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RESEARCH ARTICLE
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ASSOCIATION OF METABOLIC SYNDROME WITH CARPAL TUNNEL SYNDROME

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Abstract

Background:
Carpal tunnel syndrome (CTS) is an issue that commonly occurs when the median nerve is narrowed at the wrist. Studies are conducted on the association of metabolic syndrome with CTS, but link between them is not well understood among South Asians.

Objective: To investigate the association between Metabolic Syndrome and Carpal Tunnel Syndrome.

Methodology: This case-control study took place at Ziauddin University's Neurology Department in Karachi for the time duration of six months, i-e, 1st June, 2024 to 30th November, 2024. There were 152 metabolic syndrome patients, 76 of whom had CTS (referred to as cases) and 76 of whom did not (referred to as controls). SPSS 25 was used to analyze the data, and the Mann-Whitney U, t-test, and chi-square tests were used to compare the groups. Statistical significance was defined as a p-value of less than 0.05.

Results: Higher CTS severity levels were substantially correlated with metabolic syndrome (p=0.0001). In addition to having lower HDL cholesterol and higher fasting triglyceride levels, patients with metabolic syndrome also had greater prevalences of symptoms such as pain, numbness, and weakness (p=0.0001). Additionally, the group with metabolic syndrome had significantly higher diastolic blood pressure (p=0.007). The proportion of age and gender was similar between groups.

Conclusion: Metabolic syndrome is strongly associated with both the presence and increased clinical severity of CTS. Screening for metabolic syndrome in CTS patients may facilitate early interventions to improve clinical outcomes.

Keywords: Carpal Tunnel Syndrome, Metabolic Syndrome, Neuropathy, Dyslipidemia

Introduction

The most prevalent entrapment neuropathy, Carpal Tunnel Syndrome (CTS), is brought on by compression of the median nerve as it passes through the wrist's carpal tunnel.[1] The thumb, index, middle, and a portion of the ring fingers are the most commonly affected, and symptoms include numbness, tingling, discomfort, and weakness in the hand.[2] CTS can seriously affect quality of life and hand function, particularly in people who do repetitive hand motions.[3] While occupational and mechanical factors are well-known contributors, there is growing interest in exploring systemic factors that may predispose individuals to CTS, particularly metabolic conditions that influence vascular and nerve health.[4]

Among the metabolic disorders that make up the Metabolic Syndrome (MetS) are central obesity, insulin resistance, dyslipidemia, and hypertension.[5] It is seen as a worldwide public health issue linked to a higher prevalence of type 2 diabetes, stroke, and cardiovascular disease. The chronic low-grade inflammation, impact on vascular endothelium, and microvascular changes in MetS may also impact the peripheral nerves and make them more vulnerable to entrapment.[6] Several recent studies suggest individuals with MetS also have an increased incidence of CTS, which raises the question of a potential physiopathological association.[7-9] Structural changes in the carpal tunnel and, therefore, increased pressure on the median nerve have potentially resulted from increased adiposity and insulin resistance.[8]

With both metabolic syndrome and carpal tunnel syndrome becoming an increasing global burden, it is worthwhile to identify if any potential association exists between the two. There would be many chances for early identification, care, and ultimately prevention of both carpal tunnel syndrome and metabolic syndrome if a connection could be proven. Determining whether metabolic syndrome is a substantial risk factor for carpal tunnel syndrome in the sample population is the justification for this investigation. The present study aims to determine the prevalence and pattern of metabolic syndrome components in individuals with carpal tunnel syndrome, as well as the relationship between metabolic syndrome and CTS.

Methodology

This case-control study took place at Ziauddin University's Neurology Department in Karachi for the time duration of six months i-e 1st June, 2024 to 30th November, 2024. There were 152 individuals with metabolic syndrome, 76 of whom had CTS (referred to as cases) and 76 of whom did not (referred to as controls).

The sample size was calculated through OpenEpi software, which had 80% power and a 95% confidence level based on previous prevalence rates.[7] Adults between the ages of 18 and 70 with clinically and electrodiagnostically diagnosed CTS were recruited via non-probability sequential sampling. The study excluded patients who had systemic disorders such as rheumatoid arthritis and hypothyroidism, were receiving hormone treatments, had wrist injuries, or had symptoms that potentially mimicked CTS.

