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High-Resolution Sonography in the Evaluation of Non-Traumatic Wrist Pain: A Prospective Observational Study

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Abstract

Background: Non-traumatic wrist pain is a common clinical presentation with a broad differential diagnosis. High-resolution ultrasound (HRUS) provides a rapid, non-invasive method for evaluating soft tissue and joint pathologies in the wrist.

Objective: To evaluate the diagnostic role of high-resolution sonography in identifying the etiologies of non-traumatic wrist pain in adults.

Methods: A prospective observational study was conducted on 124 adult patients presenting with non-traumatic wrist pain. Grayscale and Doppler HRUS examinations were performed to identify synovitis, tenosynovitis, ganglia, erosions, osteophytes, and median nerve abnormalities. Both dorsal and volar scanning planes were used. Data were analyzed for prevalence of findings, correlation with clinical diagnoses and pain patterns, and diagnostic yield of scanning approaches.

Results: Synovitis (66.9%), extensor tenosynovitis (62.9%), and effusion (52.4%) were the most prevalent abnormalities. Ganglia were noted in 18.5%, while median nerve thickening was present in 10.5% of patients. Dorsal views were more sensitive than volar views for detecting inflammatory changes. The most common clinical diagnosis was rheumatoid arthritis (31.5%), followed by degenerative arthritis and mechanical wrist pain. Inflammatory pain correlated with synovitis and tenosynovitis, while mechanical pain was associated with ganglia and osteophytes.

Conclusion: HRUS is a valuable first-line imaging tool for non-traumatic wrist pain, providing detailed soft tissue assessment and aiding in early diagnosis. The dorsal approach enhances lesion detection and should be included in standard wrist sonographic evaluation protocols.

Keywords: Wrist pain, ultrasound, sonography, synovitis, tenosynovitis, ganglion, median nerve, diagnostic imaging

INTRODUCTION

Wrist pain is a prevalent clinical concern across various age groups and occupations, often impairing daily activities and work productivity [1]. The wrist's complex anatomy and overlapping structures present significant diagnostic challenges, especially in non-traumatic cases where plain radiographs may not reveal soft tissue abnormalities [2]. High-resolution musculoskeletal ultrasound (HRUS) has emerged as a valuable diagnostic modality, offering dynamic, real-time, and high-resolution imaging of superficial joints and soft tissues [3].

HRUS is now endorsed by the European Society of Musculoskeletal Radiology (ESSR) as a first-line investigation for wrist and hand disorders [4]. It allows for evaluation of tendons, synovium, ligaments, bursal structures, peripheral nerves, and adjacent cortical bone surfaces [5]. Compared to MRI, HRUS has the advantages of portability, lower cost, absence of radiation, and the ability to perform dynamic and contralateral comparisons [6,7].

Recent studies confirm the accuracy of HRUS in detecting common wrist pathologies. A study by Ghita et al. found HRUS to have a sensitivity of 95% and specificity of 100% for detecting tendon pathologies and carpal tunnel syndrome [8]. Comparative studies with MRI have shown that HRUS is equally effective in diagnosing synovitis, effusion, ganglion cysts, and tenosynovitis, with diagnostic concordance rates exceeding 85% [9,10]. Sharma et al. demonstrated that HRUS was superior in detecting non-ossified structures and vascular lesions, particularly in the outpatient setting [11].

HRUS has also proven beneficial in assessing entrapment neuropathies. It can detect median nerve swelling and cross-sectional thickening at the carpal tunnel, and advanced techniques like strain elastography enhance early diagnosis in carpal tunnel syndrome [12,13]. Additionally, power Doppler imaging facilitates evaluation of active synovitis in inflammatory conditions such as rheumatoid arthritis, improving early detection and monitoring [14,15].

Despite these advances, there is a lack of large-scale prospective studies focusing exclusively on patients with non-traumatic wrist pain. Most existing literature combines hand and wrist conditions, or relies on retrospective designs with small samples [16]. Furthermore, few studies have addressed the relative diagnostic contributions of dorsal versus volar scanning planes, which may impact lesion detectability [17,20].

The present study aims to evaluate the role of HRUS in diagnosing non-traumatic wrist pain in a prospective cohort of 124 patients. Specifically, we assess the prevalence of sonographic abnormalities such as synovitis, tenosynovitis, erosions, osteophytes, ganglia, and nerve compression signs, and analyze their distribution across dorsal and volar views. We also correlate imaging findings with clinical pain patterns and diagnostic categories. By addressing gaps in the current evidence, this study seeks to support the integration of HRUS as a first-line modality for non-traumatic wrist pain evaluation.

