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PATELLOFEMORAL JOINT – MORPHOLOGY, DYSPLASIA AND INFLUENCE ON THE ONSET OF CHONDROMALACIA OF THE PATELLA

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PATELOFEMORALNI ZGLOB - MORFOLOGIJA, DISPLAZIJA I UTICAJ NA RANI NASTANAK HONDROMALACIJE PATELE

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ABSTRACT

The patellofemoral joint, the anterior compartment of the knee, undergoes the earliest degenerative changes throughout life and joint morphology is of great importance in the appearance of pain in the anterior knee and chondromalacia of the patella. Chondromalacia of the patella is a progressive disease with a change in normal morphology and structure, with the formation of minor or major defects in the cartilage itself and represents a significant socioeconomic problem because it occurs in young, physically active people. Quadriceps wasting, patellofemoral crepitus, and effusion are obvious clinical indications. In addition, radiological examinations are also necessary for diagnosis. Magnetic resonance imaging (MRI) is a non-invasive diagnostic method, which promises a unique ability to potentially identify cartilage lesions.

Key words: *patellofemoral joint; anatomy; Chondromalacia Patellae.*

SAŽETAK

Patelofemoralni zglob, prednji kompartment kolena, tokom života podleže najranijim degenerativnim promenama i brojne su studije koje su ispitivale značaj morfologije zgloba u pojavi bola u prednjem kolenu i hondromalaciji patele. Hondromalacija patele je progresivno oboljenje sa izmenom normalne morfologije i građe, sa stvaranjem manjih ili većih defekata u samoj hrskavici i predstavlja značajan socioekonomski problem jer se javlja kod mladih, fizički aktivnih osoba. Hipotrofija m. quadricepsa, patelofemoralne krepitacije i otok kolena očigledne su kliničke manifestacije stanja. Osim toga, radiološki pregledi su takođe neophodni za dijagnozu. Magnetna rezonanca (MR) neinvazivna je dijagnostička metoda, koja omogućava suverenu identifikaciju lezija hrskavice.

Ključne reči: *patelofemoralni zglob; anatomija; hondromalacija patele.*

INTRODUCTION

The knee is the largest joint in the human body and is a complex structure and consists of three functional entities, compartments, a patellofemoral (PF) joint, and two compartments of the femorotibial (FT) joint, internal and external (1). The PF joint is a joint between the anterior segment of the distal end of the femur, the trochlear groove, and the posterior surface of the patella with associated soft tissue and medial and lateral patellar retinaculum. The normal function of the joint depends on the congruence of the articular surface of the patella and trochlea and is important for stability in the complete knee joint (2).

The articular surface of the patella is located in front of the articular surface of the trochlea, on which it lies whenever the knee is in flexion and then the patella exerts strong pressure on the femoral condyles, suppressing them backward. Measuring suppression of the femur condyle prevents crossed links of the knee joint. Developmental or acquired malformations in the morphology of the PF joint are associated with a number of clinical problems such as patellar instability, chondromalacia of the patella, and consequently anterior knee pain (3-5).

The patella is a large sesame bone incorporated into the tendon of the quadriceps muscle. The posterior surface of the patella represents an articular surface, composed of several facets, external and internal with a ridge between and with a small odd facet medially. The medial surface is usually smaller in area. This vertical ridge normally lies on the hip bone pulley and usually corresponds in size to each other (1, 2, 5). The patella increases the mechanical capabilities of the extensor muscles by transferring the power of the extensor along the knee at a greater distance from the central axis of rotation (5). The articular surfaces of the femur and the patella are covered with specialized

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connective tissue, hyaline cartilage, different thickness, from 2 to 6 mm, and complex and unique structure and its integrity is important for the proper functioning of the joint (6).

Cartilage is extremely smooth, elastic, and capable of withstanding the high pressure that occurs even with normal movements in the joint and facilitates the transfer of loads with a low coefficient of friction. Macroscopic and microscopic analyses have shown that the composition of cartilage is not the same in each segment, but is divided into layers, depending on the orientation of collagen fibers and chondrocyte density. Cartilage has no blood, lymphatic vessels, and nerves. Due to its low recovery capacity, its preservation is essential for the function of the joint, which depends on its architecture (7). Cartilage consists of an extracellular matrix and highly specialized cells, i.e. chondrocytes. EMC consists of water, collagen, proteoglycans, and non-collagenous proteins. All these elements act on water retention within the extracellular matrix, which is crucial for maintaining the mechanical properties of cartilage (8).

