Original Article

Comparative Evaluation of High-Resolution Ultrasonography and Magnetic Resonance Imaging in Painful Wrist Joint

Abhishek Kumar Singh, Rajul Rastogi, Neha, Vaibhav Khare, Vijai Pratap, Najmul Huda[1]

Departments of Radiodiagnosis, and [1]Orthopedics, Teerthanker Mahaveer Medical College and Research Center, Moradabad, Uttar Pradesh, India

Abstract

Introduction: Wrist joint is a commonly used joint in day-to-day activities and hence is not only susceptible to various pathologies but is also the cause of significant morbidity in cases of painful wrist. Although magnetic resonance imaging (MRI) is the usual imaging investigation preferred for the evaluation of painful wrist joint, its inherent limitations in form of high cost, limited availability, higher scan time, and lack of comparison with contralateral side have prompted us to design a study comparing the role of high-resolution ultrasonography (HRUS) with MRI in such cases. **Materials and Methods:** Forty patients of painful wrist joint were evaluated with HRUS and MRI following approval of IEC and after informed consent. The two imaging modalities were compared not only in the detection of various findings related to painful wrist joint as joint effusion, synovitis, synovial hypertrophy, tenosynovitis, rice bodies, bone erosions, etc., but also in diagnosing the final group of disease. Appropriate statistical tests were then used to analyze the results. **Results:** Our study revealed that HRUS is similar to MRI in the detection of joint effusion, synovitis, synovial hypertrophy, tenosynovitis, rice bodies, etc., but is very poor in the detection of bony pathologies, especially marrow edema or chronic fractures. In our study, HRUS was equivalent to MRI in the final diagnosis in 67.5% cases, was inferior to MRI in 30% cases and was superior to MRI in 2.5%. **Conclusions:** Since HRUS has a high accuracy in detecting the pathologies in cases of painful wrist joint, it should be used as the first imaging modality. Patients with equivocal diagnosis or requiring surgical planning may, however, be subjected to MRI.

Keywords: High-resolution ultrasonography, magnetic resonance imaging, painful, wrist joint

Introduction

Wrist joint is the commonly used joint in our daily activities especially in intricate works.[1] Wide variety of pathologies from simple sprain to infective, inflammatory and neoplastic pathologies can be seen in wrist joint. These pathologies are a cause of significant morbidity; hence, prompt diagnosis and treatment is mandatory.

Wrist joint is a complex synovial joint involving bones, namely distal radius and distal ulna along with eight carpal bones in addition to various soft-tissue structures such as ligaments, tendons, capsules, vessels, and nerves present at the wrist which provide stability to the joint.[2] Besides the various structures including neurovascular bundles, the scapholunate ligament which binds the scaphoid and lunate bones together is considered to be clinically important.[3]

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Painful wrist is often defined as acute pain due to injury or subacute/chronic pain due to gradually developing pathologies without prior traumatic episodes occurring due a wide variety of pathologies.[4] Broadly, the pathologies can be divided into two main categories, namely intracapsular and extracapsular [Table 1].[5]

The clinical examination often cannot distinguish the exact cause of wrist pain when the radiological investigations such as conventional radiography, high-resolution ultrasonography (HRUS), computed tomography, magnetic resonance imaging (MRI) with or without contrast plays a vital role in the diagnosis of the disease.[5]

Address for correspondence: Dr. Rajul Rastogi, Department of Radiodiagnosis, Teerthanker Mahaveer Medical College and Research Center, Moradabad - 244 001, Uttar Pradesh, India
E-mail: eesharastogi@gmail.com

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HRUS provides with a wide range of diagnostic opportunity due to its inherent qualities such as excellent evaluation of superficial soft tissues, simultaneous examination of contralateral wrist, inexpensive, time efficient, and dynamic nature, etc., but with limited role bone pathologies.[3,5]

Magnetic resonance imaging

It is the most commonly used imaging modality for the assessment of wrist pain pathologies not only due to its ability of demonstrating osseous pathologies besides those involving variety of soft tissues at the wrist joint but also due to its ability to detect early disease, for example, marrow edema.[5-7] However, it is limited by it expensive and time-consuming nature besides being sparsely available.

