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Association between Bilateral Grip and Pinch Strength in Sub-clinical Carpal Tunnel Syndrome in Patients with Unilateral Carpal Tunnel Syndrome

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Abstract

Carpal Tunnel Syndrome (CTS) patients frequently report motor symptoms such as hand weakness and difficulty grasping small objects. Nevertheless, patients who only reported unilateral symptoms had bilateral neurophysiological impairment of the median nerve. The aim of the study was to assess bilateral grip and pinch strength on asymptomatic side along with to observe the occurrence of Subclinical CTS. 66 participants were included in the study who received nerve conduction study (NCS) lab referral after clinical diagnosis of CTS made by orthopedician/physician and it was confirmed by NCS. NCS was carried out with the help of RMS EMG Salus 2C. Participants of 18 to 80 years old, getting positive result of CTS during NCS on unilateral side were included. The grip and pinch strength was measured using Baseline Hydraulic Hand Dynamometer and Baseline Pinch Gauge respectively. The hand position was set according to the guidelines from "The American Society of Hand Therapists". The mean value reduction in grip strength (subclinical) when compared to normative data is 11.32 and also lateral, tripod and tip to tip pinch has shown to decrease in strength and; when subclinical side was compared to affected side 76.74% of participants had decreased grip strength with reduction in lateral, tripod and tip to tip strength. Fisher's exact test was applied for Statistical Analysis. Patients presenting with symptoms on unilateral side also exhibit reduction of strength over the subclinical side; which suggests that early rehabilitation should be commenced over the subclinical side to prevent further deterioration of the condition.

Keywords: Carpal Tunnel Syndrome, Grip Strength, Pinch Strength, Subclinical, Nerve Conduction Study.

Introduction

CTS remains one of most prevalent debilitating disorders seen in orthopedic and rheumatology clinics, despite being well documented in the medical literature (1). It is stated as tingling and burning pain, numbness in median nerve's distal distribution to the wrist, weakening in the thenar muscles, a decline in hand function and skills (2). CTS affect 3% to 5% of general population and 6% of women over 40 years (3). When a peripheral nerve travels across an anatomical compartment that has grown too taut, it becomes entrapped. The high pressure within the tunnel, damage to the median nerve's microcirculation, compression of the nerve's connective tissue, and the expansion of the synovial tissue are the interrelated mechanisms. Potential causes of carpal tunnel syndrome include hypertrophy of the flexor tendon's synovial tissue (1). Pain, paraesthesia, and weakness in hand, particularly in the first three fingers at night, are the signs of CTS. The arm and shoulder may both experience pain (4) and in severe cases, wasting of abductor pollicis muscle is also observed (5). There is also loss in grip strength and function of the affected hand. At night, the symptoms worsen, and throughout the day, clumsiness is reported when engaging in activities requiring wrist flexion (6). Damage to myelin sheath resulting from compression of nerve manifests as reduced conduction velocities and delayed latencies (7). Several causes have been documented for the reduction in hand strength (8). One of the factors contributing to strength loss could be the sensory disruption associated with CTS, which could impair one's capacity to precisely control force production (9). Despite the fact that most prevalent symptoms are sensory complaints in CTS, patients typically describe motor complaints, such weakness in their hands and difficulty grasping small objects (10). Grip strength has an effect on gender, age, body mass, and height, and also profession and leisure activities (11). According to research by Cesar

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Fernández-de-las-Peñas *et al.,* those who first appeared with exclusively unilateral CTS actually had bilateral fine motor control deficits (12). It is crucial to measure grip strength to assess hand function because grip strength may decrease due to pain and neuropathy. However, weakened grip power and/or palmar soreness are frequently a problem, causing a delayed return to work and recreational activities (13). CTS often presents bilaterally, meaning that symptoms in the unaffected hand emerge later. Patients with unilateral symptoms reported having them for approximately a year at time of initial visit, whereas those with bilateral complaints stated they had them for almost three years. Given that individuals in the latter group eventually experienced symptoms in their non-dominant hand, we presume that bilaterality could be dependent on time (14). According to neurophysiological evaluation, there were confirmed cases of bilateral CTS and they supported having mild median nerve compression in "Subclinical" hand in all of the cases (15). According to research, the prevalence of bilateral symptoms ranges between 60% and 87% (14). In a study found that around 50% of patients in the unilateral CTS groups had "subclinical CTS" in asymptomatic hands, as figured out by neurophysiological testing, which showed a deficiency in median nerve function (16). However, to the best of our knowledge, scarce literature is available focusing on the subclinical grip and pinch strength in unilateral CTS patients, so our purpose was to find association between bilateral grip and pinch strength in subclnical CTS in patients with unilateral CTS with the help of measuring grip and pinch strength; and if favourable correlation is found, then subsequent conservative management and early rehabilitation can be commenced in the treatment of Subclinical CTS.

