BALNEO RESEARCH JOURNAL
English Edition
eISSN 2069-7619 pISSN 2069-7597
ROMANIAN ASSOCIATION OF BALNEOLOGY

Evaluating risk factors involved in the alteration of biomechanics in relation to knee osteoarthritis

TUDORACHI Nicoleta-Bianca[1], EVA Iuliana[2], MOSCALU Mihaela[3], AL- HIARY Rami[1], MORARU Aurelian-Corneliu[4], BARBIERU Bogdan[2], STANCIU Costin[2], CORCIOVA Calin[3], ARDELEANU Valeriu[5]

Corresponding author: **Moscalu Mihaela**, E-mail: moscalu.mihaela@gmail.com

Balneo Research Journal DOI: http://dx.doi.org/10.12680/balneo.2019.305 Vol.10, No.4, December 2019 p: 574–579

1. „Ovidius" University of Constanta, Faculty of Medicine, PhD student, România
2. „Iacob Czihac" Emergency Military Clinical Hospital, Iasi, România
3. "Grigore T. Popa" University of Medicine and Pharmacy, Iasi, România
4. „Iacob Czihac" Emergency Military Clinical Hospital, Hospital Manager, Iasi, România
5. „Ovidius" University, Constanta, „Dunarea de Jos" University, Galati, General Hospital CF, Galati, România

Abstract
The knee joint is very complex in terms of degrees of mobility and for normal biomechanics it is necessary for all the anatomical structures at this level to be within physiological limits. Problems can be caused by a number of risk factors such as age, sex, weight, or local risk factors such as patellar changes represented by patela alta or patella baja, which can lead to instability of the lower limb. Risk factors that may influence the development and progression of knee osteoarthritis have been evaluated. Changes in patellar position in relation to knee osteoarthritis were also studied. A group of 377 patients hospitalized for unilateral or bilateral knee pain with instability were included in the study. 239 of the 377 starting group presented knee osteoarthritis, constituting the study group. The risk factors analyzed were age, patient sex, BMI, weight status, anatomical changes in position of the patella (patella alta and patella baja), COBB angle and spine deviation. The results indicated that obesity, anatomical changes in the position of the patella, (patella alta), COBB angle and spine deviations represent significant risk factors in the onset of knee osteoarthritis.

Key words: *risk factors, joint instability, knee osteoarthritis,*

Introduction

The knee is a very complex joint from a biomechanical point of view and for the joint to function properly it is necessary for all of the anatomical structures that make up the knee to be within normal limits (1).

The knee joint has a high degree of mobility in terms of flexion and extension, and is comprised of the femuro-tibial joint that has the role of bearing the weight of the body, and the patellofemoral joint with a role in reducing friction caused by muscle contractions (2).

There are various conditions that produce changes in the joint load distribution, which alter the mechanical properties at the level of the cartilage, muscles and ligaments as well as affecting their normal composition and structure (3).

Local risk factors that can lead to disturbances in knee joint biomechanics, such as anatomical changes in position involving the patella or abnormalities in the patellofemoral surface, in combination with a number of general risk factors (such as age, sex or obesity), in time could lead to osteoarthritis, in the absence of therapeutic measures (4,5).

Anatomical changes in patellar position are described using the terms patella alta and patella baja, both of which may be due to a congenital defect, however, patella alta could be the result of various conditions such as patellar dislocation, neurological pathologies or idiopathic.

Patella baja is associated with trauma, ischemia of the patellar ligament or with knee surgery (6).

In the context of local anatomical changes, alterations of the biomechanics lead to a reduction in the joint functions, in association with pain and instability, leading to progression of osteoarthritis in the femoral-tibial compartment (7).

The knee joint is one of the most frequently affected joints by osteoarthritis, along with the hip joint or interphalangeal joints (8).

One of the most frequently encountered articular pathology in the USA is osteoarthritis; 19% of adults aged 45 and above are affected, and the alarming fact is that the number of people diagnosed is constantly increasing, and despite the ongoing research so far, the clear causes of osteoarthritis have not been fully elucidated (9).

The purpose of this study is to evaluate the modification of patellar position in relation to knee osteoarthritis, and the risk factors involved in the development of knee osteoarthritis.

Material and methods

The retrospective study included 377 patients, admitted to the Emergency Military Clinical Hospital "Dr. Iacob Czihac" Iasi, between July 2017 and July 2018. The patients included in the study were hospitalized due to knee pain (uni- or bilateral), accompanied by instability.

