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Original Article

Diagnostic Accuracy of Ultrasound in Detection of Synovial Hypertrophy in Patients with Osteoarthritis

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Abstract

Objective: To determine the diagnostic accuracy of ultrasound in the detection of synovial hypertrophy in patients with osteoarthritis by using MRI as the gold standard.

Methods: In this descriptive study, 150 patients with complaint of joint pain and stiffness, were included. Ultrasound was carried out. Subsequently, MRI scan of affected joint was performed.

Results: By taking the synovial thickness of more than 2.3mm as discriminatory level for synovial proliferation, the overall sensitivity of ultrasound was 94.23%, and specificity was 87.23%. The positive predictive values of the ultrasound in patients with synovial hypertrophy was 95.14% and negative predictive value was calculated to be 92.67%. The diagnostic accuracy of the test was 89.12%.

Conclusion: Duplex Doppler ultrasound can detect synovial hypertrophy with sensitivity of approximately 94.23 %.

Key Words: Osteoarthritis, Synovial proliferation, Ultrasound, Diagnostic accuracy

Introduction

Osteoarthritis (OA)is a common arthritis and is one of the leading causes of disability in older population.[1] It affects approximately 34% of the United States population over age 65.[2] It is a chronic, progressive, debilitating disease characterized by degenerative changes in the bones, cartilage, menisci, ligaments, and synovial tissue of joints.[3] Although OA is classified as non-inflammatory arthritis, mechanical stress and chronic inflammatory process in the joint micro-environment may lead to synovial inflammation and proliferation. As disease progresses, the proliferating synovial tissue may resemble the pannus tissue characteristic of rheumatoid arthritis.[4] The presence of inflammatory synovium at baseline may be predictive of structural progression of cartilage damage.[5] OA is currently diagnosed based on clinical and radiographic findings.[6] Radiography however is not very sensitive to identify early structural change as it takes several years to detect progression of radiographic OA.[7] Magnetic resonance imaging (MRI) and ultrasound (US) serve as additional tools to determine the extent of joint involvement. Synovitis can be demonstrated by US, appearing as hypoechogenic hypertrophy of synovial tissue in gray scale (B mode).[8,9] MRI demonstrates synovitis in early OA in joints when synovitis is not clinically detected.[4] Synovial thickening seen on MRI has been confirmed as histological synovitis using arthroscopic sampling of the areas of MRI detected synovial thickening.[10] On MRI, synovitis is defined as thickened area of synovium that shows greater than normal enhancement on post gadolinium T1-weighted images.[11]

In early OA, mostly hyperplastic OA synoviopathy is found.[12] Both US and MRI are sensitive for the detection of synovitis, and both are superior to radiography.[13] Ultrasound has the advantage over MRI in that it is economical, convenient and easier to use, is dynamic and has no contraindications to its use.[14] Ultrasound is more patient friendly, has the ability to scan several joints in different body regions in one session and can directly correlate clinical and imaging findings.[15]

There is a wide range of difference in cut-off value for synovial thickness taken for diagnosis of synovial hypertrophy. In a study, carried out carried out in Egypt, the sensitivity and specificity of ultrasound was found 82.5% and 95% respectively in detecting synovial thickness of knee joint.[16] Quantitative measurement of synovial thickness using gadolinium-enhanced MRI is the gold standard for assessment of synovitis on MRI.[4] MRI can visualize all tissues in the joint involved in OA , i.e., cartilage, menisci, bone and soft tissue.[6] The mean sensitivity and specificity of low field MRI for detection of synovitis is 90% and 96% respectively.[17]