Methodology

After receiving approval from the Institutional Ethics Committee, data collection for the cross-sectional study was collected after receiving informed consent from the patients. The study included enrollment of all individuals suffering with unilateral CTS who received an NCS lab referral to K.M. Patel Institute of Physiotherapy after clinical diagnosis of CTS made by orthopedician/physician. The study included 66 participants who were 18 to 80 years old, getting positive result of CTS on NCS over unilateral side; pain, tingling, numbness in median nerve distribution, presence of any of the following electrodiagnostic criteria (17): Distal median motor latency >4.4ms, Difference between distal motor latency of the median and ulnar nerves >1.1ms, Difference between distal sensory latency of the median and ulnar nerves >0.2ms, Difference between median and ulnar sensory latency on stimulating the fourth digit and recording from the wrist at equal distance >0.2ms, Difference between median and radial sensory latency on stimulating the thumb and recording from the wrist at equal distance >0.4ms, Palm-wrist Conduction: Difference between median and ulnar sensory latencies across 8cm >0.4ms, Inching Technique: Latency jump >0.2ms/cm. Sample size was calculated by assuming 10% of the participants strength would be affected with acceptable difference of 6% and 95% confidence interval; thus, 66 participants were recruited. Patients were excluded from the study if NCS result on the unilateral side was negative, if symptoms were bilateral, sensory or motor deficit in ulnar or radial nerve, if participant was a known case of other neurological conditions like poly-neuropathy, syringomyelia. NCS was conducted via using RMS EMG Salus 2C and EMG recorder (EMG RMS electron 201) and it was carried out by a skilled clinical therapist. Before conducting NCS, strict aseptic measures were taken and participants were described about mild discomfort during the procedure. Strength of the hand grip was evaluated with the help of Baseline Hydraulic Hand Dynamometer (18). (White Plains New York, USA). Its validity and reliability have been documented reported to 0.88-0.90. The weight reading on the baseline dynamometer was in kilograms (kg), with a 2 kg gradation and further it was converted into pounds. For all participants, the dynamometer handle was set to the second position. The American Society of Hand Therapists (18) provides guidelines for standard positioning. Participant was made to sit on chair with the back straight, shoulders adducted and neutrally rotated, elbows flexed to 90 degrees and the forearm in neutral position, also the wrists between 0 to 30 degrees of dorsiflexion and between 1 to 15 degrees of ulnar deviation (15). Participants were asked to squeeze the dynamometer handle as tightly as they can and then let go and the participants were not encouraged. With a minute of rest in between each task to prevent muscle fatigue,

three grip strength measurements for each dominant and non-dominant hand were taken. We calculated the average strength measurement over three consecutive trials (19). Strength of the pinch grip was determined using Baseline Pinch Gauge (White Plains New York, USA) (20). Excellent inter-rater reliability was shown by the Baseline hydraulic pinch meter (ICC = 0.98). The weight reading on the baseline pinch gauge was in pounds with gradation of 5 pounds. Standard positioning recommendations, calculations, and instructions are given by American Society of Hand Therapists. For assessment of lateral pinch; patient was in upright position with shoulder adducted and elbow flexed to 90 degrees and palm facing inwards. For assessment of tripod pinch; hand position was same except for the palm, which was faced downwards and for assessing the tip-to-tip strength; the position of the palm was downwards and the finger to be tested was placed on the button. The patients were asked to squeeze and then release. No encouragement was given. Three pinch strength measurements for each dominant and non-dominant hand were taken, with a minute of rest in between each task to prevent muscle fatigue. Over the course of three successive trials, we calculated the average strength measurement.

Statistical Analysis

Descriptive Statistics (Mean (SD), Frequency (%)) was used to depict the baseline profile of the study participants. Fisher's exact test was used to find association between two categorical variables. P-value <0.05 was considered statistically significant. Statistical software STATA 14.2 was used for data analysis.

