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Original Article

Diagnostic value of biplanar ultrasonographic assessment in detecting degenerative changes in femoral articular cartilage

Biplanar ultrasonografik incelemenin femoral artiküler kıkırdaktaki dejeneratif değişiklikleri saptamadaki tanı değeri

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Abstract

Aim: The aim of our study was to assess the diagnostic value of biplanar ultrasonography in detecting degenerative changes of femoral articular cartilage using magnetic resonance imaging as the reference method.

Material and Methods: Femoral articular cartilage examination was performed with ultrasonography and magnetic resonance imaging in 40 patients with knee pain. Magnetic resonance imaging of the knees were carried out on a 1.5 T scanner with proton density weighted, fat suppressed sequence in three orthogonal planes. Ultrasonographic evaluations of the knees were performed in both longitudinal and transverse planes. Taking the findings of magnetic resonance imaging as a reference, the diagnostic effectiveness of biplanar US in detecting medial condylar, lateral condylar and intercondylar notch cartilage lesions were calculated.

Results: The sensitivity of biplanar ultrasonography in detecting medial condylar, lateral condylar, and intercondylar notch cartilage lesions were 93.55%, 61.11%, and 53.85%, respectively. The specificity of the technique in detecting the lesions in these locations were 88.89%, 90.91%, and 100.00%, respectively.

Conclusion: Ultrasonography is a relatively inexpensive, easily accessible and a non-invasive imaging tool. We found that biplanar ultrasonography is a reliable method in detecting medial condylar cartilage lesions in knee osteoarthritis, and we recommend using it for the purposes of screening and follow-up evaluation of medial type knee osteoarthritis where MRI is not accessible.

Keywords: knee osteoarthritis; cartilage degeneration; ultrasonography

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Öz

Amaç: Manyetik rezonans görüntüleme referans alınarak, transvers ve longitudinal yaklaşımların beraber kullanıldığı biplanar ultrasonografik incelemenin, femoral artiküler kıkırdaktaki dejeneratif değişiklikleri saptamadaki tanı değerinin saptanması amaçlandı.

Gereç ve Yöntemler: Diz ağrısı şikayeti olan 40 hastada ultrasonografi ve manyetik rezonans görüntüleme ile femoral artiküler kıkırdak incelemesi yapıldı. Manyetik rezonans görüntüleme, 1.5 T görüntüleyicide her üç ortogonal düzlemde proton dansite ağırlıklı sekans kullanılarak uygulandı. Diz ultrasonografi incelemesi, transvers ve longitudinal planlarda gerçekleştirildi. Manyetik rezonans görüntüleme bulguları referans alınarak biplanar diz ultrasonografi incelemesinin medial kondil, lateral kondil, ve interkondiler çentik lokalizasyonlarındaki kıkırdak lezyonlarını saptamadaki tanısal etkinliği hesaplandı.

Bulgular: Biplanar ultrasonografinin medial kondil, lateral kondil, ve interkondiler çentik lokalizasyonlarındaki lezyonları saptamadaki sensitivitesi aynı sıra ile %93,55, %61,11 ve %53,85, ve spesifisitesi aynı sıra ile %88,89, %90,91 ve % 100,00 bulundu.

Sonuç: Ultrasonografi nispeten ucuz, kolay ulaşılabilir ve noninvaziv bir inceleme yöntemidir. Biplanar ultrasonografi tekniğinin diz osteoartritindeki medial kondiler kıkırdak lezyonlarını saptamada güvenilir bir inceleme metodu olduğunu saptadık ve medial tip diz osteoartriti taraması ve MRG erişiminin kısıtlı olduğu durumlarda takip değerlendirmesinde kullanımını öneriyoruz.

Anahtar kelimeler: diz osteoartriti; kıkırdak dejenerasyonu; ultrasonografi

Introduction

Knee osteoarthritis (KOA) is common among older age groups and it constitutes a significant health problem in society [1]. In the recent few years, ultrasonography (US) has increasingly been used in the evaluation of morphological changes of KOA. High sensitivities and specificities have been reported for the US in detecting bone, cartilage and meniscus lesions [2-5]. The recommended and commonly used method in the US evaluation of femoral articular cartilage damage is the supracondylar transverse US technique applied to the hyperflexed knee [6-9]. However, Yoon et al. indicated in their study that longitudinal US approach is a more efficient method than transverse US approach in evaluating medial femoral condylar cartilage [10]. In fact, beyond transverse or longitudinal examination only, US is an examination method allowing multiplanar imaging. The aim of our study was to evaluate the diagnostic value of biplanar US examination, in which transverse and longitudinal approaches are used together, in detecting degenerative changes in femoral articular cartilage by taking magnetic resonance imaging (MRI) as the reference method.

