Med. J. Cairo Univ., Vol. 90, No. 6, September: 1633-1642, 2022
www.medicaljournalofcairouniversity.net

Role of Ultrasonography in Prosthetic Joint Infection Diagnosis and Assessment

MAGED A. MOSTAFA, M.D.; HODA M. ABBAS, M.D. and ISLAM E. ELSHEWI, M.D.

The Department Radiology, Faculty of Medicine, Cairo University

Abstract

Background: The peri-prosthetic joint infection (PJI) definition and diagnosis stay a challenge in orthopedic medicine. It depends on different tools such as clinical, laboratory, and imaging assessments.

Aim of Study: Is to highlight the role of the ultrasound (US) as a diagnostic tool for the evaluation and assessment of PJI in multiple joints to provide early management and care to the patients.

Patients and Methods: This study included 70 adult patients with a prosthetic joint who were complaining of acute pain that was previously asymptomatic or persistent pain with no pain-free interval, and was evaluated by Greyscale ultrasonography scan. The final clinical diagnosis of PJI in our study was reached by the established criteria of the American Musculoskeletal Infection Society.

Results: Seventy patients were included in our study with the hips being the most affected joint. Joint effusion showed a sensitivity of 70.9%, specificity of 100%, and an overall diagnostic accuracy of 62.8% in the detection of PJI. Synovitis showed a sensitivity of 69%, specificity of 83.4%, and an overall diagnostic accuracy of 71.4% in the detection of PJI. Erosions and bone lesions showed a sensitivity of 50%, specificity of 50%, and an overall diagnostic accuracy of 50% in the detection of PJI. Soft tissue affection showed a sensitivity of 56.4%, specificity of 75%, and an overall diagnostic accuracy of 58.6% in the detection of PJI. Joint vascularity showed a sensitivity of 67.2%, specificity of 100%, and an overall diagnostic accuracy of 74.3% in the detection of PJI.

Conclusion: The US could be used as an initial diagnostic tool for painful prosthesis evaluation before proceeding with more sophisticated and invasive procedures. As it is very sensitive in fluid detection and helps in the detection of extra-articular soft tissue lesions.

Key Words: *Ultrasonography – Peri-prosthetic joint infection – Diagnosis.*

Correspondence to: Dr. Maged A. Mostafa, The Department Radiology, Faculty of Medicine, Cairo University

Introduction

HIP and knee substitutions are the foremost common operations around the world. High hopes have been associated with arthroplasty, which has been dubbed "the operation of the century" **[1]**. Effective joint replacement is painless, it reestablishes the work of the affected joint, and makes the quality of life better. Whereas most joint arthroplasty gives pain-free work, a small group of patients will require extra surgery at a certain point during their life. Aseptic failure can be caused by various factors such as releasing at the bone cement interface, periprosthetic break, break of the prosthetic fabric itself, wear and prosthesis malposition, and dislocation-instability **[2]**.

PJI is one postoperative prosthetic pain that influences the quality of life and increments the financial burden because it may lead to revision arthroplasty. Tragically, there's no gold standard symptomatic test for PJI. To reach a conclusive determination, aspirated joint fluid ordinarily remains the current issue and it is also required for the culture of periprosthetic tissue for detection of the causative microorganism. This requires more research for improving the role of different imaging modalities in aiding its final diagnosis **[3]**. Prosthetic joint disease (PJI) will continue to rise in the future, in huge portions as a result of a significant increase in the number of joint substitution strategies over a long time. For the exact determination of PJI, On the basis of individual encounters, a combination of clinical, analytical, microbiological, and imaging tests are done **[4]**.

Other cross-sectional imaging procedures (CT, MRI) are related to metal implant artifacts with poor image quality. The existing inquiries about information related to radiological bone scintigraphy and PET are so conflicting, that the esteem of

nuclear medicine is still hazy. Ultrasonography has been watched to distinguish intra-articular effusion, synovium, and pericortical injuries, whereas Doppler can be used for recognizing the bloodstream in synovium and has the points of interest of real-time energetic and non-invasiveness. There are a few factors to consider when reporting the use of ultrasonography in PJI diagnosis **[5]**.

As a result, the goal of this research was to determine the effectiveness and role of ultrasonography. As a radiological tool in detecting and identifying PJI in patients with joint prostheses, thus helping for patient care and cure.

Patients and Methods

This study was performed between May 2021 and February 2022 at our Radiology Department of our University and approved by our Research and Ethical Committee.

Study group:

We conducted a cross-sectional study that included 70 patients. Both females (n=56) and males (n=14) were included in our study. Patients were suspected clinically of either acute pain that was previously asymptomatic, persistent pain with no pain-free interval, limitation of movement, general constitutional symptoms, or discharging sinus tract to have a prosthetic joint infection and were referred to the radiology department for the assessment of their prosthetic joint. Patients with native joints were excluded.

All of the participants gave their informed consent before any study-related procedure.

Each patient was subjected to the following steps:

- History: Analysis of patient's complaint, relevant past medical and surgical history.
- Examination: The physical examination of the prosthetic joint.
- Revision of previous imaging studies (if available).
- Laboratory investigation: White blood cell (WBC) count, one week prior to ultrasonography, all patients had their blood C-reactive protein and erythrocyte sedimentation rate assessed. In certain situations, conventional joint fluid or periprosthetic tissue cultures were conducted after ultrasonography.
- US examination of the affected prosthetic joint was performed by two consultants experienced in musculoskeletal system ultrasonography of at least 10 years for all included participants.
- Complementary X-ray or CT or MRI or even two of them were performed in some cases. IV contrast was mainly needed in case of soft tissue complications on top of the prosthesis.

