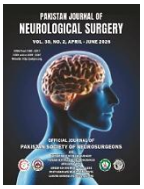

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Original Research

Association Between Vitamin D Deficiency and Carpal Tunnel Syndrome

Kamran Alamgir[1], Sajid Mehboob[2], Muhammad Imran Khan[3], Muhammad Shahbaz Tariq Khattak[4]

[1]Department of Neurosurgery, CAT-A DHQ Hospital, Landi Kotal
[2]Department of Neurosurgery, Khyber Teaching Hospital, Peshawar
[3]Department of Orthopedics, Khyber Teaching Hospital, Peshawar
[4]Department of Neurosurgery, Bahria International Hospital, Rawalpindi - Pakistan

ABSTRACT

Objective: The most common entrapment of the upper limb neuropathy is carpal tunnel syndrome (CTS). Deficiency of the vitamin may also affect the functioning of peripheral nerves, and it may serve as the etiology of CTS. This paper examined the relationship between serum levels of 25-hydroxyvitamin D and CTS, and how these two relate to the severity of the disease.

Materials & Methods: A retrospective case-control study was done using 70 participants consisting of 35 CTS patients and 35 age and sex matched controls. Serum vitamin D was measured. The severity of CTS was measured with the help of clinical assessment, nerve conduction studies (NCS), and high-resolution ultrasonography. T-tests, chi-square, Pearson correlation, and multivariate logistic regression were all done using statistical analysis.

Results: Mean serum vitamin D levels were significantly lower in CTS patients compared to controls (14.0 ± 5.8 vs. 23.2 ± 6.1 ng/mL; $p < 0.001$), and deficiency was more common among CTS (74.3 vs. 34.3; $p = 0.001$). A vitamin D deficiency was almost a five-fold risk factor of CTS (adjusted OR = 4.82; 95% 95% CI: 1.60–14.30; $p = 0.005$). Reduced vitamin D levels were associated with high severity of CTS, such as increased distal motor latency ($r = 0.39$; $p = 0.02$) and low sensory conduction velocity ($r = 0.36$; $p = 0.03$). Greater median nerve abnormalities in patients with vitamin D deficiency were depicted in ultrasonography.

Conclusion: Vitamin D deficiency is linked to CTS presence and severity considerably, and it is an independently associated factor. The evaluation of vitamin D, as well as electrophysiological and ultrasonographic studies, can help to improve diagnosis and risk, and determine possible therapeutic solutions.

Keywords: carpal tunnel syndrome, vitamin D deficiency, nerve conduction study, ultrasonography, associated factor.

Corresponding Author: Sajid Mehboob
Department of Neurosurgery, Khyber Teaching Hospital, Peshawar – Pakistan
Email: drsajid193@gmail.com

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most prevalent entrapment neuropathy of the upper extremity and a significant cause of hand pain, paresthesia, and functional impairment in adults.[1] It is caused by compression of the median nerve in the carpal tunnel, which causes sensory disturbance, nocturnal symptoms, and in severe cases, motor weakness and atrophy of the thenar muscle. CTS can severely affect the productivity of work and the quality of life, and thus it is important to consider the modifiable risk factors.[2]

Hypothesis: Vitamin D deficiency is associated with an increased risk and greater severity of CTS, and correlates with electrophysiological and ultrasonographic measures of median nerve involvement.

The pathophysiology of CTS is multifactorial with mechanical, metabolic, and systemic factors. Some of the established risk factors are obesity, diabetes mellitus, hypothyroidism, pregnancy, and inflammatory conditions.[3] In recent times, the focus has been directed towards metabolic deficiencies, especially vitamin D deficiency, because of its involvement in neuromuscular functioning, modulation of inflammation, repair of neurons, and conduction of nerves. It has been suggested that low levels of serum 25-hydroxyvitamin D have been associated with neuropathic pains and nerve dysfunctions.[4, 5]

Various studies have reported low levels of vitamin D in CTS patients and expressed a correlation between the levels of vitamin D and the intensity of the symptoms and electrophysiological anomalies.[6,10,11] The results are, however, inconsistent, and the issue of whether it is an independent risk factor is not clear. There are also limited data correlating vitamin D levels with objective indicators of severity.

