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Study of Neurophysiological Variables and its Association with Co-Morbidity in Patients with Carpal Tunnel Syndrome in Rural Amritsar Population

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Abstract

Background: Present study was envisaged to analyze neurophysiological variables in clinically diagnosed Carpal Tunnel Syndrome (CTS) patients and categorize injury into demyelinating, axonal or mixed insult on its basis. The study further evaluated co morbid conditions (diabetes, hypothyroidism and rheumatoid arthritis) in CTS patients and its impact on variation of neurophysiological variables.
Methods: This was prospective cross-sectional study in which 480 hands i.e. (240 patients) of clinically diagnosed Carpal Tunnel Syndrome (CTS) patients were studied. Nerve Conduction Study (NCS) was conducted on median sensory & median motor nerve. Various Neurophysiological variables i.e. Sensory Nerve Action Potential (SNAP), Compound muscle action potential (CMAP), Distal Latency (sensory), distal latency (motor), Nerve Conduction Velocity (sensory), Nerve Conduction Velocity (motor) were recorded. CTS patients with comorbid conditions of diabetes, hypothyroidism, rheumatoid arthritis were studied for variation of neurophysiological variables, along with CTS patients without above stated co-morbid conditions.
Results: Out of 240 patients with CTS, 75.4% were females and 24.6% were males. The mean duration of CTS symptoms exhibited was 7.55 ± 5.32 months. Median Sensory & Median Motor neurophysiological variables were affected in 73% hands while Median Sensory neurophysiological variable was affected in 26.3 % hands. CTS patients with predisposing diabetes disease were 25%, with rheumatoid arthritis were 9% and with hypothyroidism were 16%.
Conclusion: Nerve conduction studies are reliable and versatile method for diagnosis of CTS when used with clinical history. The study emphasis the importance of variation of neurophysiological variables in predisposing diseases i.e. diabetes, hypothyroidism, rheumatoid arthritis and categorization of insult to median nerve i.e. sensory, motor, axonal, demyelinating or mixed.
Keywords: Nerve conduction study (NCS), Carpal Tunnel Syndrome (CTS), Median Nerve, Sensory Nerve Action Potential (SNAP), Compound muscle action potential (CMAP), Comorbidities.

Introduction

Carpal Tunnel Syndrome (CTS) is common focal entrapment neuropathy. It is a chronic, disabling condition in which the median nerve is entrapped as it passes through the Carpal Tunnel. This compression induced neuropathy causes numbness and pain[1,2] and is more common in women (506 / 100000 person). It manifests in women and men in ratio of 5:1. It usually involves dominant hand first.[3] CTS was first reported by Brian in 1947 among patients involved in repetitive work. The diagnosis of CTS is based on clinical findings mainly numbness, burning, tingling and pain over the lateral aspect of palmer surface of the affected hand and the fingers (thumb, index finger and middle finger).[4] The electrodiagnostic studies are needed for the confirmation of CTS, generally abnormal

electrophysiological tests are taken to be confirmatory in nature.[5] The challenge tests i.e. Tinel's test and Phalen's test may exhibit positive finding in CTS and are taken to be indicator of the disease.[6]

Early diagnosis of CTS is important to prevent further median nerve damage.[7] Professions involving repetitive hand movements, repetitive forceful grasping or repetitive pinching tend to have higher prevalence of CTS. Altered neurophysiological variables found by nerve conduction study in median sensory nerve and median motor nerve are used to establish median neuropathy in patients of CTS.[8] Neurophysiological diagnosis of CTS was first established in 1956 by Simpson showing slowing of median nerve conduction at wrist. It is plausible that both sensory and motor conduction of median nerve may be abnormal but, in some instances, only one may be affected.[9] Comorbid conditions of diabetes mellitus tend to increase the susceptibility to pressure while comorbid conditions of hypothyroidism and rheumatoid arthritis tend to reduce the space of Carpal Tunnel. Both these features (i.e., reduction of space of Carpal Tunnel and increased susceptibility to pressure) tend to precipitate or cause CTS.[10]