Materials and methods

Patient population and study design

This study was conducted in accordance with the Helsinki Declaration Principles. Signed forms regarding that patients were informed about the study and agreed to participate were taken from all of the patients participated in this study. This study has been provided from local ethic committee.

Forty consecutive patients (28 male, 12 female), who applied to our hospital with knee pain complaint and were referred to Radiology Department for knee MRI between the dates April 1 - May 1 2018, were included in the study. The exclusion criteria were, history of surgical treatment or trauma of the knee. Patient group age average was 40, 67 (range: 18-71) and body mass index average was 25, 9 (range: 21,4-33). Only one knee joint of each patient was examined. MRI and US studies were performed on the same day scheduled within the first week following the patient's application. Two different radiologists independently performed and interpreted these two examinations without knowing the results of the other method. A radiologist with 19 years of experience of US, including musculoskeletal imaging, performed all of the sonographic evaluations. And a radiologist with 9 years of experience in musculuskeletal imaging made the assessement of MR images.

MRI examination

Knee MRI examinations were performed on a 1.5 T scanner (Gyroscan Intera, Philips Medical Systems, Netherland B. V.) using a dedicated knee coil. Fat suppressed, proton density weighted sequence in every three orthogonal planes was used. Sequence parameters were identified as: coronal sequence parameters; TR/TE: 2850/22 ms, ETL: 6, matrix: 320x224, FOV: 14x14 cm, sequence thickness: 3 mm; axial sequence parameters: TR/TE: 3250/30 ms, ETL: 8, matrix: 448x224, FOV: 12x12 cm, sequence thickness: 3 mm, and sagittal sequence parameters: TR/TE: 2950/22 ms, ETL: 6, matrix: 384x256, FOV: 14x14 cm, sequence thickness: 3 mm.

The medial condylar, lateral condylar, and intercondylar cartilage areas were separately evaluated. The presence of signal difference and/or partial/full thickness loss on the femoral articular cartilage surfaces were accepted as positive findings.

US examination

Each patient underwent US examination using Esaote MyLab 60 (Esaote Medical Systems, Italy) with a high-resolution 12 MHz linear sequence transducer (LA523). Examinations were applied to the knee in hyperflexion (at least 120º of knee flexion was obtained in all patients) while the patient was in supine position. The method described by Saarakkala et al. was used in transverse US examinations [6]. While transducer was in transverse position and held vertically to the bone during the whole process; medial condylar, lateral condylar and intercondylar notch cartilage surfaces of the suprapatellar area were separately scanned by sweeping the full surfaces from proximal to distal (Figure 1a,2,3). The longitudinal US examinations were based on the method described by Yoon et al. [10]. While transducer was in longitudinal position and held vertically to the bone during the whole process, cartilage surfaces of the suprapatellar area were scanned by sweeping the full surfaces in mediolateral direction. Then, both condylar cartilage surfaces were separately scanned from proximal to distal by moving the transducer continuously along the midlines of the medial and lateral condyles. Furthermore, a longitudinal parasagittal scan was performed approximately at an interval of 0,5 cm in medial femoral condyle in order to display a broader surface. The longitudinal parasagittal scan was not able to be performed in lateral condyle surface since an adequate interval was not available (Figure 1b,4,5).

