ORIGINAL ARTICLE

HIGH FREQUENCY ULTRASOUND IN DETECTION OF KNEE MENISCAL TEARS

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ABSTRACT

INTRODUCTION: Timely diagnosis of meniscal pathology is vital for determining type and timing of treatment, as well as prognosis for return to function. Ultrasonographic examination of the knee shows promise for being an effective diagnostic tool for assessing meniscal pathology with the potential to overcome many of the shortcomings of MRI. **OBJECTIVE:** To determine the diagnostic accuracy of high frequency ultrasound (HFUS) in the diagnosis of meniscal injuries keeping arthroscopy as a gold standard. **STUDY SETTINGS:** Radiology Department, Khyber Teaching Hospital Peshawar, Pakistan. **STUDY DURATION:** From 03-05-2018 to 03-11-2018 **MATERIALS AND METHODS:** This study was conducted in the Department of Radiology, Khyber Teaching Hospital, Peshawar, Pakistan. Through a Descriptive Cross Sectional Study Design, a total of 125 cases suspected of having meniscal injury were included in the study in a consecutive manner and subjected to high frequency ultrasound followed by arthroscopy for the confirmation of meniscal injuries. **RESULTS:** The mean age of the patients was 36.7 ± 9.2 years. We had 71.2% males & 28.8% females. The mean BMI of the study sample was 23 ± 2.1 kg/m^2. On HFUS we observed meniscal injury in 73.6% of patients compared to 60% on follow up arthroscopy. On applying the formulae for calculation, sensitivity of meniscal injury was found to be 81.3% and specificity 38%. The positive predictive value of the HFUS was 66.3% and negative predictive value was 57.6%. **CONCLUSION:** High frequency ultrasound has an acceptable sensitivity and specificity for the detection of meniscal injuries. As such, it is a useful radiological marker for diagnosis of meniscal injuries in adults and further studies are recommended to confirm its usefulness.

Key Words: High frequency ultrasound (HFUS), arthroscopy, knee, menisci, meniscal injuries.

Introduction

The knee menisci attached to the tibial plateau are fibrocartilaginous structures. The menisci are essential for joint stability, shock absorption, distribution of contact forces, joint lubrication, and proprioception.[1] The medial meniscus is C-shaped while lateral meniscus is semicircular, both about 3 cm wide. The lateral meniscus covers a larger portion of the tibial articular surface than the medial meniscus and is 3 to 4 cm in length compared to medial meniscus which is 4-5 cm long.[2] Tears can be described based on pattern and location. These tear patterns include vertical longitudinal, oblique, transverse (radial), horizontal, meniscal root, bucket-handle, and complex.[3]

Early and accurate diagnosis of meniscal pathology is important for determining management as well as prognosis for return to function in the short term and degree of morbidity in the long term.[4] The gold standardimaging modality for detection of meniscal abnormalities is, MRI. However MRI is costly and is

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not readily available to a large number of patients for either financial or logistical reasons, or both.[5]
Sonographic evaluation of the knee is effective tool in diagnosing meniscal pathology, with many of the shortcomings of MRI, being overcome by ultrasound. Ultrasonography has been used for diagnosis of meniscal pathology in veterinary medicine for more than a decade.[6] Based on the current results, low costs and ready availability, the portability of the equipment, and safety associated with ultrasonography, it has been reported that ultrasonography is a clinically useful diagnostic modality for assessing meniscal pathology. However, the capabilities of ultrasonography for diagnosis of meniscal abnormalities in patients have not been fully evaluated.[7]
In the assessment of medial meniscal tears vs. lateral meniscal tears, ultrasonographic examination, according to one study, had positive predictive value, negative predictive value, sensitivity and specify of 81% vs. 81%, 94% vs. 76%, 96% vs. 65%, and 74% vs. 88%, respectively.[8] In another study, the sensitivity, specificity, PPV and NPV of high frequency ultrasound (HFUS) in detecting meniscal tears was recorded to be 91.2%, 84.2%, 95.4% and 76.2% with prevalence of overall meniscal injury being 83%.[9]
Meniscal injuries are not uncommon in our population due to heavy interest in sports and to reduce morbidity early diagnosis, prompt and timely treatment is of utmost importance. The idea behind doing this study came into our mind after careful literature search and we found that very few studies are done on HFUS for detecting meniscal injury confirmed with arthroscopy. This study may provide us with a screening technique for diagnosis of meniscal injuries in our population which may be helpful in management of these injuries.

Objective

To determine the diagnostic accuracy of high frequency ultrasound in the detection of meniscal injuries keeping arthroscopy as a gold standard.