ARTICULAR CARTILAGE IS COMPOSED OF SEVERAL ZONES

The surface area of cartilage, tangential or superficial zone, protects deep layers of cartilage from stress, contains collagen fibers (type II and type IX) whose fibrils are placed in parallel relative to the outer surface, and makes up 10-20 % thickness of cartilage. The preservation of this zone is important for maintaining deep layers of cartilage. The superficial zone is in contact with synovial fluid and is responsible for tightening the cartilage which allows it to resist strain and load.

The second zone, transitional, anatomically, and functionally connects the superficial and deep cartilage zone. It occupies about 40-60 % of the total thickness of cartilage and contains proteoglycans and collagen fibrils. In this zone, collagen fibrils are obliquely placed, and chondrocytes are spherical in shape with a low density. Functionally, it is the first line that provides resistance to the load force.

The deep zone provides the strongest resistance to the load, given that collagen fibers are placed vertically relative to the cartilage. It contains collagen fibers with the largest diameter, the most proteoglycans, and the least water. Chondrocytes are typically arranged parallel to collagen fibrils and perpendicularly on the joint line. It accounts for about 30% of the total thickness of cartilage.

The deepest layer, the calcified zone, separates the cartilage from the subchondral bone and is due to the small number of cells and low metabolic activity. These cells are unique due to the synthesis of collagen type X (9-11, 16, 17).

CARTILAGE DAMAGE CAN BE POST-TRAUMATIC OR DEGENERATIVE

Changes in patella cartilage can be divided into four degrees (Outerbridge classification):

- Gradus I - the appearance of abnormalities, there is swelling of cartilage, which is registered as hyperintensity of the signal on MRI scans with normal, smooth contours of cartilage
- Gradus II- present fragmentation, swelling, and damage to the surface of cartilage in smaller areas, affected by less than 50% of the thickness of cartilage.
- Gradus III - changes affected by more than 50% of cartilage thickness without edema of the subchondral bone, present ulceration, and fragmentation of larger segments of cartilage
- Gradus IV - present large defects in cartilage with loss of cartilage thickness with edema of the subchondral bone marrow. (13, 14)

MORPHOLOGICAL CHARACTERISTICS OF THE ANTERIOR COMPARTMENT OF THE KNEE JOINT

The morphological characteristics of the patellofemoral region can be accurately measured in magnet resonance imaging (MRI), in the axial and sagittal planes, using standard sequences, T1-weighted, and fat-suppressed proton density sequences. (15-19)

1. Patella type (according to Wiberg there are three types, modified classification according to Baumgartl with four types of patella), types I and II are the most common and they correspond to trochlea of normal morphology in their form, and generally are not the cause of chondromalacia, types III and IV make the PF joint incongruent, and can cause early chondromalacia; figure 1.

   1) Type I – medial and lateral facets are almost equal in size

   2) Type II – lateral facet is dominant and medial is smaller in size

   3) Type III – very small medial facet, lateral is dominant

   4) Type IV – lateral facet is the only one that participates in PF joint, medial is almost vertical

2. Insall-Salvati index (ratio of the largest vertical length of the patella to the ligament of the patella on the sagittal image of the wrist) – normal value 0.8-1.2; A value over 1.2 indicates patella alta (longer patellar ligament, more unstable patella in PF joint), and values lower than 0.6 indicate patella baja, (short patellar ligament or long patella, more unfunctional PF joint); figure 2a)

