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Degeneration grade of a femoropatellar joint and functional status of a knee joint

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SUMMARY

Aim of the paper: The aim of the study was to assess the impact of degeneration of femoropatellar joint cartilage on selected variables related with a knee joint function

Material and methods: The studied group consisted of 50 patients that were diagnosed, through ultrasonography, changes in femoropatellar joint cartilage according to the Outerbridge classification. The data was collected with usage of a self-designed questionnaire. The study included pain assessment according to the VAS scale, Zohlen's test, rectus femoris muscle test.

Results: There is statistically significant correlation between the grade of degenerative changes and age ($p<0.0001$), and the size of the body mass index ($p=0.0098$).

With the increase of the degenerative changes grade, the percentage of patients with the positive result of Zohlen's test, and with the positive result of the quadriceps muscle test increases significantly ($p=0.0001$). Also, it is observed more frequent ($p<0.0001$) presence of the fluid in case of the III and IV grades of degeneration.

With the increase of degeneration grade of cartilage, intensification of pain symptoms, measured in the VAS scale, significantly ($p=0.0083$) increases.

Statistically significant ($p=0.0001$) relationship was also observed between the presence of fluid in the joint and the result of the quadriceps muscle function test (with the presence of the fluid, the percentage of patients with the positive test result increases).

Conclusions: 1. Degenerative changes of femoropatellar joint cartilage affect quadriceps muscle dysfunction. 2. Pain symptoms of femoropatellar joint cause motion deformity of the knee joint. 3. Increased amount of the joint fluid is related with a higher grade of the joint degeneration.

INTRODUCTION

Anatomically, the femoropatellar joint is a part of the knee joint, although, biomechanically it is separate functional unit.

Patella plays a key role in the knee extension mechanism. It is located in the quadriceps muscle tendon. During flexion and extension motion, the patella glides about 5-7 cm on femur condyles. Contact of both articular surfaces starts at flexion the joint to about 20-30 degrees. During the motion the cartilages do not contact with oneself on the whole surface. Area of their contact expands with increase in the flexion angle and is the largest at 90-degree angle. Above this value, the contact area reduces and divides into two oval areas. Pressure force generated by a quadriceps femoris muscle acts similarly. Its value increases when flexing to 90 degrees and then decreases. Forces applied on the femoropatellar joint exceed body weight multiple times and result in long lever arms of thigh (femur) and lower leg. Patella has a key role in minimizing mechanical forces on the knee joint during motion [1,2].

Articular surfaces of the patella and the femoral bone are covered with a thick layer of smooth and resistant to friction hyaline cartilage. Its thickness in right conditions oscillates around 1-6 mm, depending on the location. Its thickest layer is present in the fibula patella [3, 4].

Both location and construction of the femoropatellar joint make it particularly vulnerable to injuries. Overweight, incorrect movement patterns, deviation of the limb axis and muscle tonus dysfunction cause of articular cartilage strain. Increased pressure of articular cartilage surface and femoral bones leads to premature cartilage wear. Softening changes, defibration, cartilage defects and cysts in the subchondral layer are leading to the development of arthrosis (gonarthrosis) Its result is the occurrence of hypersensitivity for friction and compression [5,6,7,8].

Pain, limited range motion, decrease of muscle strength, feeling of patella clicking and crepitation can be seen in a clinical picture. This affects the knee joint function limitation, problems with locomotion and lowering the quality of patients' life [5,9,10,11].

Ultrasonography is a recognized method of imaging structures of knee joint. It is widely used to assess cartilage changes of a femoropatellar joint. Grade of cartilage disintegration is described according to the Outerbridge four-level classification [1,2,4,7]. Availability and speed of the exam induced authors to use this method in the presented study. The aim of the study was evaluation of cartilage changes within a femoropatellar joint and their impact on a knee joint function.

MATERIAL AND METHODS

The study group consists of 50 patients (31 women and 19 men), who have been diagnosed with cartilage degenerative changes of the femoropatellar joint. The mean age was equal to 44.5±18.2 years, for half of the patients it did not exceed 45 years (IQR: 27-60).

