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Natural Language Processing in Biomedical Literature for Analysing the Effects of Neurodynamic in Pain and Disability in Carpal Tunnel Syndrome

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***Abstract*-**Carpal tunnel syndrome (CTS) a most common peripheral neuropathy characterised by numbness, tingling in the sensory distribution area of the of the median nerve, particularly in the thumb , index finger ,middle finger and radial side of ring finger along with motor weakness, distal to wrist that results into decreased hand grip strength and hand function disability. CTS puts an economy burden on healthcare services as its incidence and prevalence are increasing day by day although a slight decline in numbers has been seen over a period time. Fuzzy logic retains expert information in an intelligent system that may be effectively utilized by others, simulating the cognitive decision-making abilities of the specialist, and helping junior doctors with less expertise make better diagnoses. Therefore, the use of such an expert system is advised to speed up and enhance the accuracy of the diagnosis in patients with suspected CTS by studying different literatures. To device, evidence based therapeutic protocol from biomedical literature for the treatment of pain and disability in CTS. To analyse the effect of openers, sliders, and tensioners on NPRS and disability in carpal tunnel syndrome, using biomedical literature. Therefore, we draw the very encouraging conclusion that further research on the application of such a fuzzy expert system for medical opinion prediction and diagnosis is warranted.

***Keywords*:** CTS, Fuzzy logic, Literature, neurodynamic

1. INTRODUCTION

"Carpal tunnel syndrome (CTS)" a most common peripheral neuropathy. The entrapment of median nerve beneath fibro-osseous band, flexor retinaculum shows prevalence of around 2.7% and 7.8% in general population and among employees who does repetitive hand activities intensively. The most common age group affected by this common neuropathy is 40 to 60 years with female (9.2%) having more prevalence than males (6%). Around 3.8% of people who complaints of ache, feeling of itchiness and unresponsiveness in their hands are having CTS [1].

A frequent upper limb nerve entrapment syndrome that significantly impairs an individual's social and economic well-being is CTS. The primary characteristic is a decrease in the volume within the carpal tunnel, which disrupts the spatial relationship among its components and results in symptoms that are farther away from the location of the lesion. The purpose of this study is to outline current research findings regarding the management of CTS and suggest future directions for clinical studies. The common medical risk factors for CTS are intrinsic, extrinsic, and neuropathic factors consisting of diabetes, pregnancy, lipoma, menopause, obesity, posttraumatic arthritis, hypothyroidism, alcoholism, vitamin deficiency or toxicity. Among these conditions, the CTS occurs around 14%, 30% and 2% in normal, diabetic patients and pregnancy respectively [2]. CTS is diagnosed clinically with characteristic symptoms, physical examinations, and electro diagnostic studies (NCV and EMG) which reveals the severity of the syndrome. CTS puts an economy burden on healthcare services as its incidence and prevalence are increasing day by day although a slight decline in numbers has been seen over a period time. However, an effective treatment protocol must be designed to treat pain and disability in carpal tunnel syndrome patients [3].

Treatment approaches for CTS involves various surgical and conservative management. Conservative management being preferred in mild to moderate CTS but rarely its efficacy has been seen in severe CTS patients. Conservative treatment lists several treatments including splinting, pharmacotherapy, hand therapy (nerve and tendon gliding exercises), Ultrasound therapy, acupuncture. However, Neurodynamic has been recently added to the treatment of CTS. It helps in diagnoses, planning and treatment of various dysfunctions of the body.11Various studies has revealed that there is lack of evidence regarding the effectiveness of Neurodynamic on CTS therefore it is a need

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of an hour to perform high quality studies including randomized control trial, blinding, and control groups.

On the other hand, a Cochrane review (2012) revealed that there is inconclusive findings and low level evidence for the treatment of CTS comprising soft tissue mobilisation, tendon gliding, and carpal bone mobilisation. Hence, a definitive protocol based on neurodynamic, and exercise therapy must be identified regarding CTS with the use of reliable parameters and scales, to decrease the pain and disability in patients [4].