Hence, this comparative study was planned to with the following aims and objectives:

Aim

The aim of this study is to comparative evaluation of HRUS and MRI in the evaluation of painful wrist joint pathologies.

Objectives

- Role of HRUS in detecting the cause in painful wrist joint
- Role of MRI in detecting the cause in painful wrist joint
- Comparison of HRUS and MRI accuracy in detecting the cause of painful wrist joint.

Materials and Methods

This hospital-based, cross-sectional, observational study was carried out on forty patients with painful wrist joint in our Institution following approval from Institutional Ethics Committee (Ref. No: TMMC and RC/IEC/18-19/072 dated: 27/12/2018) and after obtaining written informed consent using the following selection criteria:

Inclusion criteria

Patients of any gender and age presenting with painful wrist due to infective, inflammatory, and subacute or chronic traumatic manifestations.

Exclusion criteria

Patients with postoperative status, pregnancy, or acute trauma in addition to those with any MRI contraindication.

All the included patients were subjected to HRUS prior to MRI. The radiologist reporting the HRUS was blinded to MRI findings and vice versa.

HRUS examination was carried out by Siemens Acuson 2000 ultrasound scanner with high frequency probe with patient seated comfortably on the chair in front of the examiner and hands extended on the couch. The comprehensive examination of the wrist was carried out in all the flexion, extension, pronation, and supination, and the relevant images were recorded.

MRI examination was performed on a 1.5Tesla Siemens Magnetom Avanto Scanner using the standard protocol utilizing 3DT1W, 3DT2W, 3DT2GRE, 3DSTIR image sequences. Postcontrast 3DT1GRE image sequence was used, wherever needed for reaching the diagnosis.

The recorded data was analyzed using appropriate statistical tools using a $P < 0.05$ as significant.

Observations and Results [Figures 1-6]

Etiology distribution

The various disease etiologies included in our study are shown in Table 2. Majority of cases (23/40) belonged to noninfective (inflammatory) group.

Sex distribution

In our study, there were 21 females and 19 males with F: M ratio of nearly one.

Table 1: Differential diagnosis of wrist pain[5]

Intracapsular	Extracapsular
Fracture	Neuropathy (involving median or ulnar nerve)
Distal radioulnar subluxation	Tendinopathy (De Quervain's disease, repetitive strain injury, multisystem disorders, and infections)
Ligament tear	
Arthritis	
Osteoarthritis	
Neoplasm	
Ganglia	
AVN	
Others (osteochondromatosis and carpal coalition)	

AVN: Avascular necrosis

Table 2: Different disease etiologies in our study

Etiology	Number (out of 40), *n* (%)
Congenital	
Vascular malformation	1 (2.5)
Infective (inflammatory)	
Tuberculosis arthritis	3 (7.5)
Septic arthritis	3 (7.5)
Synovial abscess	1 (2.5)
Noninfective (inflammatory)	
Rheumatoid arthritis	18 (45)
Tenosynovitis	4 (10)
Carpal tunnel syndrome	1 (2.5)
Traumatic	
Nonunion	2 (7.5)
Carpal tunnel syndrome	1 (2. 5)
TFCC tear	1 (2.5)
AVN	1 (2.5)
Degenerative	
Ganglion cyst	3 (7.5)
Carpal tunnel syndrome	1 (2.5)

TFCC: Triangular fibrocartilage complex, AVN: Avascular necrosis

Age distribution

The average age of the patient in our study was 38.1 years with most patients (21/40) in 20–40 years age group followed by 40–60 years (13/40) age group.

Comparison of high-resolution ultrasonography and magnetic resonance imaging

Calculated positive predictive value, negative predictive value, and accuracy of HRUS compared to MRI in detecting various pathologies in patients of painful wrist joint in our study is shown in Table 3.