Ultrasonographic evaluation:

The greyscale US was done using Toshiba Apilo 500. Two probes were used: 1-A high-resolution linear transducer of 7-11 MHz. 2-A low-frequency curvilinear transducer 3-5 MHz was used for imaging obese patients. Initially, B mode was applied first to examine the prosthetic joint then Color Doppler was applied for the evaluation of vascularity. A water-soluble gel is applied to the prosthetic joint skin of the patient.

The following joints were examined:

1- *Hip joint examination: (Capsule bone distance).*

The front, medial, lateral, and posterior hip areas were all assessed utilizing a systematic method in all US examinations. The US identified an acoustic window in and around the articular cavity.

a- Anterior hip: Anterior joint recess and iliopsoas tendon:

In order to detect the anterior synovial recess, the femoral head was used as the landmark. In the supine position, the transducer was applied in an oblique longitudinal plane over the femoral neck. The anterior glenoid labrum of the acetabulum can be recognized as a homogeneously hyperechoic triangular structure cranial to the anterior recess.

b- Lateral hip: Gluteus minimus, gluteus medius and fascia lata:

Short-axis and long-axis The gluteus medius tendon was seen as a curvilinear fibrillar band on US images taken over the lateral facet of the greater trochanter. The anterior part of the gluteus maximus can be seen covering the posterior part of the gluteus medius tendon in the posterior view. Coronal images were used to evaluate the fascia lata. It appears as a hyperechoic band on the surface.

c- Medial hip region: Adductor muscles:

Transverse planes were conducted starting from the adductor muscle's belly and progressing to the pubic area, following the muscle's course until its insertion.

d- Posterior hip region: Gluteus maximus, semimembranosus, semitendinosus, and long head of the biceps femoris muscle:

This was examined using transverse, sagittal, coronal, and oblique planes. The landmark was the ischial tuberosity. The gluteus maximus was the

first muscle to be tested. The proximal origin of the ischiocrural muscle group (semimembranosus, semitendinosus, and long head of the biceps femoris muscle) was discovered at the posterior-inferior level.

2- Shoulder joint examination:

The elbow was flexed 90 degrees, palm up, and the arm was placed in modest internal rotation (directed towards the contralateral knee), searching for the long biceps tendon in between the greater and lesser tuberosities. Then the patients were asked to put the palm on the back pocket, abducting and internally rotating the shoulder to assess the supraspinatus tendon, then to detect the subscapularis tendon and its insertion on the lesser tuberosity by rotating the arm externally and placing the elbow on the iliac crest. The Acromioclavicular (AC) joint was demonstrated in the coronal view with the arm in the state of neutrality (hand on the thigh).

3- Knee joint examination:

While the patient was in the supine posture, the anterior portion of the knee was inspected. To avoid anisotropy, a pillow was placed under the popliteal fossa to achieve flexion of around 20-30°. The supra-patellar fat pad, which appeared as a large hyperechoic area cranially to the patella and superficial to the femur, was discovered. The supra-patellar synovial recess was seen as a thin hypoechoic S-shaped area deep within the quadriceps tendon. To detect the tiny quantity of synovial fluid that tends to build in the lateral and medial regions of the supra-patellar recess, imaging was extended over the lateral and medial sides of the quadriceps tendon.

Ultrasound interpretation of prosthetic joints was subjected to the following:

1- Joint effusion detection and measuring the depth of capsule to bone distance: For the hip joint; The distance between the metallic echo from the anterior surface of the prosthetic femoral neck and the echo from the anterior surface of the anterior capsule's outer limit was defined as capsular distension., and a value of more than 10mm was evidence of effusion. This distance was measured with the hips in a 10-15-degree outward rotation and a 45-degree internal rotation, perpendicular to the femoral neck. Color Doppler was applied to be differentiated from synovitis.

2- The presence of extra-articular fluid collection.

3- Soft tissue abnormalities: (A) Sinus tract: hypoechoic tract connecting deep collection to the overlying skin. (B) Subcutaneous edema with the characteristic cobblestone appearance. (C) Pseudotumor; anechoic or hypoechoic fluid collection with mild vascularity ± thick echogenic septations and marked synovial hypertrophy.

4- Presence of bursitis: Assessed by increased fluid in the bursa and/or thickening of the wall of the bursa.

5- Detection of mature heterotopic ossification: Highly echogenic calcific foci with acoustic shadowing.

6- Tendinosis and/or tear were also assessed.

7- Presence of synovitis assessed by increased thickness with hyperemia by power Doppler.

The final clinical diagnosis of PJI in our study was reached by the established criteria of the American Musculoskeletal Infection Society (MSIS) stated by Parvizi, J, et al., **[6]**:

(1) The presence of a sinus tract communicating with the prosthesis; or (2) The presence of a pathogen isolated by culture from at least two separate tissue or fluid samples obtained from the affected prosthetic joint; or (3) The presence of a pathogen isolated by culture from at least two separate tissue or fluid samples obtained from the affected prosthetic joint; or (3) Four out of the six requirements were met:

a- Serum erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels are elevated.

b- An increase in the number of synovial leukocytes.

c- A higher percentage of synovial neutrophils (PMN percent).

d- Purulent discharge from the afflicted joint.

e- Isolation of a microbe in one culture of periprosthetic tissue or fluid, or (f) More than five neutrophils per high-power field in five high-power fields detected from periprosthetic tissue histology.