Body mass index (BMI) in the studied group took values from 12.8 to 34.5 (mean: 24.8±4.1; median (IQR): 24.6 (22.2-27.2) kg/m^2). Most of studied subjects were people with normal weight (30 patients), 14 overweight people and 6 with I grade of obesity.

The data was collected with usage of a self-designed questionnaire. Criterion for study inclusion were cartilage degenerative changes of femoropatellar joint. Criterion for study exclusion was report of acute inflammation of the knee joint.

The Bioethics Committee of the Medical University of Łódz consent no. RNN/333/18/KE was obtained. The patients were informed about the study goal, they signed a written consent for conducting the studies. All patients were examined in accordance to the pre-set test protocol. The study included pain assessment according to the VAS scale. The Zohlen's test was used to assess the pain related to patellar compression. The rectus femoris muscle test was performed. Evaluation of a femoropatellar joint was made with usage of Echoson's ALBIT apparatus linear array transducer with 5-12MHz frequency according to the four-level Outerbridge scale. Evaluation of the amount of synovial fluid was performed with use of a linear array transducer with 10MHz frequency in the IP image of the suprapatellar recess joint area. Presence of synovial fluid above 4 mm was considered as positive result. The obtained data underwent statistical analysis.

STATISTICAL ANALYSIS

Quantitative variables were described by the mean and standard deviation (SD), median (Me) with interquartile range (IQR) and minimum and maximum (Min-Max). The number of observations (N) was provided for categorical (nominal) variables with the corresponding percentage (%).

To assess the relationships between the nominal variables Pearson's chi-squared test, ML chi-squared test or chi-squared test with the Yates's correction were applied (regarding the expected counts in the contingency tables). Cramer's V was calculated as a measure of the effect size (interpreting the values from 0.1 to 0.3 as the small effect; values from 0.3 to 0.5 as the intermediate effect and the values from 0.5 and higher as the strong effect).

The Spearman's rank correlation coefficient was used to assess the relationships between quantitative variables.

The results were considered statistically significant at $p < 0.05$.

The STATISTICA PL 13.3 software was used for calculations.

RESULTS

Fig. 1 presents patients structure according to the grade of degenerative changes. The III grade changes were most frequent (17 persons, 34%).

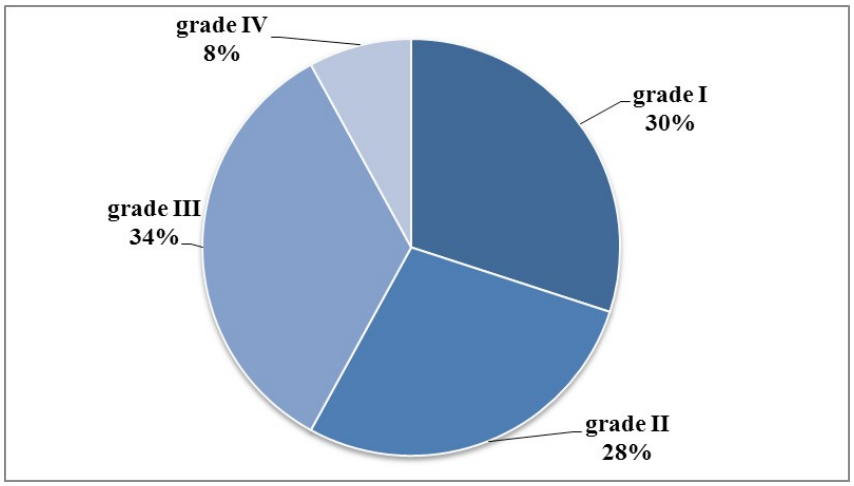

Fig. 1. Patients structure according to the grade of degenerative changes

No statistically significant differences were noted between men and women in view of degenerative grade (p=0.4878). However, it can be notice (see tab. 1) that IV grade changes were observed only in women.