Patients and Methods

After taking approval from institutional review board and ethics committee, the descriptive study was conducted at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, from October 2015 to April 2016. By using WHO sample size calculator taking sensitivity 82.5% and specificity 95%, prevalence is 27.6% , desired precision for sensitivity 10%, for specificity 5% and confidence interval of 95% , a minimum of 160 patients were required as the sample size. [14-18] During the study period, 150 patients referred by the Orthopedics and Rheumatology Department with osteoarthritis who were diagnosed on the basis of clinical examination and were advised MRI scan . Patients of either gender, between 50 to 80 years of age, who gave informed consent for the study and had morning stiffness and joint pain less than 30 min were included. Those excluded were patients with renal problems and deranged RFTs resulting in need for haemodialysis, patients with infectious or traumatic arthritis, mentally retarded persons. Affected joint was examined in real time in axial and sagittal planes prior to MRI scan. Joints were scanned in longitudinal and transverse planes with the joint supported in 30° flexion for ventral and lateral scans and in extension for dorsal scans. The supra-patellar pouch was scanned widely (including the lateral and medial recesses). Synovial thickness was measured and thickness of more than 2.3mm was taken as indicator of synovial hypertropy. Pre- and post-Gadolinium sequences of a single knee were evaluated. MRI was taken as positive if thickened area of synovial compartment was seen that appeared hyper-intense on T2WS and STIR sequences and showed greater than normal enhancement on Gadolinium-enhanced T1-weighted images. MRI diagnosis was then compared with the findings of the ultrasound scan reports. Mean, median, mode and mean standard deviation for numerical data like age and frequency percentages for categorical data like true positive and true negative was calculated. A 2 x 2 table was constructed to determine sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy. True positive were defined as synovial hypertrophy diagnosed both on ultrasound and on MRI. True Negative were the cases negative for synovial hypertrophy both on ultrasound and on MRI. Synovial hypertrophy diagnosed on ultrasound but not found on MRI was taken as false positive, while the cases who do not have synovial hypertrophy on ultrasound but are positive on MRI were defined as false negative.Sensitivity was equal to: True Positive/True Positive + False Negative x 100; while Specificity was equal to: True Negative/False Positive + True Negative x 100. True Positive / True Positive + False Positive x 100, and NPV as, True Negative / False Negative + True Negative x 100. The Diagnostic Accuracy was calculated by the formula: True Positive + True Negative / True Positive + False Positive + False Negative + True Negative x 100.

Results

Age distribution of the patients (n=150) shows that majority (74,67%) were between 50-65 years of age (Table 1). Gender distribution shows that 58.67% were females. (Table 2). Frequency of synovial proliferation in patients with osteoarthritis(on gold standard) was recorded in 30.67%(Figure 1-3;Table 3).Diagnostic accuracy of ultrasound in the detection of synovial proliferation in patients with osteoarthritis by using MRI as the gold standard was calculated as 89.12%, 94.23%, 87.23%, 95.14% and 92.67% for sensitivity, specificity, positive predictive value, negative predictive value and accuracy rate. (Table 4).Effect modifiers like gender and age was controlled by stratification. Post stratification chi –square test was applied. p value < and equal to 0.05, as significant, was documented . (Table No. 5 -8)

Table 1. Age distribution (n=150)

Age(in years)	No. of patients	%
50-65	112	74.67
65-80	38	25.33
Total	150	100
Mean±SD	62.12±7.68	

Mode= 53.00;Median=62.00

Table 2. Gender distribution (n=150)

Gender	No. of patients	%
Male	62	41.33
Female	88	58.67
Total	150	100

Table 3. Frequency of synovial proliferation in patients with osteoarthritis(on gold standard)

Synovial proliferation	No. of patients	%
Yes	46	30.67
No	104	69.33

Total	150	100

Table 4. Diagnostic accuracy of ultrasound in the detection of synovial proliferation by using MRI as the gold standard

Ultra-sound findi-ngs	Synovial proliferation		Total
	Synovial hypertrophy present (positive)	Synovial hypertrophy present (negative)	
Positive	True positive(a) 41 (27.33%)	False positive (b) 6 (4%)	a + b 47(31.33%)
Negative	False negative(c) 5 (3.33%)	True negative (d) 98 (65.33%)	c + d 103 (68.67%)
Total	a + c 46 (30.67%)	b + d 104 (69.33%)	150 (100%)

