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Comparative Study between Volar and Dorsal Moulded Wrist Handsplinting on Grip Pinch Strength and Pain in Subject with Mild to Moderate Carpal Tunnel Syndrome: A Prospective Study

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ABSTRACT

Background: Carpal tunnel syndrome describes an upper extremity neuropathy of the median nerve, often attributable to increased pressure in the carpal tunnel resulting in compression of the median nerve. The prevalence rate of the CTS to be present in 3.8% of the general population.
Material & Methodology: 30 subjects with carpal tunnel syndrome were included in this study by Convenience sample method. The subjects were divided into two groups; Group A Volar wrist hand splint and Group B Dorsal hand splint. EMG was measured by Electronic hand disability evaluation machine and force was measured by hand held dynamometer and pinchometer. First baseline data was collected and during delivery of orthosis immediate data was collected to check immediate effect, and after 6 weeks post data was collected.
Results: There was statistically no-significant between the groups at baseline for all outcome parameters, APB & FL muscle, grip force, pinch force, P value was >0.05. There was statistically significant difference in the dorsal wrist hand splint groups for APB & FL muscle, grip force, pinch force which shows p<0.05, while compared with volar wrist hand splint.
Conclusion: Volar wrist hand splint and Dorsal wrist hand splint significantly effective in terms of improving the muscle strength of APB &FL, pinch strength and grip strength. Group B, dorsal wrist hand splint was more superior in all outcome parameter except APB muscle during pinch & Grip.

Keywords: Carpal tunnel syndrome, Surface EMG, Grip, Pinch, Abductor pollicis muscle, First lumbrical

INTRODUCTION

Carpal Tunnel Syndrome is an idiopathic neuropathy syndrome, [1] there are some risk factor like environmental, prolonged posture repetitive movement and medical factors. Major medical factors are (1) Extrinsic factors that increase the volume within the tunnel. (2) Intrinsic factors within the nerve that increases the volume within the tunnel. (3) Extrinsic factors that alter the contour of the tunnel and (4) Neuropathic factors etc all are effect the condition[2] with complains of symptoms such as pain, numbness tingling sensation and clumsiness in the hands.[3] Worldwide CTS population rate is 3.8%.[4] Indian incidence rate is 139 per 100,000 person-years for men and 506 per 100,000 person-years for women.[5]CTS have the radiating pain over to the forearm, elbow and shoulder which may lead to decreased grip strength and pinch strength resulting in loss of dexterity.[6] Current clinical assessment tools for CTS is electro diagnostic (EMG) and its helpful specifically when showing either clinical improvement or worsening.[7]

Among all of the non-operative treatment options orthotic splint clinically

significant option in mild to moderate CTS to kept wrist in neutral position for controlling pain.[8] Orthotic Splinting for CTS still remains the standard option it have more successful rate in case pre-operative option as compare to postoperative option to use of the splint during day as well as night.[9] Some time is only recommended night splint to allow daily activity of wrist kinematics[10].

orthotic splinting application acts to maintains the wrist in a neutral position and block other wrist motion that relief pressure on the median nerve as it passes through the carpal tunnel is amplified in positions of wrist flexion and extension (Gelberman 1984).[11] Wrist neutral splinting significantly successful in night time to restricted unwanted motion of wrist. (Manente et al 2001).[12] Neutral Wrist Volar and Dorsal Orthotic splint exactly not provide any pressure to the carpal tunnel rather to block any external pressure over the carpal tunnel.[13]

Last decade clinical evidence based effective report on orthotic Volar and Dorsal splinting in CTS on reducing pain and maintaining position has been worked out but many few was worked out on hand and wrist muscle profile, pinch and grip forces on CTS. Many few are compared the effects of dorsal and volar splinting effects on carpal tunnel syndrome. The different splint may have different effects on grip strength and EMGs of APB & FL. This study provide a quantified value for prescribing orthotic splint either volar or dorsal wrist hand splint in terms of EMG, pinch and grip.

