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Original Article

Role of Magnetic Resonance Imaging in Assessing Etiopathogenesis of Painful Wrist Joint

Yamini Hatwal[1], Ravinder Kumar Kundu[2], Virendra Kumar Meena[3]

[1]PG resident, Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Geetanjali University, Udaipur

[2]Professor & Head, Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Geetanjali University, Udaipur

[3]Professor, Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Geetanjali University, Udaipur

Corresponding Author:
Dr. Yamini Hatwal
PG resident, Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Geetanjali University, Udaipur

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ABSTRACT

Introduction: The wrist is a complex anatomical and functional unit that connects the forearm to the hand and permits a wide range of movements while transmitting substantial mechanical forces. It is composed of the distal radius and ulna, eight carpal bones arranged in proximal and distal rows, and the bases of the metacarpals. The wrist comprises three principal articulations: the distal radioulnar, radiocarpal, and midcarpal joints. Its stability and coordinated movement depend on an intricate arrangement of intrinsic and extrinsic ligaments, tendons, fibrocartilaginous structures, nerves, and articular cartilage. [1] The ligaments are particularly important in maintaining carpal alignment and facilitating transmission of forces across the wrist

Materials And Methods: After obtaining informed consent, patients referred from the orthopaedic and rheumatology outpatient departments, with or without a history of trauma, underwent 3-Tesla MRI of the affected wrist. T1-weighted, T2-weighted and fat-suppressed proton-density sequences were obtained. Intravenous gadolinium-based contrast was administered when indicated by the clinical suspicion and findings on non-contrast images. No intra-articular contrast was used.
Results: The study population was predominantly middle-aged, with a slight female predominance, without significant sex-related differences in age or symptom duration.

Conclusion: In conclusion, MRI demonstrated a high diagnostic value in evaluating patients with painful wrist, providing comprehensive visualization of osseous, ligamentous, TFCC, inflammatory and soft-tissue abnormalities.

Keywords: Magnetic Resonance Imaging (MRI); Wrist Pain; Wrist Ligaments; Triangular Fibrocartilage Complex (TFCC); Traumatic Wrist Injuries.

INTRODUCTION

The wrist is a complex anatomical and functional unit that connects the forearm to the hand and permits a wide range of movements while transmitting substantial mechanical forces. It is composed of the distal radius and ulna, eight carpal bones arranged in proximal and distal rows, and the bases of the metacarpals. The wrist comprises three principal articulations:

the distal radioulnar, radiocarpal, and midcarpal joints. Its stability and coordinated movement depend on an intricate arrangement of intrinsic and extrinsic ligaments, tendons, fibrocartilaginous structures, nerves, and articular cartilage.[1] The ligaments are particularly important in maintaining carpal alignment and facilitating transmission of forces across the wrist.[2]

Painful wrist is a common clinical presentation and may result from a broad spectrum of traumatic and non-traumatic disorders. Chronic wrist pain has been described as the "low back pain of the hand" because of its complex and often difficult-to-localize etiology.[3] The triangular fibrocartilage complex (TFCC), scapholunate ligament (SLL), and lunotriquetral ligament (LTL) are essential stabilizing structures, and their injury may lead to abnormal carpal mechanics, persistent pain, instability, and secondary degenerative changes. [4] Common causes include fractures, ligamentous and TFCC injuries, dislocations, degenerative and inflammatory arthritis, ganglion cysts, avascular necrosis, carpal tunnel syndrome, and tenosynovitis. In addition, repetitive activities, inflammatory, infective, neoplastic, congenital, developmental, and neurological disorders may contribute to chronic wrist pain. [5]

Tendon and synovial disorders, including de Quervain tenosynovitis, extensor carpi ulnaris tendinopathy, rheumatoid tenosynovitis, tendon tears, and infectious synovitis, may also produce pain and restriction of movement. Accurate identification of the underlying pathology is important for appropriate management and prevention of progressive functional impairment.[6]