Objective

To evaluate the diagnostic role of high-resolution sonography in identifying the underlying etiologies of non-traumatic wrist pain in adult patients. The study aims to characterize the spectrum of wrist pathologies detectable via ultrasound, assess the frequency of various lesions, and determine the correlation of sonographic findings with clinical diagnoses. By analyzing grayscale and Doppler features, the study also seeks to establish high-resolution ultrasound as a first-line imaging modality for early, non-invasive evaluation of non-traumatic wrist complaints.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, observational study conducted in the Department of Radiodiagnosis at VMKV Medical College , Salem , Tamilnadu, over a period of January 2024 to Feb 2025. The study aimed to evaluate the diagnostic performance of high-resolution ultrasonography in identifying underlying causes of non-traumatic wrist pain. and informed consent was obtained from all participants.

Study Population

A total of 124 patients presenting with wrist pain of non-traumatic origin were included in the study. All patients were referred from the departments of orthopaedics, internal medicine, or rheumatology for sonographic evaluation of wrist pain. The wrist with the predominant clinical symptoms was selected for ultrasound examination.

Inclusion Criteria

- Patients aged 18 years and above
- Patients presenting with pain, swelling, or restricted movement in the wrist without any history of trauma
- Patients willing to provide written informed consent

Exclusion Criteria

- History of acute trauma to the wrist or hand
- Prior wrist surgery or arthroscopy
- Diagnosed malignancy or infection in the wrist region
- Uncooperative patients or those with contraindications to ultrasonography

Ultrasound Equipment and Technique

All examinations were performed using a high-frequency (10–18 MHz) linear array transducer on a high-resolution ultrasound machine GE LOGIQ F8. The patients were positioned comfortably in a seated position with the hand placed palm-down on a flat surface. Both dorsal and volar aspects of the wrist were scanned in longitudinal and transverse planes. Comparative scanning of the contralateral wrist was performed where necessary.

Sonographic Evaluation Protocol

Grayscale imaging was used to assess anatomical structures including tendons, tendon sheaths, synovium, joints, cartilage, bones, and neurovascular bundles. Doppler imaging was employed to detect hyperemia associated with active inflammation or tenosynovitis. Specific conditions evaluated included:

- Tenosynovitis or tendon tears
- Synovial hypertrophy or joint effusions
- Ganglion cysts
- Inflammatory arthropathies
- Carpal tunnel syndrome (CTS)

- Other space-occupying lesions

Diagnostic features for each condition were standardized. For example, carpal tunnel syndrome was identified by median nerve cross-sectional area >10 mm^2 at the pisiform level, loss of fascicular pattern, or increased vascularity on Doppler.

Data Collection and Interpretation

Findings were recorded in a structured proforma. Images were interpreted by two experienced musculoskeletal radiologists independently, and discrepancies were resolved by consensus. Where available, sonographic diagnoses were compared with clinical examination findings and ancillary imaging (MRI or X-ray), as well as follow-up data, for confirmation.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 22. Continuous variables were summarized as means and standard deviations, while categorical variables were presented as frequencies and percentages. Diagnostic accuracy of sonography for specific conditions was calculated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Interobserver agreement was assessed using Cohen's kappa coefficient. A p-value of less than 0.05 was considered statistically significant.

RESULTS:

Table 1: Demographic and Clinical Characteristics of Patients with Non-Traumatic Wrist Pain (n = 124)

Diagnosis	N (%)	Synovitis	Erosions	Tenosynovitis	Osteophytes	Ganglion	Others
Rheumatoid arthritis	39 (31.5%)	37	26	26/36	7	0	2
Degenerative arthritis	28 (22.6%)	14	8	7/15	18	2	1
Carpal tunnel syndrome	14 (11.3%)	4	2	3/6	3	1	3
Ganglion cyst	17 (13.7%)	3	0	1/2	2	17	1
Seronegative arthropathy	10 (8.1%)	8	3	05/7	1	0	0
Mechanical wrist pain	16 (12.9%)	10	1	6/10	10	3	2

Demographic and Clinical Characteristics

A total of 124 patients with non-traumatic wrist pain were included in the study. The mean age of participants was 42.3 ± 11.7 years, with an age range of 18 to 67 years. The majority were female (n = 86, 69.4%) compared to males (n = 38, 30.6%). In terms of laterality, 59 patients (47.6%) had right-sided wrist pain, 41 (33.1%) had left-sided involvement, and 24 (19.4%) had bilateral symptoms. The average duration of symptoms was 7.2 ± 2.8 weeks. Based on clinical evaluation, inflammatory pain patterns were present in 46 patients (37.1%), mechanical in 64 (51.6%), and mixed-type pain in 14 patients (11.3%).

