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CLINICAL RESEARCH / KLİNİK ARAŞTIRMA

The Relationship Between Suprapatellar Fat Pad Edema/Mass Effect and Sagittal Alignment of the Patellofemoral Joint

Suprapatellar Yağ Yastığı Ödemi/Kitle Etkisi ile Patellofemoral Eklemin Sagital Dizilimi Arasındaki İlişki

Elif Günaydın[1], **Semra Duran**[2]

[1]Yüksek Ihtisas University Faculty of Medicine, Department of Radiology, Ankara, Turkey
[2]University of Health Sciences Turkey, Ankara Bilkent City Hospital, Clinic of Radiology, Ankara, Turkey

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Abstract

Objective: This study aimed to compare the measurements of the sagittal alignment of the patellofemoral joint on magnetic resonance (MR) images between patients with suprapatellar fat pad edema/mass effect and a gender and age-matched control group of patients without suprapatellar fat pad edema.

Methods: A total of 55 patients with suprapatellar fat pad edema/mass effect was compared with the control group with anterior knee pain. Suprapatellar fat pad edema/mass effect and sagittal alignment of the patellofemoral joint were evaluated from the sagittal MR images. Sagittal alignment was evaluated using the Insall-Salvati (IS) ratio, patella-patellar tendon (P-PT) angle, and quadriceps tendon-P (QT-P) angle. The measurements were also compared between the two groups.

Results: The mean IS ratio, and P-PT angle did not significantly differ between the two groups ($p>0.05$). The mean QT-P angle was significantly higher in patients with suprapatellar fat pad edema/mass effect than in the control group ($p=0.01$).

Conclusion: The suprapatellar fat pad edema/mass effect is not associated with the sagittal alignment of the patellofemoral joint. The QT-P angle was higher in patients with a mass effect on the suprapatellar fat pad.

Keywords: Suprapatellar fat pad, edema, magnetic resonance imaging

Öz

Amaç: Bu çalışmanın amacı suprapatellar yağ yastığında ödemi/kitle etkisi bulunan hastalar ile suprapatellar yağ yastığında ödem olmayan cinsiyet ve yaş eşleştirilmeli kontrol grubu arasında manyetik rezonans (MR) görüntülemede patellofemoral eklemin sagital dizilim ölçümlerini karşılaştırmaktır.

Yöntem: Suprapatellar yağ yastığında ödem/kitle etkisi olan 55 hasta anterior diz ağrısı olan kontrol grubu ile karşılaştırıldı. Suprapatellar yağ yastığı ödem/kitle etkisi ve patellofemoral eklemin sagittal yerleşimi sagittal MR görüntülerinde değerlendirildi. Sagital yerleşimi Insall-Salvati (IS) oranı, patella-patellar tendon (P-PT) açısı ile kuadriceps tendon-P (KT-P) açısı ile incelendi. Bu ölçümler iki grup arasında karşılaştırıldı.

Address for Correspondence/Yazışma Adresi: Semra Duran MD, University of Health Sciences Turkey, Ankara Bilkent City Hospital, Clinic of Radiology, Ankara, Turkey
Phone: +90 312 562 00 00 **E-mail:** semraduran91@gmail.com
ORCID ID: orcid.org/0000-0003-0863-2443

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Öz

Bulgular: Ortalama IS oranında, P-PT açısında iki grup arasında fark saptanmadı (p>0,05) ortalama KF-P açısı kontrol grubundan suprapatellar yağ yastığında ödem/kitle etkisi bulunan grupta büyüktü (p=0,01).

Sonuç: Suprapatellar yağ yastığında ödem/kitle etkisi ile patellofemoral eklemin sagital yerleşimi ilişkili değildir. KF-P açısı suprapatellar yağ yastığında kitle etkisi olan hastalarda büyüktür.