Present study was undertaken to determine the neurophysiological pattern, severity grading, type of insult in CTS patients of rural Amritsar region in India. Study involved recording Compound muscle action potential (CMAP), Distal Latency (sensory), distal latency (motor), Nerve Conduction Velocity (sensory), Nerve Conduction Velocity (motor) to evaluate demographic, electrophysiological profile and type of neuropathy. The study tries to analyze the impact of chronic co morbid diseases i.e diabetes mellitus, hypothyroidism and rheumatoid arthritis on neurophysiological variables in patients affected by CTS. These comorbid conditions were studied as they were most frequently encountered in CTS patients.

Material and Methods

The present study is a prospective cross-sectional study conducted in the Physiology and Nerve Conduction Lab in the Department of Medicine (Neurology) at a tertiary care medical institute in Amritsar, India. Patients of CTS reporting in outpatient departments of Medicine, Neurology, and Orthopedics were included. 240 clinically confirmed CTS patients were included in this study. The clinical diagnosis of CTS was based on previously reported criteria by Vogt et al. [11] which stated that,

1. Pain or paresthesia in hand either activity-related or Nocturnal,
2. Sensory impairment in the distribution of a median nerve or reduced two-point discrimination in case of the median nerve
3. Isolated atrophy of Abductor Pollicis Brevis Muscle (APB)
4. Positive challenge test i.e. Tinel's sign or Phalen's sign

The clinical diagnosis of CTS was suspected when the patient fulfilled the 1st criteria along with one more criteria from 2 to 4. The clinical features and laboratory features were noted on the prescribed Performa. During this study period, 480 hands were studied for nerve conduction study and clinical presentation. The MS Aleron NCV machine from Recorders and Medicath System (P) Ltd was used for performing nerve conduction study.

Following NCS tests were carried out in patients

1. Median distal latency i.e. DL (motor/sensory)
2. Median nerve action potential i.e. (SNAP / CMAP)
3. Median nerve conduction velocity (motor / sensory)[12].

In the present study, disc recording electrodes for mixed nerve studies and ring electrodes for sensory studies were used. A ground electrode is placed between stimulating and recording electrodes. The same machine was used for tests using percutaneous supramaximal response. The pulse duration was 0.05/0.1 ms for sensory and 0.2/0.5 msec for motor nerve stimulation. 20hz and 2Khz filters were used. Criteria given by Hermann and Logigian was used to assess the severity grade of CTS patients. (2002).[13] Mild: prolongation of median distal motor and sensory latency alone; (2) Mild to Moderate: latency prolongation with mild reduction of SNAP; (3) Moderate: latency prolongation along with moderate reduction of SNAP or CMAP; (4) Severe: unrecordable median SNAP or severe reduction of CMAP.

The present study recorded investigation of CTS patients suffering from chronic co-morbid conditions (diabetes, hypothyroidism, rheumatoid arthritis) and CTS patients without comorbid conditions.

Inclusion & Exclusion Criteria
Patients aged 15 to 75 years who were clinically diagnosed of having CTS were included in present study.
CTS patients who did not provide informed consent to participate in the study were excluded. Patients with electronically activated implants i.e Cardiac Pacemakers were also excluded from this study. The study was approved by Institutional Ethics Committee as per the norms and was conducted in compliance with declaration of Helsinki. Study participants were given information of study. Written informed consent was obtained before enrolling.

Statistics: SPSS version 26 (IBM Corp, Armonk NY USA was used for statistical analysis. The assessment of variable distribution played a critical role in choosing a suitable statistical method. Consequently, a Shapiro-Wilk test indicated a significant departure from normality in the data distribution (p-value < 0.01). In response to these findings, a non-parametric test was applied, and the data were summarized using the median and interquartile range. To find the difference in the two groups Mann Whitney U test was applied. For statistical evaluations. The p- value < 0.05 was considered significant and p-value < 0.001 were considered highly significant. Pearson co-relation co-efficient test was applied between neurophysiological variable and co-morbidity markers (HbA1C, TSH, RA factor) to evaluate their association.