For mild to severe CTS, one to two months of medication is appropriate. Severe CTS may require referral for surgical examination if clinical symptoms worsen or persist despite conservative therapy and markedly abnormal electrodiagnostic testing. It is crucial to diagnose CTS as soon as possible since it might result in irreversible nerve damage and lower the likelihood of a good surgical outcome [5]. Since chronic CTS lowers the likelihood of a favourable surgical outcome and might result in irreversible nerve damage, it is imperative to diagnose the condition as soon as possible. About 90% of patients who have had CTS surgically corrected have had their symptoms resolved, and most of these patients have very little residual nerve damage [6].

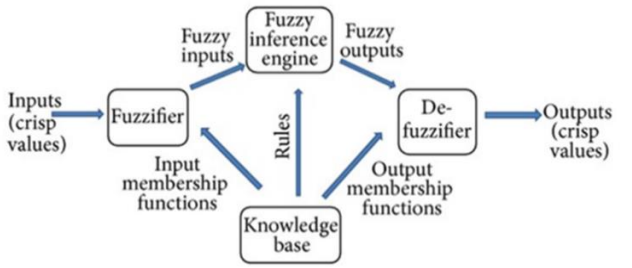

Figure 1: Shows the basic fuzzy expert system outline [7].

An expert system is computer software that uses computational decision techniques and explicitly shown domain knowledge to assist in addressing problems requiring significant human expertise. They aim to mimic the thought processes and rational choices of experts, so attempting to impart some of the expertise of an expert to non-experts. The fuzzy reasoning theory is applied by the FES. The act of creating a fuzzy logic mapping from a given input to an output that provides a foundation for decision-making, or pattern recognition is known as fuzzy inference. When opposed to fuzzy logic, where we must consider both propositions and their truth values, classical logic simplifies the inference process. Figureure 1 illustrates a basic structure that may be used to generalize the FES that was created and used in this work.

Our goal was to create a fuzzy logic controller-based FES that could identify the stage of CTS based on clinical symptoms and NCS data, assisting the physician in making an early treatment decision. Both the rule base definition and user inputs might be imprecise using this strategy. Fuzzy logic retains expert information in an intelligent system that may be effectively utilized by others, simulating the cognitive decision-making abilities of the specialist, and helping junior doctors with less expertise make better diagnoses. It may also be extremely helpful in places where the services of such professionals may not be available.

2. LITERATURE REVIEW

- Milad Zarrin, Noureddin Nakhostin Ansari et al, An investigation of the potential benefits of cervical manual therapy in addition to conventional physical therapy for individuals with carpal tunnel syndrome in terms of therapeutic results and electrodiagnostic findings (2023). A traditional physical therapy regimen included cervical manual therapy, which included manual cervical disorientation, lateral glide mobilization, alongside postero-anterior tension to the mid-cervical spine, as well as wrist splints, TENS applied to the wrist region for 20 minutes, and wrist joint mobilization. In a group of individuals with CTS, this study showed the substantial huge benefits of cervical manual treatment in addition to convectional physiotherapy [9].
- Alberto Tomás-Escolar, Javier Merino-Andrés et al, A systematic review and meta-analysis were conducted in 2023 to determine the short-term efficacy of kinesio taping as a therapeutic technique in the conservative management of carpal tunnel syndrome. The meta-analysis, which comprised thirteen studies, demonstrated a moderate degree of certainty regarding the significant impact of kinesiotaping upon distal sensory latency alongside an insignificant impact on functionality and pain. However, no discernible superior effects were observed on the severity, durability, or neurophysiological outcome in the short term when compared to other rehabilitation technique or the control group that did not receive treatment [10].
- Sidrah Shabbir, Ayesha Rasheed et al, “Comparing Effectiveness of Median Nerve Mobilization with and without Transverse Carpal Ligament Stretching in Patients with Carpal Tunnel Syndrome (2022)”. This study is a randomized control trial which included 34 participants, randomly assigned to two groups. Both the groups received 2 weeks of intervention group A received neurodynamic and group B received a combination therapy of neurodynamic and transverse carpal ligament stretching, and it was concluded that group B intervention was superior to Group A

intervention in improving pain and functional Strength [11].