The inclusion criteria consisted of patients between the ages of 18 and 70 of both genders, who were clinically examined and electrodiagnostically diagnosed with carpal tunnel syndrome (CTS) and metabolic syndrome. Patients with any condition that might mimic or complicate the diagnosis of CTS, i-e, pregnant women, those with connective tissue disorders, hypothyroidism, cervical radiculopathy, polyneuropathy, and thoracic outlet syndrome, rheumatoid arthritis, osteoarthritis, or wrist fracture, any local wrist pathology, or injuries and those who have been previously treated with corticosteroids and hormone replacement therapy (HRT) were also excluded from the study.

After being approved by Ziauddin University's Research Ethics Committee (Approval No: 8590324MANEU; Date: 17th May, 2024), data collection was started in the Neurology Outpatient Department (OPD). Patients who met the requirements for inclusion were contacted, and they were given a thorough explanation of the study's goals and methodology. Each patient who consented to take part in the study underwent a full assessment, with the first obtaining a thorough history and clinical examination focusing on neurological symptoms associated with carpal tunnel syndrome (CTS), including: paresthesia in the median nerve distribution, weakness of the thenar muscles, and

nocturnal symptoms. For each patient, electrodiagnostic nerve conduction studies (NCS) were undertaken to confirm the diagnosis of CTS based on the median nerve conduction velocity and median nerve amplitude.

Data were obtained using a structured questionnaire (proforma) which covered demographic, clinical, anthropometric, and biochemical variables. We used validated clinical scoring criteria for CTS, assigning a score to corresponding symptoms and signs: nocturnal pain (4 points), thenar atrophy (5 points), paresthesia (3.5 points), Phalen's test (5 points), Tinel's sign (4 points), and abnormal two-point discrimination (4.5 points). A cumulative score was also weighted to assess the severity of CTS. After confirming CTS, participants were evaluated for metabolic syndrome using the criteria of the Adult Treatment Panel III (ATP III).[7] Waist circumference, blood pressure, and fasting blood samples were collected under standardized and aseptic conditions. Fasting glucose, triglycerides, and HDL-C were analyzed at the institutional lab. Abnormal values based on ATP III thresholds were used to determine the presence of metabolic syndrome.

Patients meeting at least three of the ATP III criteria, abnormal waist circumference, elevated blood pressure, raised fasting glucose, high triglycerides, or low HDL-C were classified as cases (CTS with metabolic syndrome). Those without metabolic syndrome were categorized as controls (CTS without metabolic syndrome). All collected data were carefully reviewed for completeness and accuracy before being entered into SPSS for statistical analysis.

A systematic questionnaire was used to gather data, and SPSS version 25 was used for analysis. Frequencies and percentages were used to summarize qualitative factors, whereas means ± SD or medians [IQR] were used to show quantitative data. For categorical comparisons, odds ratios were computed using the chi-square or Fisher's exact test. Statistical significance was defined as a p-value of less than 0.05. To account for putative effect modifiers such as age, gender, and illness duration, stratification was done. The university's review board granted ethical approval, and each participant gave their informed consent.

Results

A total of 152 patients were enrolled in the study, with a predominant female representation (79.6%) and a mean age of 47.5 ± 12.3 years. The average duration of disease among all participants was 24.5 ± 7.7 months. Among the study population, exactly half (50%) had carpal tunnel syndrome (CTS) with metabolic syndrome, while the remaining half had metabolic syndrome without CTS. The majority of patients presented with right-sided CTS (25%), followed by bilateral involvement (15.8%), and left-sided symptoms in 9.2% of cases (Table 1).

Table 1: Socio-demographic and Clinical Characteristics of All Study Participants (n=152)

Variable	n(%)/ Mean ± SD
Gender	
Male	31 (20.4%)
Female	121 (79.6%)
Mean Age (years)	47.5 ± 12.3
Duration of Disease (months)	24.5 ± 7.7
Metabolic syndrome with CTS	76 (50%)
Metabolic syndrome without CTS	76 (50%)
Side of CTS	
Right	38 (25%)
Left	14 (9.2%)
Bilateral	24 (15.8%)

When comparing patients with metabolic syndrome with and without CTS, there were no statistically significant differences in mean age or disease duration between the groups (p=0.587 and p=0.414, respectively). However, CTS patients had a significantly higher total CTS severity score (16.3 ± 3.3)

than those without CTS (6.1 ± 2.4), with a highly significant p-value (<0.0001). While waist circumference and systolic blood pressure showed no significant group differences, diastolic blood pressure was significantly lower in CTS patients (p=0.007). Furthermore, triglyceride levels were significantly higher, and HDL-C levels significantly lower, among patients with CTS compared to those without (p<0.0001 for both), suggesting a strong association between dyslipidemia and CTS in the context of metabolic syndrome (Table 2).