Operational Definitions

Sensitivity: Is the ability of HFUS to identify those patients who have meniscal injury, out of total patients with meniscal injury (confirmed by arthroscopy) and determined as, True positives / (true positives + false negatives)
Specificity: Is the ability of an HFUS to correctly identify those patients who do not have meniscal injury out of total patients not having meniscal injury (confirmed by arthroscopy) and determined as, True negatives / (true negatives + false positives)
Positive predictive value: Is the proportion of patients who fulfill the criteria of HFUS and have arthroscopic evidence of meniscal injury and determined as True positive / (true positive + false positive)
Negative predictive value: Is the proportion of people who do not have meniscal injury and have no arthroscopic evidence of meniscal injury, and determined as True negative / (true negative + false negative)
True positive: Patients with meniscal injury (confirmed by arthroscopy) who are classified as having meniscal injury by HFUS.
True negative: Patients who are classified as having no meniscal injury (confirmed by arthroscopy) by HFUS.
False positive: Patients who are misclassified as having meniscal injury (confirmed by arthroscopy) by HFUS.
False negative: Patients who are misclassified as having no meniscal injury by HFUS (confirmed by arthroscopy)
Meniscal Injury on HFUS: The criteria for the diagnosis of a meniscal tear on high frequency ultrasound was: (1) a hypoechoic area within the meniscus itself and or hypoechoic area extending to the surface of the meniscus and (2) an irregular outlined or small sized meniscus in comparison with the contralateral knee with normal anatomy.
Meniscal injury on arthroscopy: The criteria of diagnosis of a meniscal tear on arthroscopy was: (1) mobility of meniscus by 2 mm and (2) visualized irregularity of meniscus or frank defect in the meniscus.

Material and Methods

Study Design: Cross Sectional study
Setting: Department of Radiology and Department of Orthopedics, Khyber Teaching Hospital Peshawar
Duration: Six months after the approval of synopsis from 03-05-2018 to 03-11-2018

Sample Size: Sample size of 125 cases is calculated with 95% confidence level and 2% margin of error for sensitivity of 91.2% and specificity of 84.2%, taking prevalence of meniscal injury as 71%.
Sampling Technique: Consecutive (non-probability sampling)

SAMPLE SELECTION

Inclusion criteria:

1. All patients presenting with clinical features suspected of meniscal injury (history of trauma to the affected side with pain ranging from more than 7 on visual analogue scale)
2. Adult age more than 18-60 years.
3. Either gender.

Exclusion criteria:

Patients with history of any type of intervention in the knee joint.

DATA COLLECTION PROCEDURE

Approval of the ethical committee of the hospital was sought. Patients having history of acute knee injury & fulfilling the inclusion criteria were selected from outpatient department (OPD). All the included patients were explained the purpose of procedure, use of data and publication of the study. Informed written consent was obtained.

The demographic information like name, age, sex and address was recorded. Thorough history was taken and detailed physical examination was performed. High frequency US was performed, using 10-12Hz probe of Toshiba Xario 100 machine, by single expert radiologist. After HFUS, arthroscopy was performed by an experienced orthopedic surgeon to confirm visually the presence or absence of meniscal injury.

All the results were followed and all the above mentioned information was recorded in a pre-designed proforma.

DATA ANALYSIS PROCEDURE

The data was recorded in SPSS version 22 and analyzed. Mean and SD was calculated for continuous variables like age and BMI, percentage was calculated for categorical variables like gender,while sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) of HFUS was determined with arthroscopy as gold standard from 2x2 table.

Results

The study was conducted on 125 patients suspected for meniscal injury.

The mean age of the sample was 36.7 ± 9.2 years. Minimum age of 22 years and maximum age of 50 years. (See Tab. 1 for the age categories wise distribution of the sample).

While distributing the patients with regards to gender, we observed that in our study 71.2% of the sample was male and 28.8% were female gender.

The mean BMI of the study sample was 23 ± 2.1 kg/m^2. (Tab. 2).

On HFUS, Meniscal injury was observed in 73.6% of patients while on follow up arthroscopy, meniscal injury was recorded in 60% of patients.

On applying the formulae for calculation, sensitivity of meniscal injury was found to be 81.3% and

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age of Patient	125	28.00	22.00	50.00	36.7	9.2

		Frequency	Percent
Age Groups	22 to 30 years	39	31.2
	> 30 to 40 years	36	28.8
	> 40 to 50 years	50	40.0
	Total	125	100.0

Table 1: Age-wise distribution of sample (n=125)

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Body Mass Index	125	7.00	18.50	25.5	23	2.1

		Frequency	Percent
Age Groups	18.5 to 22	41	32.8
	>22 to 25.5	84	67.2
	Total	125	100.0

Table 2: Distribution of patients with regards ot BMI (n=125)

		Meniscal injury on Arthroscopy		Total
		Yes	No	
Meniscal injury on HFUS	Yes	61	31	92
	No	14	19	33
Total		75	50	125

Sensitivity of HFUS: TP/TP + FN = 81.3%
Specificity of HFUS: TN/TN + FP = 38%
Positive Predictive Value HFUS: TP/TP + FP = 66.3%
Negative Predictive Value HFUS: TN/TN + FN = 57.6%

Table 3: HFUS and arthroscopy 2x2 table (n=125)

specificity 38%. The positive predictive value of the HFUS was 66.3% and negative predictive value was 57.6% (Tab. 3).