- Sandra Jiménez-del-Barrio, Luis Ceballos-Laita et al, A Randomized Controlled Trial (2022) found that the use of Diacutaneous Fibrolysis Intervention for individuals with mild moderate to moderate Carpal Tunnel Syndrome may prevent severe cases in the elderly. In this study, it was found that five 20-minute treatment sessions, held twice a week, improved the cross-sectional region of the median nerve, the thickness of the cross-sectional carpal ligament, the frequency and severity of symptoms in patients with CTS, and the rate at which the disease progressed less in older subjects alongside mild to moderate CTS [12].
- S.A. Raeissadat, V. Dinarvand et al, "Carpal tunnel syndrome treatment: The effect of scaphoid and hamate mobilization" (2022). In this study patients were randomized in two groups which received hamate and scaphoid mobilization and splinting respectively, and it was concluded that both the groups were effective in improving pain and symptom severity, functional status and median nerve conduction study [13].
- Sergio Núñez de Arenas-Arroyo, Iván Cavero-Redondo et al, "A systematic review and meta-analysis of the immediate consequences of neurodynamic methods in the treatment of carpal tunnel syndrome" (2021). The comprehensive evaluation covered a total of 22 studies, and the results indicated that while the neurodynamics approach was helpful in helping persons with CTS manage their pain and function, the evidence supporting this claim was extremely weak. In order to get high confidence evidence concerning neurodynamics, further study has to be done [14].
- Hayat Hamzeh, Mohammad Madi et al, A systematic parallel-group clinical study examined (2020). In this study, home exercises based on the guidelines of the Chartered Society of Physiotherapy and Arthritis United Kingdom were given to the control group, while the treatment group got manual therapy and activities based on neurodynamics. The outcome variables taken in the study were, BCTSQ quick DASH, NPRS, Wrist ROM, handgrip strength and surgery that were in the favour of both the groups but more significantly for neurodynamics group. Neurodynamics proved to improve all outcome variables so it is interesting to see how the static openers along with the sliders and tensioners improve the outcome variables such as BCTSQ, NPRS and Elbow Range of motion after 5 days and at 2 weeks follow up[15].
- Zhiyuan Bian, Jie Yu et al. CTS (2021): A technique for a systematic review along with "Bayesian network meta-analysis" using acupuncture and associated treatments. The results of this study offer trustworthy and useful recommendations for acupuncture professionals in clinical decision-making. In this systematic review, acupuncture therapy along with associated therapies were contrasted with other cautious methods, placebo, sham acupuncture, or numerous combinations of acupuncture therapies [16].
- Ghadam Ali Talebi, Payam Saadat et al, A randomized clinical study compared two manual treatment modalities for individuals with carpal tunnel syndrome (2020). This study contrasted nerve mobilization with mechanical interface mobilization. Both groups got TENS and ultrasound treatment at the start of each session. After receiving therapy for fifteen minutes, the Neurodynamics group came to the conclusion that neither group was better than the other for minimizing pain, enhancing hand symptoms, and restoring functional status. However, use of electrotherapy modalities may mask the effect of both intervention individually; further researches can be conducted to rule out the effects of above-mentioned interventions individually[17].
- Josiah D. Sault, Dhinu J. Jayaseelan et al, "Utilization of Joint Mobilization as Part of a Comprehensive Program to Manage Carpal Tunnel Syndrome: A Systematic Review" (2020). This systemic review included 10 articles where joint mobilization was used positive effects in pain additional outcome measure were noted. In these articles, it was observed that integration of joint mobilisation performed better than the comparison group not receiving joint techniques reviewing that joint mobilisation appeared to be useful in the management of CTS, however joint mobilisation was never used to isolation so the result must be interpreted cautiously [18].
- According to research by Przemysław T. Wielemborek et al., the most prevalent compression neuropathy is CTS, which has a major psychological, social, and financial cost. This study reviews the literature on our current understanding of the physiology and pathophysiology of peripheral nerves during CTS, with an emphasis on treatment methods currently in use and the justifications behind them. Of the 229 papers found through the search in the PubMed and Google Scholar databases, 71 satisfied the research requirements. The evidence supporting the conventional techniques used in conservative CTS therapy is provided. Women are more likely than males to be affected with CTS, which is a somewhat prevalent disorder. The condition is complex and primarily manifests as symptoms that are distant from the entrapment site, such as pain, tingling,