Results

A total of 66 patients with unilateral symptoms were analyzed for grip and pinch strength of affected and subclinical side. Among 66 participants, 52 were females (78.79%) and 14 were males (21.21%). 63 were right-handed (95.45%) and 3 were left handed (4.55%). According to NCS severity, for subclinical side; 57 mild (86%), 8 moderate (12%) and 1 severe (2%). For affected side; 47 mild (71%), 13 moderate (20%) and 6 severe (9%). When comparing NCS severity according to handedness, for right hands; 50 mild (75%), 12 moderate (18%), 4 severe (6%). For left hands; 54 mild (82%), 9 moderate (14%), 3 severe (4%). Frequency of grip and pinch strength on the affected and subclinical side has been described in Figure 1. Figure 1 describes the number of participants affection in hand strength among the affected and subclinical side. Normal: Strength falls within normal range according to the norms of dynamometer and pinchometer. Abnormal: Strength falls less than the range according to the norms of dynamometer and pinchometer.

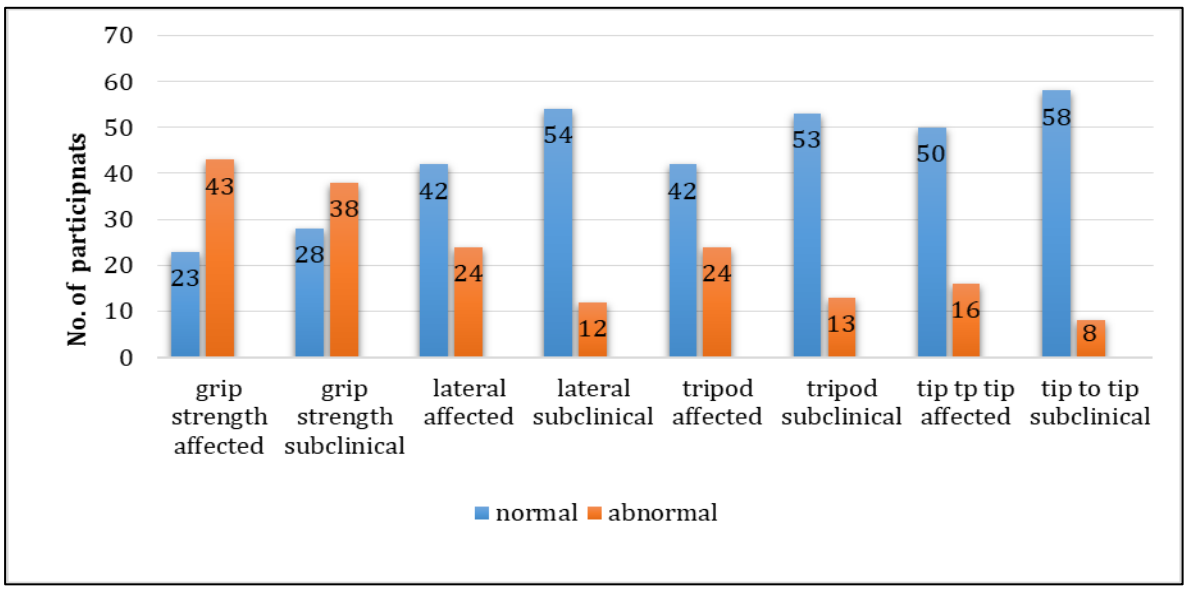

Figure 1: Frequency of Grip and Pinch Strength

Table 1: Frequency of Hands Having Reduced Grip and Pinch Strength on the Subclinical Side

Sr. No	Particular (Subclinical)		Frequency (n)	Percentage (%)
1	Grip Strength	Normal*	28	42.42
		Abnormal**	38	57.58
2	Lateral Pinch	Normal	54	81.82
		Abnormal	12	18.18
3	Tripod Pinch	Normal	53	80.3
		Abnormal	13	19.7
4	Tip to Tip	Normal	58	87.88
		Abnormal	8	12.12

*- Participants having age/gender matched normal value of hand strength.
**- Participants having age/gender matched decreased value of hand strength compared to normative data.