METHODS

Clinical prospective study was conducted with the potentials population sample were selected from the department of Prosthetics and Orthotics, National Institute for locomotor disabilities, B.T. Road, BonHooghly, Kolkata. Subject reported to hospital for the orthotic assessment with symptoms of numbness, tingling sensation or pain for more than 3 weeks. 30 samples was selected with convenience sampling method and Prospective comparative pre-post quasi experimental study design. Inclusion criteria was Both male and female, Age range: 35-60[14], Unilateral carpal tunnel syndrome, Median nerve neuropathy diagnosed by Nerve conduction velocity[15], Tinel test and Phalen's test positive[16], Pain and numbness in the hand for at least 3 months[14]. Outcome measures instrumentations were used Electronic Hand Disability Evaluation Machine (e-HDAM), Pinchometer and Jammer hand dynamometer. Studied parameters are Surface Electromyography (EMG) of Abductor Pollicis Brevis (APB) & First lumbrical muscle, Pinch strength and Grip strength. Independent variable was Dorsal Wrist Hand splint and volar wrist hand splint.

This study was approved by institutional ethical committee. Subjects were recruited from N.I.L.D, West Bengal the subjects with carpal tunnel syndrome reporting to OPD were first screened through the inclusion and exclusion criteria. Those subjects full filling the criteria were included in the study. The study procedure was explained to them. If subject willing to participate then informed consent form was obtained from the individual prior to the study participation. Firstly, the participant was assessed and evaluated. The demographic data like age, gender was taken. After that the subject were divided into two group by convenience sampling (group A and group B), then first baseline data for EMG (APB& FL), grip and pinch strength data was taken.

Orthotic measurement and casting was taken for the fabrication of the volar and dorsal hand splint. Casting was taken in patient sitting position and elbow was flexed 90 degree and wrist kept in neutral position. Casting was important to make the exact replica of the hand. For preparing the Group A splint, at the time of casting cover the volar surface of palm, wrist and proximal 1/3rd of the fore arm. Positive mould modified at the time of modification, and by

using 3 mm polypropylene moulding was done .proximal trim line was 1/3 rd of the proximal forearm and distal trim line was proximal to the palmer crease so that the finger movement was not restricted and also allow the thumb movement. Trial was taken over patient.

Group B, for preparing the dorsal hand splint casting was done on dorsal surface of the hand .positive mould modified at the time of modification then moulding has been done. Trimming was distally 1/3rd proximal of the forearm and distally 1 cm proximal to the MCP joint. Thumb movement was not restricted and trial was taken over the patient hand. Subject were advised to wear the splint only night time. Some care and maintenance of splint was advised. Orthotic adaptation period was 5 minutes one an average.

After preparing the volar and dorsal hand splint pre data was taken. At the time of delivery told the patient to come after 6 week for follow up, that day we have taken the post data. Then data was analysed to see the effect of hand splint in both group and also compare the data to check which splint was more effective in terms of EMG (APB& FL), Grip strength and Pinch strength.

Grip strength was measured by using hand held dynamometer. Participants were made to be sitting in a straight backed chair. Feet should be flat to the floor. Shoulder adducted and neutrally rotated, Elbow flexed at 90 degrees. Forearm in neutral, Wrist 0-30 degrees dorsiflexion and 0-15 degrees ulnar deviated. Dynamometer was set in position 2 and data were collected under supervision of therapist. Three trials were taken and average of three trials was recorded. 30 seconds rest period was given in between each trial. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected.

