be evaluated in future work, as its investigation is important for clarifying the mechanisms underlying pain development. The occurrence of pain in the context of suprapatellar or medial patellar plica hypertrophy cannot be explained solely by biomechanical interaction with the articular surface. Although the exact mechanisms of pain remain unresolved, the identified morphological characteristics of MPP transformation provide further insight into plica hypertrophy in the context of age-related changes. Therefore, the study of synovial plica morphology in patients with pain syndrome has significant theoretical and practical relevance for orthopedics and traumatology.

Conclusions

In patients with chronic knee pain, the MPP demonstrates a fibrous core covered by a synovial lining and exhibits pronounced zonal heterogeneity in its structural organization.

A probable association was identified between changes in MPP thickness and age-related tissue remodeling, including hyalinization, regeneration, and microvascular proliferation within the fibrous stroma. These findings suggest that loss of elasticity and progressive thickening represent key morphological features of plica degeneration.

No statistically significant association was found between MPP morphology and history of trauma, sex, or type of occupational physical activity. This indicates that pathological transformation of synovial plicae is likely multifactorial in origin and warrants further investigation in larger clinical cohorts.

Conflict of interest. The authors declare no conflict of interest.

Prospects for further research. Future studies should focus on the suprapatellar and infrapatellar plicae, evaluate the relationship between articular cartilage changes and hypertrophic plicae, and further investigate the pathophysiological mechanisms underlying pain development in patients with synovial plica hypertrophy of the knee joint.

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Authors' contributions. Kostohryz O. A. — study conception, supervision, study design refinement, critical revision, synthesis of conclusions; Merezhko Ya. V. — study conception, data collection, manuscript drafting; Hrabovyi O. M. — histological analysis and interpretation of results; Savosko S. I. — histological analysis and statistical processing.

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HYPERPLASIA OF THE MEDIOPATELLAR PLICA OF THE KNEE JOINT IN PATIENTS WITH CHRONIC PAIN SYNDROME

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