RESULTS

A prospective cross-sectional study on 240 patients of CTS was conducted at tertiary care medical institute at Amritsar, India. Out of 480 hands analyzed, 449 hands were Symptomatic of CTS. The mean age of CTS patient was 49.18 ±11.92 years. Female patients predominated the study, with female: male ratio of 3.06:1. Out of 449 hands affected by CTS, 344 (77 %) belonged to female gender while 105 (23%) affected hands belonged to male gender. The mean symptom duration of CTS was observed 7.55 ± 5.32 months while maximum patients exhibited symptom duration of 6-12 months i.e., 134 patients (55.8%). Majority of patients were housewives (50%), dairy and farming (21.2%), manual workers (9.2%) while teaching, clerical, white colored job (19.6%).

In the present study of 240 patients, 61 (25.4%) patients had diabetes, 38 (15.8%) patients had hypothyroidism while 22 patients (9.2 %) had rheumatoid arthritis while 119 (49.6%) patients had no comorbid condition. The mean HBA1C in 61 patients observed was 7.94 ± 3.69 (%), mean RA factor in affected 22 patients was 46.23 ± 12.52 (IU/ml) while mean T_3 was 0.48 ± 0.13 (pg/ml) , mean T_4 was 0.48 ±0.13(ng/dl), TSH 5.22 ± 0.6 (mIU/L) in affected 38 patients of hypothyroidism.
In our study of 240 patients, 51-60 years age group had 70 patients (29.2%) while 41-50 years age group had 67 patients (27.9%). Consequently, maximum patients were observed in 40-60 age group (57%). This age group was most prone to CTS.

In the present neurophysiological study, Median sensory and median motor neurophysiological variables were affected in 328 hands (73 %) while median sensory nerve neurophysiological variables were affected in 118 (26.3%) hands, while median motor alone were affected only in 3 (0.7%) hands. In the study undertaken Tingling, numbness and pain was observed in distal end of index, middle and ring finger in 181 hands (40.3%), thumb, index and middle finger was affected in 221 hands (49.2%), index and middle finger were affected in 34 hands (7.6%) and thumb alone was affected in 30 (6.7%).

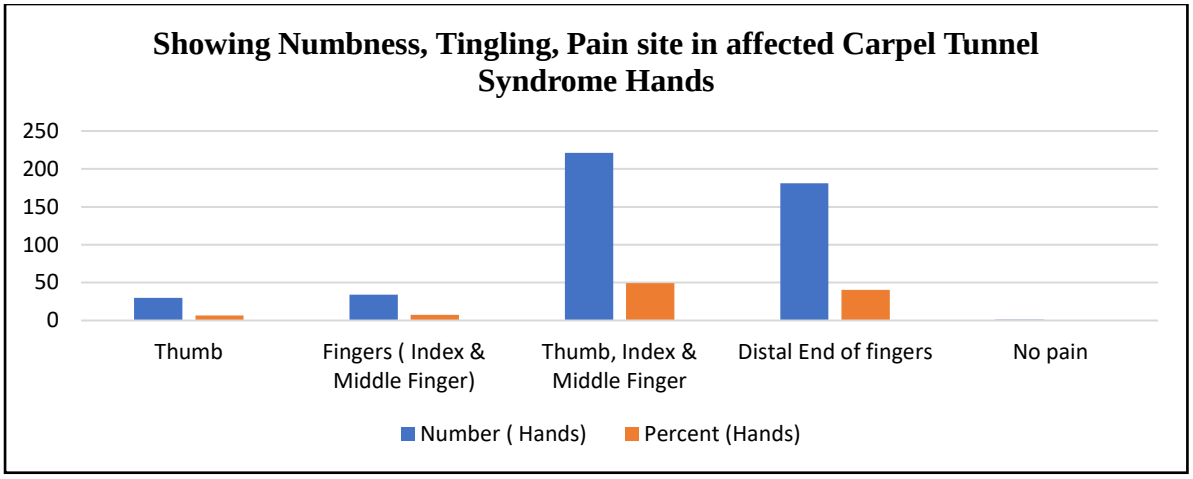

Figure: 1 Showing Numbness, Tingling, Pain site in affected Carpal Tunnel Syndrome Hands.