Pinch strength was measured by pinchometer. Tip to tip pinch strength was measured. Participants were made to be sitting in a straight backed chair. Feet should be flat to the floor. Shoulder adducted and neutrally rotated, Elbow flexed at 90 degrees. Forearm in neutral, Wrist 0-30 degrees dorsiflexion and 0-15 degrees ulnar deviated. Pinchometer was set in position and data were collected under supervision of therapist .MCP and PIP joint of index finger was flexed. Pinchometer device held by injured hand. All the information and demographic data stored before the measurement in computer. Three repetitions were selected for each measurement. The average data was shown in the computer screen was recorded. The average strength of pinch recorded in kilograms. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected

EMG data was taken for 10 seconds. EMG data was taken from Electronic Hand Disability Evaluation Machine .The device Length: 11.35 cm, Width: 6.2 cm, Height: 18.5 cm. This device was reliable because interclass correlation coefficient (0.84). Patient sit to straight back chair with shoulder in mid sagittal plane zero position and the elbow flexed 90 degree with the for arm and wrist in neutral position. For taking the data of APB muscle signal during grip and pinch. Placed the surface electrode on specific landmark. Positive electrode placed on affected side and ground electrode placed on non affected side, told the patient to hold the grip machine for 5 sec. Data was recorded in computer. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected. For taking the data of APB muscle during pinch hold the pinch machine for 5 sec and data was recorded in computer. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected. For taking the data of FL muscle signal during grip and pinch. Placed the surface electrode on specific landmark. Positive electrode placed on affected side and ground electrode placed on non affected side, told the patient

to hold the grip machine for 5 sec. Data was recorded in computer. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected. For taking the data of APB muscle during pinch hold the pinch machine for 5 sec and data was recorded in computer. First data was collected without splint, then at the time of delivery pre data was collected and after 6 week later post data was collected. Electronic Hand Disability Evaluation, dynamometer and pinchometer this instruments were validate with pilot study and original research work in this study set up with the affiliation with The West Bengal University of Health Sciences, Kolkata.

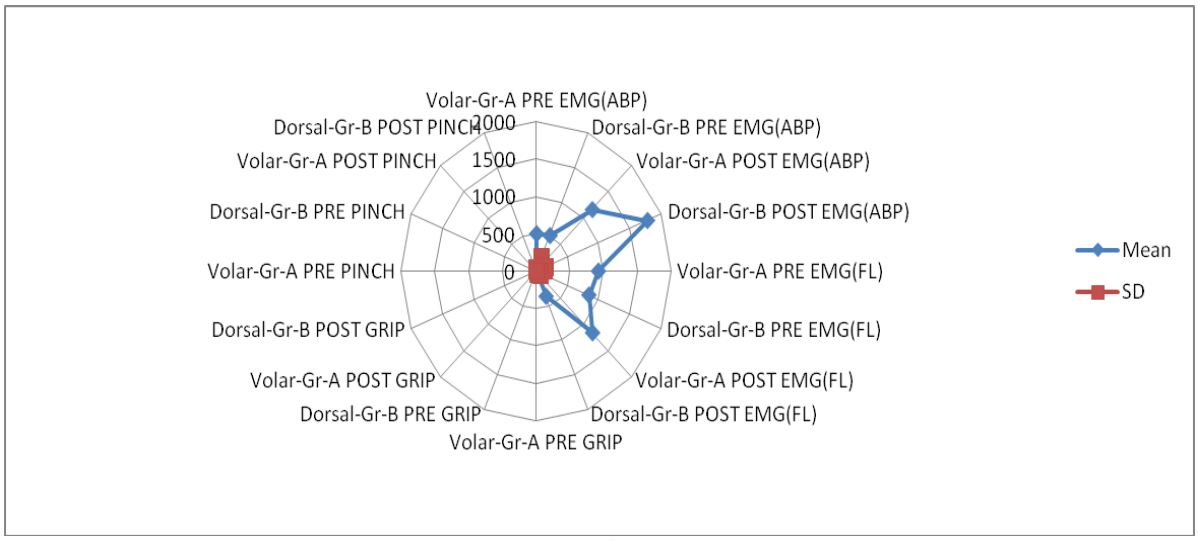
Data Analysis

The study was conducted between March 2018 to February 2019. The data were recorded in the data collection form as shown in the master chart and tabulated for statistical analysis. Raw data were exported from dynamometer and pinchometer into Microsoft Excel, and final data analysis was performed in SPSS version 23.0(SPSS Inc, Chicago, Illinios). The data were explored using appropriate descriptive and graphics techniques. Each data set was examined for a normal distribution prior to conducting any inferential analysis. Independent t test was used to analyze the difference between volar and dorsal hand splint group. The tests were applied at 95% confidence interval on α value set at 0.05. The results were taken to be significant of p-value <0.05.