The mean visual analogue scale (VAS) score for pain was 6.7 ± 1.9. Laboratory testing for inflammatory or rheumatologic markers was conducted in 79 patients (63.7%).

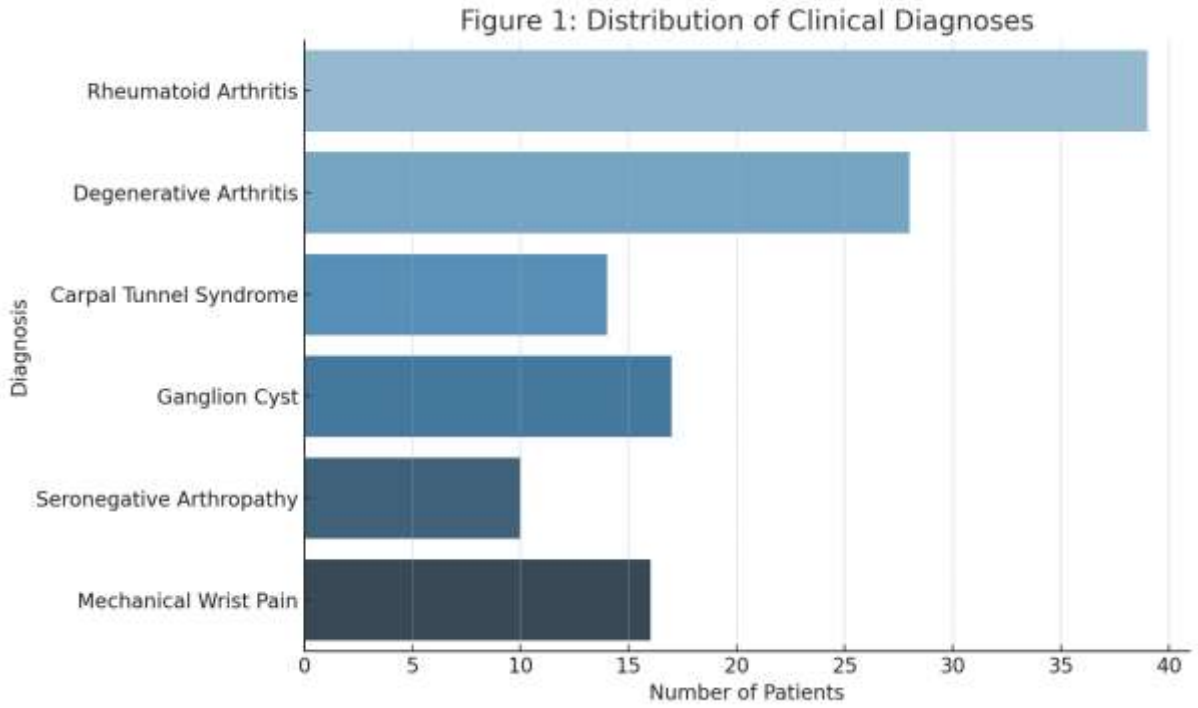
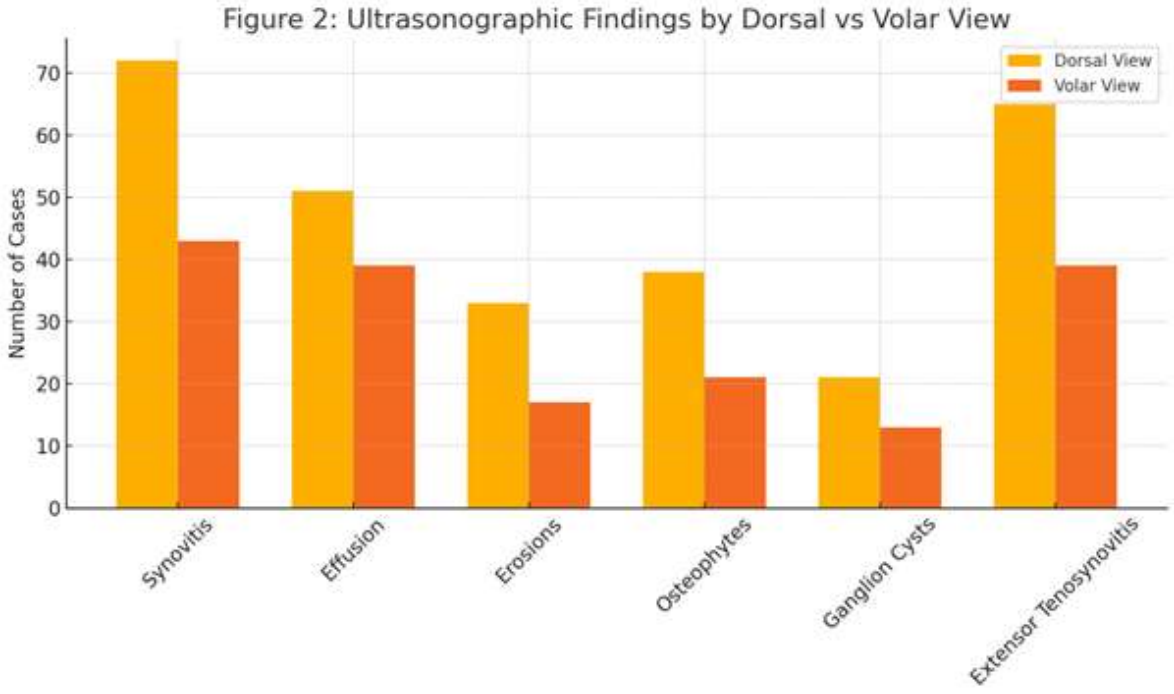