Statistical analysis and sample size calculation:

The sample size was calculated using the Wnarifin online sample size calculator for diagnostic tests and upon the following parameters; sensitivity of detecting PJI 100%, specificity 74%, 95% confidence interval, 10% precision, the prevalence of PIJ 12%, and level of significance 0.05. The sample size was estimated at N = 70 patients. Statistical analysis was conducted using SPSS 22nd edition, numeric variables were presented in mean ± standard deviation and compared using the Mann-

Whitney U test. Categorical variables were presented in frequency and percentages and were compared using the Chi^2 test. Paired comparison of US findings and the final diagnosis was conducted using McNamara's test. Diagnostic indices were calculated using 2x2 contingency tables. Any *p*-value <0.05 was considered significant.

Results

A total of 70 patients were included in our final analysis, all patients were presented with joint pain and had previous joint replacement surgery. They had a mean age of 52.4 ± SD 18.5 years old.

Among the included patients 80% (n=56) were females while 20% (n=14) were males. Only three patients had a general constitutional symptom, 40 (57.1%) patients had limitations of movement. And 8 (11.4%) patients had a discharging sinus tract from the affected joint.

Primary diagnosis of the included patients was osteoarthritis in (n=27) 37.5%, traumatic in (n=22) 31.3%, ankylosing spondylitis in (n=9)12.5%, (n=4) 6.3% fibrous dysplasia, (n=4) 6.3% pathological fracture, (n=2) 3.1% rheumatoid arthritis and (n=2) 3% inflammatory.

Hips were the most affected joints (50 patients); twenty-two on the left side, and 28 1on the right side. While 6 cases presented with the affected left shoulder, 4 with the right shoulder, 7 in the right knee, and 3 in the left knee. 12 (37.5%) patients had a free medical history, while the remaining patients had a history contributing to the cause of joint replacement surgery.

A- *Ultrasound findings:*

During ultrasound evaluation, Capsule-bone distance showed a mean of 11.1 ± SD 4.4 mm, 62 (88.6%) patients had joint effusion, 16 (22.8%) patients had Non-PJI synovitis, 12 (17.1%) patients had mild cortical irregularities, 10 (14.3%) patients had mild cortical irregularities with periprosthetic calcifications (heterotopic ossifications). Table (1).

Only eight patients had normal soft tissue without any affection, while 15 patients had soft tissue edema only. Extra-articular fluid collection and sinus tract communicating with joint space were reported in 8 patients each. Moreover, distended periarticular bursa (iliopsoas bursa) was found in 8 cases, Extra-articular encysted complex fluid collection did not communicate with joint space detected in one case. Table (1).

One case showed a deeply seated hematoma/ infection on top which was revised with CT/MRI Fig. (1). Distended Periarticular bursa (trochanteric bursa), Distended periarticular bursa (nonspecific), and distended peri articular bursa [suprapatellar bursa Fig. (2)] were reported in two patients each. Table (1).

B- Diagnosis:

Non-PJI cases: (Table 1)

14 (20%) patients were diagnosed with bursitis [8 (11.4%) patients were diagnosed with iliopsoas bursitis while trochanteric bursitis, suprapatellar bursitis, and nonspecific bursitis with heterotopic ossifications were reported in two patients each (2.9%)].

16 (22.8%) patients were diagnosed with synovitis, and heterotopic ossifications were found in 4 of them. 6 (8.6%) patients were diagnosed as pseudotumors while seroma and periprosthetic fracture complicated by infected hematoma with heterotopic ossifications were reported in one patient each (1.4%).

PJI cases: (Table 1)

PJI was diagnosed with joint aspirate and positive culture results in 20 (28.6%) patients, 8 (11.4%) patients diagnosed with one major PJI criteria Fig. (3), and 8 (11.4%) patients had 2 minor criteria.

Heterotopic ossification was found as an associated pathology in 7 patients, 6 of them were associated with non-PJI cases and one case presented as PJI by major criteria. Regarding joint vascularity, we depicted most of our cases showed joint vascularity changes ranged from mild to severely increased Fig. (4) with significant comparison between Non-PJI and PJI groups regarding the grade IV increased joint vascularity.

36 (51.4%) of the patients were definitively finally diagnosed with PJI, while 34 (48.6%) had other diagnoses.

C- Diagnostic indices of US findings:

A comparison between the radiological findings reached by ultrasound and the final diagnosis reached by the established criteria of MSIS was done. The sensitivity, specificity, PPV, and accuracy were measured for each ultrasonographic finding as follows:

1- *Joint effusion:*

Joint effusion showed a sensitivity of 70.9%, specificity of 100%, PPV 70.9%, and overall diagnostic accuracy of 62.8% in the detection of PJI. The paired comparison showed a significant difference with a *p*-value of 0.016 (Tables 2,3).

Capsule-bone distance:

Regarding PJI cases, the mean anterior hip capsule-bone distance equals 13.2 mm ± SD 3.2 mm. On setting 10mm as a cut-off value for capsule-bone distance, the paired comparison showed a significant difference with a *p*-value of 0.0001 (Table 4).

2- Synovitis:

Synovitis showed sensitivity 69%, specificity 83.4%, PPV 95.2%, NPP 35.7% and overall diagnostic accuracy 71.4% in detection of PJI. The paired comparison showed no significant difference with a *p*-value of 0.15 (Tables 5,6).

3- Bone lesions:

Erosions and bone lesions showed sensitivity 50%, specificity 50%, PPV 31.4%, NPP 68.6% and overall diagnostic accuracy 50% in detection of PJI. The paired comparison showed no significant difference with a *p*-value of 0.60 (Tables 7,8).