Plain radiography remains an important initial imaging investigation, particularly for assessment of fractures, alignment, and osseous abnormalities. However, its ability to demonstrate soft-tissue pathology, early marrow abnormalities, cartilage lesions, and radiographically occult injuries is limited. Magnetic resonance imaging (MRI), because of its excellent soft-tissue contrast, multiplanar capability, and absence of ionizing radiation, provides comprehensive evaluation of the bones, bone marrow, cartilage, ligaments, tendons, nerves, and vascular structures. It is particularly valuable in detecting occult osseous lesions and characterizing ligamentous, tendinous, cartilage, and inflammatory abnormalities. [7]

MRI also plays an important role in evaluating carpal instability, TFCC disorders, avascular necrosis, fractures, synovial abnormalities, nerve entrapment, tendinopathy, and soft-tissue masses.Its high spatial and contrast resolution permits detection of subtle marrow and soft-tissue abnormalities that may not be apparent on conventional imaging. With advances in MRI technology, including MR arthrography and high-field imaging, diagnostic confidence and preoperative assessment of wrist pathology have further improved. Standard musculoskeletal MRI protocols incorporate T1-weighted, STIR, T2-weighted fat-suppressed, post-contrast and proton-density fat-suppressed sequences. High spatial resolution and signal-to-noise ratio are particularly important for evaluating the small anatomical structures of the wrist, with 3-T MRI providing improved image quality compared with lower-field systems. [8]

Therefore, the present study was undertaken to evaluate the role of 3-T MRI in assessing the etiopathogenesis of painful wrist joint, with particular emphasis on identifying traumatic and non-traumatic abnormalities and their anatomical distribution.

MATERIALS AND METHODS

Study Design

An observational, time-bound study was conducted to evaluate the role of magnetic resonance imaging (MRI) in assessing the etiopathogenesis of painful wrist joint.

Study Setting

The study was conducted in the Department of Radiodiagnosis, Geetanjali Medical College and Hospital, Udaipur, Rajasthan.

Study Period

The study was carried out over a period of 18 months.

Study Population and Sample Size

Adult patients presenting with painful wrist joint and fulfilling the eligibility criteria were included. A total of 50 patients were evaluated using MRI. Patients were recruited by consecutive sampling.

Inclusion Criteria

- All adult patients presenting with painful wrist joint.

Exclusion Criteria
Patients were excluded if they had:

- Contraindications to MRI, including claustrophobia, non-MRI-compatible pacemaker or cochlear implants, metallic implants, or aneurysmal clips.
- Painless wrist conditions or isolated swelling.
- Pediatric age.
- Unwillingness to provide informed consent.

MRI Protocol
After obtaining informed consent, patients referred from the orthopaedic and rheumatology outpatient departments, with or without a history of trauma, underwent 3-Tesla MRI of the affected wrist. T1-weighted, T2-weighted and fat-suppressed proton-density sequences were obtained. Intravenous gadolinium-based contrast was administered when indicated by the clinical suspicion and findings on non-contrast images. No intra-articular contrast was used.

Image Evaluation
MRI images were assessed for abnormalities involving the bones, bone marrow, ligaments, triangular fibrocartilage complex (TFCC), tendons, cartilage, synovium and other soft tissues. Findings were categorized into traumatic, degenerative, inflammatory, infectious and miscellaneous etiological groups.

Statistical Analysis
The collected data were compiled and analyzed statistically. Categorical variables were expressed as frequencies and percentages, and appropriate statistical tests were applied to assess associations between the study variables. A **p-value <0.05** was considered statistically significant.

RESULTS
The study population was predominantly middle-aged, with a slight female predominance, without significant sex-related differences in age or symptom duration. [Table 1]

MRI demonstrated a diverse spectrum of wrist pathology, with traumatic lesions forming the major etiological group, followed by degenerative and miscellaneous conditions. This highlights the value of MRI in evaluating both traumatic and non-traumatic causes of wrist pain. [Table 2]

Traumatic cases showed involvement of multiple structures, including bone, TFCC, ligaments and soft tissues, demonstrating the ability of MRI to detect injuries beyond fractures. Degenerative and inflammatory cases predominantly reflected osteoarthritic and inflammatory changes, respectively, while the miscellaneous group emphasized the range of non-traumatic causes of wrist pain. [Table 3]