Tab. 1. Grade of degenerative changes by gender

Gender		Degenerative grade				p-value	Cramer's V
		I	II	III	IV		
K	N	9	8	10	4	0.4878	0.2319
	%	29.0	25.8	32.3	12.9		
M	N	6	6	7	0		
	%	31.6	31.6	36.8	0.0		

To assess the relationships between age, BMI and the grade of degeneration, the Spearman's rank correlation coefficients were used. There was observed a statistically significant very strong positive correlation between the age and the grade of degenerative changes (R=0.8770; p<0.0001). It means that the grade of cartilage degeneration increases with age (see also fig. 2).

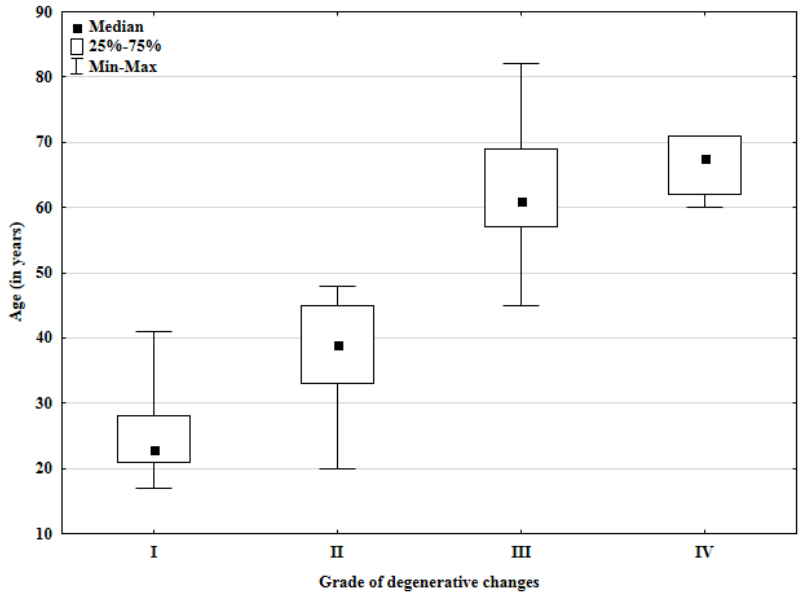

Fig. 2. Age comparison in groups by the grade of degeneration

Also, the presence of statistically significant positive correlation was observed of moderate strength between the body mass index (BMI) and the degeneration grade (R=0.3621; p=0.0098). With the increase of BMI ratio, the grade of cartilage degeneration increases (fig. 3).

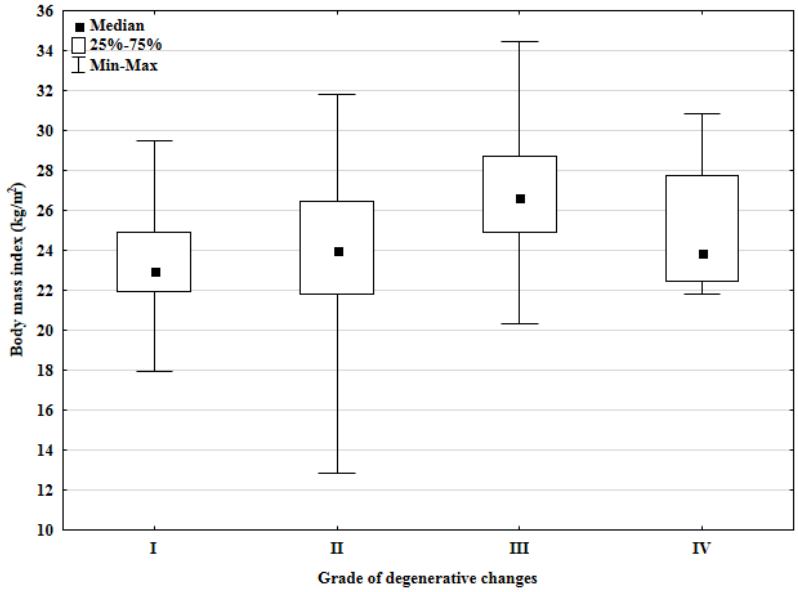

Fig. 3. Comparison of body mass index in groups by the grade of degenerative changes

In tab. 2 the effect of the cartilage degeneration grade on the results of the Zohlen's test, the rectus femoris muscle test and presence of fluid in the joint were assessed. In each case a statistically significant relationship was found.