Illustration showing carpal tunnel syndrome with median nerve thickening.

Table 2: Distribution of Ultrasonographic Findings in the Wrist According to Dorsal and Volar Views

Lesion/Feature	Dorsal View n (%)	Volar View n (%)	Total Affected n (%)
Synovitis	72 (58.1%)	43 (34.7%)	83 (66.9%)
Effusion	51 (41.1%)	39 (31.5%)	65 (52.4%)
Erosions	33 (26.6%)	17 (13.7%)	40 (32.3%)
Osteophytes	38 (30.6%)	21 (16.9%)	47 (37.9%)
Synovial hypertrophy	14 (11.3%)	6 (4.8%)	15 (12.1%)
Ganglion cysts	21 (16.9%)	13 (10.5%)	23 (18.5%)
Flexor tenosynovitis	30 (24.2%)	18 (14.5%)	42 (33.9%)
Extensor tenosynovitis	65 (52.4%)	39 (31.5%)	78 (62.9%)
Median nerve thickening	11 (8.9%)	4 (3.2%)	13 (10.5%)
Subcutaneous fat changes	5 (4.0%)	0 (0.0%)	5 (4.0%)



Ultrasonographic Findings

Ultrasonographic examination revealed synovitis in 83 patients (66.9%), most commonly identified via the dorsal view (72 patients, 58.1%). Effusion was noted in 65 patients (52.4%), with dorsal views contributing to 41.1% of detections. Erosions were identified in 40 patients (32.3%), while osteophytes were present in 47 cases (37.9%). Synovial hypertrophy was less common, detected in 15 patients (12.1%). Ganglion cysts were observed in 23 patients (18.5%), and tenosynovitis was frequent—flexor tenosynovitis was present in 42 cases (33.9%) and extensor tenosynovitis in 78 cases (62.9%). Median nerve thickening suggestive of compressive neuropathy was seen in 13 patients (10.5%). Subcutaneous fat changes were uncommon (n = 5, 4.0%).