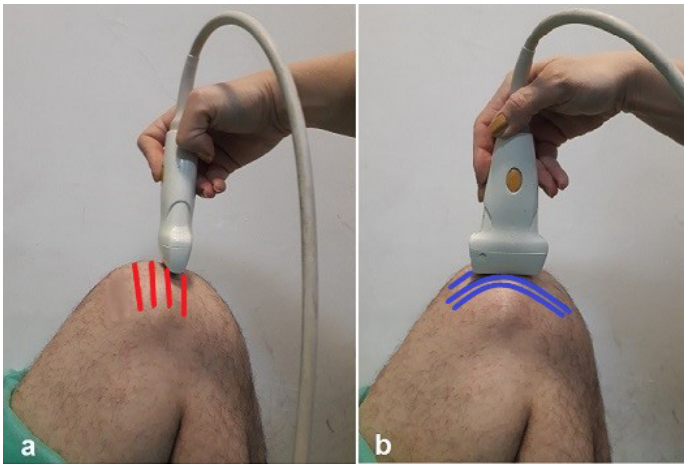

Figure 1. Clinical photographs demonstrating the techniques used in transverse (a) and longitudinal (b) US imaging. Examinations were applied to the hyperflexed knee while the patient was in supine position. In transverse US technique, holding the transducer in transverse position and vertical to the bone during the whole process, cartilage surfaces were scanned by sweeping the full surfaces from proximal to distal (a). In longitudinal US technique, holding the transducer in longitudinal position and vertical to the bone during the whole process, cartilage surfaces were scanned by sweeping the full surfaces in mediolateral direction (b).

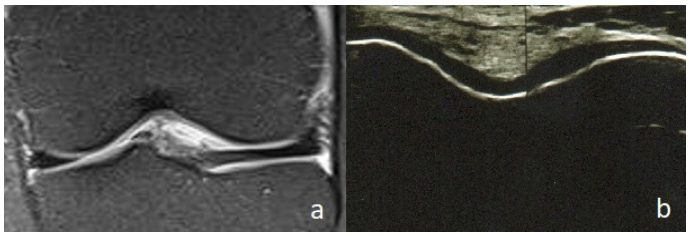

Figure 2 Coronal, fat suppressed, proton density weighted knee MRI (a) and transverse US (b) images of a 20 years old male patient. We see in both images that femoral articular cartilage integrity is protected.

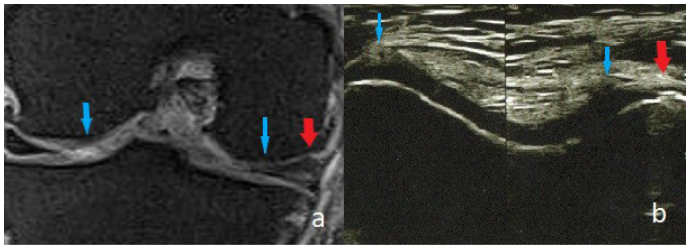

Figure 3 Coronal, fat suppressed, proton density weighted knee MRI (a) and transverse US (b) images of a 57 years old female patient. It can be seen in both images that there are contour irregularity areas in both condylar cartilage planes (blue lines) and there is partial thickness loss in medial condylar cartilage (red line).

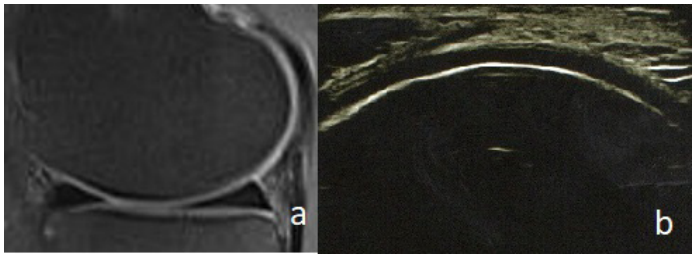

Figure 4 Sagittal, fat suppressed, proton density weighted knee MRI (a) and longitudinal US (b) images of a 20 years old male patient displaying normal cartilage findings. Note that the signal character, contour regularity and the thickness of condylar cartilage are protected in both images.

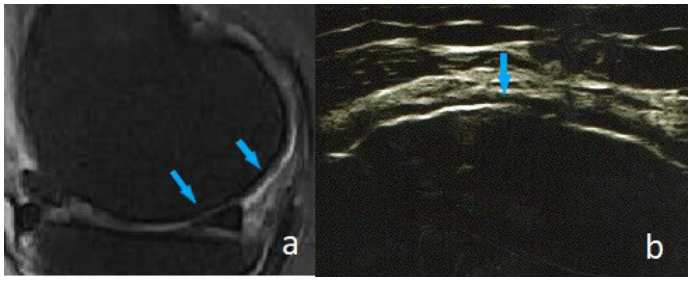

Figure 5 Sagittal, fat suppressed, proton density weighted knee MRI (a) and longitudinal US (b) images through the medial femoral condyle of a 63 years old male patient. Note that the contour irregularity and partial thickness loss of relatively posterior parts of the condyle can be clearly seen (blue lines).