Overall, MRI provided comprehensive characterization of the underlying pathology, enabling assessment of osseous, ligamentous, fibrocartilaginous, inflammatory and soft-tissue abnormalities in patients with painful wrist. [Tables 2–3]

The overall distribution of individual MRI findings indicates that osteoarthritic changes, fractures/occult fractures, ganglion cysts, and nerve entrapment constituted important contributors to painful wrist presentations. The findings also demonstrate that wrist pain may arise from diverse osseous, fibrocartilaginous, degenerative and soft-tissue abnormalities, highlighting the comprehensive diagnostic utility of MRI. [Table 4]

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	Category	Male, n (%)	Female, n (%)	Total, n (%)
Age (years)	<20	1 (2.0)	4 (8.0)	5 (10.0)
	20–40	9 (18.0)	9 (18.0)	18 (36.0)
	41–60	9 (18.0)	10 (20.0)	19 (38.0)
	61–80	3 (6.0)	3 (6.0)	6 (12.0)
	>80	1 (2.0)	1 (2.0)	2 (4.0)
Total		23 (46.0)	27 (54.0)	50 (100)
Duration of symptoms	<1 month	11 (22.0)	11 (22.0)	22 (44.0)
	1–3 months	9 (18.0)	10 (20.0)	19 (38.0)
	3–6 months	4 (8.0)	1 (2.0)	5 (10.0)
	6–12 months	2 (4.0)	1 (2.0)	3 (6.0)

	>12 months	1 (2.0)	0 (0)	1 (2.0)
Total		27 (54.0)	23 (46.0)	50 (100)

Table 2. Overall Distribution of MRI-Detected Wrist Pathologies

MRI etiological category	No. of patients	Percentage
Traumatic	21	42
Degenerative	10	20
Inflammatory	7	14
Infectious	2	4
Miscellaneous	10	20
Total	50	100

Table 3. Specific MRI Findings According to Etiological Category

Etiological category	Specific MRI finding	No.	% within category	% of total
Traumatic (n=21)	Fractures/occult fractures	5	23.81	10
	TFCC injury	4	19.05	8
	Ligament tears	2	9.52	4
	AVN/malunion	3	14.29	6
	Bone marrow edema	4	19.05	8
	Soft-tissue injury/edema	3	14.29	6
Degenerative (n=10)	Osteoarthritis	7	70	14
	Other degenerative lesions	3	30	6
Inflammatory (n=7)	Rheumatoid arthritis	4	57.14	8
	Synovitis	3	42.86	6
Infectious (n=2)	Tuberculosis	1	50	2
	Abscess	1	50	2
Miscellaneous (n=10)	Ganglion cyst	5	50	10
	Carpal tunnel syndrome/nerve entrapment	5	50	10

Table 4. Summary of Principal MRI Findings in the Study Population

Principal MRI finding	No. of patients	Percentage of total
Fractures/occult fractures	5	10
Osteoarthritis	7	14
Ganglion cyst	5	10
Carpal tunnel syndrome/nerve entrapment	5	10
TFCC injury	4	8
Bone marrow edema	4	8
Rheumatoid arthritis	4	8
Synovitis	3	6
AVN/malunion	3	6
Soft-tissue injury/edema	3	6
Other degenerative lesions	3	6
Ligament tears	2	4
Tuberculosis	1	2
Abscess	1	2

DISCUSSION

Magnetic resonance imaging provides comprehensive evaluation of the painful wrist because of its excellent soft-tissue contrast and multiplanar capability. It permits simultaneous assessment of bones, bone marrow, TFCC, ligaments, tendons, synovium and neural structures, facilitating identification of abnormalities that may remain inconclusive on conventional imaging.[9]

The predominance of traumatic lesions in the present study is consistent with the findings of Jadhav et al. (29.8%), although their reported proportion was lower. In contrast, Shingne et al. reported inflammatory disorders as the predominant category (38%). Such differences may be related to variations in study population, referral patterns and clinical indications for MRI.

