

1 **Carpal Tunnel Syndrome in Rheumatoid Arthritis: Performance Assessment of High**  
2 **Resolution Ultrasound and Electrophysiological Studies as A Diagnostic Tool.**

3

4 **Abstract**

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

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

13 **Material and Methods:**This cross-sectional study enrolled 60 adult RApatients, diagnosed  
14 by the 2010 American College of Rheumatology/European League Against Rheumatism  
15 classification criteria, recruited from the National Institute for Neuro-Motor System. Here, we  
16 assessed disease activity utilizing the Disease Activity Score in 28 joints (DAS28), which  
17 categorizes RA status from remission to high activity. CTS was evaluated using nerve  
18 conduction velocity (NCV) studies following the American Association of Neuromuscular  
19 and Electrodiagnostic Medicine guidelines, while using musculoskeletal Ultrasoundto  
20 determine median nerve cross-sectional area.

21 **Results:**Among the 60 patients with RA (76.7% female), 40% exhibited moderate disease  
22 activity by DAS28. There was statistically significant agreement between NCV and  
23 Ultrasound findings in grading CTS severity. Mean disease duration was longest in the  
24 moderate NCV severity group for both hands. The findings manifested significant disparities  
25 between the normal versus mild and moderate NCV severity groups, with no significant  
26 difference between the mild and moderate groups bilaterally. Mean morning stiffness  
27 duration was greatest in the moderate NCV severity group and similarly in the moderate  
28 Ultrasound severity group for both hands. The results showcased a significant association  
29 between DAS28 categories and NCV findings in the right hand, but not in the left hand. In  
30 both hands, a highly significant association was found between DAS28 categories and  
31 Ultrasound grading, with all cases of high disease activity demonstrating moderate  
32 Ultrasound findings.

33 **Conclusion:**CTS is highly prevalent among patients with RA. Ultrasound and nerve  
34 conduction studies demonstrate strong concordance in CTS diagnosis, supporting that  
35 peripheral nerve involvement is a common consequence of chronic RA.

## 36 **Introduction**

37 Rheumatoid arthritis (RA) represents the predominant form of inflammatory arthritis and  
38 may result in irreversible disability due to cartilage degradation and bone erosion, with carpal  
39 tunnel syndrome (CTS) representing a common extra-articular symptom. Previous studies  
40 demonstrate that CTS in RA patients is mostly associated with inflammation of the tendons,  
41 joints, and the median nerve. Accordingly, hand and finger symptoms resulting from CTS in  
42 this demographic may complicate the evaluation of RA disease activity (*Dede et al.,*  
43 *2023*).RA impairs axonal transport and, by compressing the median nerve and its intraneural  
44 arteries within the perineurium, can induce ischemia of the median nerve. Alternative  
45 hypothesized etiologies of rheumatoid neuropathy encompass pharmacological toxicity,  
46 vasculitis, and amyloid accumulation(*Sakthiswary and Singh, 2017*).

47 CTS arises from median nerve compression as it passes through the carpal tunnel,  
48 mainly due to increased pressure within the carpal tunnel. Frequent early symptoms  
49 encompass pain, numbness, and paresthesia impacting the first three digits and the lateral  
50 portion of the fourth digit. Symptoms may differ, but discomfort can occur at the wrist, affect  
51 the entire hand, and possibly radiate up the forearm or beyond the elbow (*Genova et al.,*  
52 *2020*).CTS diagnosis relies on clinical history and physical examination; yet, nerve  
53 conduction investigations and ultrasound can yield additional clinically pertinent information  
54 (*Smerilli et al., 2021*).

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

## 64 **Material and Methods**

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

## 69 **Methodology**

70 Patients underwent a comprehensive medical history assessment. Disease activity was  
71 evaluated using the Disease Activity Score in 28 joints (DAS28) (*Prevo et al., 1995*) as  
72 follows: remission ( $< 2.6$ ), low ( $\geq 2.6$  to  $\leq 3.2$ ), moderate ( $> 3.2$  to  $\leq 5.1$ ), and high ( $> 5.1$ ).