The exclusion criteria from this study was a history of knee surgery. Radiographs were obtained with a conventional radiology machine: Telediagnostic Philips Optimies.

Measurements of the narrowing of the tibio-femoral joint space and the Insall-Salvatti index were performed on radiographs, digitized in the FCR Prima Console Viewer program.

In order to grade the severity of knee osteoarthritis, according to the Kellgren-Lawrence classification, radiographs of the knee in the anterior view in orthostatic position were studied.

I performed the measurements using as a reference the middle portion of the lateral and medial joint spaces of each knee, and determined the maximum height of the radiotransparent area between the edges of the tibio-femoral articular surfaces.

Radiographs that showed a joint space of less than 5 mm were graded according to the Kellgren-Lawrence classification.

The Kellgren-Lawrence classification (10):

- Grade 0: Absence of radiological changes;
- Grade 1: possible narrowing of the joint space with a tendency for osteophyte formation;
- Grade 2: detecting osteophytes and possible narrowing of the joint space;
- Grade 3: definite narrowing of the joint space, significant osteophytosis and possible bone deformities;
- Grade 4: marked narrowing of the joint space accompanied by deformations, bone sclerosis and major osteophytes.

Using the Kellgren-Lawrence classification, two study groups were established. The first group consisted of 138 patients without knee osteoarthritis (grade 0), the second group consisted of 239 patients with knee osteoarthritis (grades I-IV).

Patellar instability is caused by the abnormal positioning of the patella, characterized by high or low positions; patella alta and patella baja.

To determine the patellar position, I calculated the Insall-Salvatti index, which represents the ratio between the length of the patellar tendon and the height of the patella. Insall-Salvatti index normal values are between 0.8-1.2, an index lower than 0.8 suggests patella baja; and greater than 1.2, patella alta.

Technique: I evaluated lateral knee radiographs with the knee flexed at 30°. In order to determine the length of the patellar tendon, I measured the distance between the lower pole of the patella and the tibial tuberosity. To obtain the height of the patella, I measured the greatest pole-to-pole length.

Patients were classified according to weight and height using the BMI index: underweight - BMI <18.5; normal weight - BMI between 18.51 - 24.99; overweight - BMI between 25.00 - 29.99; grade I obesity - BMI between 30.00 - 34.99; grade II obesity - BMI between 35.00 - 39.99; morbid obesity - BMI of 40.00 or above.

The study evaluated the risk factors with significant predictability in the presence of knee osteoarthritis.

Results

In this study group 52.72% of cases had grade I knee osteoarthritis on the left while 51.88% had grade I knee osteoarthritis on the right. Grade II was found at 19.67% on the left and 20.92% on the right, III on 10.04% on the left, respectively 10.04% on the right, and Grade IV had a proportion comparable to the III, 10.04% on the left and 14.23% on the right (Table 1). The mean age in patients with knee osteoarthritis was significantly ($p < .001$) higher (64.39 ± 10.26) compared to the age of patients without knee osteoarthritis (43.83 ± 13.42).

Insall-Salvatti index on both left and right showed significantly higher values for patients with knee osteoarthritis ($P < .001$). Abnormal patella positioning such as patella alta frequency is 91.82% in patients with knee osteoarthritis, a significantly higher value ($p < .001$) compared to its frequency in the patients without knee osteoarthritis (8.18%). Also, the frequency of patella baja was significantly higher for patients with knee osteoarthritis (90.24%) (Table 1).

Spine deviations were represented in the study group of 95.24% dextroscoliosis and 99.01% levoscoliosis (Table 1).