4- Soft tissue affection:

Soft tissue affection showed sensitivity 56.4%, specificity 75%, PPV 94.6%, NPP 18.2% and overall diagnostic accuracy 58.6% in detection of PJI. The paired comparison showed a significant difference with a *p*-value of 0.003 (Tables 9,10).

5- Joint vascularity:

Joint vascularity showed sensitivity 67.2%, specificity 100%, PPV 100%, NPP 45.4% and overall diagnostic accuracy 74.3% in detection of PJI. The paired comparison showed a significant difference with a *p*-value of 0.008 (Tables 11,12).

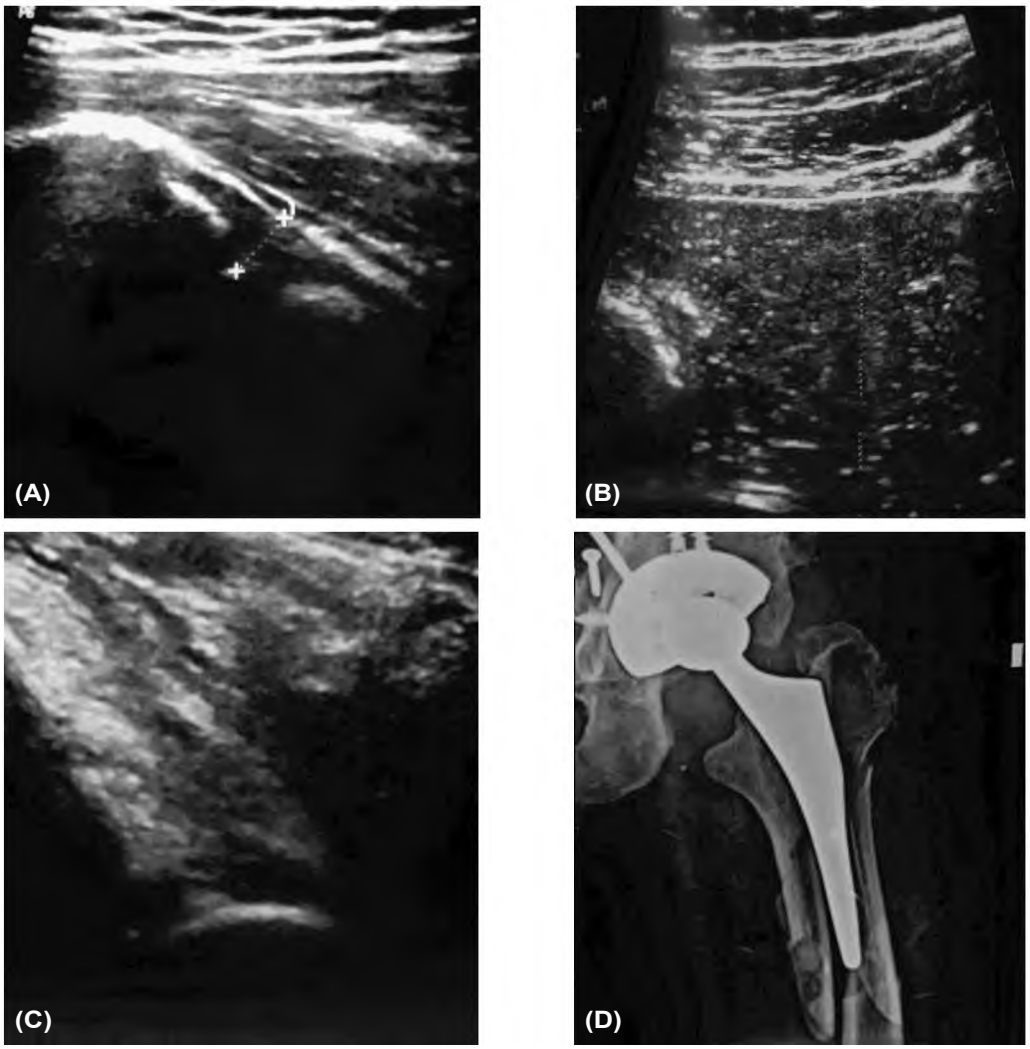

Fig. (1): A 28-year-old male patient, known schizophrenic with history of fall from height during suicidal attempt, underwent left THA 5 years ago. (A&B) Joint effusion with bone to capsule distance measuring 7.2mm. Deeply seated well defined lesion of internal echoes and mild vascularity on applying color Doppler (infected hematoma??), not communicating with the joint space. Cortical irregularities with small peri prosthetic calcific foci representing heterotopic calcifications. (C&D) Peri prothetic femur fracture was diagnosed. Fracture was complicated by infected hematoma causing severe tenderness and high TLC count.