Anahtar Kelimeler: Suprapatellar yağ yastığı, ödem, manyetik rezonans görüntüleme

Introduction

The knee has three anterior fat pads: the infrapatellar fat pad, also known as Hoffa's fat pad, the anterior suprapatellar (quadriceps), and the prefemoral (posterior suprapatellar) fat pads. Suprapatellar fat pads are the smallest of the three fat pads and bordered anteriorly by the distal quadriceps tendon, inferiorly by the patella with retropatellar cartilage surface, and posteriorly by the suprapatellar recess of the knee joint[1-5]. They act as a protective cushion between the quadriceps and patellar tendon, patella, and distal femur, prevent friction and improve patellofemoral engagement during deep knee flexion and extension[3,5]. In infrapatellar fat pad impingement syndrome (Hoffa's disease), the cause is usually due to single or repetitive traumatic episodes; the inflamed fat pad then becomes hypertrophied with a predisposition to impingement between the tibia and femur. Magnetic resonance imaging (MRI) is the method of choice for analysing Hoffa's fat pad. An areas of increased signal intensity on T2- weighted MRI represent acute edema and hemorrhage within the swollen fat. Bowing of the patellar tendon from the mass effect is frequently seen[1,3,6-8]. We noted similar MRI findings in patients with suprapatellar fat pad edema. To the best of our knowledge, there are no studies have showing the effect of the edematous suprapatellar fat pad on the quadriceps tendon. The cause of suprapatellar fat pad edema is unknown. In the literature, few studies have evaluated the sagittal alignment of the patellofemoral joint using MRI and its relation to suprapatellar fat pad edema/mass effect[1,4]. Previous studies have revealed that the measurement of the Insall-Salvati (IS) ratio is primarily used to assess the sagittal plane alignment of the patella. Another measure of sagittal plane alignment that has recently been reported in the literature is the sagittal patellar tilt[9-11]. To the best of our knowledge, there is no study analyzing the association between sagittal patellar tilt and suprapatellar fat pad edema/mass effect. Therefore, this study determined whether the measurements of the sagittal alignment of the patellofemoral joint were associated with suprapatellar fat pad edema/mass effect.

Materials and Methods

Patients: Ninety patients who were diagnosed with suprapatellar fat pad edema/mass effect based on an MRI evaluation between January 2019 and December 2019 was retrospectively evaluated. The exclusion criteria were history of knee surgery or trauma (evidence of ligament and tendon tears or bone contusion), inflammatory arthritis, meniscal tears, patellofemoral malalignment in the horizontal plane (patellar tilt and displacement), and patellar cartilage defects. After applying these criteria, a total of 55 patients were included in the study. The control group comprised an age-matched cohort of 55 patients who had no suprapatellar fat pad edema as confirmed by MRI, and underwent MRI with the indication of anterior knee pain. This study was approved by the Institutional Review Board (Yuksek Ihtısas Unıversıty, 2020-13-04).

Magnetic Resonance Imaging: All MRI were examined using a 1.5-T unit (Optima; GE Medical System, Milwaukee, Wisconsin, USA), employing an extremity coil with the patient in the supine position with the knee full extension. A standardized MRI examination protocol was used, and the following evaluation was undertaken using five sequences: Sagittal fast spin-echo T1-weighted [repetition time (TR)/echo time (TE): 300-500/5-10 ms, matrix: 288×224, field of view (FOV): 18×18 cm, slice thickness: 3 mm]; sagittal fat-suppressed proton density-weighted (PDW) (TR/TE: 2300-2800/20-40 ms, matrix: 256×192, FOV: 18×18 cm, slice thickness: 3 mm); sagittal 3D T2W Cube FSE (TR/TE: 300-500/5-10 ms, matrix: 288×224, FOV: 20×20 cm, slice thickness: 1 mm); coronal fat-suppressed PDW (TR/TE: 2300-2800/20-40 ms, matrix: 288×224, FOV: 20×20 cm, slice thickness: 3 mm); and axial fat-suppressed PDW (TR/TE: 2300-2800/20-40 ms, matrix: 288×224, FOV: 18×18 cm, slice thickness: 3 mm). To evaluate the presence of suprapatellar fat pad edema/mass effect and determine the alignment of the patella in the sagittal plane, we used sagittal T1 and fat-suppressed PDW sequences.