Both HRUS and MRI were compared based on their ability to identify the underlying disease etiology group. Table 4 shows the comparative evaluation of HRUS and MRI in various disease groups related to painful wrist joint in our study.

In majority of cases, the diagnosis of HRUS was similar to MRI while in one-third cases MRI was better than HRUS in reaching the final diagnosis. In only one case, HRUS was better than MRI. The overall sensitivity and accuracy of HRUS compared to MRI in our study are 70% and 67.5%, respectively [Table 5].

Discussion

The various parameters that were evaluated in our study for the comparison between HRUS and MRI included joint effusion, synovitis/tenosynovitis, tendon thickening, increased vascularity, presence of rice bodies and ganglion cyst, reduction in joint space, presence of bone erosions and edema, bony pathologies (like AVN/Nonunion), thickening of carpal tunnel, and vascular malformations.

Comparative statistical evaluation between HRUS and MRI for wrist joint effusion revealed 100% accuracy of HRUS meaning, thereby that HRUS is as good as MRI in detecting joint effusion. This finding is consistent with a study conducted by Hoving *et al*.[8]

Table 3: Positive predictive values, negative predictive values, and accuracy in different disease pathologies

	PPV	NPV	Accuracy
Effusion	100	100	100
Synovitis	94.7	100	97.5
Tenosynovitis	100	100	100
Tendon thickening	96.8	100	97.5
Increased vascularity	100	100	97.5
Rice bodies	100	100	100
Ganglion cyst	100	100	100
Joint space narrowing	100	89.5	90
Bony erosions	100	100	87.5
Bony edema	0	77.5	77.5
AVN and nonunion	0	92.5	92.5
Thickening carpal tunnel	100	100	100
Vascular malformations	100	100	100

PPV: Positive predictive values, NPV: Negative predictive values, AVN: Avascular necrosis

When HRUS was compared with MRI in synovitis, it revealed an accuracy of 97.5%. The findings are again consistent with a study conducted by Hoving *et al*.[8] However, Bao *et al*.[9] reported the comparable sensitivity rates of HRUS and MRI which was lower in our study as cases of subclinical synovitis were included. Issar *et al*.,[10] however, revealed a significant difference between HRUS and MRI in the assessment of synovitis partly as HRUS is operator dependent.

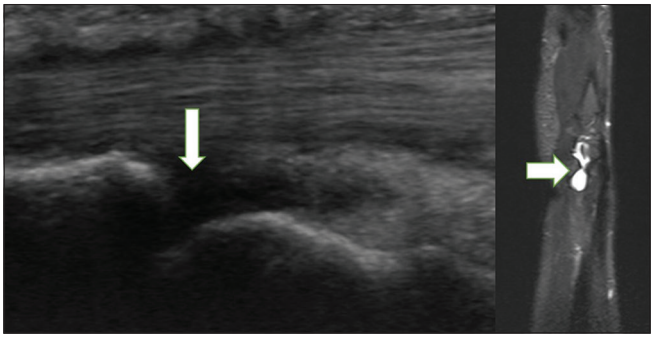

Figure 1: High-resolution ultrasonography sagittal image (left side) shows joint effusion (arrow) while FS-T2W sagittal magnetic resonance image (right side) also show joint effusion (arrow)

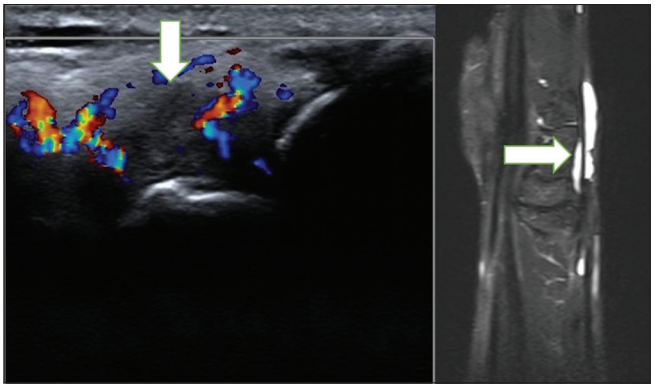

Figure 2: High-resolution ultrasonography sagittal image (left side) shows effusion along tenosynovium and increased vascularity (arrow) while short-tau inversion recovery sagittal magnetic resonance Imaging image (right side) also shows fluid along tendon sheath (arrow)