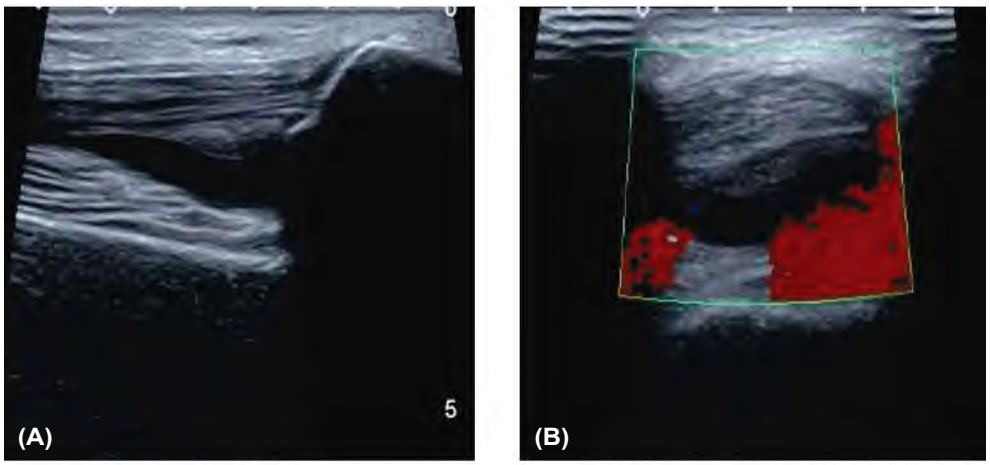

Fig. (2): A 45-year-old male patient, not diabetic nor hypertensive with a history of RTA, underwent Right TKA 8 years ago. (A&B) Distension of suprapatellar recess by hypoechoic well-circumscribed collection measuring 9mm in AP diameter, representing suprapatellar bursitis. Mild bony irregularities. Mildly edematous quadriceps tendon. Normal vascularity of surrounding tissue.

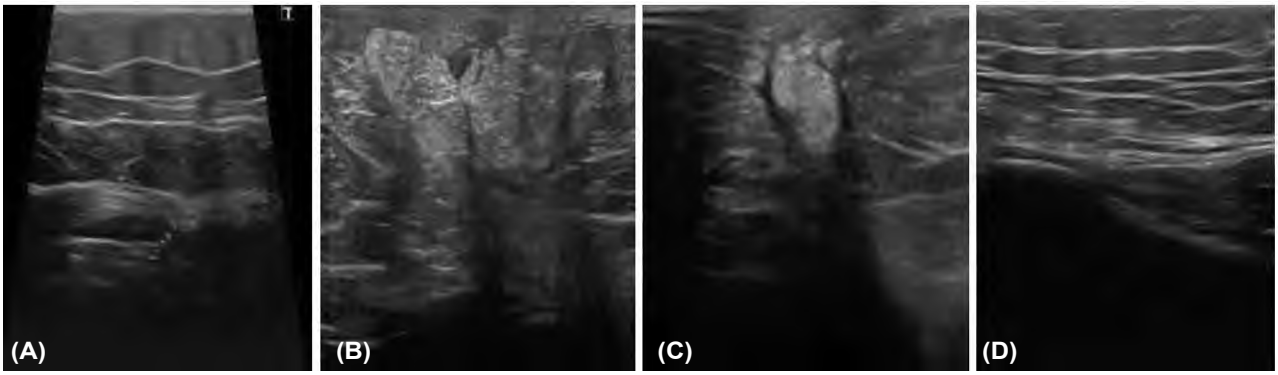

Fig. (3): 24-year-old male patient, not diabetic nor hypertensive, underwent Right THA 3 years ago. (A) Showing joint effusion with capsule-bone distance measuring 10mm. (B) Showing periprosthetic soft tissue edema with a cobblestone appearance. (C) Showing a hypoechoic line (sinus tract) communicating with the joint effusion, with echogenic content within (Pus). (D) Showing No bony or articular abnormalities.

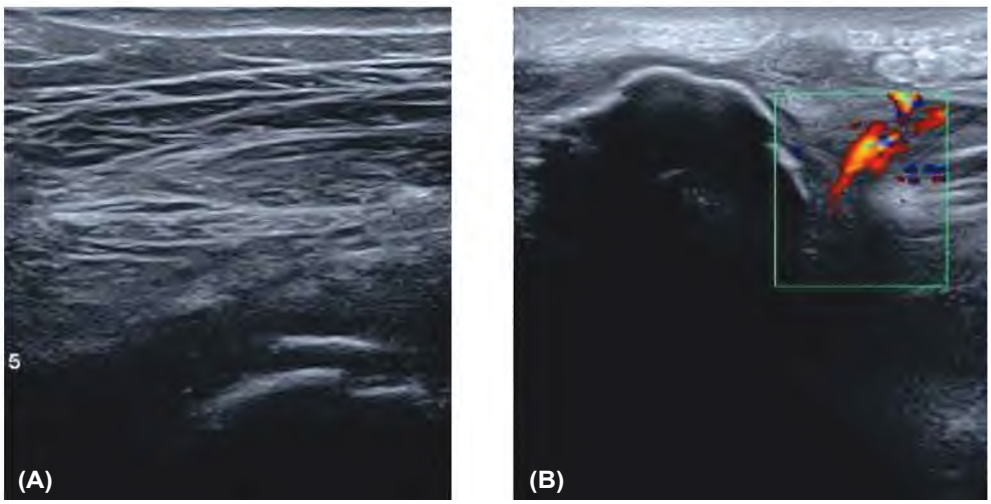

Fig. (4): A 20-year-old male patient, not diabetic nor hypertensive with a history of RTA, underwent Right THA 1 year ago. (A) Showing joint effusion with capsule-to-bone distance measuring 15mm. Peri prosthetic small foci of calcifications representing heterotopic calcifications. Peri articular muscle hypertrophy and tendinosis in comparison to the contralateral joint. (B) Showing soft tissue edema and increased vascularity. No definite sinus tract could be detected.

Table (1): Possible diagnosis based on diagnostic criteria of PJI.