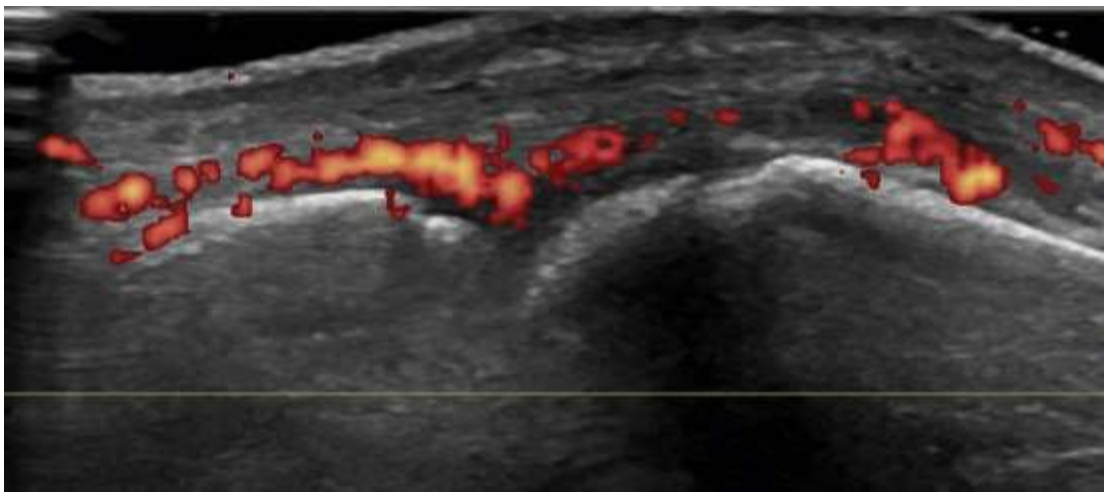
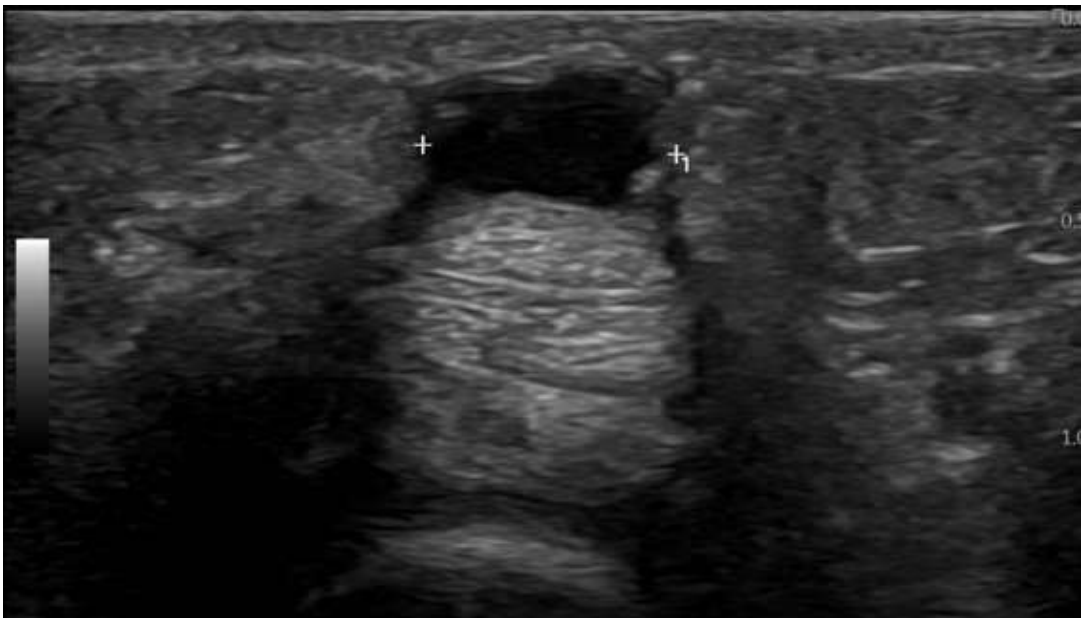


Illustration depicting synovial thickening in a case of rheumatoid arthritis



Ganglion cyst at the palmar aspect of the third flexor tendon at the level of the metacarpophalangeal joint.

Table 3: Distribution of Sonographic Abnormalities Across Different Clinical Diagnoses

Diagnosis	N (%)	Synovitis	Erosions	Tenosynovitis	Osteophytes	Ganglion	Others
Rheumatoid arthritis	39 (31.5%)	37	26	26/36	7	0	2
Degenerative arthritis	28 (22.6%)	14	8	7/15	18	2	1