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numbness, and weakening. When diagnosing CTS, electrodiagnostic investigations are regarded as the gold standard. Researchers conclude that conservative CTS therapy is extremely safe based on the present body of evidence, however the effectiveness of examined techniques varies. The first encouraging findings from a number of studies support the necessity for more investigation into cutting-edge therapeutic approaches [19].

- CTS is a common medical disorder that arises from compression of the hand's median nerve, generally due to age-related causes or misuse. Marwa Elseddik et al. A total of 160 patients took part in this study, 80 of whom had CTS and presented at varied degrees of severity depending on their age. Next, SHAP is employed to offer a comprehensible justification for the ultimate forecast. Overall, our study offers a thorough method for the diagnosis, prediction, and monitoring of CTS. It also shows encouraging outcomes for the diagnosis of CTS in terms of accuracy, precisions, and recalls, as well as successful disease progression prediction and statistical analysis-based treatment efficacy assessment [20].
- According to Haiying Zhou et al., CTS is a prevalent peripheral nerve disorder that negatively impacts a patient's everyday activities and employment. It can induce discomfort, numbness, and even muscle atrophy. The outcomes of the experiments showed that the suggested deep learning framework outperforms existing segmentation networks when it comes to tiny item performance. Our results show significant potential for the clinical use of our algorithm [21].
- Amit Shrivastava and Nikita Gautam carried out research. The pertinent medical literature on CTS symptoms, pathogenesis, and different clinical diagnostic and treatment approaches is included in this page. A comparison of the benefits and drawbacks of many diagnostic techniques is provided. Lastly, it shows that conservatives contrast different surgical techniques. Compared to the conservative steroid injection and splinting treatments, the surgical approach has been demonstrated to be more beneficial. Numerous research supports the benefits and drawbacks of surgery as well as its problems. This page provides a thorough summary of all the medical elements of CTS to keep medical professionals informed and to increase knowledge of this illness.[22].
- The goal of Ting-Yu Lin et al.'s review was to compile the data pertaining to the use of ultrasound imaging to diagnose CTS from systematic reviews and meta-analyses. The criteria for performing an umbrella review were followed throughout the critical appraisal, data extraction, and synthesis processes. In the general population, the best diagnostic performance was obtained with a cutoff CSA value of 9–10.5 mm2. The severity of CTS was linked with the extent of CSA enlargement. Given that these individuals had increased wrist vascularity and median nerve stiffness, sonoelastography and Doppler ultrasonography may offer more information for the assessment of CTS. The most robust metric in sonography is the inlet CSA, which makes it a dependable tool for diagnosing CTS. Doppler ultrasonography and sonoelastography can be used as supplementary methods to validate CTS diagnosis. Expanding the use of sonography to diagnose CTS requires more research, particularly when coexisting neuromuscular disease(s) is present [23].

3. METHODOLOGY

Need of study

To device, evidence based therapeutic protocol from biomedical literature for the treatment of pain and disability in CTS.

Aim of study

To analyze the effect of openers, sliders, and tensioners on NPRS and disability in carpal tunnel syndrome, using biomedical literature.

4. RESEARCH HYPOTHESIS

Experimental Hypothesis

- **E1**: Neurodynamics group may show significant improvement on NPRS and disability in carpal tunnel syndrome than control group.
- **E2**: Control group may show significant improvement on NPRS and disability in carpal tunnel syndrome than control group.
- **E3**: Both groups may show similar improvement on NPRS and disability in carpal tunnel syndrome than control group.