	Count	%
Possible Diagnosis:		
Non-PJI : Bursitis:		
Non PJI- Iliopsoas bursitis	8	11.4
Non PJI - Trochanteric bursitis	2	2.9
Non PJI- Supra patellar bursitis	2	2.9
Non PJI- Nonspecific bursitis with heterotopic ossifications	2	2.9
Non-PJI : Synovitis:		
Non PJI-Synovitis only	12	17.2
Non PJI- Synovitis associated with heterotopic ossification	4	5.7
Non-PJI : Miscellaneous:		
Non PJI-Infected hematoma on top of peri prosthetic fracture with heterotopic ossifications	1	1.4
Non PJI-pseudotumor	6	8.6
Non PJI-Seroma	1	1.4
PJI:		
PJI (diagnosed by joint aspiration and culture)	20	28.6
PJI (1 major criteria)	8	11.4
Possible PJI (2 minor criteria)	8	11.4

Table (2): Paired comparison between joint effusion finding by US and final diagnosis by McNamar test.

	Final diagnosis				*p*-value
	Negative		Positive		
	Count	Row N %	Count	Row N %	
Joint Effusion:					0.016
Negative	8	100.0	0	0.0	
Positive	18	29.1	44	70.9	

Table (3): Diagnostic indices of joint effusion.

Statistic	Value	95% CI
Sensitivity	70.9	48.91% to 87.38%
Specificity	100%	100.0% to 36.94%
Positive predicitve value (*)	70.9%	62.18% to 73.31%
Negative predicitve value (*)	0	
Accuracy (*)	62.8%	34.74% to 70.91%

Table (4): Comparison of Capsule-bone distance based on final diagnosis.

	Final diagnosis				*p*-value
	Negative (n=8)		Positive (n=62)		
	Count	%	Count	%	
- Capsule-bone distance <10mm	29	46.7	0	0.0	0.0001
- Capsule-bone distance ≥10mm	0	0.0	33	100.0	

Table (5): Paired comparison between joint synovitis finding by US and final diagnosis by McNamar test.

	Final diagnosis				*p*-value
	Negative		Positive		
	Count	Row N %	Count	Row N %	
Synovitis:					
Negative	10	83.4	2	16.6	0.15
Positive	18	31	40	69	

Table (6): Diagnostic indices of joint synovitis.

Statistic	Value	95% CI
Sensitivity	69%	0.28% to 48.25%
Specificity	83.4%	13.21% to 52.92%
Positive likelihood ratio	4.15	0.02 to 1.03
Negative likelihood ratio	0.37	1.51 to 5.65
Positive predictive value (*)	95.2%	0.96% to 28.80%
Negative predictive value (*)	35.7%	31.15% to 62.86%
Accuracy (*)	71.4%	11.46% to 43.40%

Table (7): Paired comparison between erosions and bone lesions finding by US and final diagnosis by Mc-Namar test.

	Final diagnosis				*p*-value
	Negative		Positive		
	Count	Row N %	Count	Row N %	
Erosions/bone lesions:					
No	24	50.0	24	50.0	0.60
Mild cortical irregularities	4	33.3	8	66.7	
Mild cortical irregularities-peri prosthetic calcifications	7	70	3	30	

Table (8): Diagnostic indices of erosion and bone lesions.

Statistic	Value	95% CI
Sensitivity	50.00%	31.53% to 76.94
Specificity	50.00%	21.09% to 78.91%
Positive likelihood ratio	1	0.55 to 2.19
Negative likelihood ratio	1	0.43 to 1.90
Positive predictive value (*)	31.4%	47.88% to 78.53%
Negative predictive value (*)	68.6%	24.04% to 58.41%
Accuracy (*)	50%	34.74% to 70.91%

Table (9): Paired comparison between soft tissue affection by US and final diagnosis by McNamar test.

	Final diagnosis				*p*-value
	Negative		Positive		
	Count	Row N %	Count	Row N %	
Soft tissue affection:					
No	6	75	2	25.7	0.003
Yes	27	43.6	35	56.4	

Table (10): Diagnostic indices of soft tissue affection.

Statistic	Value	95% CI
Sensitivity	56.4%	37.18% to 75.54%
Specificity	75%	19.41% to 99.37%
Positive likelihood ratio	2.25	0.41 to 12.86
Negative likelihood ratio	0.58	0.28 to 1.16
Positive predictive value (*)	94.6%	73.98% to 98.90%
Negative predictive value (*)	18.2%	10.95% to 33.69%
Accuracy (*)	58.6%	40.64% to 76.30%

Table (11): Paired comparison between joint vascularity by US and final diagnosis by McNamar test.

	Final diagnosis				*p*-value
	Negative		Positive		
	Count	Row N %	Count	Row N %	
Vascularity:					
Normal	15	100.0	0	0.0	0.008
Mild increase	11	55	9	45	
Significantly increased	7	20	28	80	

Table (10): Diagnostic indices of joint vascularity.

Statistic	Value	95% CI
Sensitivity	67.20%	46.50% to 85.05%
Specificity	100.00%	59.04% to 100.00
Negative likelihood ratio	0.328	0.18 to 0.57
Positive predictive value (*)	100.00	59.04% to 100.00
Negative predictive value (*)	45.4%	33.07% to 60.78%
Accuracy (*)	74.3%	56.60% to 88.54%

Discussion

Prosthetic joints are one of the most common operations done globally to relieve joint pain. The risk factors for periprosthetic contamination are progressed age, weight, DM, HIV, and contamination in past arthroplasty. PJI signs can be either acute (high fever, toxemia, and surgical wound emissions) or chronic (skin fistulae and purulent emissions without fever). The nature of the contaminated tissue, the route of administration, and the advancement of the illness are the factors that the severity of the clinical illness depends on **[7,8,9]**.

The conclusion of PJI depends on a combination of clinical scenarios, blood, and synovial fluid tests, microbiological tests, histological assessment of periprosthetic tissue, intraoperative results, and radiographic information **[2]**.