Pinglikar et al. also demonstrated the ability of MRI to identify a wide range of osseous and soft-tissue wrist abnormalities. [10-12]

Among traumatic lesions, the abnormalities extended beyond fractures to include TFCC injuries, bone marrow edema, malunion/AVN, soft-tissue injury and ligament tears. This emphasizes that traumatic wrist pain may involve several stabilizing structures. Mehta et al. and Cherian et al. highlighted the importance of TFCC assessment in chronic wrist pain, while Götestrand et al. demonstrated the diagnostic value of MRI in wrist ligament trauma.[11,13-14]

Degenerative disease constituted an important component of the study, with osteoarthritis predominating within this group. This is consistent with Hampole et al.,[15] while the overall frequency was higher than that reported by Shingne et al. [10] and Jadhav et al. [16] MRI is particularly useful in degenerative disease because it can demonstrate cartilage, subchondral and associated soft-tissue abnormalities.

Inflammatory pathology represented a smaller proportion than reported by Shingne et al. and Jadhav et al. Rheumatoid arthritis and synovitis were the major inflammatory patterns. MRI has particular value in this setting because it can demonstrate synovial abnormalities, bone marrow edema and early erosive changes, sometimes before advanced radiographic abnormalities develop.[10,16]

Infectious lesions were relatively uncommon but clinically important. Their frequency was comparable to that reported by Jadhav et al.[16] but lower than that of Shingne et al.[10] MRI can help distinguish infective pathology from inflammatory or degenerative disease and delineate associated soft-tissue involvement.

Miscellaneous abnormalities, particularly ganglion cysts and nerve entrapment disorders, further demonstrate the broad spectrum of causes of wrist pain. MRI is valuable in these conditions because it provides detailed assessment of soft-tissue lesions and neural structures that may not be adequately characterized by conventional radiography.[17,18]

Overall, the findings support the role of MRI as a comprehensive diagnostic modality for establishing the underlying etiology of painful wrist, particularly when pathology involves soft tissues, ligaments, TFCC, marrow or neural structures. [19,20]

CONCLUSION

In conclusion, MRI demonstrated a high diagnostic value in evaluating patients with painful wrist, providing comprehensive visualization of osseous, ligamentous, TFCC, inflammatory and soft-tissue abnormalities. Traumatic lesions constituted the predominant etiology, while degenerative, inflammatory, infective and miscellaneous pathologies represented additional important causes. The ability of MRI to characterize both traumatic and non-traumatic abnormalities highlights its role in establishing the underlying etiopathogenesis of wrist pain and facilitating appropriate clinical management.