Tab. 2. Assessing the impact of the degenerative changes on the Zohlen's test results, the rectus femoris muscle test results, and presence of fluid in the joint

Degenerative grade	N (%)	Zohlen's Test		Quadriceps muscle test		Fluid in the joint	
		no	yes	no	yes	no	yes
I	N	15	0	13	2	14	1
	%	100.0	0.0	86.7	13.3	93.3	6.7
II	N	14	0	12	2	11	3
	%	100.0	0.0	85.7	14.3	78.6	21.4
III	N	11	6	3	14	3	14
	%	64.7	35.3	17.6	82.4	17.6	82.4
IV	N	1	3	0	4	0	4
	%	25.0	75.0	0.0	100.0	0.0	100.0
p-value		<0.0001		0.0001		<0.0001	
Cramer's V		0.6102		0.7208		0.7296	

With the increase of degenerative changes grade, the percentage of patients with positive result of Zohlen's test and the rectus femoris muscle test increases. Also, it can be observed significantly more frequent presence of fluid in the joint when it comes to the III and IV grades of degeneration.

The results of the relationship assessment between the grade of degeneration and the occurrence of pain symptoms are presented in tab. 3.

There is no statistically significant association between variables (at $p<0.05$), however, it can be observed that with the increase of the degeneration grade, the percentage of patients with pain symptoms increases. In particular, at the IV degeneration grade, every patient has pain symptoms. A p-value equal to 0.0638 suggests that by increasing the sample size, one can get a statistically significant result.

Tab. 3. Assessment of the degeneration grade impact to the occurrence of pain symptoms

Degenerative grade	N (%)	Pain	
		no	yes
I	N	10	5
	%	66.7	33.3
II	N	8	6
	%	57.1	42.9
III	N	9	8
	%	52.9	47.1
IV	N	0	4
	%	0.0	100.0
p-value		0.0638	
Cramer's V		0.3385	

Taking into account the degree of severity of pain symptoms measured by the VAS scale, it was stated that Spearman's rank correlation coefficient equal to 0.3695 is statistically significant (p=0.0083) and its value indicates moderate positive correlation between the degeneration grade and severity of pain symptoms (higher degeneration grades were accompanied by severer pain symptoms).

Also, statistically significant relationship was observed (p=0.0001) between presence of the synovial fluid in the joint and result of the rectus femoris muscle test – in case of presence of the fluid, the percentage of patients with a positive test result definitely increases (see tab. 4).

Tab. 4. Assessment of the impact of the fluid presence in the joint on the results the rectus femoris muscle test

Fluid in the joint		Quadriceps muscle test		p-value	Cramer's V
		no	yes		
no	N	23	5	0.0001	0.5942
	%	82.1	17.9		
yes	N	5	17		
	%	22.7	77.3		

DISCUSSION

Conditions of the anterior knee compartment are very often clinical problem. Femoropatellar joints is subjected to significant strains resulting from its location and function. Walking on stairs, intensive motor activity and injuries affect the formation of strains and degenerative changes [1,6,7].

The degenerative changes within the joint cartilage depend on age [6,11,13]. Pop et al. by analyzing occurrence of gonarthrosis, they found that its frequency increases with age [14]. Similar dependence is presented by Jastrzębiec-Święcicka et al. [5]. In their study they found that age was significant in occurrence and progress of the gonarthrosis within the femoropatellar joint. The correlation results from natural process of reducing reparation functions and adding strains and injuries over the life span which result in deep and irreversible changes of the knee cartilage structure, without the possibility of reparation [11,13].