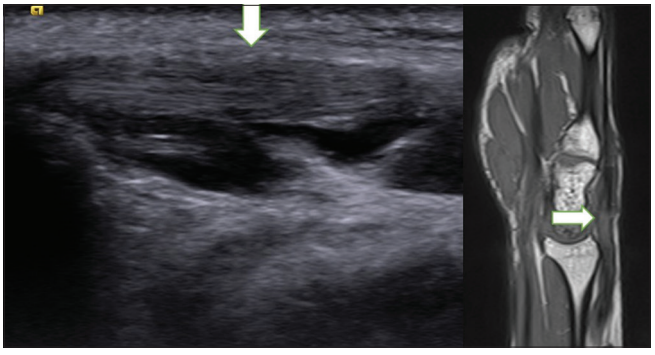

Figure 3: Sagittal high-resolution ultrasonography image (left side) shows tendon thickening (arrow) while T1W sagittal magnetic resonance image (right side) also shows tendon thickening (arrow)

Table 4: Comparative evaluation of high-resolution ultrasonography and magnetic resonance imaging based on various etiologies

Etiology	Sensitivity	Specificity	PPV	NPV	Accuracy
Congenital	100	100	100	100	100
Infective (inflammatory)	42.8	100	100	89.1	90
Noninfective (inflammatory)	77	94.4	94.4	77.2	85
Trauma	20	100	100	89.7	90
Degenerative	100	100	100	100	100

PPV: Positive predictive values, NPV: Negative predictive values

Table 5: Overall performance of diagnostic test

Over-all performance	Number of cases, *n* (%)
HRUS < MRI	12 (30)
HRUS = MRI	27 (67.5)
HRUS > MRI	1 (2.5)

HRUS: High-resolution ultrasonography, MRI: Magnetic resonance imaging

HRUS had an accuracy of 100% in case of tenosynovitis when compared with MRI. Hoving *et al*.[8] also reported the excellent sensitivity of HRUS for tendon sheath inflammation. Bao *et al*.[9] reported the comparable sensitivity rates of HRUS and MRI, although the sensitivity value lower as compared to our study owing to a subclinical case in their study.

For tendon thickening, the reported accuracy of HRUS compared to MRI was 97.5%. Similar results were reported by El-Deek *et al*.[4] and Robinson[11] who reported that HRUS is an efficient imaging modality for the diagnosis of common tendon pathologies.

Statistical analysis of increased soft-tissue vascularity revealed an HRUS accuracy of 97.5% compared to MRI. Issar *et al*.[10] reported a similar high level of agreement between Doppler ultrasound and MRI with contrast for increased synovial vascularity.

For the diagnosis of rice bodies, HRUS had accuracy similar to that of MRI being 100%. Chau *et al*.[12] reported a similar result. The study mentioned the usefulness of both sonography and MRI in the detection of rice bodies.

Similar to the detection of rice bodies, HRUS had an accuracy of 100% in the detection of ganglionic cystic lesions compared to MRI. The results are consistent with Orman *et al*.[13] in which all the four cases of ganglion cystic lesions were correctly diagnosed by ultrasonography. Similar results were also reported by El-Deek *et al*.[4] However, in the study by Teefey *et al*.,[14] HRUS was able to detect 87% of ganglion cysts. The difference may be in part due to operator dependence of HRUS.

For bony erosions, HRUS had an accuracy of 87.5% relative to MRI. Our findings are similar to that of Issar *et al*.[10] Hoving *et al*.[8] reported the similar lower rates of HRUS as compared to MRI.