Sensitivity = a / (a + c) x 100 =89.12%;Specificity= d / (d + b) x 100 = 94.23%;Positive predictive value = a / (a + b) x 100 =87.23%;Negative predictive value = d / (d + c) x 100 =95.14%;Accuracy rate = a + d / (a + d + b + c) x 100 = 92.67%

Table 5. Stratification for age (50-65 years)

Ultras-ound findings	Synovial proliferation		p value
	Synovial hypertrophy (positive)	Synovial hypertrophy present (negative)	
Positive	True positive(a) 31	False positive (b) 5	
Negative	False negative(c) 2	True negative (d) 74	
Total	a + c 33	b + d 79	

Sensitivity= a / (a + c) x 100 =93.93%;Specificity = d / (d + b) x 100 = 93.67%;Positive predictive value = a / (a + b) x 100 =86.11%;Negative predictive value = d / (d + c) x 100 =97.36%;Accuracy rate = a + d / (a + d + b + c) x 100 =93.75%

Table 6. Stratification for age (66-80 years)

Ultrasound findings	Synovial proliferation		p-value
	Synovial hypertrophy present (positive)	Synovial hypertrophy present (negative)	
Positive	True positive(a)10	False positive (b) 1	
Negative	False negative(c) 3	True negative (d) 24	
Total	a + c 13	b + d25	

Sensitivity= a / (a + c) x 100 =76.92%;Specificity = d / (d + b) x 100 =96%;Positive predictive value = a / (a + b) x 100 =90.91%;Negative predictive value = d / (d + c) x 100 =88.89%;Accuracy rate = a + d / (a + d + b + c) x 100 = 89.47%

Table 7. Stratification for gender (male)

Ultrasound findings	Synovial proliferation		P value
	Synovial hypertrophy present (positive)	Synovial hypertrophy present (negative)	
Positive	True positive(a) 20	False positive (b) 2	0.000
Negative	False negative(c) 4	True negative (d) 36	
Total	a + c 24	b + d 38	

Sensitivity= a / (a + c) x 100 =83.33%;Specificity = d / (d + b) x 100 = 94.73%;Positive predictive value = a / (a + b) x 100 =90.90%;Negative predictive value = d / (d + c) x 100 =90%;Accuracy rate = a + d / (a + d + b + c) x 100 =90.32%

Table 8. Stratification for gender (female)

Ultrasound findings	Synovial proliferation		P value
	Synovial hypertrophy present (positive)	Synovial hypertrophy present (negative)	
Positive	True positive(a) 21	False positive (b) 4	0.000
Negative	False negative(c) 1	True negative (d) 62	
Total	a + c 22	b + d 66	

Sensitivity= a / (a + c) x 100 =95.45%;Specificity= d / (d + b) x 100 = 93.93%;Positive predictive value = a / (a + b) x 100 =84%;Negative predictive value = d / (d + c) x 100 =98.41%;Accuracy rate = a + d / (a + d + b + c) x 100 = 94.32%

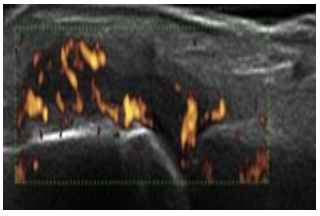

Figure 1: Ultrasound image of thickened vascularized synovium longitudinal

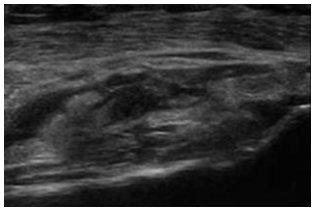

Figure 2 :Suprapatellar recess with thickened synovium longitudinal

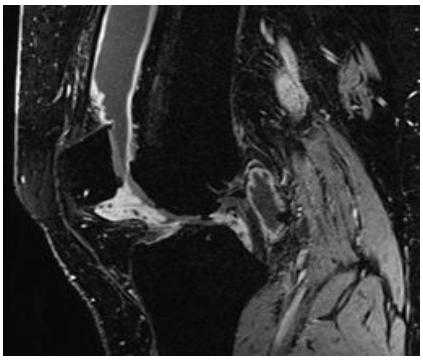

Figure 3: Gadolinium enhanced sagittal T1 weight MRI of a patient with osteoarthritis showing joint effusion and enhanced synovium indicating synovitis