Table 1. Characteristics of patients in the study group and the control group

	Knee osteoarthritis (n=239) †		Control group (n=138) †	Test statistic	p-value‡
Age (year)	64.39±10.26		43.83±13.42	-12.71	<.001*
Male/Female	86/153 (44.33%/83.61%)		108/30 (55.67%/16.39%)	62.60	<.001*
BMI	29.72±4.09		26.81±3.5	48.65	<.001*
Normal weight	20 (39.22%)		31 (60.78%)		
Over weight	113 (56.78%)		86 (43.22%)		
obesity grade I	91 (82.73%)		19 (17.27%)		
obesity grade II	12 (85.71%)		2 (14.29%)		
obesity grade III	3 (100%)		0 (0%)		
Kellgren-Lawrence classification	left	right		348.29	<.001*
Grad 0	18 (7.53%)	7 (2.93%)			
Grad I	126 (52.72%)	124 (51.88%)			
Grad II	47 (19.67%)	50 (20.92%)			
Grad III	24 (10.04%)	24 (10.04%)			
Grad IV	24 (10.04%)	34 (14.23%)			
Insall-Salvatti index left	1.18±0.14		1.07±0.13	4.393	0.0125*
Insall-Salvatti index right	1.29±0.12		1.09±0.13	4.006	0.0097*
Anatomical changes of position: patella: *norma / alta / baja left*	88(41.71%)/146(91.82%)/5(71.43%)		123(58.29%)/13(8.18%)/2(28.57%)	98.34	<.001*
normală / alta / baja right	86(41.75%)/148(90.24%)/5(71.43%)		120(58.25%)/16(9.76%)/2(28.57%)	92.73	<.001*
COBB angel (grade)	5.824±6.05		2.12±3.48	-3.842	.0001
Spine deviation				146.25	<.001*
Normal	79 (37.09%)		134 (62.91%)		
Dextroscoliosis	60 (95.24%)		3 (4.76%)		
Levoscoliosis	100 (99.01%)		1 (0.99%)		

† Values were expressed as number (%) mean ± SD or percent at%;
‡ ANOVA or Mann-Whitney U Test; Chi-square test or Fisher's exact test
(*) Marked effects are significant at p < .05

Table 2. Model coefficients and Wald test in logistic regression on predictive factors for knee osteoarthritis onset

Multiple regression, dependent variable: knee osteoarthritis onset	B	SE	Wald	Sig. p	Odd ratio Exp(β)	95% CI for Exp(B) Lower	Upper
Age	.694	.126	3.984	.026*	1.532	1.113	3.505
Female	1.687	.215	5.816	.003*	1.976	1.769	4.587
BMI	2.874	.307	4.682	.001*	2.064	1.668	5.669
Normal weight	.614	.019	.664	.237	.879	.687	.991
Over weight	.889	.208	.795	.069	.785	.432	.875
obesity grade I	2.684	.067	6.804	.004*	2.687	1.864	6.881
obesity grade II	3.632	.817	5.972	.002*	2.935	1.904	8.557
obesity grade III	3.314	.061	5.991	.000*	4.588	2.671	9.644
Anatomical position abnormality							
Patella alta	2.464	.154	9.331	.000*	5.971	4.677	9.471
Angel COBB	6.541	.249	5.615	.025*	3.587	1.694	7.871
Spine alignment							
dextroscoliosis	1.336	.607	10.063	.021*	2.571	1.864	3.541
levoscoliosis	1.864	.239	8.004	.038*	2.108	1.526	2.875

SE- standard error; 95%CI - Confidence Interval
(*) Marked effects are significant at p < .05

The assessment of the risk factors was performed on the basis of multiple logistic regression assessing the predictive power of several independent variables introduced simultaneously regarding the occurrence of knee osteoarthritis. Logistic regression (binomial: the present absence of an event) is a form of regression that is used when the dependent variable is dichotomous and the independent variables are of any type. Even if the independent variables are introduced in the model simultaneously, it will evaluate the degree of independent prediction for each variable, but the prediction will be adjusted considering the full context of the model. The variables included in the analysis, which in the univariate analysis (Table 1) showed a significant association with the presence of knee osteoarthritis. The independent variables (presumed predictive factors) introduced in the study were: age, female gender, BMI, obesity (normal weight, overweight, grade I obesity, grade II obesity, morbid obesity), anatomical position abnormality (patella alta), COBB angle, spine deviation (dextroscoliosis, levoscoliosis). The ENTER model was applied in which all the independent variables were introduced in one step.

The results indicated that the most significant risk factors are the presence of patella alta (OR=5.97, 95% CI: 4.677-9.471, p <.001), followed by obesity grade III (OR = 4.588, 95% CI: 2.671- 9.644, p <.001) and COBB angle value (OR = 3.587, 95% CI: 1.694, 7.871, p = .025) (Table 2). Although there is a slightly lower risk of spine deviation, BMI, female gender, and high age are important risk factors for knee osteoarthritis (p <.001) (Table 2).

Discussion

A normal patellar position is a very important element in the biomechanical function and its alteration is associated with the appearance of symptomatology (11).

In the literature, patellofemoral osteoarthritis is reported to affect 65% of persons aged over 50 years old (12) and the association of patellofemoral osteoarthritis with an abnormal patellar position is emphasized (13).

All the patients included in this study with at least grade 1 according to the Kellgren-Lawrence classification had patellofemoral osteoarthritis in varying degrees; further research is needed on this aspect.