Discussion

The first-line diagnostic imaging modality for meniscal pathologies is magnetic resonance imaging (MRI); however, it is costly and contraindicated for some patients. Ultrasound is a possible alternative to MRI and can be performed rapidly, is less costly, and can be used to evaluate muscles and tendons.[10-11] Although the depth of penetration of ultrasound is limited, recent developments in ultrasound have led to greater spatial resolution as well as finer imaging detail than are possible with standard clinical musculoskeletal MRI;[12,13] therefore, its usefulness for diagnosing meniscal disease seems promising. The use of ultrasound for identifying meniscal tears have been proposed, but its diagnostic accuracy remains controversial.[10] Problems with previous studies of ultrasound include failure to address the resolution of the machine.[14-15] In the current study, we assessed the diagnostic accuracy of high-resolution ultrasound for diagnosing the presence of meniscal pathologies.

Petersen and Rasmussen reported the sensitivity and specificity of ultrasound for diagnosing meniscal tears to be 86% and 83%, respectively,[16] whereas Shetty et al. reported them to be 86% and 69%, respectively,[10] when an Esaote Technos MPS machine (Bracco UK, High Wycombe, United Kingdom) with a linear array probe of 5.0 to 13.0 MHz was used. However, because those authors did not determine the resolution of ultrasound for defining meniscal tears, we cannot directly compare their results and ours to evaluate the effect of ultrasound resolution on diagnostic accuracy.

The distance from the skin surface to the posterior horn can be shortened by compressing the gastrocnemius through skin, but the distance from the skin surface to the anterior horn cannot be changed. In addition, the infrapatellar fat pad is located in the anterior part of the knee joint. Fat tissue has a higher acoustic absorption coefficient than muscle tissue.[17] Casser et al. reported difficulty with anatomical delineation of the infrapatellar fat pad.[18] This could explain difficulties in observing the anterior horn. Practically, meniscal tears are most common in the posterior third of the medial meniscus and not common in the anterior horn, so the difficulty of observing the anterior horn does not substantially affect the diagnostic accuracy of ultrasound formeniscal tears;[19,20] therefore, ultrasound is considered to be useful for screening of meniscal tears.

In the present study, the diagnostic accuracy of ultrasound for meniscal tears was relatively acceptable. However, although ultrasound performed well for detection of a discoid lateral meniscus, detection of the morphology of meniscal tears was difficult. Selby et al. reported that the diagnosis of radial tears using ultrasound was difficult in a cadaveric study,[21] although they did not detail the diagnostic accuracy. Yaniv and Blumberg[22] and Achour et al.[23] reported ultrasound to be useful for the diagnosis of discoid menisci.

On the basis of a previous report[24] and our results, ultrasound appears to be useful for the screening of meniscal tears but detection of the morphology of meniscal tears seems insufficient. Therefore, using ultrasound to determine surgical indications or anticipate the type of surgical procedure needs to be done with caution, which is true even for MRI diagnosis. The sensitivity of 3Tesla MRI for the detection of meniscal tears was 84% which is close to HFUS sensitivity of 81.3% as in our study.[25-26] Thus, we did not conclude that ultrasound was far inferior to MRI for the detection of meniscal pathology. Additionally, ultrasound has some advantages over MRI. First, it costs less. Jacobson reported that the Medicare physician fee schedule payment for the technical fee and for the professional fee for a diagnostic ultrasound of an extremity jointis $101 and $31 while $371 and $73 for MRI of a joint.[11] Second, with ultrasound it is possible to obtain dynamic imaging and observe meniscal motion and dislocation by moving the knee.[27] Third, all patients, including those who are claustrophobic, can undergo ultrasound.[28] Fourth, ultrasound facilitatesbilateral comparison and repetitions at will.[29] Fifth, many ultrasound machines can be brought to the patient, and examination and explanation of the results can be rapid.[30] However, the possibility of a poor-quality ultrasonographic study is a flaw that rarely occurs with MRI.

Sex, age, and BMI did not affect the diagnostic accu-

racy of meniscal tears, findings that were similar to the results reported by Wareluk and Szopinski.[31]
In summary, in detection of meniscal tears, high-resolution ultrasound exhibited relatively high sensitivity. Ultrasound examination may be suitable for screening of meniscal tears, but discrimination of the type pattern was not satisfactory even with a high-resolution machine.

Conclusion

For detecting the meniscal injuries, high frequency ultrasound has an acceptable sensitivity and specificity. As such, it is a useful radiological marker for detection of meniscal injuries in adults and further studies are recommended to confirm its usefulness.

Conflict of Interest: None

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