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3. Caton-Deschamp index (ratio of patella cartilage height and distance from the lower edge of the patella cartilage to the front edge of the tibia plateau) – normal value 0.6-1., (higher or lower value can cause OA of the joint); figure 2b)
4. Patella-ligament patella angle (angle between lines shouted through the longest diameter of pallet height and patella ligaments), a new parameter that can safer predicts the possible onset of chondromalacia; figure 2c)
5. Ventral trochlear prominence (sagittal plane, the distance of parallel lines drawn through the anterior contour of the femoral diaphysis and the most prominent point of the cartilage trochlea), the value over 8 mm is significantly associated with trochlear dysplasia and early onset of chondromalacia; figure 2d)
6. Transverse diameter of the patella (mean value about 38 mm), significantly narrower or wider patella makes the joint more unstable and leads to an earlier occurrence of chondromalacia; figure 3a.
7. Trochlear depth (the ratio of the height of the medial and lateral condyle and the line that connects the bottom of the trochlea with the line joining posterior edge of both condyles of the femur), a depth of less than 3 mm indicates a certain dysplasia of the trochlea, makes the joint unstable and is significantly associated with the early onset of chondromalacia; figure 3b)
8. Sulcus angle (the angle between the lines drawn from the center of the trochlea towards the highest points of the anterior segment of the medial and lateral condyle of the femur), normal value is around 135 degrees, greater angle represents a shallow trochlear groove and unstable PF joint; figure 3c)
9. Asymmetry of trochlear facets, the ratio of lateral and medial facets of the trochlea, a value of less than 40% indicates a trochlear dysplasia and can lead to early chondromalacia; figure 3d)
10. Patellar lateralization (the distance between the most lateral point of the patella and the line parallel to the outer cortex of the femoral condyle), the value over 6mm has a big correlation with the trochlea dysplasia; very important for patellofemoral stability; figure 3e)
11. Lateral trochlear inclination (the angle between the line connecting the posterior contours of both femoral condyles and the line parallel to the subchondral bone of the lateral facet of the patella), the value over 11 degrees is significantly related to the diagnosis of trochlear dysplasia and significantly affects the early onset of chondromalacia of the patella; figure 3f)

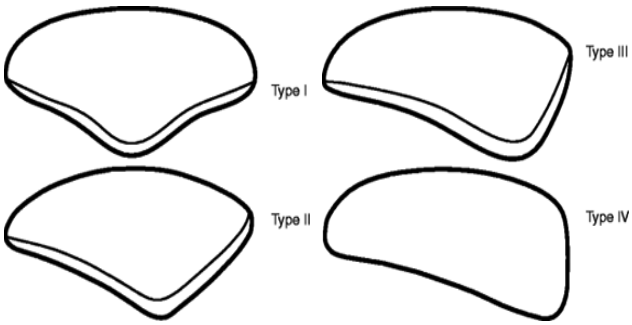

Figure 1: Type I-III Wiberg patellar classification, Type I- IV Baumgartl modified classification, (type IV, no medial facet "jockey cap")

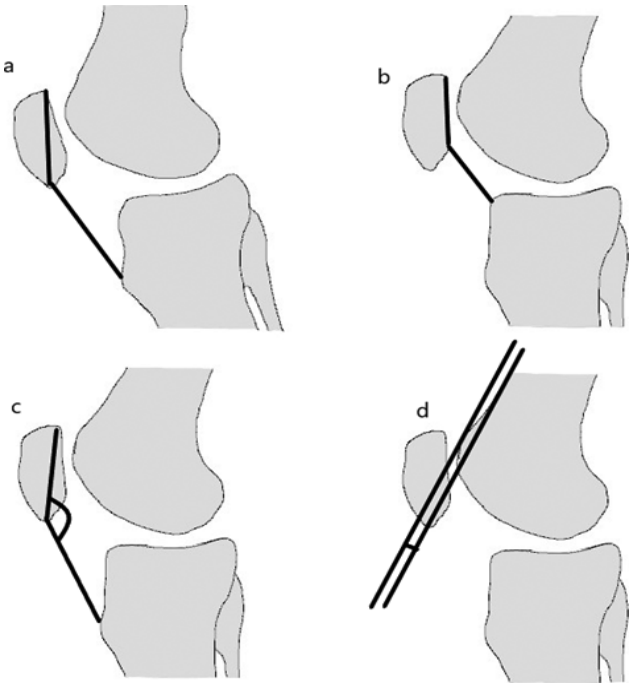

Figure 2: sagittal plane; a) Insall-Salvati index, b) Caton-Deschamp index, c) patella-ligament patella angle, d) ventral trochlear prominence