Table 2: Frequency, Mean with SD and Percentage of Grip and Pinch Strength of Subclinical Side

Sr. No	Variable (Abnormal Sub-clinical)	Frequency (n)	Mean and SD	Percentage (%)
1	Grip Strength	38	11.32 ± 8.62	17
2	Lateral Pinch	12	2.08 ± 1.86	13
3	Tripod Pinch	13	2.39±0.94	13
4	Tip to Tip	8	1.16±0.53	9

Subclinical Side"Side

Table 3: Association between the Grip and Pinch Strength with the Affected and Subclinical Side

Sr. No	Factors	Particulars	Subclinical Finding of Strength n (%)		p value
1	Grip Strength affected side	Normal n(23) Abnormal n (43)	Normal n(28) 18(78.26%) 10(23.26%)	Abnormal n(38) 5(21.74%) 33(76.74%)	0.001*
2	Lateral Pinch affected side	Normal n(42) Abnormal n (24)	Normal n(54) 40(95.24%) 14(58.33%)	Abnormal n(12) 2(4.76%) 10(41.67%)	0.000*
3	Tripod Pinch Affected side	Normal n(42) Abnormal n(24)	Normal n(53) 40(95.24%) 13(54.17%)	Abnormal n(13) 2(4.76%) 11(45.83%)	0.000*
4	Tip to Tip Pinch Affected side	Normal n(50) Abnormal n(16)	Normal n(58) 46(92%) 12(75%)	Abnormal n(8) 4(8%) 4(25%)	0.09

Table 4: Comparison of Grip and Pinch Strength with NCS Severity

Sr. No	Factors	Particulars	NCS severity			p value
1	Grip Strength affected side		**Mild n(47)**	**Moderate n (13)**	**Severe n(6)**	
		Normal n(23)	19(82.61%)	3(13.04%)	1(4.35%)	0.397
		Abnormal n(43)	28(65.12%)	10(23.26%)	5(11.63%)	
2	Grip Strength Subclinical side		**Mild n(57)**	**Moderate n (8)**	**Severe n(1)**	
		Normal n(28)	25(89.29%)	2(7.14%)	1(3.57%)	0.263
		Abnormal n(38)	32(84.21%)	6(15.79%)	0(0.0%)	
3	Lateral Pinch affect-ed side		**Mild n(47)**	**Moderate n (13)**	**Severe n(6)**	
		Normal n(42)	28(66.67%)	9(21.43%)	5(11.90%)	0.594
		Abnormal n(24)	19(79.17%)	4(16.67%)	1(4.17%)	
4	Lateral Pinch Sub-clinical side		**Mild n(57)**	**Moderate n (8)**	**Severe n(1)**	
		Normal n(54)	47(87.04%)	6(11.11%)	1(1.85%)	0.7
		Abnormal n(12)	10(83.33%)	2(16.67%)	0(0.0%)	
5	Tripod Pinch Af-fected side		**Mild n(47)**	**Moderate n (13)**	**Severe n(6)**	
		Normal n(42)	30(71.43%)	8(19.05%)	4(9.52%)	>0.99
		Abnormal n(24)	17(70.83%)	5(20.83%)	2(8.33%)	
6	Tripod Pinch Sub-clinical side		**Mild n(57)**	**Moderate n (8)**	**Severe n(1)**	
		Normal n(53)	46(86.79%)	6(11.32%)	1(1.89%)	0.7
		Abnormal n(13)	11(84.62%)	2(15.38%)	0(0.0%)	
7	Tip to Tip Pinch Af-fected side		**Mild n(47)**	**Moderate n (13)**	**Severe n(6)**	
		Normal n(50)	37(74%)	8(16%)	5(10%)	0.46
		Abnormal n(16)	10(62.50%)	5(31.25%)	1(6.25%)	
8	Tip to Tip Pinch Sub-clinical side		**Mild n(57)**	**Moderate n (8)**	**Severe n(1)**	
		Normal n(58)	50(86.21%)	7(12.07%)	1(1.72%)	>0.99
		Abnormal n(8)	7(87.50%)	1(12.05%)	0(0.0%)	

Table 5: Comparing NCS Severity with Handedness

Sr. No	Factors	Particulars	Handedness		p value
			Right n(63)	Left n(3)	
1	NCS Severity (Right)	Mild n(50)	47(74.60%)	3(100%)	>0.99
		Moderate n(12)	12(19.05%)	0(0.0%)	
		Severe n(4)	4(6.35%)	0(0.0%)	
2	NCS Severity (Left)	Mild n(54)	51(80.95%)	3(100%)	>0.99
		Moderate n(9)	9(14.29%)	0(0.0%)	
		Severe n(3)	3(4.76%)	0(0.0%)	