Representative cases

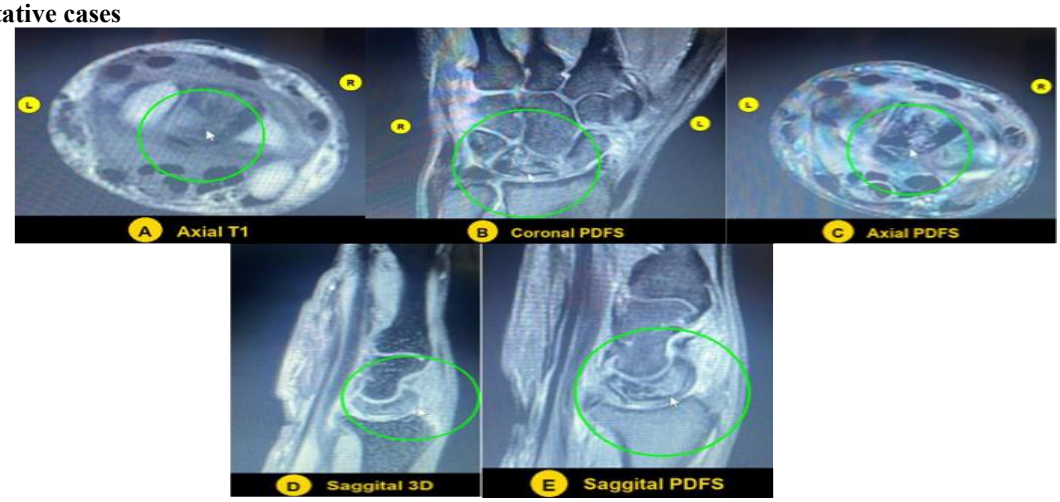

Fig. 1: Patient came with history of fall and complaints of wrist joint pain and tenderness. The case shows MRI of the right wrist joint. The Axial T1 (A), Coronal PDFS (B), Axial PDFS (C), Sagittal 3D (D), and Sagittal PDFS (E) sequences demonstrate Avascular Necrosis of the lunate bone. The lunate bone shows areas of sclerosis and fragmentation with associated marrow edema, appearing hypointense on T1 (A) and hypo- to hyperintense on T2/PDFS sequences (B, C, E),

representing osteonecrosis. There is also associated negative ulnar variance along with mild intercarpal, carpometacarpal, and distal radioulnar joint effusion.

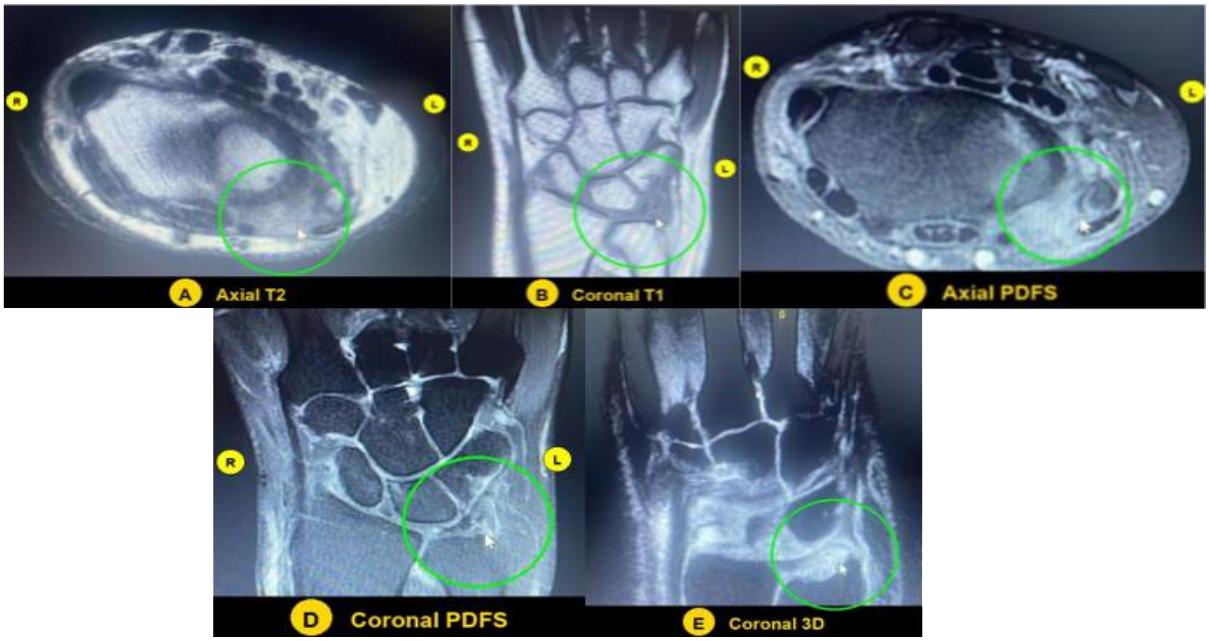

Fig. 2: Patient came with complaints of wrist joint pain, decreased range of motion (ROM), and tenderness. Case shows MRI of the left wrist joint. The Coronal T1 (A), Axial T2 (B), Axial / Coronal PDFS (C), and Coronal 3D (D) sequences demonstrate T2 and PDFS hyperintense signals along the TFCC with minimal effusion and adjacent soft tissue edema, suggestive of a TFCC tear. This is also associated with minimal joint effusion in the DRUJ (Distal Radioulnar Joint).