73 NCV studies were interpreted per the American Association of Neuromuscular and  
74 Electrodiagnostic Medicine guidelines. CTS severity was graded as follows (*Campbell,*  
75 *1999*): (1) Mild: Abnormal sensory conduction, characterized by a sensory conduction  
76 velocity of  $\leq 50$  m/s or a sensory nerve action potential amplitude of  $< 10$   $\mu$ V, while motor  
77 distal delay remains within normal parameters; (2) Moderate: Abnormal sensory parameters  
78 accompanied by extended distal motor latency; (3) Severe: Absent sensory potential, delayed  
79 distal motor latencies, absent or low-amplitude thenar compound muscle action potential, and  
80 denervation findings observed on thenar needle electromyography.

81 Musculoskeletal Ultrasound was conducted to determine the median nerve cross-sectional  
82 area ( $\text{mm}^2$ ) and assess echogenicity. Examinations were performed using a medical  
83 ultrasound system (Aplio 400; Toshiba, Japan) equipped with a high-resolution linear-array  
84 transducer (7–18 MHz).

85 Exclusion criteria included: age  $< 18$  years; history of carpal tunnel decompression  
86 surgery; neurological deficits (e.g., peripheral neuropathy, radiculopathy); comorbid diabetes  
87 mellitus, endocrine, or metabolic disorders; history of local corticosteroid injection; or prior  
88 surgical decompression for CTS.

## 89 **Statistical Analysis**

90 Data were analyzed with SPSS for Windows (v15.0; SPSS Inc., Chicago, IL, USA).  
91 Numerical data were presented as mean, median, standard deviation (SD), and range  
92 (minimum–maximum), while reporting categorical data as frequency and percentage. The  
93 one-sample Kolmogorov-Smirnov test was employed to evaluate distribution normality.  
94 Parametric data were examined utilizing an independent-samples t-test to compare the means  
95 of two groups. The Mann-Whitney U test was employed to assess nonparametric data while  
96 analyzing categorical variables via the Chi-square test, using Fisher's exact test when expected

97 cell frequencies were <5. Statistical significance was defined as  $P \leq 0.05$ ;  $P \leq 0.01$ : high  
 98 significance;  $P > 0.05$ : non-significant.

99 **Results**

100 The participants had a mean age of  $47.6 \pm 9.8$  years, a mean disease duration of  $6.7 \pm 5.2$   
 101 years, and a mean morning stiffness duration of  $28.0 \pm 17.8$  minutes. Females comprised  
 102 76.7% of the cohort. Regarding pharmacotherapy, dual-drug therapy was most common  
 103 (43.3%). Moderate DAS28 was observed in 40% of patients (**Table 1**).

104 **Table 1. Baseline Characteristics of the Participants (n = 60)**

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

105 Agreement between NCV and Ultrasound assessments was evaluated for both hands.  
 106 Significant agreement was observed between right-hand NCV and Ultrasound ( $\kappa = 0.708$ ,  $p <$   
 107  $0.001$ ) and between left-hand NCV and Ultrasound ( $\kappa = 0.652$ ,  $p < 0.001$ ; **Table 2**).

108 **Table 2. Agreement Between Nerve Conduction Velocity and Ultrasound Grading for Both**  
 109 **Hands**

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

110 Disease duration demonstrated a significant association with NCV grading for both hands  
 111 (right:  $p < 0.001$ ; left:  $p = 0.001$ ). Post-hoc comparisons revealed significantly longer disease

112 duration in moderate versus normal and mild NCV categories for both hands ( $p < 0.001$ ),  
 113 with no significant differences between mild and moderate categories (**Table 3**). Similarly,  
 114 Ultrasound grading correlated significantly with disease duration for both hands ( $p < 0.001$   
 115 for each), with moderate Ultrasound grades related to the longest disease duration (**Table 4**).

116 **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.			
<i>Right Nerve Conduction Velocity</i>	<i>Normal<sup>a</sup></i>	18	3.0	0.8	3.0	1.0	4.0	10.3	<0.001	HS
	<i>Mild<sup>b,c</sup></i>	14	6.4	5.6	3.0	1.0	15.0			
	<i>Moderate<sup>c,b</sup></i>	28	9.2	5.3	9.0	1.5	17.0			
<i>Left Nerve Conduction Velocity</i>	<i>Normal<sup>a</sup></i>	18	3.0	0.8	3.0	1.0	4.0	8.4	0.001	HS
	<i>Mild<sup>b,c</sup></i>	12	7.3	5.2	7.5	1.0	14.0			
	<i>Moderate<sup>c,b</sup></i>	30	8.6	5.7	8.0	1.5	17.0			