The standard of reference for evaluating signal on T1-weighted images were prefemoral fatty tissues and abnormal signal, which we defined as complete replacement of the suprapatellar fat pad with a low signal compared to that of the prefemoral fat pad (Figure 1a)[12]. The standard of reference for evaluating signal on the PDW images was fluid and muscle[12]. On fat-suppressed PDW images, we identified abnormal fat pads based on the presence of edema indicated by a signal greater than muscle and less than fluid (Figure 1b). The presence of a mass effect on the suprapatellar recess was assessed on the sagittal PDW MR images. We drew a line connecting the junction points of the suprapatellar fat pad with the patella upper pole and the quadriceps tendon. The thickness of the suprapatellar fat pad posterior to this line was measured and recorded as the convexity thickness of the suprapatellar fat pad (Figure 2). Sagittal T1-weighted MRI were used to evaluate the alignment of the patella in the sagittal plane using the IS ratio, patella-patellar tendon (P-PT) angle, and the quadriceps tendon-P (QT-P) angle. These measurements were performed in the midsagittal section where the quadriceps tendon, the patellar tendon, and upper and lower poles of the patella were visible. The IS ratio was defined as the ratio of the patellar tendon length (length of the tendon from the lower pole of the patella to its insertion on the tibia) to the height of the patella (greatest pole -to-pole length) (Figure 3a)[13], the P-PT angle was defined as the angle between the upper patellar pole and the lower patellar pole, and the tuberositas tibia (Figure 3b)[9-11], and the QT-P angle was defined as the angle between the line passing behind the deepest fibers of the quadriceps tendon and a line drawn between the patella upper pole (Figure 3c). The images were analyzed on the picture archiving and communications system. All measurements were undertaken by observers using electronic calipers.

Reliability Assessment: All measurements of sagittal alignment were repeated at two-week intervals by the first author. The second author , who was blinded to all subject information, performed all measurements in 55 knees randomly selected from 110 knees.

Statistical Analysis

SPSS (version 20.0; SPSS Inc., Chicago, IL) was used for statistical Co.. The distribution between the groups was found to be normal using the Kolmogorov-Smirnov test. The homogeneity of data distribution was determined using Levene's test, and parametric tests were used for inter-group comparisons. The convexity thickness of the suprapatellar fat pad, IS ratio, P-PT angle, and QT-P angle were compared between the patients with suprapatellar fat pad edema and the control group using the independent t-test. The level of statistical significance was considered as 0.05. G* Power analysis was performed to determine the simple size. In a given 0.25 effect size, 0.05 and 0.9 values were implemented as alpha and (1- beta) error rates, respectively. Because of this calculation, 80 patients were needed to perform this study.

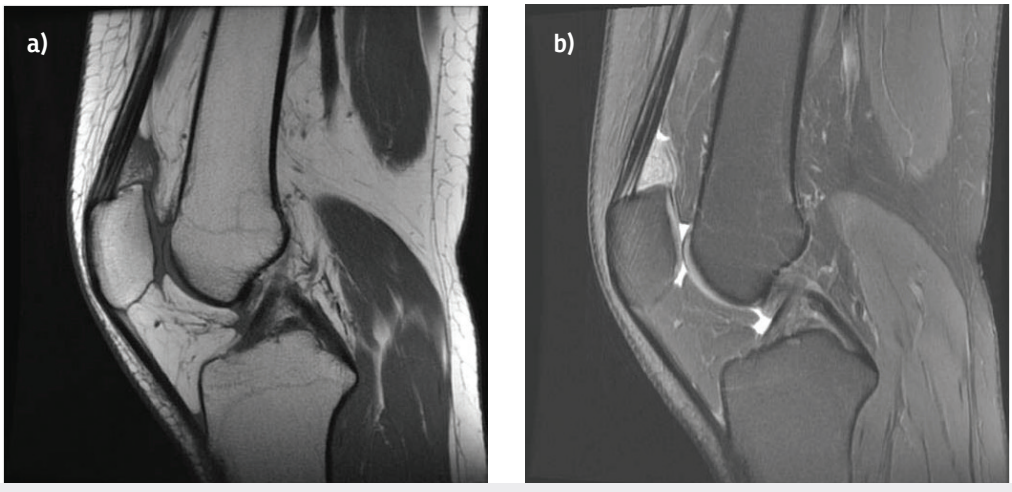

Figure 1. A 22-year-old woman with suprapatellar fat pad edema/mass effect. **(a)** Sagittal T1-weighted and **(b)** sagittal proton-density-weighted fast spin echo MRI with fat suppression show an enlarged suprapatellar fat pad with an abnormal convex posterior border and increased signal intensity

MRI: Magnetic resonance imaging

Approval was obtained from the Ethics Committee of the Yuksek Ihtisas University (decision no: 2020/13/04, date: 11.11.2020).

Results

The characteristics of the study patients are presented in Table 1. The mean convexity thickness of the suprapatellar fat pad was measured to be 2.27±1.9 mm in patients with a mass effect, while it was measured as 1.24±1.1 mm in the control group. The mean convexity thickness of the suprapatellar fat pad was significantly higher in patients with a mass effect than in the control group (p=0.01). The mean IS ratio (p=0.12) and P-PT angle (p=0.82) did not significantly differ between the two groups. The mean OT-P angle (p=0.01) was significantly higher in patients with a mass effect on the suprapatellar fat pad than in the control group.