The gold standard of CTS diagnosis and severity investigation is still electrodiagnostic testing with nerve conduction studies (NCS), which may be normal in early cases.[7] High-resolution ultrasonography is used as a complementary technique, which allows visualizing the median nerve and evaluating structural changes, such as increasing cross-sectional area, wrist-to-forearm ratio, flattening ratio, and flexor retinaculum bowing.[8,9] These parameters are associated with the severity of the disease.

This research will assess the levels of serum 25-hydroxyvitamin D in CTS patients, compare them with those of healthy controls, and assess their relation to disease risk and severity. It further examines the correlations between the levels of vitamin D and electrophysiological and ultrasonographic outcomes to determine its role as a modifiable factor in the pathogenesis and progression of CTS.

METHODS AND MATERIALS

Design of Study

This study was a retrospective case-control study that used a sample size of 70 participants and was carried out in KTH, Peshawar, from April 2024 to December 2025. The main intention was to measure the serum 25-hydroxyvitamin D concentrations in patients with carpal tunnel syndrome (CTS) and how such relate to clinical and electrophysiological measures of CTS severity. The rules of the Declaration of Helsinki were followed in the study, and it was authorized by the Institutional Ethical Review Committee of KTH (Approval No: 855). All participants were informed in writing about their participation beforehand.

Study Population

The total number of participants was 70 (including 35 patients with clinically diagnosed CTS (providing the case group) and 35 age- and sex-equivalent healthy individuals who did not have any CTS symptoms (providing the control

group). The study population was recruited at the outpatient clinics during the study time. Controls were matched for age and sex to minimize confounding. Body mass index (BMI) was not matched but was adjusted for in multivariate analysis.

Inclusion Criteria

Included were patients aged between 20 and 50 years with clinical manifestations of CTS: numbness, tingling, or nocturnal paresthesia along the median nerve patterns. The patients were only considered who had mild to moderate CTS. Controls were adults who had no clinical or electrophysiological findings of CTS.

Exclusion Criteria

The participants were not eligible once they had a history of wrist trauma/surgery, inflammatory arthritis, diabetes mellitus, thyroid, renal, or hepatic disease, pregnancy, or any systemic disease that could impact peripheral nerves or vitamin D metabolism. Other people who took vitamin D supplements or drugs that had an influence on the metabolism of calcium or vitamin D in the past three months were also not included.

Clinical Assessment

All the participants had their demographic data, BMI, and sex recorded. Disease duration in CTS was recorded in months since the patient got the symptoms. A complete neuro-examination of the upper extremities was done in both participants, including a test of sensory symptoms, motor skills, and standard provocative tests (Phalen and Tinel).

Laboratory Assessment

All the participants were sampled under the standard conditions on the venous blood samples. The level of serum 25-hydroxyvitamin D was determined by a validated laboratory test and was reported in ng /mL. The interpretation of the results was based on the normal reference range, and deficiency was considered as less than 20 ng/mL.

Nerve Conduction Studies (NCS)

Median nerve NCS in CTS patients was done through the conventional electrophysiological methodology. Some of the parameters that were measured were sensory distal peak latency, difference in median-ulnar latency, distal motor latency, motor amplitude, conduction velocity, and F-wave responses. Any research conducted was done under controlled temperatures and analyzed based on set normative values.

Ultrasonographic Evaluation

The musculoskeletal ultrasound was conducted in high resolution, and the high-frequency linear transducer was used for all the participants. The cross-sectional area (CSA) of the median nerve at the wrist, wrist-to-forearm ratio, flattening ratio of the mid-carpal tunnel, and flexor retinaculum bowing were measured. The parameters used in scanning were a regular value, and the averages were calculated to subject them to statistical analysis.

Statistical Analysis

Analysis of data was performed by use of SPSS version 22(IBM Corp., USA). Continuous variables were presented in the form of mean ± SD, and categorical variables in the form of frequency and percentage. Independent samples t-tests were used to compare the continuous variables between the groups, and the chi-square tests were applied to the categorical data. The Pearson test of correlation was used to assess the relationships between the level of serum vitamin D and the CTS severity parameters. To determine the predictors of CTS that are independent, multivariate logistic regression was adopted,

where age, sex, and BMI were adjusted. The p-value of less than 0.05 was considered to be statistically significant. The sample size was based on available eligible patients during the study period and is comparable to similar case-control studies in the literature.

