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RESEARCH ARTICLE

CARPAL TUNNEL SYNDROME IN RHEUMATOID ARTHRITIS: PERFORMANCE ASSESSMENT OF HIGH-RESOLUTION ULTRASOUND AND ELECTROPHYSIOLOGICAL STUDIES AS A DIAGNOSTIC TOOL

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Abstract

Background: Rheumatoid arthritis (RA), a prevalent inflammatory disorder,causes permanent disability due to cartilage and bone deteriora tion. Carpal tunnel syndrome (CTS) represents a common extra-articular manifestation. RA consequence,frequently associated with inflammation in the joints, tendons, and median nerve. The overlapping symptoms of CTS and RA in the hands can make assessing RA disease activity challenging. RA-associated CTS can involve median nerve ischemia due to vessel compression and impaired axonal transport.

Aim: This study aimed to compare high-resolution Ultrasound with electrophysiological studies in patients having RA and CTS.

Material and Methods: This cross-sectional study enrolled 60 adult RApatients, diagnosed under the 2010 American College of Rheumatol ogy / European League Against Rheumatism classification criteria, recruited from the National Institute for Neuro-Motor System. Here, we assessed disease activity utilizing the Disease Activity Score in 28 joints (DAS28), which categorizes RA status from remission to high activity. CTS was evaluated using nerve conduction velocity (NCV) studies following the American Association of Neuromuscular and Elec trodiagnostic Medicine guidelines, while using musculoskeletal Ultraso und to determine median nerve cross-sectional area .

Results: Among the 60 RA patients (76.7% female), 40% of the patients exhibited moderate disease activity by DAS28. There was statistically significant agreement between NCV and Ultrasound findin gs in grading CTS severity. Mean disease duration was longest in the moderate NCV severity group for both hands. The findings manifested significant disparities between the normal versus mild and moderate NCV severity groups, with no significant difference between the mild and moderate groups bilaterally.

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The results showcaseda significant association between DAS28 categories and NCV findings in the right hand, but not in the left hand. In both hands, a highly significant association was found between DAS28 categories and Ultrasound grading, with all cases of high disease activity demonstrating moderate Ultrasound findings.
Conclusion:CTS is highly prevalent among patients with RA. Ultrasound and nerve conduction studies demonstrate strong concordance in CTS diagnosis, supporting that peripheral nerve involvement is a common consequence of chronic RA.

Introduction:-

Rheumatoid arthritis (RA) represents the predominant form of inflammatory arthritis and may result in irreversible disability due to cartilage degradation and bone erosion, with carpal tunnel syndrome (CTS) representing a common extra-articular symptom. Previous studies demonstrate that CTS in RA patients is mostly associated with inflammation of the tendons, joints, and the median nerve. Accordingly, hand and finger symptoms resulting from CTS in this demographic may complicate the evaluation of RA disease activity (Dede et al., 2023).RA impairs axonal transport, by compressing the median nerve and its intraneural arteries within the perineurium, which can induce ischemia of the median nerve. Alternative hypothesized etiologies of rheumatoid neuropathy encompass pharmacological toxicity, vasculitis, and amyloid accumulation(Sakthiswary and Singh, 2017).

CTS arises from median nerve compressionas it passes through the carpal tunnel, mainlydue to increased pressure within the carpal tunnel. Frequent early symptoms encompass pain, numbness, and paresthesia impacting the first three digits and the lateral portion of the fourth digit. Symptoms may differ, but discomfort can occur at the wrist, affect the entire hand, and possibly radiate up the forearm or beyond the elbow (Genova et al., 2020).CTS diagnosisrelies on clinical history and physical examination; yet, nerve conduction investigations and Ultrasound can yield additional clinically pertinent information (Smerilli et al., 2021).

Nerve conduction velocity (NCV) is regarded as the definitive method for diagnosing CTS since it offers objective, quantifiable data concerning the physiological condition of the median nerve. Challenges may emerge while conducting electrodiagnostic investigations in patients exhibiting unusual CTSsigns (Rosario and De Jesus, 2023).Ultrasound is widely used to diagnose CTS and to assess median nerve anatomy and morphology. Nerve compression within the carpal tunnel results in nerve hypertrophyimmediately proximal to the compression location at the tunnel entrance (Cartwright et al., 2012). Accordingly, we aimed to compare high-resolution Ultrasound with electrophysiological studies in patients havingRA and CTS.

Material and Methods:-

This cross-sectional observational study enrolled 60 adult RA patients recruited from the National Institute for Neuro-Motor System who fulfilled the 2010 American College of Rheumatology/European League Against Rheumatism classification criteria for RA (Aletaha et al., 2010).