The IS ratio, P-PT angle and QT-P angle comparisons between the groups are given in Table 2.

The inter- and-intra-observer intraclass correlation coefficients for all measurements were calculated as 0.92 and 0.90, respectively.

Discussion

The main finding of the current study was the absence of a relationship between suprapatellar fat pad edema/mass effect and patellofemoral alignment in the sagittal plane. Another finding was that the QT-P angle was higher in patients with a mass effect on the suprapatellar fat pad. The suprapatellar fat pad is an extrasynovial structure with a triangular shape and is one of the fat pads located in the anterior knee[1-5,14]. Suprapatellar fat pad edema is seen in

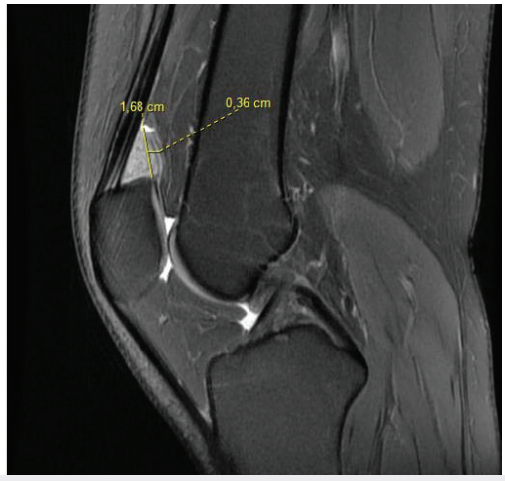

Figure 2. Measurement of the convexity thickness of the suprapatellar fat pad

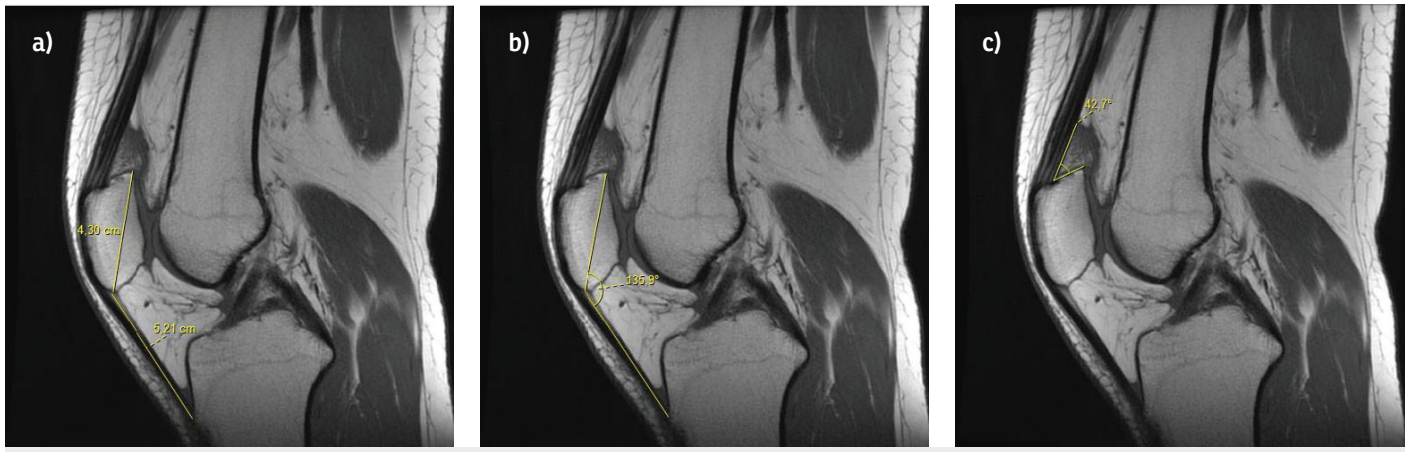

Figure 3. Midsagittal T1-weighted MRI. Measurement of the Insall-Salvati ratio **(a)**, patella-patellar tendon angle **(b)**, and quadriceps tendon-patella angle **(c)**

MRI: Magnetic resonance imaging

4.2-13.8% of the population, with a male preponderance[2,15]. Suprapatellar fat pad edema and the mass effect are characterized by diffuse enlargement on MRI[1,3,4].