Null Hypothesis

- **N1**: Neurodynamics group may not show any significant improvement on NPRS and disability in carpal tunnel syndrome than control group.
- **N2**: Control group may not show any significant improvement on NPRS and disability in carpal tunnel syndrome than Experiment group.

Study Setting

Physiotherapy OPD, Himalayan Hospital, Swami Rama Himalayan University Jolly grant, Dehradun

- **Sample size**: 30
- **Study Sampling**: Random Sampling Technique
- **Study Duration**: 6 Months

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- **Study Design:** Experimental Study
- **Study Population**: CTS Patient's Coming to the Physiotherapy OPD

Selection Criteria Inclusion Criteria:2
Consent from the Patient Age Above 18
Positive Carpal Compression Test Presence of Flick's Sign
Positive ULTT
Nerve Conduction Study <50 M/S and Increased Motor Latency >4m/S

Exclusion Criteria:38
Lack of consent or cooperation
Previous surgery or trauma to upper limb. Muscular atrophy to thenar muscles. Metabolic disorders such as diabetes, pregnancy and severe thyroid disorders. Previous steroid injections in carpal tunnel.
Instrumentation*:* Universal Goniometer Stopwatch, Micro pore.

PROCEDURE
The subjects the detailed explanation of the purpose of the study before being screened.
Based on the inclusion and exclusion criterias the subject are included in the study and divided into two groups:
1.Experimental group (Neurodynamics + general exercises)
2.Control group (General exercises)
Patient's demographic and contact details were obtained. BCTSQ, NPRS, Elbow ROM in ULTT position was taken in both groups for pretest evaluation. Total 30 minutes of intervention given to both the groups.

Experimental group
The intervention was given to the patients in upright sitting position. Total 10 reps /3 sets with rest of 10 seconds in between each sets for 5 days was performed by the therapist or is done under the supervision of the therapist starting with the static opener and ending with the tensioner.

Phases of intervention: Static opener for 1 minute repeated if tingling sensation persists. While holding static opener position patient was made to perform,
Two ended sliders: C/L side neck flexion + I/L median nerve mobilization followed by One ended slider: I/L median nerve mobilization.
Afterwards, four levels of tensioners were performed to conclude the intervention, LEVEL 1: I/L side neck flexion + C/L side median nerve mobilization.
LEVEL 2: C/L side neck flexion + C/L side median nerve mobilization. LEVEL 3: I/L side neck flexion + I/L side median nerve mobilization. LEVEL 4: C/L side neck flexion + I/L side median nerve mobilization.
First two sets of sliders and tensioners performed with the wrist held in cupped position (static opener) and the last set with the wrist in extended or stretched position. For every tensioner performed there was 10 seconds of hold at the end range of motion. General exercise protocol same as control group given to the patient, which is to be performed at home. The patient made to perform a supervised session of general (home) exercises on the very first day of the intervention.

Control group
Patients were made to perform general exercises under the supervision of therapist for one time as followed, Active range of motion exercises Tendon gliding exercises. Nerve gliding exercises, Wrist flexion and extension stretches. Soft tissue manipulation and lymphatic drainage. Patient asked to perform in a dosage of 10 repetitions / set, 3 times a day for 2 weeks. No patient was restrained from Night splinting (Dynamic splint), pharmacotherapy. Ergonomics advices provided to the patients of both the groups. Post-test evaluation done for both the groups in which NPRS and Elbow range of motion in ULTT position was assessed. After two weeks, follow up was taken over telephone or in person and outcome variables (NPRS and BCTSQ) were assessed in both the groups.
Data analysis performed on IBM SPSS software version 20. Microsoft excel was used for descriptive statistics.
For Normality, Shapiro Wilk test is used.
"Paired t-test", "*Wilcoxon signed rank test" is used to find out significant difference between pre and post data for both experimental and control group.
"Unpaired t-test" and "**Mann Whitney test" was used to find out in between differences between the group.
If the p-value < 0.05, then the result is said to be statistically significant. Thirty patients were included in the study. Data acquired from the patients showed that there were a total of 10 males and 20 female patients in the study. In Figure 2 Gender distribution varies globally, with factors like culture and socio-economic status influencing proportions of males, females, and non-binary individuals.