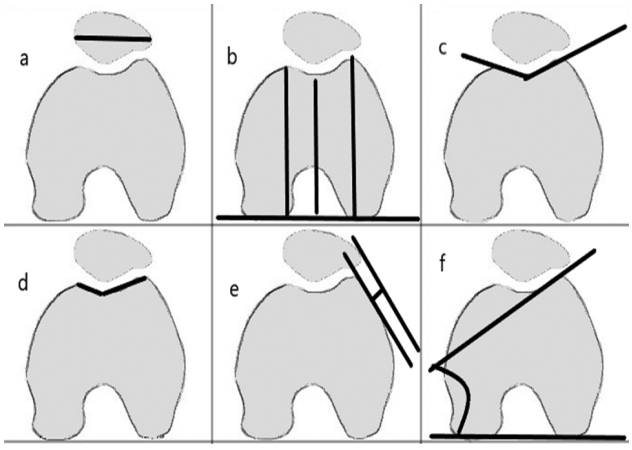

Figure 3: axial plane; a) transversal diameter of the patella, b) trochlear depth, c) sulcus angle, d) trochlear articular facet asymmetry, e) patellar lateralization, f) lateral trochlear inclination

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IMAGE METHODS FOR PF JOINT

Conventional radiology cannot see chondral tissue, only bones. So, joint space that can be seen in radiography can give us some basic information about the thickness of the joint chondral tissue. Using sagittal and coronal radiography and special axillar radiography of the patellofemoral joint we can measure some of the numerous morphological characteristics of the PF joint, but not all of them (20-22, 24). Also computed tomography (CT), can give us limited information about chondral tissue, but we can measure all of the morphological characteristics of the joint. Ultrasound has a minor role in the visualization of the patellofemoral joint characteristics and can only detect characteristics of trochlear chondral tissue, its thickness, and surface area. Magnetic resonance imaging (MRI) is a superior method for visualization of the knee and patellofemoral joint and all its structures. Using sagittal and axillar plains, we can measure all morphological characteristics of the PF joint and see chondral tissue (23).

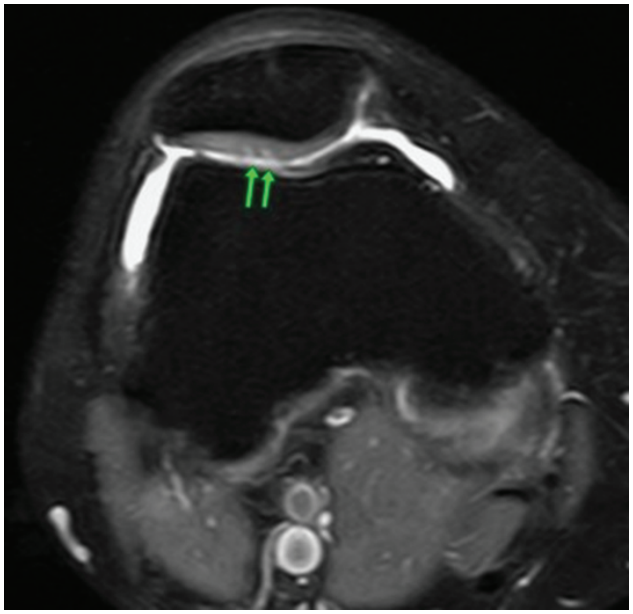

Figure 4: Axial plane, FS-PD, chondromalacia of the patellar lateral facet, gradus II and trochlear articular facet asymmetry