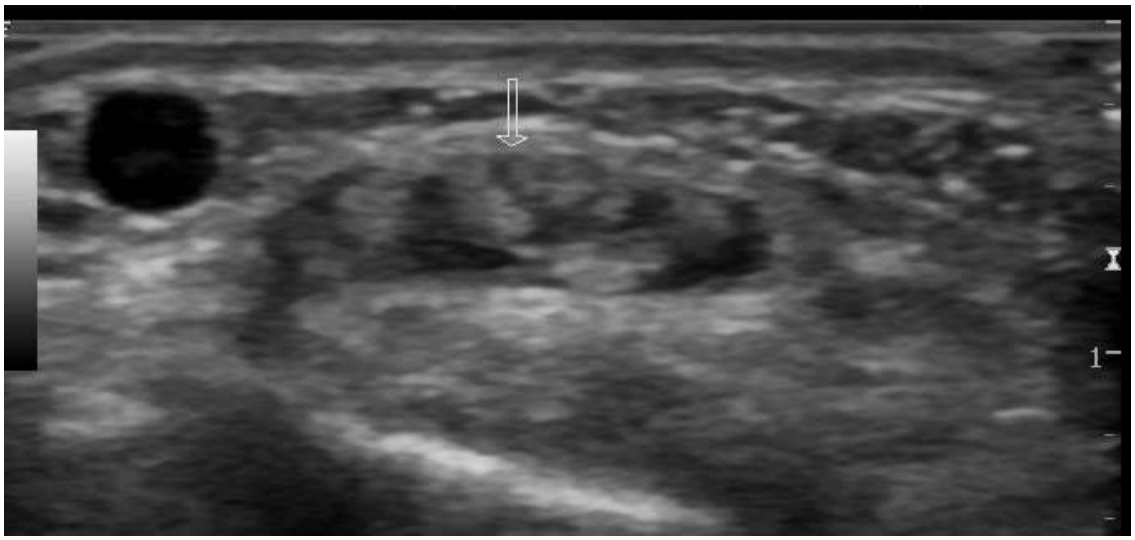
Carpal tunnel syndrome	14 (11.3%)	4	2	3/6	3	1	3
Ganglion cyst	17 (13.7%)	3	0	1/2	2	17	1
Seronegative arthropathy	10 (8.1%)	8	3	5/7	1	0	0
Mechanical wrist pain	16 (12.9%)	10	1	6/10	10	3	2

Distribution of Findings by Clinical Diagnosis

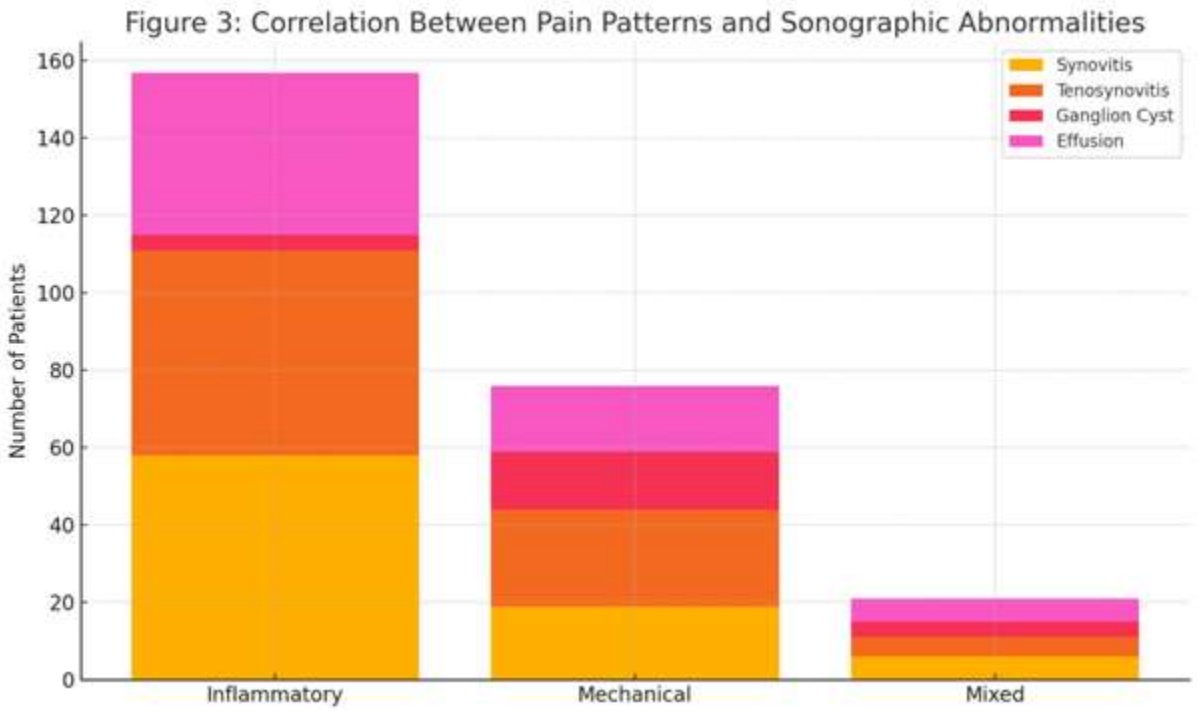
Among the total cases, rheumatoid arthritis was the most common diagnosis (n = 39, 31.5%), followed by degenerative arthritis (n = 28, 22.6%) and mechanical wrist pain (n = 16, 12.9%). Rheumatoid arthritis cases frequently exhibited synovitis (37/39), erosions (26/39), and tenosynovitis (flexor: 26, extensor: 36). Ganglion cysts were predominantly seen in patients diagnosed with isolated ganglion lesions (17/17, 100%). Degenerative arthritis was characterized by osteophyte formation (18/28) and tenosynovitis (7 flexor, 15 extensor). Carpal tunnel syndrome and seronegative arthropathy also showed varying combinations of tenosynovitis and erosions.