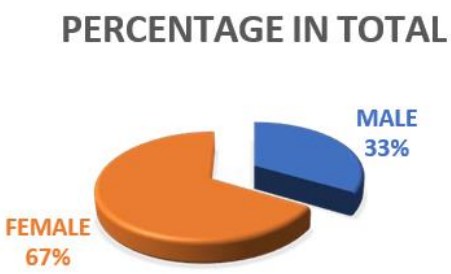

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Figure 2. Gender distribution in total

Further patients randomized into control and experimental group. In Control group, there were 4 male and 11 female while in Experimental group, there were 6 male and 9 female as mentioned to the table 2.

Table 2. Gender distribution within Groups.

Group	Gender	Frequency	%
Experimental group	Male	6	40
	Female	9	60
Control group	Male	4	26.7
	Female	11	73.3

In Figure 3 and Figure 4 Experimental and control groups typically aim for gender balance to minimize biases. Balanced representation ensures results are not skewed by gender-related factors, enhancing the study's validity and generalizability.

Figure 3. Control group gender distribution.

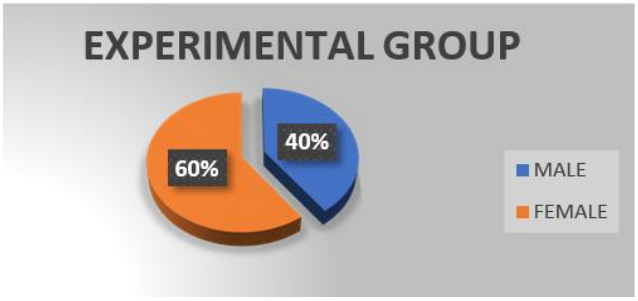

Figure 4. Experimental group gender distribution.

The mean age ±S.D is 48.67 ± 11.68 and 45.67 ± 11.68 in control and experimental group, respectively.

Table 3: Mean Age distribution between groups.

Variable	Experimental group (mean)	Experimental group (S.D)	Control group (Mean)	Control group (S.D)
Age	45.67	11.39	48.13	11.68

In table 3 and Figure 5 Mean age distribution between groups is crucial for comparing effects accurately, ensuring that results are not confounded by age-related factors.

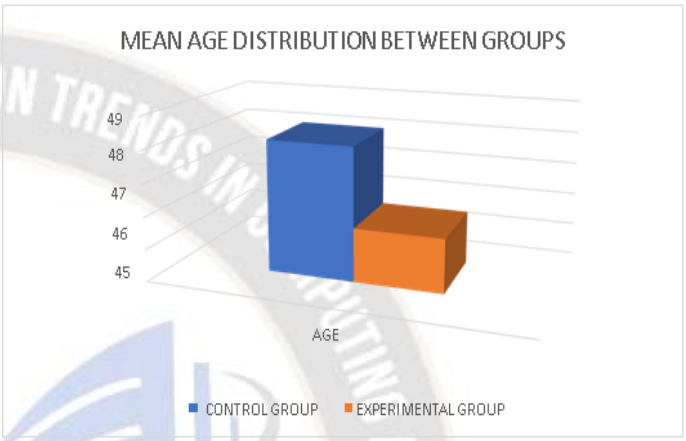

Figure 5. Mean Age distribution between groups.

Among 30 patients, 17 patients were affected on right side, 1 patient was affected on the left side and remaining 12 patients were affected bilaterally. In control group, 8 patients were affected, bilaterally while 7 patients were right sided affected. In experimental group, 4 patients were affected bilaterally, 10 patients were affected right side and only 1 patient was affected left side.

Table 4: Percentage of side involved in both the groups.

GROUP	SIDE AFFECTED % (n)		
	RIGHT	LEFT	BILATERAL
Control group	46.6 (7)	0 (0)	53.3 (8)
Experimental group	66.6 (10)	0.06 (1)	26.6 (4)

Table 4 shows the percentage of side involved in control group and the Experimental group

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Figure 6: Control group side involvement.