HRUS had an accuracy of 90% in the detection of reduction in joint space compared to MRI similar to that shown by Issar *et al*.[10]

HRUS is as accurate as MRI in detecting the thickening of carpal tunnel, i.e., 100% similar to that shown by El-Deek *et al*.[4] showed similar results in their study. Similar result with accuracy of 100% was noted in cases of vascular malformations. Samadi and Salazar[15] mentioned the usefulness of both ultrasound and MRI for the evaluation of vascular malformations.

While comparing the overall performance of the HRUS and MRI, it is observed that HRUS is equal or nearly equal to MRI (67.5%) in the diagnosis of wrist pathologies. This equality between these two modalities was observed mainly in nonosseous disorders. MRI was superior to HRUS in 30% patients with bone and bony pathologies. In a small proportion of 2.5% cases, HRUS was found to be superior to MRI namely in synovial hypertrophy. Our findings are in congruence with El-Deek *et al*.[4] and Oneson *et al*.[16] who emphasized the role of MRI in the diagnosis of osseous and intra-articular pathologies.

El-Deek *et al*.[4] reported the almost equal detection rates of HRUS and MRI for effusion, synovial findings, tendon pathologies, ganglion cysts and carpel tunnel syndrome consistent with our results. Robinson[11] and Stevic *et al*.[17] mentioned the role of HRUS in the detection of tendon pathologies. For the assessment of thickening of the carpal tunnel, ultrasonography is an excellent imaging modality as mentioned by Ulasli *et al*.[18] Singh *et al*.[2] in their study revealed a high correlation of HRUS with MRI in the diagnosis of ganglion cysts, vascular malformations, tendinopathy, and tenosynovitis, similar to that seen in our study; however, with poor accuracy for ligamentous pathologies.

Although features like bony edema and nonunited fracture cannot be evaluated on HRUS, MRI is an excellent modality for the detection of same as stated by Issar *et al*.[10] and Seymour and White.[19]

Comparative statistical analysis of HRUS and MRI based on broad etiology showed excellent results in cases of congenital and degenerative disorders with an accuracy of 100% similar to that described by Samadi and Salazar[15] who mentioned the usefulness of both HRUS and MRI in vascular malformations. The degenerative group consisted of ganglion cysts and our results were consistent with Orman *et al*.[13]

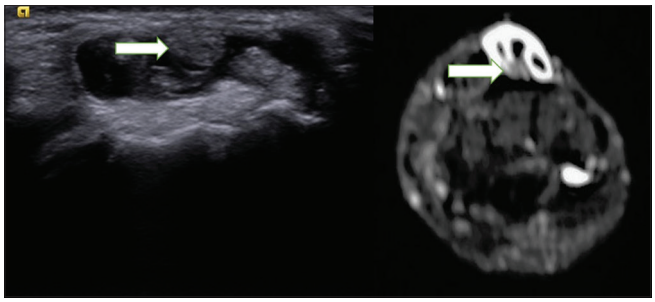

Figure 4: High-resolution ultrasonography transaxial image (left side) shows rice bodies (arrow) while transaxial short-tau inversion recovery magnetic resonance image (right side) also shows rice bodies (arrow) within the hyperintense fluid around the extensor tendons