In our study, we evaluated 70 patients referred from orthopedic clinics and emergency departments with clinical signs suggesting the presence of prosthetic joint infections.

According to the study by Izakovicova et al., **[7]**, Early indications of PJI include persistent or growing local discomfort, erythema, and swelling. Early PJI symptoms include persistent or worsening local discomfort, erythema, edema, wound healing disruption, and fever. Our study revealed that; three patients had a general constitutional symptom, 40 (57.1%) patients had painful limitations of movement, and 8 (11.4%) patients had a discharging sinus tract from the affected joint.

We noticed that in 70.9% (n=50) of our cases; the hips were the most affected joints. This is could be explained by Tande et al., **[2]** that stated that a larger number of patients have undergone hip arthroplasty than knee arthroplasty. Furthermore, shoulder, elbow, and ankle arthroplasties are available recently.

The inflammatory response of PJI is increasing apparently. In this study, ultrasonography could reveal PJI with extracapsular effusion or sinus, a large amount of intracapsular effusion, poor acoustic window, and hypertrophic synovium with rich blood flow signal. Regarding the joint effusion; almost all patients in our study had intracapsular effusion while 10 patients showed extracapsular effusion±communicating with joint space with a sensitivity of 70.9% and specificity of 100%. That was in line with Wei et al., **[5]** as most PJI cases presented by intracapsular effusion and 14 cases presented by extracapsular effusion with a sensitivity of 53.5%, specificity of 100% when effusion volume ≥25.5mm.

Wei et al., **[5]** mentioned that a distance between the anterior hip joint capsule and the femur of more than 10mm is indicative of a hip effusion. This cut-off value was found in 33 finally diagnosed PJI hip cases, and our mean capsule-bone distance was 11.1 ± SD 4.4mm with a *p*-value of 0.0001for PJI final accuracy diagnosis compared to non PJI cases.

We concluded that patients had synovitis with a sensitivity of 69%, specificity of 83.4%, and overall diagnostic accuracy of 71.4% in the detection of PJI. In our study, almost all patients had increased synovial blood flow (58/70) ranging from mild increased to significantly increased blood flow. A significant comparison was noted between our PJI and non-PJI groups in grade 3 synovial blood flow with a *p*-value of 0.008. This was in line with Wei et al., **[5]** who showed that the PJI group had more severe synovial thickening with increased blood supply ($p<0.01$).

Mujtaba B et al., **[10]** depicted that ultrasound is not ideally proven to detect the prosthesis and periprosthetic bone, yet it is proved to be a sensitive imaging modality for soft tissue lesions and calcifications. Twenty-two patients in our study had mild cortical irregularities of the replaced joint associated with heterotopic ossification for both groups with no significant difference. This finding disagreed with a study by Manrique et al., **[11]** who found that; the incidence of overall HO in PJI and aseptic groups was 84% (47/56) and 11% (12/112), respectively. In the multivariate analysis, PJI was found to be an independent risk factor for HO (odds ratio of 9.3, 95 percent CI: 2.9-29.9, *p*0.001). Ultrasound has been effectively used for the evaluation of pseudotumors in patients with large-diameter metal on metal (MoM) Total Hip Arthroplasty and hip resurfacing. A comparative study done by Donald et al., **[12]**, to detect US accuracy for the evaluation of pseudotumors on top of arthroplasty, depicted that negative ultrasound ruled out pseudotumors in asymptomatic patients. We agreed with this study, as 6 patients in our study were diagnosed with pseudotumor on top of arthroplasty were detected at the hip joint rather than other joints, and they were first detected by the US. Various soft tissue affections were noted in our study groups and could easily be depicted by the US; skin thickening, subcutaneous edema, extraarticular seroma, and even a sinus tract. We could easily track the chronic discharging sinus or visible purulence around the prosthesis. That was matched with Romanò et al., **[13]** who mentioned that; ultrasound could be successfully used to follow sinus tracts within soft tissues.

Conclusion:

PJI is one of the causes of painful prostheses which affects the quality of life and increases the economic burden as it may result in revision arthroplasty. To reach the definitive diagnosis, invasive joint fluid aspiration is usually needed or a culture of periprosthetic tissue for detection of the causative microorganism. This requires improving the current method of diagnosis for PJI. The US is very sensitive to fluid detection, extra-articular soft tissue lesions, and vascularity. As well it could be used to guide joint fluid aspiration. So it could be helpful with significant value in the differential diagnosis of PJI and non-PJI groups.

References

1- ZAJONZ D., WUTHE L., TIEPOLT S., et al.: Diagnostic workup strategy for periprosthetic joint infections after total hip and knee arthroplasty: A 12-year experience on 320 consecutive cases. Patient Safety in Surgery, 9: 20, 2015. {PubMed}.

2- TANDE A.J. and PATEL R.: Prosthetic joint infection. Clinical Microbiology Revision, 27 (2): 302-45, 2014. {PubMed}.

3- SEUNG-JU KIM and YUN JAE CHO: Current Guideline for Diagnosis of Periprosthetic Joint Infection: A Review Article. Hip Pelvis, 33 (1): 11-17, 2021. {PubMed}.

4- SIGNORE A. and SCONFIENZA L.M. et al.: Consensus document for the diagnosis of prosthetic joint infections: A joint paper by the EANM, EBJIS, and ESR (with ESCMID endorsement). European Journal of Nuclear Medicine and Molecular Imaging, 46: 971-988, 2019. {PubMed}.