In the present study out of 449 symptomatic CTS hands, neurophysiological variables like SNAP i.e. sensory nerve action potential were decreased in 226 hands (50.3%) while compound muscle action potential decreased in 50 hands (11.1%), whereas increase of distal latency (motor) in median nerve was observed in 109 hands (24.3%), while increase of distal latency (sensory) median nerve was observed in 102 hands (22.7%). Decrease in nerve conduction velocity (sensory) was observed in 79 hands (17.6%) while decrease in nerve conduction velocity (motor was observed in just 19 hands (4.2%).

Table1: Showing Neurophysiological variables affected in CTS Hands

In the present study neurophysiological variables were studied for CTS hands without any co-morbid disease in 9 hands i.e. (diabetes, hypothyroidism, rheumatoid arthritis) and in CTS hands with co morbid disease (diabetes) i.e. 121 hands (26.9%). Duration of predisposing diabetes disorder ranged from 1 year to 5 years, however mean duration of diabetes was 2.54 ±1.26 years (short duration).

Parameter affected in CTS hands (n=449)	*Number (Hands)*	*Percent (Hands)*
Dec. SNAP	226	50.3
Dec NCV (Motor)	19	4.2
Dec NCV (Sensory)	79	17.6
Dec CMAP	50	11.1
Inc DL (Motor)	109	24.3
Inc DL (Sen)	102	22.7
Inc Diff DL(Sen & Motor)	159	35.4

The median motor amplitude in CTS hands with diabetes was 9.20(4.75 – 12.90) mv and median sensory amplitude was 43.50(26.35-50.10) µv. Distal latency (sensory) was 2.58 (2.42-3.08) milli sec., distal latency (motor) hands with diabetes was 4.17 (3.52 -4.79) milli sec. We found statistically highly significant (<0.001) difference in the observation of neuro physiological variables between CTS hand without any comorbidity and CTS hand with diabetes as per Mann – Whitney U test.

Table 2: Neurophysiological / Nerve conduction study in CTS hands with co-morbidity (diabetes) and CTS hands without any co morbidity

	CTS Hands with Diabetes		*CTS Hands Without Co Morbidity*		
	N	*Median(25-75)*	*N*	*Median(25-75)*	*p value*
Motor Latency(ms)	121	4.17(3.52-4.79)	209	3.65(3.02-4.12)	<0.001
Motor Amplitude(mv)	121	9.2(4.75-12.9)	209	14.2(10.87-16.75)	<0.001
Motor NCV(m/sec)	121	48.03(43.34-53.74)	209	52(48-55.44)	<0.001
Sen Latency(ms)	37	2.58(2.42-3.08)	194	3.03(2.41-3.76)	0.027
Sen Amplitude(uv)	37	43.5(26.35-50.1)	194	30.3(17.38-41.3)	0.001
Sen NCV(m/sec)	37	44(37.29-48.05)	194	40.01(31.23-47.46)	0.066
Diff f. between Mn and Un(Motor) latency	121	0.83(0-1.72)	209	1.35(0.85-1.87)	<0.001
Diff f. between Mn and Un(Sen) latency	121	0.75(0-1.72)	209	0.88(0.5-1.76)	0.020

Out of 121 studied diabetic CTS hands, 32 hands were categorized in Grade-I (demyelinating injury) i.e. (26.4%) Severity scale, 4 in Grade-II (demyelinating and axonal injury) i.e. (33%), 1 in Grade-III (demyelinating and axonal injury) i.e. (0.82%), 84 in Grade-IV (axonal injury) i.e. (69.4%). While 209 CTS hands without any co-morbid disease were categorized on severity scale as 131 hands in Grade-I (62.6%), 39 hands in Grade-II (18.6%), 24 hands in Grade- III (11.4%) and 15 hands in Grade-IV (7.1%). In the present study 75 hands (16.7%), out of 449 CTS hands had comorbidity hypothyroidism. A comparison of neurophysiological variables between CTS hands with co-morbidity (hypothyroidism) and CTS hands without any Co morbidity was done.