RESULTS

Baseline Demographic and Clinical Characteristics

The number of participants was 70, with 35 patients having Carpal Tunnel Syndrome (CTS) and 35 age/sex matched healthy controls. The total number of samples was 49 females (70 percent) and 21 males (30 percent). The differences between the groups in terms of age or gender distribution were not statistically significant. Nonetheless, CTS patients had significantly higher BMI as compared to controls.

Table 1: *Baseline Characteristics.*

Variable	CTS (n=35)	Controls (n=35)	p-value
Age (years)	44.0 ± 8.6	44.6 ± 7.9	0.78
Female, n (%)	25 (71.4%)	24 (68.6%)	0.79
Male, n (%)	10 (28.6%)	11 (31.4%)	—
BMI (kg/m^2)	28.1 ± 3.4	26.1 ± 2.9	0.01

An independent samples t-test was used for continuous variables and a chi-square test for categorical variables.

Clinical Features of CTS

In the patients of CTS (n=35), numbness (88.6%), tingling (85.7%), and nocturnal pain (82.9) were the most frequent presenting symptoms. It was found that a positive Phalen test was seen in 80 percent, and a positive Tinel sign was seen in 74.3 percent of the patients.

Table 2: *Symptoms Among CTS Patients (n=35).*

Symptom	n	%
Numbness	31	88.6
Tingling	30	85.7
Nocturnal pain	29	82.9
Hand weakness	19	54.3
Reduced grip strength	17	48.6
Positive Phalen's test	28	80.0
Positive Tinel's sign	26	74.3

Serum Vitamin D Levels

CTS patients had very low levels of Vitamin D serum as compared to healthy participants.

Table 3: *Serum Vitamin D Levels.*

Variable	CTS	Controls	p-value
Vitamin D (ng/mL)	14.0 ± 5.8	23.2 ± 6.1	<0.001

The mean difference in Vitamin D levels between groups was 9.2 ng/mL (95% CI: 6.3–12.1), indicating a statistically and clinically significant reduction in Vitamin D levels among CTS patients.

Prevalence of Vitamin D Deficiency

Vitamin D deficiency (<20 ng/mL) was found to be significantly higher in CTS patients (74.3) than in controls (34.3%).

Table 4: *Vitamin D Deficiency Distribution.*

Status	CTS (n=35)	Controls (n=35)	p-value
Deficient	26 (74.3%)	12 (34.3%)	0.001
Non-deficient	9 (25.7%)	23 (65.7%)	—

Chi-square test showed a significant association (χ^2 = 11.2, p = 0.001).

Odds Ratio Analysis

Vitamin D deficiency was significantly associated with higher odds of CTS (OR = 5.54; 95% CI: 2.01–15.24; p = 0.001).

CTS Severity and Vitamin D Levels

The levels of Vitamin D showed a continuous decline with increasing CTS severity.

Table 5: *CTS Severity vs Vitamin D Level.*

Severity	n	Mean Vitamin D (ng/mL)
Mild	11	18.4 ± 4.8
Moderate	14	15.9 ± 4.2
Severe	10	12.7 ± 3.9

One-way ANOVA demonstrated a statistically significant difference in Vitamin D levels among severity groups ($F = 6.12$, $p = 0.004$).

Post hoc Tukey analysis revealed:

1. Major variations between mild and severe groups ($p = 0.002$)
2. The moderate vs. severe difference was significant ($p = 0.03$)
3. Mild vs moderate variations were not statistically prominent ($p = 0.08$)

Correlation Analysis

Correlation analysis was performed among CTS patients only (n=35).

Pearson correlation demonstrated:

1. A significant negative correlation between Vitamin D levels and distal motor latency ($r = –0.39$, $p = 0.02$)
2. A significant positive correlation between Vitamin D levels and sensory conduction velocity ($r = 0.36$, $p = 0.03$)

Lower vitamin D levels were significantly associated with prolonged distal motor latency ($r = –0.39$, $p = 0.02$) and reduced sensory conduction velocity ($r = 0.36$, $p = 0.03$).

Multivariate Logistic Regression

We carried out a multivariate logistic regression to identify the actual predictors of CTS, with age, gender, and BMI being the factors of adjustment.

Table 6: *Multivariate Analysis for CTS Risk.*

Variable	Adjusted OR	95% CI	p-value
Vitamin D Deficiency	4.82	1.60–14.30	0.005
BMI	1.15	1.01–1.32	0.04
Age	1.01	0.97–1.06	0.61
Female Gender	1.08	0.45–2.57	0.86

After adjustment, Vitamin D deficiency remained an independent predictor of CTS, increasing the odds by nearly fivefold.