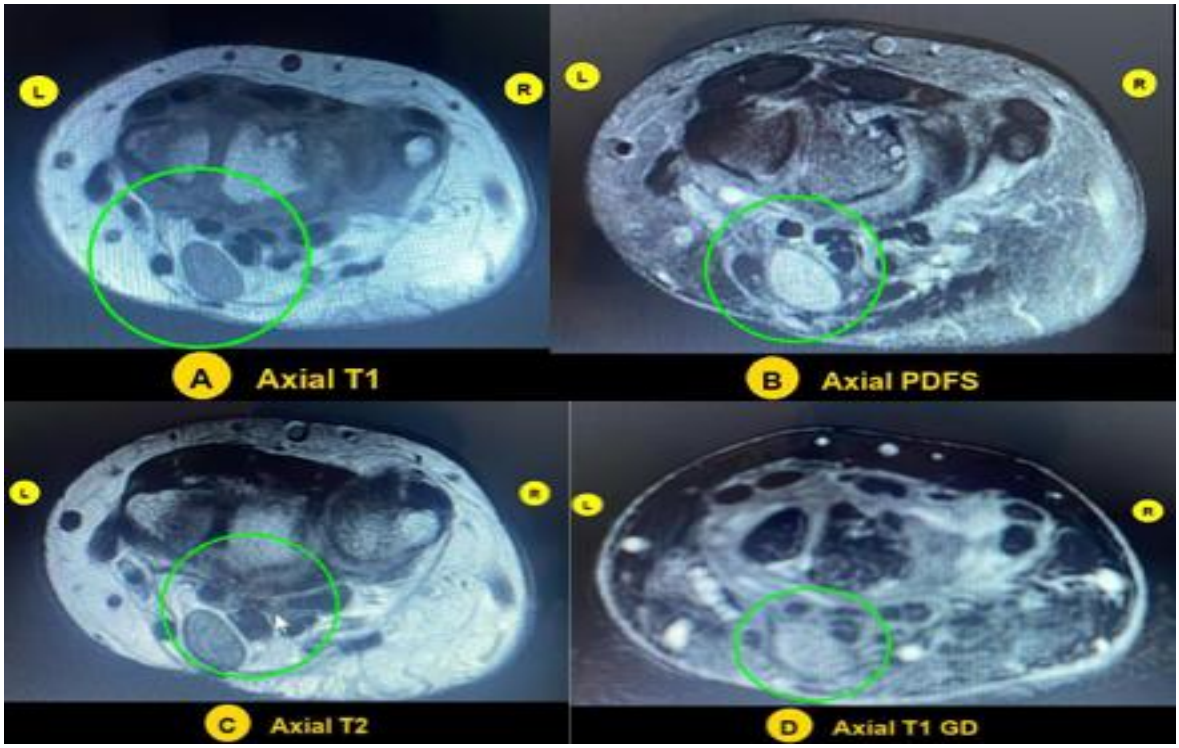

Fig. 3: Patient came with complaints of pain, numbness, tingling sensation, and weakness. Case shows MRI of the right wrist joint. The Axial T1 (A), Axial PDFS (B), Axial T2 (C), and 3D Axial GD (D) sequences demonstrate Carpal Tunnel Syndrome. There is median nerve flattening at the carpal tunnel level with significant nerve thickening (increased cross-sectional area) and loss of the normal fascicular pattern at the carpal tunnel inlet. This is also accompanied by a mild loss

of fat in the carpal tunnel, suggestive of Carpal Tunnel Syndrome (CTS), and is associated with tenosynovitis of the FPL (Flexor Pollicis Longus) tendon.