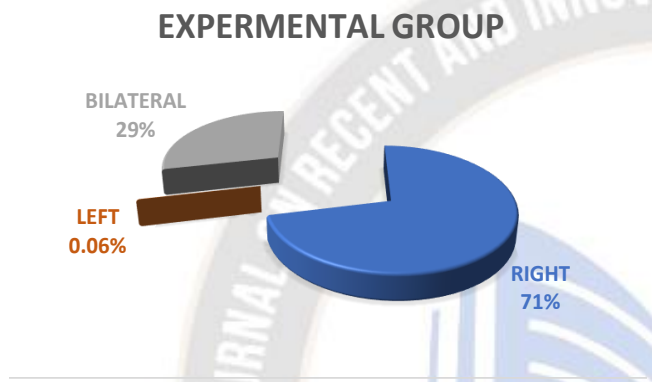

Figure 7. Experimental group side involvement.

For right side (control group) pre intervention, NPRS mean ± SD is 6 ± 1.41, Mean ± SD for SSS is 23.4+8.18, mean ± S.D for FSS is 13±4.54, mean ± S.D for EROM 110.87±15.48.

In comparison between pre and post intervention, the mean±SD for NPRS showed difference of 0.27 (p-value-0.46) which is statistically not significant and mean±SD for EROM showed difference of – 1.8 (p-value=0.22), which is statistically significant.

In comparison between post intervention and 2 weeks follow up, NPRS mean ± SD showed difference of 1.86 which is statistically significant, Mean ± SD for SSS showed a difference of 3.39 which is statistically significant, mean ± S.D for FSS showed difference of 2.47 which is statistically significant.

For right side (experimental group) NPRS mean ± SD is 5.50±1.74, Mean ± SD for SSS is 18.21±5.82, mean+ S.D for FSS is 11.21±3.06, mean± S.D for EROM 112.29±9.49.

In comparison between pre and post intervention, the mean ±S. D for NPRS showed difference of 2.93 which is statistically significant and mean±SD for EROM showed difference of –13.28 (p-value - 0.007) which is statistically significant.

In comparison between post and 2 weeks follow up, NPRS mean ± SD showed difference of
1.21 which is statistically significant, mean ± SD for SSS showed a difference of 6.21 (p-value < 0.01), mean ± S.D for FSS showed difference of 2.71 (p value - 0.002) which is statistically significant.

Table 5: Within-group descriptive statistics and comparison for control and experimental group (Right side).

Outcome measure	Group	Pre intervention	Post intervention	Follow up (2weeks)	Difference after the intervention	Difference at 2 weeks	p-value (pre-post)	p-value (post-follow-up)
NPRS	CONTROL median (SD)	6 (1.41)	5.73 (1.44)	4(1.18)	0.27	1.86	.046*	<0.01
	EXPERIMENTAL mean SD	5.50 (1.74)	2.57 (1.08)	1.36 (0.49)	2.93	1.21	.000	<0.01
SSS	CONTROL mean (SD)	23.4 (8.18)	------	19.47 (7.86)	-----	3.39	-----	<0.01
	EXPERIMENTAL mean (SD)	18.21(5.82)	------	12(1.6)	------	6.21	-----	<0.01
FSS	CONTROL Median (SD)	13 (4.54)	-------	11(3.58)	------	2.47	-----	<0.01
	EXPERIMENTAL mean(SD)	11.21 (3.06)	------	8.50 (2.09)	------	2.71	-----	.002
E.ROM	CONTROL mean (SD)	110.87 (15.48)	112.67 (14.09)	-------	-1.8	-----	.022	-----
	EXPERIMENTAL mean (SD)	112.29 (9.49)	125.57 (4.7)	------	-13.28	-----	.007	------

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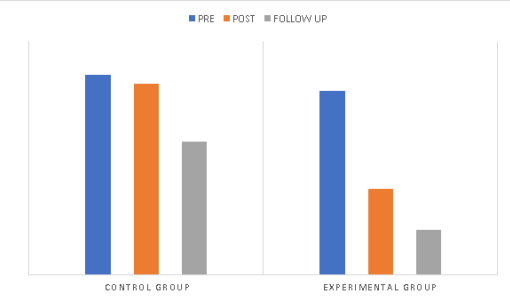

Figure 8. NPRS mean (pre, post and at follow up) comparison.