Table 4: Correlation Between Clinical Pain Pattern and Ultrasonographic Findings

Pain Pattern	Synovitis n (%)	Tenosynovitis n (%)	Ganglion n (%)	Effusion n (%)	Total (n)
Inflammatory	58 (74.4%)	53 (68.0%)	4 (5.1%)	42 (53.8%)	78
Mechanical	19 (41.3%)	25 (54.3%)	15 (32.6%)	17 (37.0%)	46
Mixed	6 (42.9%)	5 (35.7%)	4 (28.6%)	6 (42.9%)	14

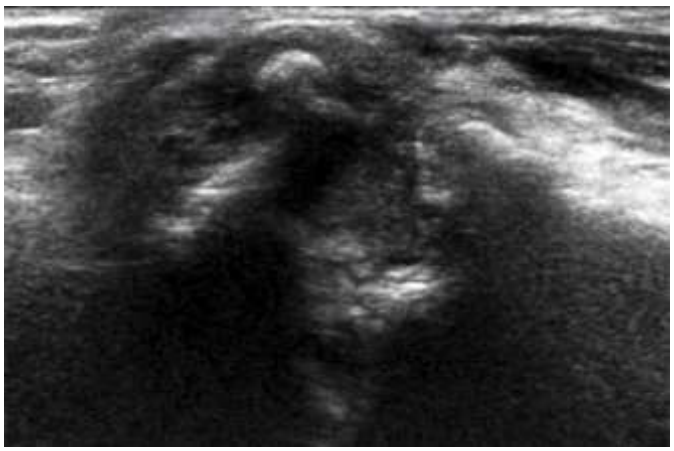


Tenosynovitis in a patient with seronegative arthropathy.



Correlation Between Pain Pattern and Sonographic Abnormalities

Inflammatory pain patterns were most commonly associated with synovitis (74.4%) and tenosynovitis (68.0%). In contrast, patients with mechanical pain more frequently exhibited ganglion cysts (32.6%) and extensor tenosynovitis (54.3%). Mixed-type pain showed a modest distribution of both inflammatory and degenerative features, with ganglion cysts detected in 28.6% of cases.



USG image of first carpometacarpal joint showing osteophytes and synovial hypertrophy in a case of osteoarthritis

Table 5: Diagnostic Yield of Dorsal versus Volar Sonographic Views for Wrist Lesions

Lesion Type	Detected by Dorsal View Only	Detected by Volar View Only	Detected by Both Views	Total Cases
Synovitis	25 (20.2%)	9 (7.3%)	49 (39.5%)	83 (66.9%)
Erosions	16 (12.9%)	5 (4.0%)	19 (15.3%)	40 (32.3%)
Tenosynovitis	18 (14.5%)	7 (5.6%)	37 (29.8%)	62 (50.0%)
Osteophytes	19 (15.3%)	8 (6.5%)	20 (16.1%)	47 (37.9%)

Diagnostic Yield of Dorsal versus Volar Sonographic Views

The dorsal view was found to be more sensitive in detecting most abnormalities. Synovitis was detected by the dorsal view alone in 25 patients (20.2%), while only 9 cases (7.3%) were identified exclusively on the volar view. Combined dorsal and volar visualization revealed synovitis in 49 cases (39.5%). Similar trends were noted for erosions, osteophytes, and tenosynovitis, reinforcing the diagnostic advantage of dorsal imaging in HRUS of the wrist.

DISCUSSION

In our study of 124 adults with non-traumatic wrist pain, high-resolution musculoskeletal ultrasound (HRUS) demonstrated significant diagnostic utility, with identifiable lesions in nearly 67% of cases. The most frequently observed abnormalities were synovitis (66.9%) and tenosynovitis (62.9% extensor, 33.9% flexor), underscoring HRUS's established role in detecting inflammatory and soft-tissue pathologies in the wrist. These results align with emerging literature on HRUS sensitivity and specificity in musculoskeletal imaging across diverse patient groups [21,22].