RESULT

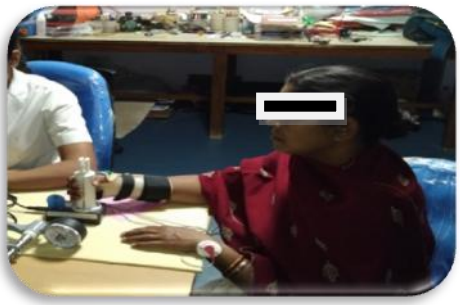
Table:- Mean Value and Significances parameters of Volar and Dorsal splints.

Group	Condition	Parameters	Mean	SD	T-Value	Significance
Volar-Gr-A	PRE	EMG(ABP)	501.3333	41.38092	-.689	0.139
Dorsal-Gr-B			516.0000	203.184		
Volar-Gr-A	POST		1166.67	93.018	-13.599	0.026
Dorsal-Gr-B			1775.33	146.281		
Volar-Gr-A	PRE	EMG(FL)	914.60	114.63	2.222	0.233
Dorsal-Gr-B			836.66	73.06		
Volar-Gr-A	POST		1170.00	77.644	36.025	0.008
Dorsal-Gr-B			365.33	38.148		
Volar-Gr-A	PRE	GRIP	2.220	0.1289	2.251	0.152
Dorsal-Gr-B			2.058	0.2480		
Volar-Gr-A	POST		2.2381	0.0691	-23.291	0.001
Dorsal-Gr-B			4.5588	0.3796		
Volar-Gr-A	PRE	PINCH	2.9113	0.772	.828	0.136
Dorsal-Gr-B			2.2981	0.998		
Volar-Gr-A	POST		1.7613	0.0960	-18.35	0.016
Dorsal-Gr-B			2.7161	0.1771		



Graph: 1 Comparative graph for Volar and Dorsal splints.

Picture:-1 Data was taken without splint.



Picture:-2 Data was taken with splint.

DISCUSSION

The aim of the study was to compare the effectiveness of volar and dorsal wrist hand splinting approaches in terms of muscle activation , pinch strength and grip strength in case of carpal tunnel syndrome. Objectives were to determine the effect of volar wrist hand splinting on Abductor Pollicis Brevis and First lumbrical muscle activation, pinch strength and grip strength, determine the effect of dorsal wrist hand splinting on Abductor Pollicis Brevis and First lumbrical muscle activation, pinch strength and grip strength. And lastly compare the effect of muscle activation (Abductor pollicis brevis and first lumbrical), pinch strength and grip strength while using volar and dorsal wrist hand splinting.

As a result of median nerve compression, most of the hand muscle that are supplied by median nerve become effected i.e. abductor pollicis muscle, lumbrical muscle and Dorsal interossei .[14] As results EMG signal of theses muscle become hampered which directly affects the motor function of the hand as demonstrated by weakness of grip and pinch strength.[15]

This study shows there is a non significant difference between the groups on baseline data of EMG signal of APB muscle during gripping activity *(p = 0.139, t=-0.689).* There were also significant difference found between the groups after using the both types of splint for 6 weeks ($p<0.05$, t=-13.599) and mean of APB muscle signal was more on Group B compared to Group A. The cause of this finding may be patients use dorsal splints more than volar splints. This present study is in consistent with findings of the Zinnuroglu et al, [17] which mentioned that Dorsal splint can be used as alternative to volar wrist orthosis and in that study it was found that Patients in the dorsal orthosis group used the orthosis 89.6% of the prescribed time, whereas those in the volar-supporting orthosis group used the orthosis 79.2% of the prescribed time ($P < 0.05$). More usages of splinting were the cause of these findings. No significant differences were present between two groups on baseline data of EMG signal of FL muscle during grip ($p = 0.233$, t=2.222). This shows that condition was same for both groups. Another finding of the study after the use of both hand splints for 6 weeks suggested that significant difference present on EMG signal of FL between both groups ($p<0.05$, t=36.02). The findings of the study are in agreements with the findings of the Marc A. Maier et al, [18] where it suggests that EMG of Lumbrical muscles have significantly greater role to play in the intricate movements of the fingers. It is quite unique in its position as it connects the flexors of the digits to the extensors and that both of its attachments are mobile and it provide high correlation during grip. In current study, FL muscle shows more activity during use of dorsal hand splint compared to volar hand splint. Activity of first lumbricals muscle increased parallelly with the grip force. As in dorsal hand splint subject can apply more grip force, activity of lumbricals also increased. Other similar findings by Jennifer Di Domizio et al, [19] showed that use of a splint significantly