The median motor distal latency in CTS hands with hypothyroidism was 3.75 (3.33-4.48) mill sec, while median motor amplitude (mv) 12.90 (10.40-15.70) mv and median motor nerve conduction velocity was 49.73 (43.34 -53.74) m/sec. In case of sensory parameters, the sensory median latency was 3.38 (2.58 – 3.83) mill sec., while median sensory motor amplitude was 27.00 (16.75 – 36.30) µv and median sensory nerve conduction velocity was 38.19 (29.37 -45.47) m/sec.

There was statistically significant difference in observations of neurophysiological variables between CTS hands with hypothyroidism and CTS hands without any co-morbidity (diabetes, hypothyroidism, rheumatoid arthritis) as per Mann Whitney Test. Out of 75 CTS hands with hypothyroidism, severity grading was done. There were 19 hands in Grade-I (demyelinating injury) (25.33%), 7 in Grade-II (demyelinating and axonal injury) (9.33%), 11 in Grade-III (demyelinating and axonal injury) (14.66%) and 38 in Grade-IV (axonal injury) (50.66%). In the study undertaken 44 hands (9.79%) had rheumatoid arthritis out of 449 CTS hands. In the present study we compared neurophysiological variables of CTS hands having rheumatoid arthritis and CTS hands without comorbidity. The median motor latency in CTS hands with Rheumatoid Arthritis was recorded to be 3.85 (3.44-4.79) mill sec. while median motor amplitude was 13.60 (10.80 – 18.10) mv and median nerve conduction velocity (motor) was observed to be 51.76 (5.33 – 57.14) m/sec. In CTS hands with comorbidity Rheumatoid Arthritis, the sensory studies yielded following results: The median sensory latency was 3.08 (2.46- 3.85) mill sec., sensory amplitude 33.10 (19.05 – 41.60) µv and sensory nerve conduction velocity was observed to be 38.19 (32.75 – 45.09) m/sec. There was statistically significant difference in observations of neurophysiological variables between CTS hands with hypothyroidism and CTS hands without any co-morbidity (diabetes, hypothyroidism, rheumatoid arthritis) as per Mann Whitney Test.

Table 3: Neurophysiological / Nerve conduction study in CTS hands with co-morbidity (Hypothyroidism) and CTS hands without any co morbidity.

	CTS Hands with Hypothyroidism		CTS Hands without Comorbidity		p value
	N	Median(25-75)	N	Median(25-75)	
Motor Latency(ms)	75	3.75(3.33-4.48)	209	3.65(3.02-4.12)	0.039
Motor Amplitude(mv)	75	12.9(10.4-15.7)	209	14.2(10.87-16.75)	0.065
Motor NCV(m/sec)	75	49.73(43.34-53.74)	209	52(48-55.44)	0.008
Sen Latency(ms)	37	3.38(2.58-3.83)	194	3.025(2.41-3.755)	0.230
Sen Amplitude(uv)	37	27(16.75-36.3)	194	30.3(17.38-41.3)	0.160
Sen NCV(m/sec)	37	38.19(29.37-45.47)	194	40.01(31.23-47.46)	0.373
Diff f. between Mn and Un(Motor) latency	75	1.56(1.15-2.09)	209	1.35(0.85-1.87)	0.005
Diff f. between Mn and Un(Sen)latency	73	0.3(0-1.55)	209	0.88(0.5-1.76)	<0.001

It was observed that when grading of CTS hands as per severity scale was done in CTS hands with Rheumatoid Arthritis, 20 hands were categorized in Grade I (demyelinating injury)45.45 %, 6 hands in Grade II (demyelinating and axonal injury) ie 13.6%, 3 Hands in Grade III (demyelinating and axonal injury) 6.8% and 15 hands in Grade IV (axonal injury) 34.09 %. Study emphasized preponderance of axonal insult (median nerve) in CTS hands with Rheumatoid Arthritis.