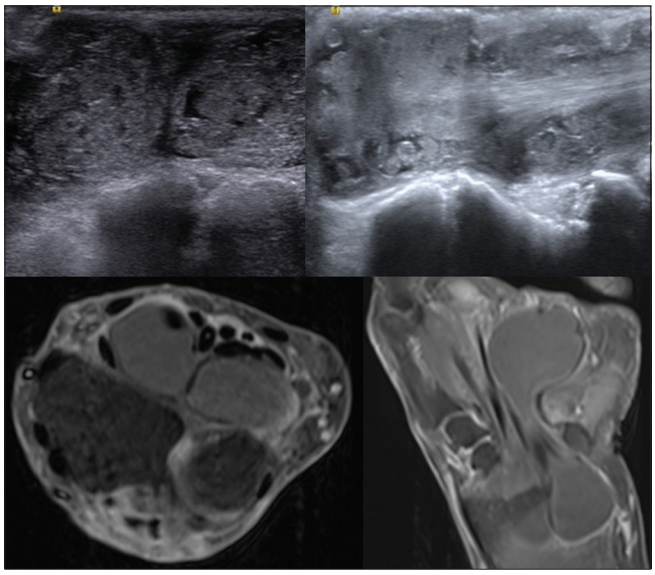

Figure 5: High-resolution ultrasonography images of the left wrist and hand (upper row) shows nodular synovium completely encasing the intact tendon while axial and coronal T1WI magnetic resonance imaging images of same wrist (lower row) shows isointense synovial proliferation in the dumbbell shape across the carpal tunnel of left hand

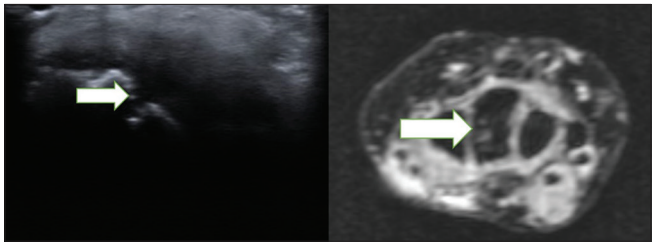

Figure 6: High-resolution ultrasonography transaxial image (left side) shows bony erosions in carpal bones (arrow) while T2GRE axial image (right side) also shows bony erosions (arrow)

For the infective group, the accuracy of HRUS in our study was 90% similar to that reported by Bortolotto *et al*.[20] In the noninfective (inflammatory) group primarily represented by rheumatoid arthritis, HRUS had an accuracy of 85% in our study. Our results are consistent with Hoving *et al*.[8] Hetta *et al*.[21] and El-Sayed *et al*.[22] also showed high correlation between HRUS color Doppler with MRI findings and diagnosis in patients with rheumatoid arthritis. In fact, Xu *et al*.[23] revealed high correlation of HRUS findings in painful wrist joint due to rheumatoid arthritis with not only MRI but also with clinical and laboratory findings.

In the traumatic group, the accuracy value was 90%. Seymour and White[19] mentioned that MRI is an excellent modality for the diagnosis bony pathology.

The overall accuracy of HRUS compared to MRI was 67.5% similar to a study by El-Deek *et al*.[4]

Conclusions

- Painful wrist joint is equally common among both sexes, mostly in 20–40 years
- Noninfective (Inflammatory) causes form the main group of patients with painful wrist joint
- Rheumatoid arthritis is the single most common disease etiology in painful wrist joint
- Accuracy of HRUS is 100% in detecting joint effusion, tenosynovitis, tendon pathologies, ganglionic cysts, carpal tunnel thickening, and vascular malformations
- Accuracy of the HRUS is similar when compared to MRI in cases of synovitis, increased vascularity, and reduction in the joint spaces
- HRUS is significantly limited in cases of bony pathologies with its inability of to detect bone edema, AVN, and nonunion fracture at the wrist joint.

Limitations

- Small sample size due to time-bound nature of the study
- Majority of cases belonged to noninfective inflammatory etiology based on the broad categorization of disease etiology.

Summary

HRUS is an excellent imaging modality for making diagnosis in a large variety of pathologies at wrist joint due to its dynamic nature, easy accessibility, lower cost, and rapidity. Simultaneous clinical evaluation and examination of contralateral joint are an additional advantage. HRUS should be the first-line modality for the evaluation of painful wrist joint as it can detect joint effusion, tendon pathologies, ganglion cysts, carpal tunnel syndrome, vascular malformations, etc., with a high degree of accuracy. MRI should be reserved as problem-solving tool in cases of uncertain diagnosis or suspected bony pathologies or when surgical planning is contemplated.

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Conflict of interest

There are no conflicts of interest

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