increased hand muscle activity. From the result of the grip force comparison between two group shows no significant difference present between the baseline data of two groups ($p = 0.152$, $t=2.251$). Significant difference found between the groups after using the both types of splint for 6 weeks ($p<0.05$, $t=-23.291$). And mean of grip force is more on Group A compared to Group B. The study is in accordance with the findings of Ulla Nordenskiold et al. suggested use of wrist orthosis increase the grip force. The study in consistent with findings of the Harris Gellman[20] which mentioned that Volar splint can be used as alternative to Dorsal wrist orthosis and in that study it was found that Patients in the dorsal orthosis was more superior than the volar group in terms of grip force.

The mean difference of the pinch force comparison between the two groups. The mean difference of the Group A and Group B was found with ($p =0.136$, $t=0.828$) so this finding defined no significant difference in both groups. There is significant difference found between the groups after using the both types of splint for 6 weeks ($p<0.05$, $t=-18.35$) and mean of pinch force is more on Group A compared to Group B. Similar finding has been found by Harris Gellman et al.[20] his study shows the Dorsal wrist hand splint was more effective during pinch.CTS splint immobilized the wrist joint motion and maintain the wrist in neutral position with minimum EMG contraction of APB & FL muscle during activity. Jennifer Di Domizioet al.[19] said that the Wrist splints were commonly prescribed to limit wrist motion and provide support at night and during inactive periods. Splinting the wrist should reduce wrist extensor muscle activity by stabilizing the joint and reducing the need for co-contraction to maintain posture.

The current study quantified hand muscle activity with and without splinting while gripping and pinching. The present study showed statistically improvement in pinch, grip strength and EMG activity of APB & FL Muscle. But EMG of APB muscle during grip and pinch using volar hand splint was better than dorsal hand splint. The improvement of pinch, maximum voluntary grip strength to be clinically significant in both the groups; but marked improvement was noticed in patients with volar wrist hand splint as compared to the dorsal wrist hand splint. In this prospective study the wrist hand splint was advantageous for patients with Carpal tunnel syndrome because the splint would offer additional protection for the tunnel by preventing passive stretching of the tunnel and reducing muscle activity during activities of daily living. The current evident prospective results supported the experimental hypothesis in a way that significant improvement was seen in EMG profile, Grip & Pinch with silently reducing the pain and increasing the ADL activity and suggests to extend these services to Whole population.

CONCLUSION

We assessed the optimal approach to rest the wrist applying such modalities as the use of volar wrist hand splint and dorsal wrist hand splint in the target population-namely, patients with carpal tunnel syndrome.

On the basis of the current prospect findings of this study, it concluded that volar wrist hand splint was more effective in muscle signal of ABP & FL during pinch but dorsal wrist hand was more superior in muscle activation of ABP & FL during grip. Dorsal wrist hand was also effective in terms of force. Therefore the dorsal wrist splint could be recommended in rehabilitation settings for the CTS patients. These findings have implications for the standards of care and orthotic clinical use in rehabilitation program.

Limitation of this study is relatively small sample size; Sample was taken from only one hospital, Follow up of short duration. Future recommendation is Future double blinded studies may be conducted with more number of subjects. A long

follow up may be included to find out long efficacy.

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