Table 2: Comparison of Variables Between Patients of Metabolic Syndrome with and Without Carpal Tunnel Syndrome (CTS)

Variables	Metabolic Syndrome		Shapiro-Wilk Sig.	P-value
	With CTS (n=76)	Without CTS (n=76)		
Age in years	47.0 ± 13.8	48.1 ± 10.6	0.092	0.587 Independent t-test
Duration of Disease in months	28.3 ± 45.6	20.6 ± 27.2	0.000	0.414 Mann–Whitney U test
Total CTS Score	16.3 ± 3.3	6.1 ± 2.4	0.000	0.0001 Mann–Whitney U test
WC (Male > 102 cm & Female > 88 cm)	101.5 ± 11.9	100.3 ± 12.6	0.000	0.839 Mann–Whitney U test
BP (Systolic)	148.3 ±11.7	148.0 ± 8.9	0.000	0.694 Mann–Whitney U test
BP (Diastolic)	96.7 ±7.0	99.4 ± 6.7	0.000	0.007 Mann–Whitney U test
FBG (> 100 mg/dl)	143.4 ± 52.1	144.6 ± 45.7	0.000	0.211 Mann–Whitney U test
Fasting triglycerides (> 150 mg/dl)	257.2 ± 74.8	212.9 ± 69.5	0.000	0.0001 Mann–Whitney U test
Fasting HDL-C (Male < 40 & Female < 50 mg/dl)	37.1 ±9.3	31.1 ± 8.2	0.010	0.0001 Mann–Whitney U test

In terms of clinical presentation, symptoms such as numbness, weakness, pain, and positive results on Phalen's and Tinel's tests were significantly more prevalent in the metabolic syndrome group with CTS. Notably, 96.1% of CTS patients reported numbness, and 77.6% reported pain. Weakness was observed in 38.2% of CTS patients compared to only 11.8% in those without CTS. Similarly, Phalen's and Tinel's signs were positive in 89.5% and 51.3% of CTS patients, respectively, highlighting the diagnostic importance of these clinical tests in this population (Table 3).

Table 3: Frequency of CTS Symptoms by Group (With vs. Without Metabolic Syndrome)

Symptom	Metabolic Syndrome		P-value
	With Carpal Tunnel Syndrome	Without Carpal Tunnel Syndrome	
Numbness	73 (96.1%)	65 (85.5%)	0.025
Weakness	29 (38.2%)	9 (11.8%)	0.0001
Pain	59 (77.6%)	27 (35.5%)	0.0001
Positive Phalen's Test	68 (89.5%)	2 (2.6%)	0.0001
Positive Tinel's Sign	39 (51.3%)	4 (5.2%)	0.0001
Loss of Discrimination	23 (30.3%)	14 (18.4%)	0.089
The chi-square test is applied to calculate the p-value. P< 0.05 is taken as significant.			

Lastly, gender-wise distribution showed that females constituted the majority of both CTS and non-CTS groups with metabolic syndrome, with no statistically significant difference between them (p=0.546). This trend suggests a higher overall prevalence of metabolic syndrome and CTS among females in this cohort, though not statistically different between the groups (Table 4).

Table 4: Gender-wise Distribution of Metabolic Syndrome in CTS Patients

Gender	Metabolic Syndrome		P-value
	With Carpal Tunnel Syndrome	Without Carpal Tunnel Syndrome	
Male	17 (22.4%)	14 (18.4%)	0.546
Female	59 (77.6%)	62 (81.6%)	

Discussion

This study explored the association between carpal tunnel syndrome (CTS) and metabolic syndrome, evaluating clinical and biochemical variables in a population sample of 152 participants. Our findings demonstrate a statistically significant relationship between CTS and several components of metabolic syndrome, particularly dyslipidemia and elevated diastolic blood pressure. Notably, 50% of the patients with metabolic syndrome also had CTS, suggesting a potentially strong interplay between these two conditions.