Methodology:-

Patients underwent a comprehensive medical history assessment. Disease activity was evaluated using the Disease Activity Score in 28 joints (DAS28) (Prevoo et al., 1995)as follows: remission (< 2.6), low (≥ 2.6 to ≤ 3.2), moderate (> 3.2 to ≤ 5.1), and high (> 5.1). NCV studies were interpreted per the American Association of Neuromuscular and Electrodiagnostic Medicine guidelines. CTS severity was graded as follows (Campbell, 1999): (1) Mild: Abnormal sensory conduction,characterized by a sensory conduction velocity of ≤50 m/s or a sensory nerve action potential amplitude of <10 μV, while motor distal delay remains within normal parameters; (2) Moderate: Abnormal sensory parameters accompanied by extended distal motor latency; (3) Severe: Absent sensory potential, delayed distal motor latencies, absent or low-amplitude thenar compound muscle action potential, and denervation findings observed on thenar needle electromyography.

Musculoskeletal Ultrasound was conducted to determine the median nerve echogenicity as well as assess cross-sectional area (mm^2) measured using continuous tracing at the level of maximal swelling along the level of the tunnel inlet. Such an area was obtained by the addition of both divisions in cases of a variant bifid median nerve. Examinations were performed using a medical ultrasound system (Aplio 400; Toshiba, Japan) equipped with a high-resolution linear-array transducer (7–18 MHz). Exclusion criteria included: age <18 years; history of carpal tunnel decompression surgery; neurological deficits (e.g., peripheral neuropathy, radiculopathy); comorbid diabetes mellitus, endocrine, or metabolic disorders; history of local corticosteroid injection; major carpal osseous deformity detected through ultrasound examination.

Statistical Analysis:-

Data were analyzed with SPSS for Windows (v15.0; SPSS Inc., Chicago, IL, USA). Numerical data were presented as mean, median, standard deviation (SD), and range (minimum–maximum),while reporting categoricaldata as frequency and percentage.The one sample Kolmogorov Smirnov test was employed to evaluate distribution normalit. Parametric data were examined utilizing an independent-samples t-test to compare the means of two groups. The Mann-Whitney U test was employed to assess nonparametric data while analyzing categorical variables via the Chi-square test, using Fisher's exact test when expected cell frequencies were<5. Statistical significance was defined as $P \leq 0.05$: $P \leq 0.01$: high significance; $P > 0.05$: non-significant.

Results:-

The participants had a mean age of 47.6 ± 9.8 years,a mean disease duration of 6.7 ± 5.2 years, and mean morning stiffness duration of 28.0 ± 17.8 minutes. Females comprised 76.7% of the cohort. Regarding pharmacotherapy dual-drug therapy was most common (43.3%). Moderate DAS28 was observed in 40% of patients (Table 1).

Table 1:Baseline Characteristics of the Participants (n = 60)

Age (Years)	**Mean ±SD**	**Min.**	**Max.**
	47.6 ± 9.8	**26**	**61**
Disease Duration (Years)	**6.7 ± 5.2**	**1**	**17**
Morning Stiffness (Minutes)	**28 ± 17.8**	**0**	**60**
Gender	**Male**	**14**	**23.3%**
	Female	**46**	**76.7%**
Drug	**Single Therapy**	**20**	**33.4%**
	Double Therapy	**26**	**43.3%**
	Triple Therapy	**14**	**23.3%**
DAS28 Score	**Remission**	**20**	**33.3%**
	Low Disease Activity	**10**	**16.7%**
	Moderate Activity	**24**	**40.0%**
	High Activity	**6**	**10.0%**

Agreement betweenNCV and Ultrasound assessments was evaluated for both hands. Significant agreement was observed between right-hand NCV and Ultrasound ($\kappa = 0.708$, $p < 0.001$) and between left-hand NCV and Ultrasound ($\kappa = 0.652$, $p < 0.001$; Table 2).