Table 1 describes the frequency and percentage of hands (abnormal) with reduced grip and pinch strength over the Subclinical side. Table 2 explains the number of hands with reduced grip strength over the Subclinical side when compared to the normal values of strength with mean of 11.32 for grip strength, 2.08 for lateral pinch, 2.39 for tripod pinch and 1.16 for tip-to-tip pinch and reduction in percentage of strength 17%, 13%, 13% and 9% for grip, lateral pinch, tripod pinch and tip to tip pinch respectively. Table 3 describes among 66 participants, 43 participants had decreased grip strength over the affected side and out of which 33(76.74%) participants had decreased grip strength over the Subclinical side. For Lateral Pinch Strength; among abnormal population in the affected side 41.67% were affected in the Subclinical Population. For Tripod Pinch, among 24 participants in the affected side, 45.83% were affected in the Subclinical Side. In the Tip-to-Tip Strength, among 16 participants in the affected side, 25% of participants were affected in the Subclinical Side. As described in Table 4, there is no association between NCS Severity and Affected and Subclinical strength. As described in Table 5, No association was found between the NCS severity of right side and left side with handedness with p value of both >0.99 respectively.

Discussion

This observational study intended to find the affection in the grip and pinch strength of the Subclinical side in unilateral CTS. Secondary aim was to look for the Subclinical occurrence of CTS in Unilateral CTS.

According to Table 1, we have observed the frequency of affected hands on the Subclinical side and in which among grip strength, more than 50% of the participants have decreased grip strength and also decrease in lateral pinch, tripod and tip to tip pinch of 18.18%, 19.7% and 12.12% respectively. The findings from the current study, Table 2; demonstrates that there was a decrease in the strength on the Subclinical side when compared to the norms of the dynamometer and pinch meter in which there is a mean decrease in grip strength is 11.32, lateral pinch is 2.08, tripod pinch 2.39 and tip to tip pinch 1.16. In addition, the grip and pinch strength on the Subclinical side decreases when compared to the affected side and it was related to a study carried out by a writer who demonstrated that when compared to healthy controls, patients with unilateral CTS show bilateral impairments in pinch grip force and motor control (12). Furthermore, our findings concur with those of the authors, who found that, in comparison to healthy participants, CTS sufferers had a reduced capacity to efficiently coordinate grip (12). According to Table 3, it has been demonstrated that the grip strength reduces on the Subclinical side when compared to the affected side (Figure 1). We have also obtained favorable outcome for the reduction of Lateral Pinch and Tripod Pinch strength in the subclinical population but no significant difference was observed in Tip to Tip Pinch Strength. This could be explained by an author's investigation (21), which found that when performing a precise pinch, the thumb applied a comparatively lesser normal force than the index finger. This was because of the result of built-in anatomical and neural 40 connections which predetermine the synergistic models for force coordination in the human digits and which lead to asymmetrical contribution in the pinch strength of thumb and index finger. The thumb applies forces with less accuracy, more variability, and less structural variability than the index fin-