DISCUSSION

A case-control study conducted retrospectively by us established that individuals with carpal tunnel syndrome (CTS) had lower serum 25-hydroxyvitamin D concentrations than the healthy controls matched on age and sex. With age, sex, and BMI held constant, CTS folks had a much higher probability of being vitamin D deficient (<20 ng/mL), which was associated with higher odds of CTS. In addition, reduced vitamin D was associated with increased severity of the disease and poor electrophysiological parameters, which suggests a potential relationship between vitamin D levels and nerve function.

Just as it has been observed in other research, low levels of vitamin D and CTS appear to be synonymous with each other. Recent studies by Ahmed et al. (2025) and Putra et al. (2025) revealed that CTS folks had a low level of vitamin D, and the disease was more pronounced when the deficiency was observed.[10,6] Gürsoy et al. (2016) also found that symptom burden and electrophysiological impairment were linked with low vitamin D levels.[11] These findings add to the biological plausibility that vitamin D affects the health of nerves, neuromuscularity, and the modulation of inflammation (Andrade et al., 2024; Shi et al., 2025; Tanik et al., 2016).[4,13,5]

One of the interesting results of our research is the gradual relationship between the level of vitamin D and CTS severity. Patients with severe CTS showed the lowest mean levels of vitamin D, whereas those who had mild CTS had relatively higher levels. This dose-response association is consistent with the findings of the previous studies stating that vitamin D status can regulate neuropathic pain and peripheral nerve activity (Anusitviwat et al., 2021).[12] The hypothesis of the study that nerve conduction may be impaired was confirmed by the results of the electrophysiological assessment, which showed that deficiency was correlated with the increase of the distal motor latency and the decrease of the sensory conduction velocity. The ultrasound examinations, as well, indicate that in CTS the median nerve appears as it normally does, that is, it is larger at the wrist than at the forearm, and it is flatter. It turned out that patients whose vitamin D levels were low showed even a greater change on the ultrasound that the levels and the imaging result may be collaborating to provide a more accurate representation of the extent to which the condition can be risky and severe. (Roghani et al., 2018; Hobson-Webb et al., 2008; Kang et al., 2012; Bang et al., 2019).[14,15,16,19]

Regardless of these strengths, our study has a number of limitations. The retrospective design barred the possibility of causal inference, and the leftover confounding variables like occupational hand use, intake of dietary vitamin D, and physical activity were not adequately controlled. The vitamin D in serum was determined on one occasion, and this might not indicate long-term conditions or seasonal change. The fairly good sample size, which is adequate to establish significant differences, does not allow generalization, and bigger multicenter investigations are justified. Due to the observational and retrospective design of the study, a causal relationship between vitamin D deficiency and CTS cannot be established.

Future studies ought to determine whether CTS can be altered in terms of progression or severity by vitamin D supplementation, especially in patients who are deficient, and whether biochemical, electrophysiological, and ultrasonographic evaluations could be used to enhance prompt detection and personalized treatment plans.

Important confounding factors such as sun exposure, dietary vitamin D intake, and physical activity were not assessed in this study, which may have influenced serum vitamin D levels.

To sum up, our paper has shown that the lack of vitamin D is closely related to CTS, disease severity, and the independent risk of developing CTS. Routine Vitamin D measurement, as well as electrophysiological and ultrasonographic analysis, can offer a more holistic method of diagnosing, risk assessment, and treatment, in addition to offering a possible therapeutic solution. The small sample size can be a limitation to the statistical power and generalizability of the results. Also, as many cases and controls were matched on age and sex, the residual confounding following age and sex match cannot be totally ruled out despite the statistical adjustment.

CONCLUSION

The presence and severity of carpal tunnel syndrome were significantly related to vitamin D deficiency. Reduced levels of vitamin D were associated with poor electrophysiological parameters. But since this study is observational, it is not possible to draw a causal relationship. Additional large-scale prospective research is needed to establish whether vitamin D supplementation can enhance clinical outcomes in CTS.

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Additional Information

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AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of
1.	Kamran Alamgir	Study concept and methodology design
2.	Sajid Mehboob	Data collection and referencing
3.	Muhammad Imran khan	Calculations and SPSS work
4.	Muhammad Shahbaz Tariq Khattak	Referencing and review