Table 2:Agreement Between Nerve Conduction Velocity and Ultrasound Grading for Both Hands

		Normal	Mild	Moderate	Total	Kappa	P-value	Sig.
Right-Hand Ultrasound	**Normal**	**18(100%)**	**0**	**0**	**18(30%)**	**0.708**	**<0.001**	**HS**
	Mild	**0**	**14(100%)**	**12(42.9%)**	**26(43.3%)**			
	Moderate	**0**	**0**	**16(57.1%)**	**16(26.7%)**			
	Total	**18(100%)**	**14(100%)**	**28(100%)**	**60(100%)**			
Left-Hand Ultrasound	**Normal**	**18(100%)**	**0**	**0**	**18(30%)**	**0.652**	**<0.001**	**HS**
	Mild	**0**	**10(83.3%)**	**12(40%)**	**22(36.7%)**			
	Moderate	**0**	**2(16.7%)**	**18(60%)**	**20(33.3%)**			
	Total	**18(100%)**	**12(100%)**	**30(100%)**	**60(100%)**			

Disease duration demonstrated a significant association with NCV grading for both hands (right: $p < 0.001$; left: $p = 0.001$). Post-hoc comparisons revealed significantly longer disease duration in moderate versus normal and mild NCV categories for both hands ($p < 0.001$), with no significant differences between mild and moderate categories (Table 3). Similarly, Ultrasound grading correlated significantly with disease duration for both hands ($p < 0.001$ for each), with moderate Ultrasound grades related to the longest disease duration (Table 4).

Table 3: Disease Duration by Nerve Conduction Velocity Grading for Both Hands

Disease Duration (Years)	Group	N	Mean	SD	Median	Range		F	P-value	Sig.
						Min.	Max.			
Right Nerve Conduction Velocity	Normal [a]	18	3.0	0.8	3.0	1.0	4.0	10.3	<0.001	HS
	Mild [b,c]	14	6.4	5.6	3.0	1.0	15.0			
	Moderate [c,b]	28	9.2	5.3	9.0	1.5	17.0			
Left Nerve Conduction Velocity	Normal [a]	18	3.0	0.8	3.0	1.0	4.0	8.4	0.001	HS
	Mild [b,c]	12	7.3	5.2	7.5	1.0	14.0			
	Moderate [c,b]	30	8.6	5.7	8.0	1.5	17.0			

Table 4: Disease Duration by Ultrasound Grading for Both Hands

	Disease Duration (Years)									
Ultrasound Grading	Group	N	Mean	SD	Median	Range		F	P-value	Sig.
						Min.	Max.			
Right-Hand Ultrasound	Normal [a]	18	3.0	.8	3.0	1	4	10.8	<0.001	HS
	Mild [b]	26	7.1	6.0	3.0	1	17			
	Moderate [c]	16	10.1	4.0	10.0	5	15			
Left-Hand Ultrasound	Normal [a]	18	3.0	.8	3.0	1.0	4.0	10.2	<0.001	HS
	Mild [b,c]	22	7.0	4.4	8.0	1.0	15.0			
	Moderate [c,b]	20	9.7	6.3	13.0	1.5	17.0			

Morning stiffness duration did not differ significantly across NCV grading categories for both hand (right: p = 0.274; left: p = 0.242; Table 5). Likewise, no significant associations were found between morning stiffness and Ultrasound grading for the right (p = 0.149) or left hands (p = 0.103; Table 6).

Table 5: Morning Stiffness Duration by Nerve Conduction Velocity Grading for Both Hands

Morning Stiffness (Min.)	Group	N	Mean	SD	Median	Range		F	P-value	Sig.
						Min.	Max.			
Right Nerve Conduction Velocity	Normal	18	23.6	11.3	30	0	30	1.32	0.274	NS
	Mild	14	26.8	18.4	30	0	60			
	Moderate	28	33.3	20.3	30	15	60			
Left Nerve Conduction Velocity	Normal	18	22.5	12.0	30	0	30	1.5	0.242	NS
	Mild	12	27.0	17.8	30	0	60			
	Moderate	30	33.3	20.3	30	15	60			

Table6: Morning Stiffness Duration by Ultrasound Grading for Both Hands

	Morning Stiffness (Minutes)									
Ultrasound Grading	Group	N	Mean	SD	Median	Range		F	P-value	Sig.
						Min.	Max.			
Right-Hand Ultrasound	Normal	18	23.1	11.4	30.0	0	30.0	1.97	0.149	NS
	Mild	26	30.0	21.9	30.0	.0	60.0			
	Moderate	16	33.3	20.3	30.0	15	60.0			
Left-Hand Ultrasound	Normal	18	21.8	12	30.0	0	30.0	2.4	0.103	NS
	Mild	22	30.0	19.5	30.0	0	60.0			
	Moderate	20	33.3	20.3	30.0	15	60.0			

Analysis of DAS28 categories in relation to NCV grading revealed a statistically significant association for the right hand ($p = 0.014$) but not for the left hand ($p = 0.249$) (Table 7). In contrast, DAS28 categories showed statistically significant associations with Ultrasound grading for the right ($p < 0.001$) and left hands ($p = 0.026$; Table 8).