Several studies have demonstrated the MRI characteristics of the suprapatellar fat pad edema/mass effect, and their relationship with the patellofemoral alignment of the knee[1,3,4]. However, the association between the sagittal alignment of the patellofemoral joint and suprapatellar fat pad edema/mass effect remains unknown.

Patella alta, or a "high-riding" patella, is a distinct feature of the patellofemoral alignment. Patella alta is measured by the IS ratio, referring to the ratio between the length of the patellar tendon and height of the patella, based on a value of >1.5[16]. In the current study, we did not find a significant association between suprapatellar fat pad edema/mass effect and the IS ratio, which is consistent with previous studies[1,4]. The alignment of the patella in the sagittal plane is a newly defined phenomenon "called 'sagittal patellar tilt' "[9-11]. To the best of our knowledge, there is no study analyzing the association between sagittal patellar tilt and suprapatellar fat pad edema/mass effect. In this study, we analyzed the sagittal alignment of the patella on the patellofemoral joint using the P-PT angle and found no association between sagittal tilt and suprapatellar fat pad edema/mass effect.

These results suggest that there was no significant relationship between the sagittal plane localization of the patella and suprapatellar fat pad edema/mass effect. The suprapatellar fat pad lies on the patellar base and fills the gap between the superior aspect of the patellar cartilage and the posterior aspect of the insertion of the quadriceps tendon. The suprapatellar joint recess separates the suprapatellar fat pad from the prefemoral fat pad[1-5]. Suprapatellar fat pad edema has a mass effect on the surrounding structures[1,3,16]. In most studies in the literature, the mass effect of the suprapatellar fat pad has been defined based on the presence of a convex posterior border[1,3,4,12,16]. Tsavalas and Karantanas[1] demonstrated that the anteroposterior and oblique diameters of the suprapatellar fat pad were significantly greater in patients with a mass effect. Can et al.[4] found that the convexity in the posterior contour of the suprapatellar fat pad was significantly higher in patients with higher grade edema. In these studies, the convexity thickness of the suprapatellar fat pad was used to measure the mass effect on the prefemoral fat pad. Similarly, we determined that the convexity thickness of the suprapatellar fat pad was significantly greater in patients with a mass effect. To our knowledge, there is no study evaluating the anterior mass effect of the suprapatellar fat pad. In this study, we found that the QT-P angle was higher in patients with a mass effect of the suprapatellar fat pad. This finding can also be used to determine the anterior convexity of the suprapatellar fat pad. Tsavalas and Karantanas[1] and Shabshin et al.[12] suggested that suprapatellar fat pad edema had similarities to Hoffa's disease in that it also resulted from repetitive microtrauma or overuse injury. Our study showed that suprapatellar fat pad edema had a mass effect on the quadriceps tendon.

Table 1. Characteristics of the study population (n=110)

Patients	Suprapatellar fat pad edema/mass effect	Control group
Sample size	55	55
Female/male	22/33	22/33
Age (year)	42.5±9.22*	42.4±11.8*
Rigt/left	30/25	30/25

*Values are expressed as mean ± standard deviation

Table 2. Descriptive analyses of the Insall-Salvati ratio, patella -patellar tendon angle, and quadriceps tendon -patella angle by group

	Suprapatellar fat pad edema mass effect	Control group	p value
Insall-Salvati ratio	1.09±0.13	1.05±0.15	0.12
Patella-patellar tendon angle	141.1±4.3	140.9±5	0.82
Quadriceps tendon-patella angle	38.6±7.7	33.4±5.8	0.01

Values are expressed as mean ± standard deviation

These finding support the idea that suprapatellar fat pad edema may have commonalities with Hoffa's disease. Future randomized, prospective studies, including histopathologic and radiological evaluations, are required to clarify this subject. Schwaiger et al.[17] demonstrated that subjects with suprapatellar fat pad edema had a more severe progression of patellofemoral osteoarthritis over 48 months compared with those with a normal suprapatellar fat pad signal. The new medical and surgical modalities in these patients may help in both the prevention and treatment of patellofemoral osteoarthritis.

Study Limitations

Our study had some limitations. The study design was retrospective. However, it was impossible to evaluate the clinical findings of patients and follow-up imaging data reporting treatment. Another limitation is that the sociodemographic status (sports activities and medical information), and occupational information of these patients with a tendency to develop suprapatellar fat pad edema were not evaluated. Additionally, no histopathologic correlation was undertaken. It was impossible to give the patient a standard position during MRI.