Table 4: Neurophysiological / Nerve conduction study in Carpal Tunnel Syndrome hands with co-Morbidity (Arthritis) and Carpal Tunnel Syndrome hands without any co-morbidity

	CTS Hands with Rheumatoid Arthritis		*CTS Hands without Any Comorbidity*		
	N	*Median (25-75)*	*N*	*Median (25-75)*	*p value*
Motor Latency(ms)	43	3.85(3.44-4.79)	209	3.65(3.02-4.12)	0.012
Motor Amplitude(mv)	43	13.6(10.8-18.1)	209	14.2(10.87-16.75)	0.918
Motor NCV(m/sec)	43	51.76(45.53-57.14)	209	52(48-55.44)	0.953
Sen Latency(ms)	29	3.08(2.46-3.85)	194	3.03(2.41-3.76)	0.442
Sen Amplitude(uv)	29	33.1(19.05-41.6)	194	30.3(17.375-41.3)	0.932
Sen NCV(m/sec)	29	38.19(32.75-45.09)	194	40.01(31.23-47.46)	0.386
Diff. between Mn and Un (Motor) latency	43	1.82(1.28-2.35)	209	1.35(0.85-1.87)	<0.001
Diff. between Mn and Un (Sen) latency	44	0.86(0-1.2)	209	0.88(0.5-1.76)	0.070

TABLE 5 : Showing Co-relation between Neurophysiological variables and co-morbidity markers (HbA1C, TSH, RA Factor)

	HBA1C		*RA factor*		*T3*		*T4*		*TSH*	
	r value	*p value*	*r value*	*p value*	*r value*	*p value*	*r value*	*p value*	*r value*	*p value*
Motor Latency(ms)	0.178	0.051	-0.070	0.654	0.042	0.704	-0.046	0.696	0.214	0.066

Motor Amplitude(mv)	-0.024	0.795	0.041	0.793	-0.086	0.436	-0.102	0.384	0.074	0.529
Motor NCV(m/sec)	0.004	0.967	-.353*	0.020	-0.159	0.146	-0.056	0.632	-0.096	0.411
Sen Latency(ms)	-0.102	0.550	-0.209	0.277	-0.114	0.457	-0.213	0.205	0.129	0.448
Sen Amplitude(uv)	0.057	0.738	-0.235	0.219	0.129	0.399	.378*	0.021	-.331*	0.045
Sen NCV(m/sec)	-0.124	0.466	-0.017	0.929	0.212	0.163	0.213	0.207	-0.263	0.116
Diff f. between Mn and Un(Motor) latency	-0.014	0.880	0.088	0.573	-.227*	0.037	-0.098	0.402	0.190	0.103
Diff f. between Mn and Un(Sen)latency	-0.017	0.856	-.362*	0.016	-0.038	0.731	-0.117	0.326	-0.021	0.861
Spearman's rho test was applied										

In present study to unveil the finding Pearson Co-Relation Test was applied to neurophysiological variables and comorbidity markers i.e HbA1C, TSH and RA factor. In the case of diabetic CTS hands, increase in HbA1C level showed positive co-relation with median (motor) latency and negative co-relation with median (motor) amplitude. There was a negative co-relation between HbA1C and sensory NCV. In the case of hypothyroid CTS hands TSH showed positive co-relation with distal latency (motor), distal latency (sensory). However, TSH showed negative correlation with NCV (motor), NCV (sensory). In the case of CTS hands with RA factor, the comorbid RA factor showed negative correlation with NCV (motor) and NCV (sensory). Study also showed negative co relation between RA factor and sensory (amplitude).