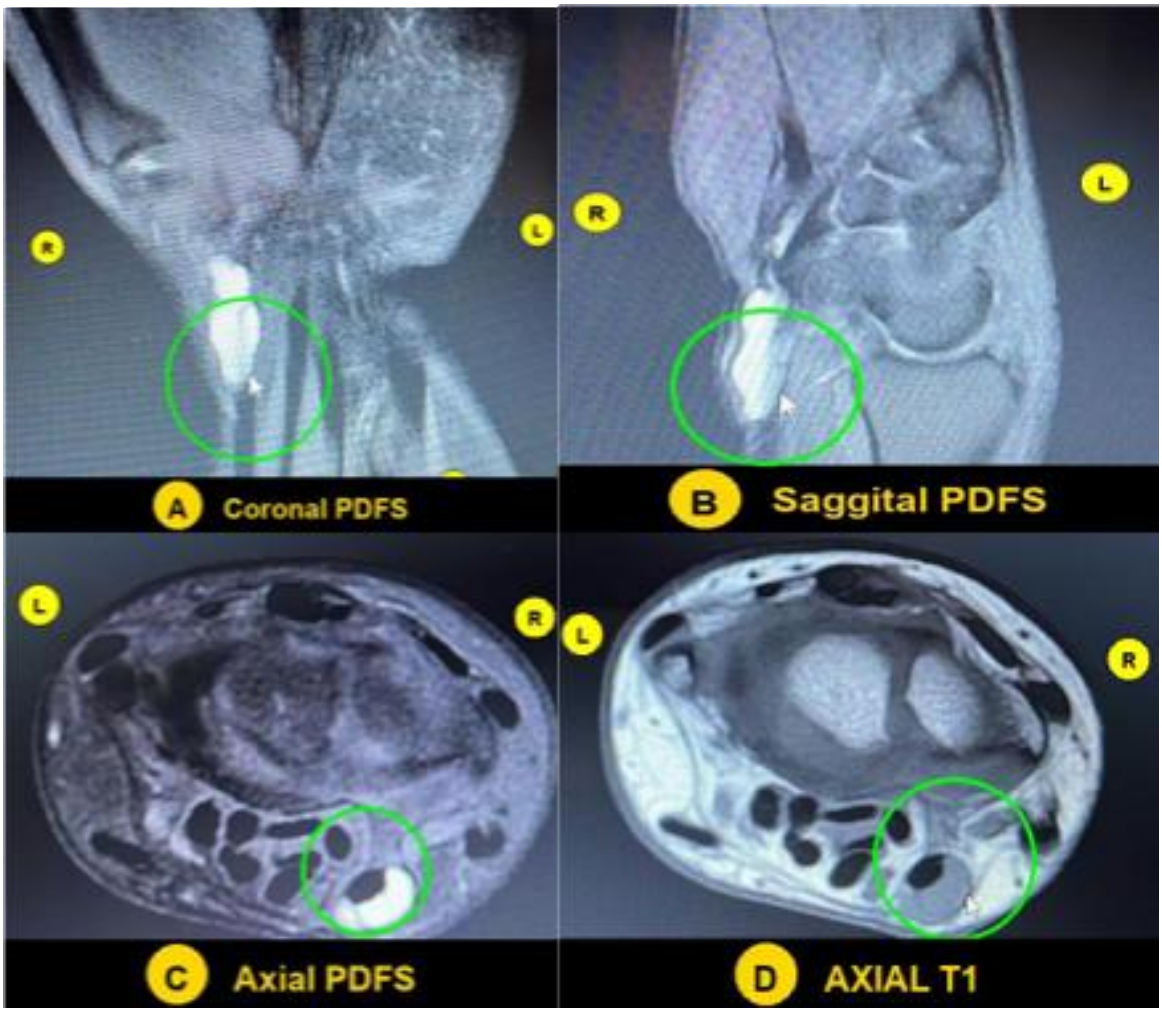

Fig. 4: Patient came with complaints of palpable swelling at the palmar aspect with mild pain and discomfort. Case shows MRI of the left wrist joint. The Axial T1 (A), Coronal PDFS (B), Sagittal PDFS (C), and Axial PDFS (D) sequences demonstrate a well-defined, lobulated, septated cystic lesion at the palmar aspect of the wrist along the FCR (Flexor Carpi Radialis) tendon. The lesion appears hyperintense on T2 and PDFS sequences (B, C, D) and hypointense on the T1 sequence (A), representing a Ganglion Cyst (GC).

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