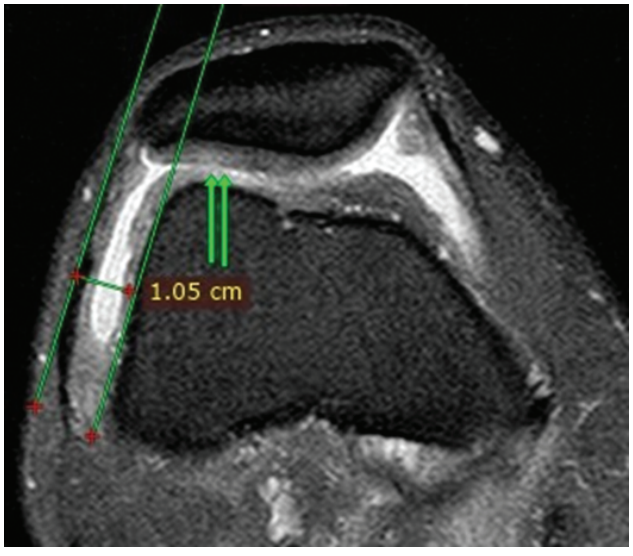

Figure 5: Axial plane, FS-PD, chondromalacia of the patellar lateral facet, gradus I, patellar lateralization over 10 mm

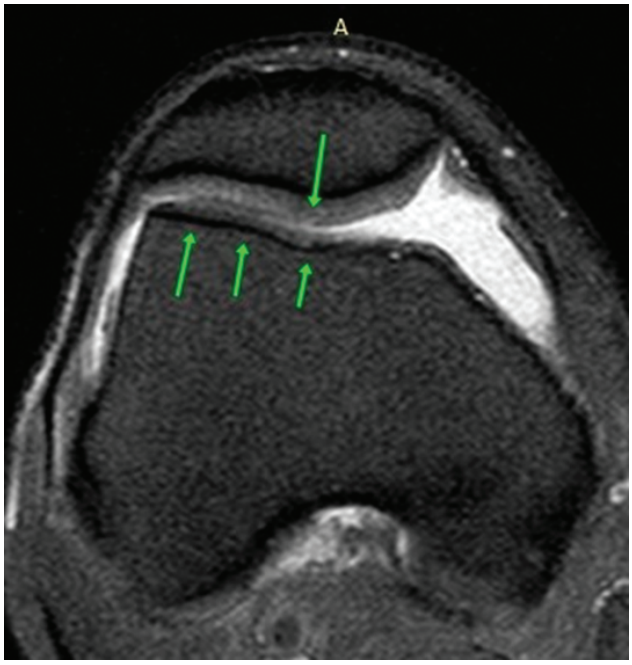

Figure 6: Axial plane, FS-PD, chondromalacia of the patellar lateral facet, gradus I

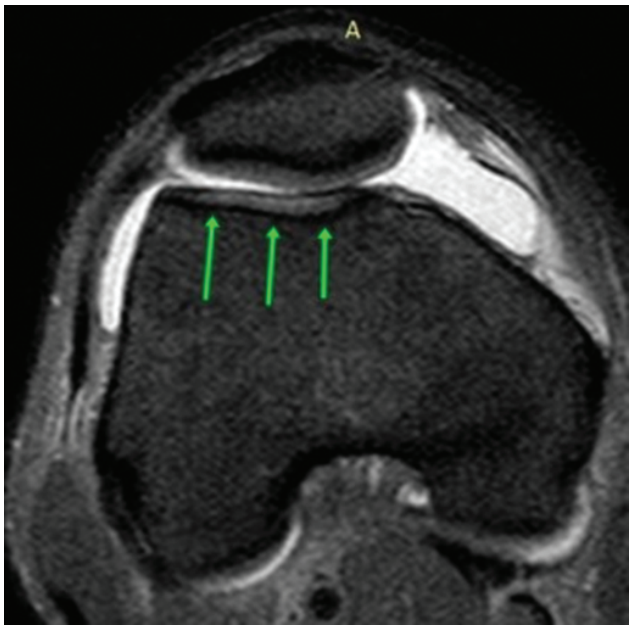

Figure 7: Axial plane, FS-PD, no chondromalacia, sulcus angle over 150 degree

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CONCLUSION

Morphology of the patellofemoral joint is very important for stable and functional knee joints. Dysplasia of this joint can lead to chondromalacia of the patella and anterior knee pain syndrome which represents a significant socioeconomic problem because it occurs in young, physically active people. Using MRI in the early stage of anterior knee pain syndrome and knowing the normal morphology of the PF joint, with adequate changing of lifestyle, physical procedures, and if necessary some orthopedics procedures we can prevent pathological changes of the chondral tissue and early appearance of osteoarthritis of the knee.

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