Our results are consistent with the findings of Bekele et al. (2022), who reported a high prevalence of metabolic syndrome among patients diagnosed with CTS, particularly highlighting the contribution of abdominal obesity and hypertriglyceridemia to the development of median nerve entrapment.[10] In our study, patients with CTS had significantly higher fasting triglyceride levels (257.2 ± 74.8 mg/dL vs. 212.9 ± 69.5 mg/dL) and lower HDL-C levels (37.1 ± 9.3 mg/dL vs. 31.1 ± 8.2 mg/dL), both of which align with components of dyslipidemia described in the ATP III criteria. This observation is further supported by Zakaria *et al.* (2024), whose meta-analysis confirmed that individuals with dyslipidemia were at an increased risk of developing CTS.[11]

Another interesting aspect of our findings is the significantly elevated total CTS symptom severity scores in patients with metabolic syndrome (16.3 ± 3.3) compared to those without (6.1 ± 2.4), indicating more intense clinical symptoms. This could reflect the compounding effect of metabolic inflammation and microvascular changes commonly seen in metabolic syndrome, which may exacerbate median nerve compression. Prabhakar et al. (2021) also noted that metabolic syndrome, through chronic low-grade inflammation, can contribute to peripheral nerve damage and delay nerve conduction, which could explain the clinical severity seen in our CTS patients [12]

Another key finding in our study is the association between elevated diastolic blood pressure and CTS (p=0.007). Although systolic BP did not show significant variation between groups, higher diastolic BP may suggest an early vascular compromise in patients with CTS. Sethi *et al.* (2023) found similar results, indicating that patients with higher blood pressure, particularly diastolic, had more severe

nerve conduction abnormalities, potentially due to increased endoneurial edema or compromised microcirculation.[13]

Furthermore, clinical signs such as numbness, pain, weakness, and positive Phalen's and Tinel's signs were significantly more prevalent in CTS patients with metabolic syndrome. This observation is supported by Tonga *et al.* (2022), who reported that obesity and metabolic risk factors not only increase the prevalence of CTS but also intensify its clinical symptoms.[4]

In terms of gender distribution, although females represented the majority of CTS patients in both groups, the difference was not statistically significant. This is in line with epidemiological data indicating a higher overall incidence of CTS among women, possibly due to anatomical and hormonal differences.[14, 15] However, the lack of a significant difference in our study may be attributed to the matched design and equal representation of metabolic syndrome in both groups.

Overall, our findings reinforce the hypothesis that metabolic syndrome, through mechanisms such as dyslipidemia, hypertension, and central obesity, may contribute to the pathogenesis and severity of carpal tunnel syndrome. These results highlight the importance of a comprehensive metabolic assessment in patients presenting with CTS, as early identification and management of metabolic risk factors may help in alleviating symptoms and preventing progression.

Limitations

Given the insightful information this study provided, several limitations must be noted. The cross-sectional design of the study makes it difficult to prove a link between carpal tunnel syndrome (CTS) and metabolic syndrome. To ascertain the direction of this link, longitudinal research would be more suitable. The fact that only one institution provided the data may have limited the findings' applicability to larger populations with various sociodemographic and clinical characteristics.

Although the sample size of 152 participants was sufficient to detect statistically significant differences, a larger and more diverse sample may have provided more robust conclusions. Diagnosis of carpal tunnel syndrome is utilized mainly by clinical signs and symptoms without any form of electrophysiological confirmation (e.g. nerve conduction studies), which could under- or over-estimate cases. The study also did not monitor any changes in metabolic parameters or carpal tunnel syndrome symptoms over time or post-intervention for a more comprehensive understanding of the findings.

Conclusion

The findings revealed an important relationship between metabolic syndrome and carpal tunnel syndrome, with dyslipidemia, elevated diastolic blood pressure, and severity of clinical symptoms found to be the strongest drivers of carpal tunnel syndrome in cases of metabolic syndrome. Patients with metabolic syndrome had higher total carpal tunnel syndrome scores and more clinical signs (e.g. pain, numbness, and weakness). These results may support the idea that metabolic syndrome influences or exacerbates the clinical presentation of carpal tunnel syndrome.

Patients presenting with symptoms of carpal tunnel syndrome should be screened and managed early for metabolic risk factors, which might facilitate reduced severity of the disease and improved functional outcome. Larger multi-center prospective studies with electrophysiological confirmation are warranted to further explore this issue and guide clinical decision-making.

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