Discussion

CTS is a medical state in which median nerve is compressed at the wrist. Its diagnosis involved combining clinical and neurophysiological approach for evaluating median nerve entrapment[14]. Neurophysiological study undertaken emphasized sensory-motor distortion in 73 % hands while sensory disturbance alone was recorded in 26.3% hands. This commensurate with loss of cutaneous sensation on palmer surface of hand involving first three digits and in radial half of fourth digit [15]. Objective diagnosis of CTS is based on electrodiagnostic studies. In the present study, neurophysiological variables like SNAP i.e. Sensory Nerve Action Potential, CMAP i.e. Compound Muscle Action Potential, Distal latency (motor), Distal latency (sensory), Nerve Conduction Velocity (sensory), Nerve Conduction Velocity (motor), Difference in Distal latency between median and ulnar nerve (sensory), Difference in Distal latency (motor) between median and ulnar nerve, were used for grading the severity of CTS.

In the study undertaken, 240 patients of CTS were studied, of which 181(75.4%) were females and 59 (24.5%) were male. Female patients outnumbered male patients. Out of 480 hands analyzed 449 were symptomatic. The study emphasized importance of nerve conduction study (neurophysiological variables) in CTS especially in mild case where clinical signs and tests (Tinel's Test & Phalen's test) may not suffice to diagnose in holistic manner. It is reported work of author Saggar etal[16]

Out of 240 CTS patients, 61 patients (25.4%) had pre-existing diabetes, while 22 patients (9.2%) had pre-existing Rheumatoid Arthritis and 38 patients (15.8%) had hypothyroidism for 2.54±1.26 years. In case of 119 (49.5%) CTS patients, there was no comorbidity. In the present prospective study, a comparison of neurophysiological variables between hypothyroidism CTS hands with CTS hands without co-morbidity were analyzed. The median motor latency and median sensory latency were significantly higher in CTS hands with hypothyroidism. This is in line with results obtained by Lalithamma etal.[17] & Beniwal etal.[18] who exhibited prolongation of distal latencies in median motor and median sensory nerve effected by hypothyroidism.

Even median motor amplitude and median sensory amplitude were significantly less in CTS hands with hypothyroidism when compared to CTS hands without co-morbidity as per analysis by Mann Whitney test. In the present study, latency, amplitude & velocity of conduction are affected in median nerve. Probably median nerve entrapment at the wrist is due to deposition of mucinous material in tissue surrounding median nerve and is a cause of nerve damage in hypothyroidism [19]. Most pertinent observation in present study was that hypothyroidism caused Axonal injury in 50% CTS hands i.e 38 hands (Grade IV) while 24 % CTS hands exhibited Demyelinating & Axonal injury (Grade II & Grade III) and 25.33 % hands presented with only Demyelinating injury i.e (Grade I). Our study emphasizes of impairment of median nerve conduction defect in sensory and motor components, with more of axonal damage to median nerve. This is in line with reported work of Meshram et al.[20,] who reported predominant decrease in SNAP amplitude and decrease in median nerve signifying a mixed type of neuropathy. This peripheral nerve disfunction is linked to evidence of primary axonal degeneration in the form of shrinkage of axons, disintegration of microtubules and neurofilaments and active axonal breakdown [21,22].

In the present study, 121 CTS hands with diabetes were compared to 209 hands without any comorbidity (diabetes, hypothyroidism and rheumatoid arthritis). The median motor distal latency was significantly higher in CTS hand with diabetes, while median motor amplitude (CMAP) in milli volts and median motor nerve conduction velocity ie m/s was significantly less as compared to CTS hands without any co morbidity. Similar results were observed by Tony et al.[23] reported significant decrease in CMAP, decrease in NCV (motor) and increase in distal latency (motor) in median nerve in CTS hands with comorbidity diabetes. In the present study however sensory amplitude and median sensory nerve conduction velocity were significantly higher in CTS hands with diabetes, while sensory median distal latency was significantly less as compared to CTS hands without any co morbidity. This is attributed to more of Axonal injury cases (Grade-IV) in CTS diabetic hands while CTS hands without co morbidity tended to show more of demyelinating injury cases (Grade-I). In the present study, diabetic CTS hands tended to show more profound electrophysiological abnormalities indicating prominent demyelinating distortions during early stage of disease. As the disease progressed, axonopathy distortions became prominent in median sensory & median motor nerve. Diabetes is a risk factor and leads to higher incidence of CTS in patients with diabetes than in the general population [24,25].