The morphology and eco-signal characteristics of femoral articular cartilage surfaces were evaluated. Homogeneous hypoechoic cartilage structures having sharp front and back

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interphases were accepted as normal. The sharpness loss in front and back interphases, cartilage echogenicity increase and/or partial/full thickness loss were accepted as positive findings.

Statistical analysis

The statistics of diagnostic test effectiveness was calculated by using version 17.5.5 of Medcalc software.

Results

The MRI compared results of biplanar ultrasonography in detecting degenerative lesions in femoral articular cartilage are depicted in Table 1. It was remarkable to notice that only 2 of 31 medial condylar cartilage lesions detected in MRI were not able to be detected in the US, whereas 7 of 18 MRI depicted lateral condylar cartilage lesions were not able to be seen in US examination. It was also seen that US examination was not able to detect 12 of 26 lesions in intercondylar notch. The number of lesions, which were sonographically recorded but were not available in MRI images, was 1 for medial condyle, and 2 for lateral condyle. No false positive lesion result of the method was noted in intercondylar notch. The diagnostic indicators of biplanar US in detecting lesions in medial condylar, lateral condylar and intercondylar notch locations are demonstrated in Table 2. The sensitivity of biplanar US in detecting medial condylar, lateral condylar, and intercondylar notch cartilage lesions were 93.55%, 61.11%, and 53.85%, respectively. The specificity of the technique in detecting the lesions in these locations were 88.89%, 90.91%, and 100.00%, respectively.

Table 1 The comparative evaluation of biplanar US and MRI results in detecting degenerative cartilage lesions in medial condyle, lateral condyle and intercondylar notch planes.

		Positive MRI	Negative MRI
Medial condyle	The positive US	29	1
	The negative US	2	8
Lateral condyle	The positive US	11	2
	The negative US	7	20
Intercondylar Notch	The positive US	14	0
	The negative US	12	14

Table 2 The diagnostic indicators of biplanar US in detecting degenerative cartilage lesions in medial condyle, lateral condyle and intercondylar notch planes.

	Medial condyle	Lateral condyle	Intercondylar Notch
Sensitivity (95% CI)	93.55 (78.5- 99.21)	61.11 (35.75- 82.70)	53.85 (33.37-73.41)
Specifity (95% CI)	88.89 (51.75-99.72)	90.91 (70.84- 98.88)	100.00 (76.84-100.00)
PPV (95% CI)	96.67 (82.01-99.46)	84.62 (58.25- 95.59)	100.00 (76.84-100.00)
NPV (95% CI)	80.00 (50.65-93.97)	74.07 (61.20- 83.81)	53.85 (43.51-63.86)

PPV Positive Prediction Value, NPV Negative Prediction Value

Discussion

We evaluated the diagnostic value of biplanar US examination in which the transverse and longitudinal approaches were used together, in detecting degenerative changes in femoral articular cartilage by taking MRI as the reference method. We determined that the biplanar US is a considerably reliable method in detecting medial condylar cartilage lesions, however, its success in detecting lateral condylar and intercondylar notch lesions are relatively low.

KOA is one of the most common diseases causing pain and function loss in the knee joint, and its incidence in the older population is reported to be 6-10% [1]. The diagnosis of the disease is traditionally made based on the clinical and radiographic evaluations [11]. In clinical practice, cartilage thickness is mostly evaluated by joint space width measurement on radiograph. However, since joint space measurement does not correspond to only one cartilage thickness but to the total thickness of two cartilage layers and meniscus, radiography is not sensitive enough to evaluate the cartilage integrity. MRI, which is accepted as the most reliable method in evaluating the cartilage and commonly used with this intent, is a difficult-to-reach-in method for many patients [10]. However, the US is relatively cheap, practical and easy-to-reach-in imaging instrument. It successfully displays morphological changes of cartilage, bone and meniscus in the knee [1]. In several publications, it is reported that the US is a reliable method in both quantitative and semi-quantitative evaluations of femoral articular cartilage [6-10, 13].