Table 7: Association Between Disease Activity Score and Nerve Conduction Velocity Grading

Right Nerve Conduction Velocity					X^2	P value	Sig.
DAS	Normal	Mild	Moderate	Total			
Remission	6(30%)	4(20%)	10(50%)	20(100%)	14.6	0.014	S.
Low Disease Activity	4(40%)	0	6(60%)	10(100%)			
Moderate Activity	8(33.3%)	10(41.7%)	6(25%)	24(100%)			
High Activity	0	0	6(100%)	6(100%)			
Total	18(30%)	14(23.3%)	28(46.7%)	60(100%)			
Left Nerve Conduction Velocity							
DAS	Normal	Mild	Moderate	Total			
Remission	6(30%)	3(15%)	11(55%)	20(100%)	7.6	0.249	NS.
Low Disease Activity	4(40%)	0	6(60%)	10(100%)			
Moderate Activity	8(33.3%)	7(29.2%)	9(37.5%)	24(100%)			
High Activity	0	2(33.3%)	4(66.7%)	6(100%)			
Total	18(30%)	12(20%)	30(50%)	60(100%)			

Table 8: Association Between Disease Activity Score Categories and Ultrasound Grading

Right-Hand Ultrasound					X^2	P value	Sig.
DAS	Normal	Mild	Moderate	Total			
Remission	6(30%)	8(40%)	6(30%)	20(100%)	17.5	<0.001	HS.
Low Disease Activity	4(40%)	4(40%)	2(20%)	10(100%)			
Moderate Activity	8(33.3%)	14(58.3%)	2(8.3%)	24(100%)			
High Activity	0	0	6(100%)	6(100%)			
Total	18(30%)	26(43.3%)	16(26.7%)	60(100%)			
Left-Hand Ultrasound							
Remission	6(30%)	10(50%)	4(20%)	20(100%)	13.3	0.026	S.
Low Disease Activity	4(40%)	2(20%)	4(40%)	10(100%)			
Moderate Activity	8(33.3%)	10(41.7%)	6(25%)	24(100%)			
High Activity	0	0	6(100%)	6(100%)			
Total	18(30%)	22(36.7%)	20(33.3%)	60(100%)			

Discussion:-

CTS encompasses multiple signs and symptoms that occur commonly in RA, often explained by pathologic mechanisms such as inflammation in the tendons and joints. Median nerve compression within the carpal tunnel causes hypertrophy of the nerve immediately proximal tothe compression siteat the tunnel entrance Dede et al., 2023). Herein, CTS was identified in 70% of assessed wrists (84 of 120), a prevalence consistent with George et al. (2025), who reported that RA patients face a higher CTS risk than the general population. Demographically, RA affected women more frequently than men (76.7% vs. 23.3%), with a mean patient age of 47.6 ± 9.8 years, indicating that RA prevalence varies by sex and age, corroborated by Eriksson et al. (2013).

Regarding disease activity, assessed via the DAS28, patients exhibited multiple activity levels from remission to high activity. A significant correlation was observed between disease activity and NCV grading in the right hand, but not the left. This finding aligns with Erdem and Ataoğlu (2025), who identified high RA disease activity as a risk factor for neuropathic entrapement detected by NCV. Diagnostic agreement between NCV and Ultrasound was significant for both hands, supporting Kanagasabai (2022), who noted a strong relation between Ultrasound findings and nerve conduction studies in CTS detection. Furthermore, disease duration correlated significantly with NCV

grading, with moderate nerve involvement associated with longer disease duration. This supports the conclusion by Erdem and Ataoğlu (2025) that CTS in RA patients is related to the disease's chronic course.

Conclusion:-

CTS is highly prevalent among patients with RA, affecting approximately 70% of assessed wrists. The condition is more common in women, and disease activity correlates significantly with nerve conduction abnormalities, particularly in the right hand. Ultrasound and NCV demonstrate strong diagnostic agreement, and longer disease duration is associated with increased nerve involvement, suggesting CTS is a consequence of chronic RA.

Recommendation:-

Clinicians should implement routine screening for median nerve symptoms, particularly in female patients with RA and those with prolonged disease duration. NCV and musculoskeletal Ultrasound should be utilized as complementary diagnostic tools; while NCV confirms the severity of nerve dysfunction, Ultrasound is essential for identifying underlying synovial inflammation or tenosynovitis contributing to compression.

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