In our study when diabetic CTS hands were categorized based on severity, 84 hands showed Axonal injury (69.4%), 5 hands showed Axonal & demyelinating injury (ie 4%) while 32 hands showed demyelinating injury (26.4%). Our results indicated that diabetes led to a more advanced form of CTS. Above all SNAP & CMAP abnormalities (Axonotmesis) were more prominent in CTS hands with diabetes. Similar results were reported by Park etal [26], who reported significant decrease in CMAP and decrease in NCV in median nerve in CTS hands with comorbidity diabetes. In the study undertaken a comparison of Neurophysiological variables between Rheumatoid arthritis CTS hands ie 44 hands (9.79%) with CTS hands without co-morbidity (Diabetes, RA factor, hypothyroidism) were studied and analyzed. The median motor distal latency was significantly higher in CTS hands with rheumatoid arthritis, while median motor amplitude (CMAP) and median motor nerve conduction velocity was significantly less than CTS hands without co-morbidity.

However, in case of sensory component, in CTS hands with Rheumatoid Arthritis, sensory nerve conduction velocity was significantly less while sensory distal latency in median nerve was slightly greater than CTS hands without co-morbidity. However sensory amplitude in median sensory nerve in CTS hands with rheumatoid arthritis was greater than sensory amplitude in median sensory nerve in CTS hands without co-morbidity. In our study Rheumatoid Arthritis CTS hands were categorized according to severity scale. 15 hands (34.09%) showed i.e. severe / Grade IV (Axonal Injuries), 20 hands (45.45%) showed i.e. Grade I (Demyelinating injury) / mild while 9 hands (20.45) showed both i.e. Grade II and Grade III (Demyelinating and Axonal Injuries) / moderate.

Study indicated Rheumatoid Arthritis CTS hands tend to show more electrophysiological abnormalities in motor component of median nerve though demyelinating changes were observed in sensory component of median nerve during early stage of disease also. Similar results were observed by Mahmoud et al[27], who reported decrease of NCV (sensory / motor), decreased amplitude of SNAP and increase of distal latency (sensory / motor) in CTS hands with comorbidity rheumatoid arthritis. Probably for rheumatoid arthritis patients, joint inflammation is the main cause of CTS, it could lead to

mechanical irritation of median nerve leading to CTS. Smerilli et al [28] , reported tissue inflammation as cause for distortion in CTS hands with comorbidity rheumatoid arthritis.

Conclusion

Carpal Tunnel Syndrome patients exhibit sensory motor distortions. Hypothyroidism, diabetes, rheumatoid arthritis may precipitate or exaggerate symptoms in CTS patients. Neurophysiological variables tend to show more distortion in CTS patients with comorbidity (hypothyroidism, diabetes, rheumatoid arthritis). The present study emphasizes that combination of electrophysiological study along with clinical sign & symptoms provides a diagnostic tool for entire range of CTS patients especially with comorbidity. Neurophysiological variable provides an important gadget to grade the insult, indicate the type of insult (axonal, demyelinating, sensory, motor) in CTS hands and helps in accurate prognosis of disorder. Present study analyzes the co relation of neurophysiological variables with change of HbA1C, TSH, RA factor. The study proposes all-embracing approach of integrating variation of neurophysiological variables, clinical signs & symptoms recorded, grading of insult to median nerve in prognosis of CTS hands with & without comorbidity (hypothyroidism, diabetes, rheumatoid arthritis).

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