Conclusion

There is no relationship between the suprapatellar fat pad edema/mass effect and patellofemoral alignment in the sagittal plane. The QT-P angle was higher in patients with a mass effect on the suprapatellar fat pad.

Ethics

Ethics Committee Approval: Approval was obtained from the Ethics Committee of the Yuksek Ihtisas University (decision no: 2020/13/04, date: 11.11.2020).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: S.D., Design: E.G., Data Collection or Processing: E.G., S.D., Analysis or Interpretation: E.G., S.D., Literature Search: E.G., S.D., Writing: S.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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References

1. Tsavalas N, Karantanas AH. Suprapatellar fat-pad mass effect: MRI findings and correlation with anterior knee pain. AJR Am J Roentgenol 2013;200:W291-6.
2. Jarraya M, Diaz LE, Roemer FW, Arndt WF, Goud AR, Guermazi A. MRI Findings Consistent with Peripatellar Fat Pad Impingement: How Much Related to Patellofemoral Maltracking?. Magn Reson Med Sci 2018;17:195-202.
3. Roth C, Jacobson J, Jamadar D, Caoili E, Morag Y, Housner J. Quadriceps fat pad signal intensity and enlargement on MRI: prevalence and associated findings. AJR Am J Roentgenol 2004;182:1383-7.
4. Can TS, Yilmaz BK, Özdemir S. Magnetic resonance imaging of the quadriceps fat pad oedema pattern in relation to patellofemoral joint pathologies. Pol J Radiol 2019;84:e375-80.
5. Staeubli HU, Bollmann C, Kreutz R, Becker W, Rauschning W. Quantification of intact quadriceps tendon, quadriceps tendon insertion, and suprapatellar fat pad: MR arthrography, anatomy, and cryosections in the sagittal plane. AJR Am J Roentgenol 1999;173:691-8.
6. Hoffa A. The influence of the adipose tissue with regard to pathology of the knee joint. JAMA 1904;43:795-6.
7. Roemer FW, Jarraya M, Felson DT, et al. Magnetic resonance imaging of Hoffa's fat pad and relevance for osteoarthritis research: a narrative review. Osteoarthritis Cartilage 2016;24:383-97.
8. Jacobson JA, Lenchik L, Ruhoy MK, Schweitzer ME, Resnick D. MR imaging of the infrapatellar fat pad of Hoffa. Radiographics 1997;17:675-91.
9. Aksahin E, Aktekin CN, Kocadal O, et al. Sagittal plane tilting deformity of the patellofemoral joint: a new concept in patients with chondromalacia patella. Knee Surg Sports Traumatol Arthrosc 2017;25:3038-45.
10. Aksahin E, Yilmaz S, Karasoy I, et al. Sagittal patellar tilt and concomitant quadriceps hypotrophy after tibial nailing. Knee Surg Sports Traumatol Arthrosc 2016;24:2878-83.
11. Kim YM, Joo YB, Lee WY, Park IY, Park YC. Patella-patellar tendon angle decreases in patients with infrapatellar fat pad syndrome and medial patellar plica syndrome. Knee Surg Sports Traumatol Arthrosc 2020;28:2609-18.
12. Shabshin N, Schweitzer ME, Morrison WB. Quadriceps fat pad edema: significance on magnetic resonance images of the knee. Skeletal Radiol 2006;35:269-74.
13. Shabshin N, Schweitzer ME, Morrison WB, Parker L. MRI criteria for patella alta and baja. Skeletal Radiol 2004;33:445-50.
14. Ozdemir ZM, Gormeli CA, Kahraman AS, Demirtas G, Gormeli G. Unusual Symptomatic Multipartite Patella Associated with Quadriceps Fat Pad Edema. J Belg Soc Radiol 2016;100:49.
15. Gutierrez LB, Morgan TA, Link T, Feeley B, Motamedi D. Utility of musculoskeletal ultrasound in the diagnosis and treatment of suprapatellar fat pad impingement : A case report J Clin Case Report 2016;6:7.
16. Wang J, Han W, Wang X, et al. Mass effect and signal intensity alteration in the suprapatellar fat pad: associations with knee symptoms and structure. Osteoarthritis Cartilage 2014;22:1619-26.
17. Schwaiger BJ, Mbapte Wamba J, Gersing AS, et al. Hyperintense signal alteration in the suprapatellar fat pad on MRI is associated with degeneration of the patellofemoral joint over 48 months: data from the Osteoarthritis Initiative. Skeletal Radiol 2018;47:329-39.