5- WEILI WEI, XIAOHUA HUANG, LIYAN HUANG, et al.: Application of Ultrasound in Diagnosis of Prosthesis Loosening and Infection After Total Hip Arthroplasty. {Research Square}, DOI: 10.21203/rs.3.rs-222251/v1, 2021.

6- GOSWAMI K., PARVIZI J. and MAXWELL COURTNEY P.: Current recommendations for the Diagnosis of Acute and Chronic PJI for Hip and Knee-Cell Counts, Alpha-Defensin, Leukocyte Esterase, Next-generation Sequencing. Current Review in Musculoskeletal Medicine, 11 (3): 428-438, 2018. {PubMed}.

7- IZAKOVICOVA P., BORENS O., et al.: Periprosthetic joint infection: Current concepts and outlook. EFORT Open Review, 4 (7): 482-494, 2019. {PubMed}.

8- AYOADE F., LI D.D., MABROUK A., et al.: Prosthetic Joint Infection in Stat Pearls (Internet). https://www.ncbi.nlm.nih.gov/books/NBK448131. {StatPearls}, 2022.

9- KIM S.J. and CHO Y.J.: Current Guideline for Diagnosis of Periprosthetic Joint Infection: A Review Article. Hip Pelvis, 33 (1): 11-17, 2021. {PubMed}.

10- MUJTABA B., TAHER A. and FIALA M.J., et al.: Heterotopic ossification: radiological and pathological review. Radiology and Oncology, 53 (3): 275-284, 2019. {PubMed}.

11- MANRIQUE J., ALIJANIPOUR P. and PARVIZI J.: Increased Risk of Heterotopic Ossification Following Revision Hip Arthroplasty for Periprosthetic Joint Infection Arch. Bone Jt. Surg., Nov. 6 (6): 486-491, 2018. {PubMed}.

12- DONALD S. GARBUZ, BRIAN A. HARGREAVES and BRUCE B. FORSTER: The John Charnley Award: Diagnostic Accuracy of MRI Versus Ultrasound for Detecting Pseudotumors in Asymptomatic Metal-on-Metal THA Clin. Orthop. Relat. Res., Feb; 472 (2): 417-423, 2014 {PubMed}.

13- CARLO LUCA ROMANÒ, NICOLA PETROSILLO, GIUSEPPE ARGENTO, et al.: The Role of Imaging Techniques to Define a Peri – Prosthetic Hip and Knee Joint Infection: Multidisciplinary Consensus Statements J. Clin. Med., Aug. 9 (8): 2548, 2020 {PubMed}.

دور الموجات فوق الصوتية
فى تشخيص عدوى المفاصل الصناعية

تعد عدوى المفاصل الصناعية من المضاعفات الخطيرة غير شائعة الحدوث بعد عمليات تغيير المفاصل. تزداد نسبة حدوثها نتيجة للزيادة المستمرة فى هذا النوع من العمليات. تختلف الأعراض اعتماداً على مناعة المريض وشراسة الميكروبات المسببة للعدوى. يعد الألم بالمفصل الصناعى هو العرض الأكثر شيوعاً.

لا يزال البرنامج التشخيصى للمرض تحت التطوير ولا يوجد حتى الآن فحص تشخيصى متخصص، حيث يتم الوصول للتشخيص النهائى فقط بعد عزل الميكروب المسبب للعدوى من الأنسجة المحيطة للمفصل.

الهدف من هذا البحث هو تقييم دور الموجات فوق الصوتية فى تشخيص عدوى المفاصل الصناعى. الصناعية بغرض تطوير البرنامج التشخيصى لهذا المرض.

تضمن هذا البحث اثنين وثلاثين مريضاً (ذكوراً وإناثاً) ممن يشتبه بهم الإصابة بعدوى المفاصل الصناعية بالفحص الطبى ثم تم فحصهم جميعاً بالموجات فوق الصوتية على المفاصل الصناعية ومقارنة النتائج بالمفصل المقابل. لقد تم إدماج النتائج مع الحالة المرضية والتحاليل والأشعة الأخرى المتاحة بالإضافة إلى نتائج الباثولوجى والتشخيص الجراحى.

لقد وجدنا أن الموجات فوق الصوتية شديدة الدقة فى كشف ارتشاح المفاصل والتغيرات المصاحبة فى الأنسجة المحيطة والأوعية الدموية، بالإضافة إلى كشف التغيرات المصاحبة فى العظام ولكن تظل الأشعة السينية والمقطعية أكثر حساسية، كما أنها تقوم أيضاً بتوجيه سحب العينة من الارتشاح المحيط بالمفصل.

لقد استنتجنا أن الموجات فوق الصوتية يمكن استخدامها كوسيلة أولية فى تشخيص عدوى المفاصل الصناعية. إنها تستطيع استبعاد الأسباب الأخرى المسببة لآلام المفاصل الصناعية مثل الالتهاب الكيسى والتهاب غشاء المفصل والورم الكاذب. كما أنها تساعد فى التشخيص عن طريق كشف ارتشاح المفصل والتغيرات المصاحبة فى الأنسجة المحيطة مثل الناسور والتجمعات السائلة خارج المفصل وزيادة التغذية الدموية، وتزداد دقتها فى كشف التغيرات المصاحبة فى العظام مثل الكسور عند استخدامها مع الأشعة تعتبر الموجات فوق الصوتية وسيلة سهلة، رخيصة، وغير تداخلية، من مميزاتها القدرة على السينية. الفحص المتحرك بالإضافة إلى التواصل مع المريض أثناء الفحص وعدم التعرض للإشعاع الضار.