117 **Table 4. Disease Duration by Ultrasound Grading for Both Hands**

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

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

122 **Table 5. Morning Stiffness Duration by Nerve Conduction Velocity Grading for**  
 123 **Both Hands**

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

**Table 6. Morning Stiffness Duration by Ultrasound Grading for Both Hands**

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

125 Analysis of DAS28 categories in relation to NCV grading revealed a statistically  
 126 significant association for the right hand ( $p = 0.014$ ) but not for the left hand ( $p = 0.249$ )  
 127 (Table 7). In contrast, DAS28 categories showed statistically significant associations with  
 128 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			
<i>Remission</i>	6(30%)	4(20%)	10(50%)	20(100%)	14.6	0.014	S.
<i>Low Disease Activity</i>	4(40%)	0	6(60%)	10(100%)			
<i>Moderate Activity</i>	8(33.3%)	10(41.7%)	6(25%)	24(100%)			
<i>High Activity</i>	0	0	6(100%)	6(100%)			
<i>Total</i>	18(30%)	14(23.3%)	28(46.7%)	60(100%)			
Left Nerve Conduction Velocity					$X^2$	P value	Sig.
DAS	Normal	Mild	Moderate	Total			
<i>Remission</i>	6(30%)	3(15%)	11(55%)	20(100%)	7.6	0.249	NS.
<i>Low Disease Activity</i>	4(40%)	0	6(60%)	10(100%)			
<i>Moderate Activity</i>	8(33.3%)	7(29.2%)	9(37.5%)	24(100%)			
<i>High Activity</i>	0	2(33.3%)	4(66.7%)	6(100%)			
<i>Total</i>	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			
<i>Remission</i>	6(30%)	8(40%)	6(30%)	20(100%)	17.5	<0.001	HS.
<i>Low Disease Activity</i>	4(40%)	4(40%)	2(20%)	10(100%)			
<i>Moderate Activity</i>	8(33.3%)	14(58.3%)	2(8.3%)	24(100%)			
<i>High Activity</i>	0	0	6(100%)	6(100%)			
<i>Total</i>	18(30%)	26(43.3%)	16(26.7%)	60(100%)			
Left-Hand Ultrasound					$X^2$	P value	Sig.
DAS	Normal	Mild	Moderate	Total			
<i>Remission</i>	6(30%)	10(50%)	4(20%)	20(100%)	13.3	0.026	S.
<i>Low Disease Activity</i>	4(40%)	2(20%)	4(40%)	10(100%)			
<i>Moderate Activity</i>	8(33.3%)	10(41.7%)	6(25%)	24(100%)			
<i>High Activity</i>	0	0	6(100%)	6(100%)			
<i>Total</i>	18(30%)	22(36.7%)	20(33.3%)	60(100%)			

131 **Discussion**

132 CTS encompasses multiple signs and symptoms that occur commonly in RA, often  
133 explained by pathologic mechanisms such as inflammation in the tendons and joints. Median  
134 nerve compression within the carpal tunnel causes hypertrophy of the nerve immediately  
135 proximal to the compression site at the tunnel entrance (*Dede et al., 2023*). Herein, CTS was  
136 identified in 70% of assessed wrists (84 of 120), a prevalence consistent with *George et al.*  
137 (*2025*), who reported that RA patients face a higher CTS risk than the general population.  
138 Demographically, RA affected women more frequently than men (76.7% vs. 23.3%), with a  
139 mean patient age of  $47.6 \pm 9.8$  years, indicating that RA prevalence varies by sex and age,  
140 corroborated by *Eriksson et al. (2013)*.

141 Regarding disease activity, assessed via the DAS28, patients exhibited multiple activity  
142 levels from remission to high activity. A significant correlation was observed between  
143 disease activity and NCV grading in the right hand, but not the left. This finding aligns with  
144 *Erdem and Ataoğlu (2025)*, who identified high RA disease activity as a risk factor for  
145 neuropathic entrapment detected by NCV. Diagnostic agreement between NCV and  
146 Ultrasound was significant for both hands, supporting *Kanagasabai (2022)*, who noted a  
147 strong relation between Ultrasound findings and nerve conduction studies in CTS detection.  
148 Furthermore, disease duration correlated significantly with NCV grading, with moderate  
149 nerve involvement associated with longer disease duration. This supports the conclusion by  
150 *Erdem and Ataoğlu (2025)* that CTS in RA patients is related to the disease's chronic course.

151 **Conclusion**

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

157 **Recommendation**

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

163

164 **Reference**

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