ger. This data thus supports our investigation of the negative correlation for Tip-to-Tip strength between the affected and subclinical sides (21). Few mechanisms have been put out to address the reduction of strength on the Subclinical side which were quoted by few authors demonstrated the mechanism of Segmental Sensitization in which pain on one side causes sensitization of the contra-lateral segment and that can have an influence on pinch grip strength and fine motor skills (12, 22-24). Additionally, our research proves that CTS occurs bilaterally; that is, NCS shown to be positive even on the asymptomatic hand (Table 1) and this finding was corroborated by an author who reported that CTS is a bilateral symptom, and it usually presents bilaterally (23). Additionally, another author's investigation validated the existence of subclinical CTS in which participants with symptoms on unilateral side had positive electro diagnostic test on the Subclinical side. At the time of initial visit, patients with unilateral symptoms had their symptoms for about a year, whereas those with bilateral complaints stated that they had them for almost three years (6). Likewise, an author discovered that 38% of the patients in their series with unilateral complaints had bilateral neurophysiological dysfunction of the median nerve (24). In the current study, risk factors such as BMI, co-morbidity, Trauma, Pregnancy, duration of the commencement of symptoms, occupation was not considered. One author revealed that people with acromegaly had increased incidence of subclinical CTS (25). In an additional study, the author found that CTS is more prevalent in patients with diabetes mellitus and acromegaly group when compared to control group which is explained by metabolic and structural changes caused by the disease. But patients with diabetes were more vulnerable to develop CTS when compared to hypothyroid and acromegaly patients (4). As observed in Table 4, there is a negative association between the NCS severity and the strength of Affected and Subclinical side. The motor deficit in CTS was not associated with mild, moderate and severe NCS findings. The results of the present investigation can be corroborated by the authors' (26) discovery that bilateral deficits of grip and pinch strength force were not related to the electro diagnostic findings in CTS. In addition, bilateral deficit in control over fine motor skills has been reported in patients with lateral epicondylalgia which supports that patients having unilateral symptoms may present with bilateral motor deficits (26). As shown in Table 5, it demonstrates the relationship between the NCS severity with the handedness wherein we haven't found any noteworthy connections between them. Also, no such literature is available to those who have studied the connection between the NCS severity and handedness. But in a research project headed by an author demonstrated that distribution of hand dominance was different among patients with right- and left-hand CTS. Furthermore, right hand CTS was more frequent in younger and female population (27). The author's finding is similar to our study in which we discovered that women were more affected than males and left hand was less impacted as compared to the right hand and it is also supported by writers that women are more impacted and the right hands are more affected as compared to the left hands (2, 28). Our secondary purpose was to observe the Subclinical occurrence of CTS in patients with unilateral CTS in which; According to Table 2, For grip strength, among 28 participants with normal grip strength; 25(89.29%) mild NCS, 2 (7.14%) moderate NCS and 1 (3.57%) severe NCS. For lateral pinch strength, among 54 participants with normal strength; 47 (87.04%) were mild, 6(11.11%) moderate and 1 (1.85%) severe. For tripod pinch strength, among 53 normal participants; 46 (86.79%) had mild, 6 (11.32%) moderate and 1(1.89%) Severe. For tip-to-tip pinch strength, among 58 normal participants, 50 (86.21%) mild, 7 (12.07%) moderate and 1(1.72%) Severe. From the current study, we have found a significant reduction in grip and pinch strength on subclinical side when compared to the normal values of the dynamometer and pinchometer. Additionally, we have obtained significant reduction in Grip Strength, Lateral Pinch and Tripod Pinch over the Subclinical Side when compared to the Affected Side. Moreover, our study disclosed that when NCS was performed on the asymptomatic side, subclinical CTS was found to be positive for grip strength-78%, lateral pinch-40%, tripod pinch-95% and tip to tip pinch-92%; so we can conclude that there is subclinical occurrence of CTS in patients with unilateral CTS. Thus, the mean value reduction in grip strength when compared to normative data is 11.32 (17%) and also lateral (13%), tripod (13%) and tip to tip

pinch (9%) has shown to decrease in strength and; when subclinical side was compared to affected side, 76.74% of participants had decreased grip strength and also reduction in lateral, tripod and tip to tip strength. The information obtained from the results indicates that patients with a decrease in subclinical strength may benefit from physiotherapy rehabilitation, and that prompt intervention may enhance the patient's health and quality of life. It is necessary to do additional research to evaluate the degree of improvement in subclinical side strength over time as it will help the heath-care professionals to make informed, data driven decisions that optimize patient outcomes and by demonstrating the benefits of early rehabilitation, we can better advocate for timely physio therapeutic interventions in clinical practice.

Conclusion

This study's objective was to assess bilateral grip and pinch strength (key, tripod and tip to tip pinch) in Unilateral CTS and to find subclinical occurrence of CTS in patients with unilateral CTS. So, in conclusion, the subclinical grip and pinch strength has been shown to reduce when compared to normative values of dynamometer and pinchometer in patients with unilateral CTS. Moreover, there is reduction in grip and pinch strength when compared to affected side. Besides, our study observed that when NCS was performed on the asymptomatic side, subclinical CTS was found to be positive; so we can conclude that there is subclinical occurrence of CTS in patients with unilateral CTS. Thus, this study warrants early rehabilitation of subclinical CTS in form of various manual therapies such as median nerve mobilization, mechanical interface techniques, carpal bone mobilization, splinting and strength training (29, 30) of both the hands and emphasis should be given for the subclinical side as the risk for developing weakness increases when unilateral side gets involved.

Abbreviations

CTS: Carpal Tunnel Syndrome, NCS: Nerve Conduction Study.

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Authors Contributions

All the authors have equally contributed to this study.

Conflict of Interest

The authors do not have any potential conflicts of interest with respect to this manuscript.

Ethics Approval

The ethical approval was obtained from "Institutional Ethics Committee (IEC)" of HM Patel Centre for Medical care and Education, Karamsad for conducting the study. IEC approval no. IEC/ BU/ 143/ Faculty/ 19/81/2023 on 27/02/2023.

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