In their semi-quantitative study where the standard transverse US technique was used and arthroscopy was taken as the reference method, Saraakkala et al. reported the sensitivity of US in detecting medial condylar, lateral condylar and intercondylar notch cartilage lesions to be %85,3, %51,9 and %54,3, respectively [6]. The sensitivity values that we detected in the current study which included a longitudinal approach in addition to the standard transverse US technique were %93,55, %61,11 and %53,85, respectively. It is thought that the relative overachievement of our study in detecting lesions in medial and lateral condylar planes is based on longitudinal US approach added into the examination scheme. However, it should be taken into consideration that the reference methods used in the two studies are different. The lesion detection sensitivity of arthroscopy is higher than that of MRI, and this situation can partially explain the difference between the results of these two studies. Similar results were obtained in detecting intercondylar notch lesions in both studies, and this is interpreted as the longitudinal scan in this area does not contribute to the transverse scan.

It is recommended that US examination of femoral articular cartilage is performed when the knee is flexed in the highest degree possible [6,10,13]. As the flexion degree of the knee is increased, patella skids into inferior and patellofemoral contact area move towards posterior through intercondylar fossa [14]. This motion of patella in inferoposterior direction uncovers the cartilage surfaces of intercondylar notch and anterior parts of both femoral condyles. These areas can be

easily imaged thanks to standard suprapatellar transverse US method in which the knee is given approximately 120° of flexion. However, the transverse sonographic imaging of posterior cartilage surfaces, which take place in relatively posterior parts of condyles and have special importance since they correspond to load bearing areas in both condyles, is relatively difficult due to patellar superposition and acoustic shadowing [9,10]. These thin and band-like regions located in both parapatellar areas are not quite suitable for scanning with standard transverse US method. Instead, it can be predicted that the scanning of these difficult areas with a longitudinal approach from front to back is easier and more productive [10].

As the flexion degree of the knee approaches to upper limits, quadriceps muscle contraction applies attraction to the patella in the lateral direction [14]. Consequently, while medial condylar cartilage surface becomes gradually apparent during flexion, lateral condylar cartilage surface is covered gradually by the patella. The average mediolateral patellar displacement value of the knee occurred during the knee's maximum flexion (140°) is reported to be 10.2±4.8 mm [15]. This situation increases both transverse and longitudinal sonographic maneuverability in medial condyle. As in many studies in which femoral articular cartilage was quantitatively and semi-quantitatively evaluated with US [6-10], the sensitivity of US in detecting medial condylar lesions (%93,55) was found to be higher than that in lateral condyle (%61,11) in our study. Another effect of mediolateral patellar displacement occurred during hyperflexion of the knee is that it allows the longitudinal parasagittal scanning of the posterior parts of the medial condyle. Accordingly, this increases the detection chance of posterior medial condylar cartilage lesions with the longitudinal US. Indeed, Yoon et al. demonstrated in their comparative quantitative study done by taking MRI as the reference method that; transverse and longitudinal US techniques perform equally in detecting cartilage lesions in lateral condyle, whereas longitudinal US is more reliable than the transverse US in detecting medial condylar cartilage lesions [10].

The most significant limitation of this study is the failure to evaluate the sensitivity of transverse, longitudinal and biplanar US approaches in detecting femoral articular cartilage lesions separately and comparatively. Other significant limitation of the study is that all knee US examinations were applied by the same radiologist only for once; therefore, inter- and intra-observer reliability of the study were not tested. The last limitation is that the patient number formed the study group was relatively low. To establish the certain value of biplanar US examination in detecting femoral articular cartilage lesions, comprehensive and comparative studies with broader patient groups to be done are needed.

Consequently, US is a relatively inexpensive, easily accessible and a non-invasive imaging tool. We found that biplanar US is a reliable method in detecting medial condylar cartilage lesions in KOA, and we recommend using it for the purpose of screening for medial type KOA. Besides, it may be used for the purpose of follow-up evaluation of medial type KOA where MRI is not accessible.

Declaration of conflict of interest

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

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