Knee osteoarthritis is addressed in most studies as a combination of pathophysiological processes that produce cartilage destruction, pain and disability, which have an effect on the social and professional life of patients; this pathology in advanced stages produces disability (14,15) . Patients with knee osteoarthritis demonstrate instability during gait due to pain, with or without patellar height changes.

In this study a series of risk factors associated with the occurrence or progression of the pathology are represented by age, sex, body mass index, anatomical or biomechanical changes or various pathologies (Table 2), as well as the literature report (16). Although in theory, it can develop at any age, osteoarthritis is found especially in adults over 40 years old and affects both sexes.

Comparative studies in the international literature highlight an increased prevalence of knee osteoarthritis in women (17).

The results obtained from the group show the same conclusions and demonstrate that females are most affected by osteoarthritis (83.61%).

The data obtained in the study supports the research carried out so far and underlines that knee osteoarthritis has a high prevalence among individuals with high body mass index (29.7±4.09).

In a meta-analysis of the literature, it was demonstrated that obesity is the risk factor with a major impact on knee osteoarthritis, joint pain and functional impotence (18).

Given that obesity has the potential of being reduced, it is possible to propose a physical exercise program and a rigorous diet (19,20).

The findings of a recent study on the influence of changes in patellar position in patellofemoral osteoarthritis, using magnetic resonance investigations, conclude that patella alta is a predictive factor for lateral patellofemoral osteoarthritis (21). In the analyzed group, patients with knee osteoarthritis presented patella alta with a frequency of 91.82% on the left and 90.24% on the right. The Cobb angle showed a significantly higher mean value (p=.0001) in the study group 5.824±6.05 compared with the average value found in the patients in the control group 2.12±3.48.

Abnormal values of spine curvature angles, especially in the case of lumbar lordosis, has a positive association with knee osteoarthritis, explained by the fact that the spine forces the patient to bend their knees to maintain their centre of gravity (22).

Maintaining the physiological alignment in the sagittal plane at both the spine, the hip joints and the knee is essential for the prevention of increased mechanical stress in any of these segments, and for this, researchers emphasize the importance of postural and gait correction (23, 24).
B. Supartono outlines in his study that the changes in spine alignment have a great influence on the installation and progression of knee osteoarthritis, the risk being 7.5 times higher in patients with moderate changes in the Cobb angle (25).
The literature highlights the importance of detecting risk factors in the installation and progression of knee osteoarthritis and also underlines and attempt to eliminate or reduce them (26, 27).

Conclusion
Unfortunately, knee osteoarthritis cannot be treated curatively yet; it is important to evaluate and eliminate risk factors involved in its installation and progression as much as possible. Risk factors such as obesity, anatomical changes in position and spinal deviation may be considered to prevent the installation of knee osteoarthritis.
Since a vicious cycle is generated by the fact that joint instability influences the installation and progression of osteoarthritis, which in turn aggravates instability, it is important to take measures to eliminate them.
Pain and functional impotence are important causes of disability. Pain and its psychological impact are subjective from one individual to another and it offers researchers perspectives that can aid doctors in their practices, since in general a physician's view on the real degree of the loco-regional changes can be distorted by the patient.

Acknowledgement
All authors have equal contribution.

References

1. Stefano Zaffagnini, David dejour, Alberto Grassi, et al. Patellofemoral anatomy and biomechanics: current concepts Joints. 2013; 1(2):15–20.
2. Jawad F. Abulhasan, Michael J. Grey Anatomy and physiology of knee stability J Funct Morphol Kinesiol. 2017: 2:34.
3. Farshid Guilak Biomechanical factors in osteoarthritis Best Pract Res Clin Rheumatol. 2011;25(6):815-823.
4. Farshid Guilak, Ph.D. Biomechanical factors in osteoarthritis Best Pract Res Clin Rheumatol. 2011; 25(6): 815–823.
5. Ashraf Ramadan Hafez, Aqeel Mohammed Alenazi, Shaji John Kachanathu, Abdulmohsen Meshari Alroumi and Elham Saed Mohamed Knee osteoarthritis: A review of literature Phys Med Rehabil Int. 2014;1(5): 8.
6. Konstantinos Anagnostakos, Olaf Lorbach,Sarah Reiter,Dieter Kohn Comparison of five patellar height measurement methods in 90° knee flexion Int Orthop 2011;35(12):1791–1797.
7. E.M. Macri, D.T. Felson, Y. Zhang, et al. Patellofemoral morphology and alignment: reference values and dose-response patterns for the relation to MRI features of patellofemoral osteoarthritis Osteoarthritis and Cartilage 2017;25(10):1690-1697.
8. Belluzzi E, El Hadi H, Granzotto M, et al. Systemic and Local Adipose Tissue in Knee Osteoarthritis J Cell Physiol. 2017;232(8):1971-1978.
9. Ian J. Wallace, Steven Worthington, David T. Felson, et al. Knee osteoarthritis has doubled in prevalence since the mid-20th century Proc Natl Acad Sci U S A. 2017;114(35): 9332–9336.
10. Mark D. Kohn BA, Adam A. Sassoon, Navin D. Fernando, Classifications in Brief: Kellgren-Lawrence Classification of Osteoarthritis Clin Orthop Relat Res.2016;474(8): 1886–1893.
11. Fitzpatrick CK, Baldwin MA, Laz PJ, FitzPatrick DP, Lerner AL, Rullkoetter PJ Development of a statistical shape model of the patellofemoral joint for investigating relationships between shape and function. J Biomech. 2011;44(13):2446-52.