Gender is an important determinant of the occurrence of the gonarthrosis [10,11,15]. Jastrzębiec-Święcicka et al., Stevens-Lapssley et al. and Ząbek et al. found in their study

increased predisposition of women to have gonarthrosis [5,15,16]. It can be related to deficiencies of sexual hormones resulting from menopause [10,15]. In addition, high heels, increased pelvic anteversion and valgus knees (genu valgum, commonly called "knock-knee") disturb the walk biomechanic, and cause strains and degeneration of the knee joint [7]. In own study there were no statistically significant differences between men and women due to their occurrence of the cartilage changes. However, it was noted that the highest degree of cartilage wear concerned only women.

Obesity is an important factor of the knee joint cartilage degeneration [11,14,15]. The conducted study showed a statistically significant relationship between body mass index (BMI) and progress grade of degenerative changes in articular cartilage. The influence of overweight and obesity on the prevalence of the gonarthrosis is also confirmed by Alfieri et al., Chojnacki et al. and Jastrzębiec-Święcicka et al. [5,10,13]. Jasik et al. state that obesity is the second, right after age, negative factor conducing degenerative changes [6].

Pain is one of the most important criteria for assessing the clinical condition from the patient point of view. Even though, it is subjective sensation, it is often analyzed. On the basis of conducted study increased intensity of the symptoms was found with the degeneration grade of cartilage in the femoropatellar joint. Święcicka et al., emphasize that the pain is most common symptom of the gonarthrosis, which affects the increase of reflex muscle tension and leads to further strains of the passive joint elements [5].

Many authors pay attention to the patients' limitation of the joint mobility and functions gonarthrosis [17,18,19]. Additional changes within femoropatellar joint particularly affects dysfunction of quadriceps [7]. Mobility reduction in order to reduce the pain adversely affects muscle strength. Kim et al. when they were studying proprioception and isokinetic strength of the quadriceps, they found less strength and worse stability among female patients with pain symptoms caused by gonarthrosis [17]. Luc-Harkey et al. in the study evaluating the strength and function of the quadriceps muscle confirmed that greater muscle strength is associated with a better mobility and function, and lesser pain of knee joints that suffer from gonarthrosis [18].

In own studies, it is stated that wear of the femoropatellar joint cartilage limits the joint mobility. The higher grade of cartilage degeneration affected the occurrence of contracture of the rectus femoris muscle. During studying the pain symptoms related to patellar compression with use of Zohlen's test, the correlation between cartilage degeneration grade and pain was stated.

Clinical symptoms and conditions resulting from gonarthrosis gradually progress and lead to unfavorable compensation and further development of disorders. To slow down the development of the disease and improve the quality of life of patients, physiotherapy is commonly used. Scientific studies describe the beneficial effects of motion and physical stimuli on reducing pain and improving functioning [9,19]. Studies conducted by Bakhtiary et al. showed that the improvement in quadriceps strength among patients with changes within cartilage of femoropatellar joint, it reduces pain and improves joint function [20].

Gonarthrosis is very often accompanied by inflammation of the synovial membrane. The effect of this is the overproduction of synovial fluid. In the conducted studies, the relationship between the severity of degeneration of joint cartilage and the amount of synovial fluid was checked. Increased amount of synovial fluid was most common in joints with limited mobility and with a higher grade of cartilage wear. It should be noted that the excess fluid in the joint is also the result of degradation changes of other joint-forming structures (injury of meniscus, ligament, etc.) that have not been evaluated because they have not been studied.

This study is a preliminary report describing the impact of degenerative changes in femoropatellar joint cartilage on the function of the knee joint. The presented clinical material is too small to draw far-reaching conclusions and requires further research.

CONCLUSIONS

1. Degenerative changes of femoropatellar joint cartilage affect quadriceps muscle dysfunction.
2. Pain symptoms of femoropatellar joint cause limitation of knee joint mobility.
3. Increased amount of the joint fluid is related with a higher grade of the joint degeneration.

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