Discussion

Ultrasound can be used to detect synovial proliferation with greater sensitivity than clinical examination. Ultrasound has also been utilized to define the presence of synovitis in OA patients, and at least one report indicates that contrast-enhanced US may be as sensitive as contrast-enhanced MRI in detecting synovitis.[19] On average the synovitis of OA is low-grade in comparison to the high-grade synovitis of RA, but still distinguishable from normal SM.[20]

It has been demonstrated that synovitis can be accurately quantified without using contrast[21] but recent studies have incorporated the use of contrast-enhanced MR imaging techniques to distinguish synovial thickening from effusion.[22] For example, in a recent study by Roemer et al[23] the authors used both contrast-enhanced and non-enhanced images to examine a group of subjects with knee OA, and noted that synovitis was present in over 95% of the knee joints with an effusion, but also in 70% of knee joints in patients without an effusion.[23] Loeuille and colleagues noted that areas of synovial thickening identified on MR images correlated well with individual histologic changes, including inflammatory cell infiltration and lining hyperplasia.[24]

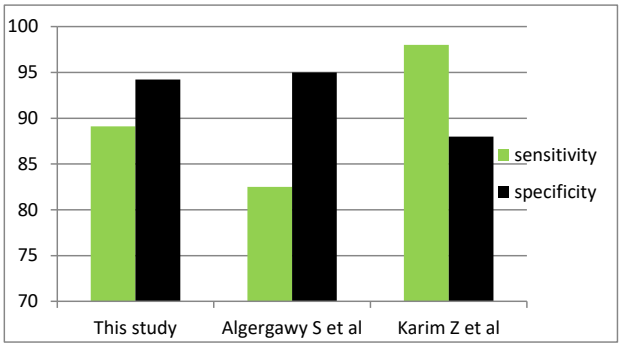

Figure 4: Comparison of the current study with others

We compared our results with a study carried out at Benha University, Al Qalyubiyah, Egypt in 2011 where the sensitivity and specificity of ultrasound was 82.5% and 95% respectively in detecting synovial thickness of knee joint by taking synovial thickness of 2.3mm as a cut off.[16] Karim Z and others assessed the validity and reproducibility of ultrasonography (US) as a means of detecting synovitis in the knee, by comparing US findings with findings of arthroscopy and clinical examination (Figure 4). [25] They demonstrated that with the use of arthroscopy as the gold standard, US had a higher sensitivity (98% versus 85%), specificity (88% versus 25%), accuracy (97% versus 77%), positive predictive value (98% versus 88%), and negative predictive value (88% versus 20%) compared with clinical examination. They concluded that ultrasonography is a valid and reproducible technique for detecting synovitis in the knee, and is more accurate than clinical examination. It may be valuable as a tool in studies investigating pain, diagnosis, and treatment response in knee arthritis.

Value of ultrasound, focusing on major applications of ultrasound in rheumatologic diseases shows concluded that ultrasound is emerging as a tool in the management of rheumatology patients through its gradual incorporation into routine clinical use in many countries and rheumatology centers. Evidence for the reliability, validity as well as clinical value of ultrasound is increasing with continuing studies of this modality. Future development in technology together with consensus of international and national educational programs may spur the wider application of ultrasound for various rheumatologic diseases, enabling it to become a powerful imaging tool for rheumatologists. [15,26,27]

Conclusion

Diagnostic accuracy of ultrasound is higher for the detection of synovial proliferation in patients with osteoarthiritis by using MRI as the gold standard.

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