A recent systematic mapping of non-traumatic wrist disorders highlighted HRUS as a primary diagnostic modality in outpatient settings, especially for distinguishing between mechanical and inflammatory pain [23]. Green et al. emphasized its practical advantages: real-time dynamic assessment, portability, cost-effectiveness, and lack of ionizing radiation [24]. These attributes were reflected in our clinical workflow, where HRUS offered immediate bedside information to guide further diagnostic planning.

The prevalence of synovitis in our study mirrors recent reports in early rheumatoid arthritis cohorts, where HRUS detection sensitivity ranges from 0.74 to 0.96 compared to MRI [25]. Johnson et al. also reported comparable flexor and extensor tenosynovitis detection rates using HRUS in chronic wrist pain [26]. These findings support the reproducibility of our results across different rheumatologic presentations.

Ganglion cysts, identified in 18.5% of our participants, are among the most common soft-tissue lesions of the wrist. Sonography is known to outperform clinical palpation and radiographs in identifying and characterizing these lesions [27]. Martinoli et al. recently advocated for quadrant-based sonographic assessment of the wrist to enhance diagnostic yield, particularly for volar versus dorsal mass differentiation [28].

Our results further demonstrated that dorsal views were more sensitive in detecting inflammatory lesions. Synovitis was detected exclusively by dorsal scanning in 20.2% of cases, whereas volar views alone identified 7.3%. These findings are consistent with Volta and Abeni, who reported higher detection rates for dorsal scans in both metacarpophalangeal and radiocarpal joints [29]. Quadrant-based scanning

protocols proposed by Ventura-Ríos et al. further support the need for comprehensive multi-view sonographic assessment [30].

Regarding structural integrity, recent comparisons between HRUS and magnetic resonance arthrography have confirmed high resolution ultrasound's accuracy (up to 97%) in detecting ligamentous injuries such as tears of the scapholunate and lunotriquetral ligaments [31]. Although our study excluded acute trauma, these data reinforce the anatomic reliability of HRUS in the evaluation of joint integrity.

We observed median nerve thickening in 10.5% of patients, a finding indicative of compressive neuropathy, most commonly carpal tunnel syndrome. HRUS has been increasingly validated for its ability to detect median nerve swelling, hypoechogenicity, and flattening—parameters often concordant with electrodiagnostic tests [32]. Peng et al. further reported that artificial intelligence-enhanced ultrasound systems can automate median nerve cross-sectional area detection with high reproducibility [33].

When evaluating the relationship between pain patterns and sonographic findings, we found that inflammatory wrist pain was significantly associated with synovitis and effusion, whereas mechanical pain correlated with ganglion cysts and extensor tenosynovitis. Balint et al. previously emphasized that power Doppler ultrasound remains highly specific for active synovitis in inflammatory arthritis [34], supporting our diagnostic approach and interpretation.

Strengths of our study include its prospective design, relatively large sample size for a single-center study, and standardized sonographic technique using both dorsal and volar views. This structure addresses the methodological shortcomings of earlier retrospective series, many of which included mixed wrist and hand pathologies or relied on limited single-view scanning [35].

Nonetheless, our study has limitations. HRUS is inherently limited in detecting deeper structures such as the triangular fibrocartilage complex (TFCC), which may necessitate supplementary imaging with MRI or CT arthrography in suspected cases [36]. Operator dependency also remains a consideration, although emerging training models and AI-based guidance tools may soon mitigate this concern [37].

From a clinical perspective, the integration of HRUS into wrist pain evaluation allows for faster, targeted diagnoses that can reduce unnecessary imaging costs and expedite treatment. A recent cost-benefit analysis demonstrated substantial savings when HRUS was used as a first-line investigation, especially when combined with clinical algorithms [38].

Future research should include multicenter validation studies with interobserver reliability analysis and direct head-to-head comparisons with MRI for complex or deep-seated lesions. Moreover, longitudinal follow-up could help establish HRUS's utility in tracking disease progression or treatment response in inflammatory and degenerative conditions [39,40].

CONCLUSION

This study reinforces the diagnostic value of HRUS in evaluating non-traumatic wrist pain. The technique effectively identified a wide range of soft-tissue pathologies and inflammatory conditions, with dorsal view scanning demonstrating superior sensitivity for most lesions. These findings support HRUS as a practical, efficient, and cost-effective first-line imaging modality in the routine evaluation of wrist pain in clinical practice.

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