12. E.M. Macri, D.T. Felson , Y. Zhang, et al. Patellofemoral morphology and alignment: reference values and dose-response patterns for the relation to MRI features of patellofemoral osteoarthritis Osteoarthritis and Cartilage 2017;25(10):1690-1697.
13. Lu W, Yang J, Chen S, Zhu Y, Zhu C Abnormal Patella Height Based on Insall-Salvati Ratio and its Correlation with Patellar Cartilage Lesions: An Extremity-Dedicated Low-Field Magnetic Resonance Imaging Analysis of 1703 Chinese Cases. Scand J Surg.2016;105(3):197-203.
14. Jones G What's new in osteoarthritis pathogenesis? Intern Med J. 2016;46(2):229-36.
15. Spinoso DH, Bellei NC, Marques NR, Navega MT Quadriceps muscle weakness influences the gait pattern in women with knee osteoarthritis Adv Rheumatol.2018;58(1):26.
16. Behzad Heidari Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I Caspian J Intern Med 2011;2(2): 205–212.
17. Plotnikoff R, Karunamuni N, Lytvyak E, et al. Osteoarthritis prevalence and modifiable factors: a population study BMC Public Health.2015;15:1195.
18. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis Osteoarthritis Cartilage. 2015;23(4):507-15.
19. Brosseau L, Taki J, Desjardins B, et al. The Ottawa panel clinical practice guidelines for the management of knee osteoarthritis. Part two: strengthening exercise programs Clin Rehabil.2017;31(5):596-611.
20. Yázigi F, Espanha M, Marques A, Teles J, Teixeira P Predictors of walking capacity in obese adults with knee osteoarthritis Acta Reumatol Port.2018;43(4):256-263.
21. Haj-Mirzaian A, Guermazi A, Pishgar F, et. al. Association of patella alta with worsening of patellofemoral osteoarthritis-related structural damage: data from the Osteoarthritis Initiative Osteoarthritis Cartilage. 2019;27(2):278-285.
22. Ryoji Tauchi , Shiro Imagama, Akio Muramoto, Masaki Tsuboi, Naoki Ishiguro, Yukiharu Hasegawa Influence of spinal imbalance on knee osteoarthritis in community-living elderly adults Nagoya J Med Sci. 2015;77(3): 329–337.
23. W. J. Wang, F. Liu, Y.W. Zhu, M.H. Sun, Y. Qiu, W. J. Weng Sagittal alignment of the spine-pelvis-lower extremity axis in patients with severe knee osteoarthritis Bone Joint Res. 2016; 5(5): 198–205.
24. Hiroshige TATEUCHI Gait- and postural-alignment-related prognostic factors for hip and knee osteoarthritis: Toward the prevention of osteoarthritis progression Phys Ther Res. 2019; 22(1): 31–37.
25. B. Supartono, R. Gamma, S. Wiyono, S. Yuli The influence of scoliosis towards secondary osteoarthritis of the knee joint in athletes BMJ Journals 2016;50(1)A33.1-A33.
26. Michl GL, Katz JN, Losina E Risk and risk perception of knee osteoarthritis in the US: a population-based study. Osteoarthritis Cartilage. 2016;24(4):593-6.
27. Boiculese, V. Lucian, Dimitriu, Gabriel, Moscalu, Mihaela, Nearest neighbor classification with improved weighted dissimilarity measure, Proceedings of the Romanian Academy Series A-Mathematics Physics Technical Sciences Information Science, 2009;10(2): 205-213.