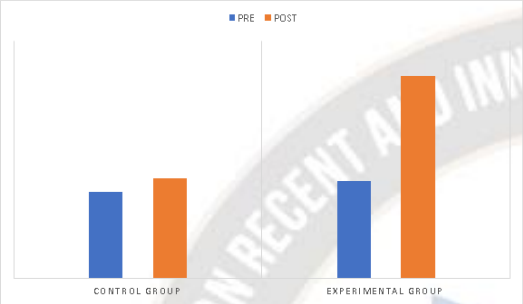

Figure 9: EROM mean (pre and post) comparison.

For left side (control group) pre intervention, NPRS mean ± SD is 4.63± 2.26, Mean ± SD for SSS is 20.13, mean ± S.D for FSS is 12±4.03, mean ± S.D for EROM 125±15.12.

In comparison between pre and post intervention, the mean±SD for NPRS showed difference of 0.13 (p-value=.351) which is statistically not significant and mean± SD for EROM showed difference of 0.00 (p-value=1.00) which is statistically not significant.

In comparison between post intervention and 2 weeks follow up, NPRS mean ± SD showed difference of 1.5 (p-value=0.001) which is statistically significant. In comparison between pre intervention and 2 weeks follow up mean ± SD for SSS showed a difference of 2.5 (p-value -- 0.11) which is statistically significant, mean ± S.D for FSS showed difference of 1.62 (p value - 0.24) which is statistically significant.

For left side (experimental group) pre intervention, NPRS mean ± SD is 5.60±1.34, Mean ± SD for SSS is 18.80±6.22, mean±SD for FSS is 12.80±5.02, mean±SD for EROM 109.40±12.89.

In comparison between pre and post intervention, the mean±SD for NPRS showed difference of 3.8 (p-value < 0.001) which is statistically significant and mean±SD for EROM showed difference of -12.85 (p-value=0.19 which is statistically significant). In comparison between pre intervention and 2 weeks follow up, NPRS mean ± SD showed difference of 0.6 (p-value=.305) which is statistically not significant, Mean ± SD for SSS showed a difference of 7.2 (p-value =0.40) which is statistically significant, mean ± S.D for FSS showed difference of 4.6 (p value=0.98) which is statistically significant.

Table 6: Within group descriptive statistics and comparison for control and experimental group (Left side).

Outcome measure	Group	Pre intervention	Post intervention	Follow up	Difference after the intervention	Difference at 2 weeks	p-value (Pre-post)	p-value (post-follow-up)
NPRS	CONTROL mean (SD)	4.63 (2.26)	4.50 (2.20)	3.00 (1.77)	0.13	1.5	.351	.001
	EXPERIMENTAL mean (SD)	5.60 (1.34)	1.80(0.83)	1.20 (0.44)	3.8	0.6	.001	.305
SSS	CONTROL mean (SD)	20.13 (11.83)	------	17.63 (10.25)	-----	2.5	-----	0.11
	EXPERIMENTAL mean (SD)	18.80 (6.22)	------	11.60 (0.89)	------	7.2	------	0.40
FSS	CONTROL mean (SD)	12.00 (4.03)	-------	10.38 (2.50)	------	1.62	-------	0.24
	EXPERIMENTAL mean(SD)	12.80 (5.02)	------	8.20 (0.45)	---------	4.6	-------	0.98
E.ROM	CONTROL Median (SD)	125(15.12)	125 (15.12)	----------	0.00	-------	1.000*	------
	EXPERIMENTAL Mean (SD)	109.40 (12.89)	122.25 (6.89)	----------	-12.85	---------	0.19	------

*Wilcoxon Signed Ranks Test

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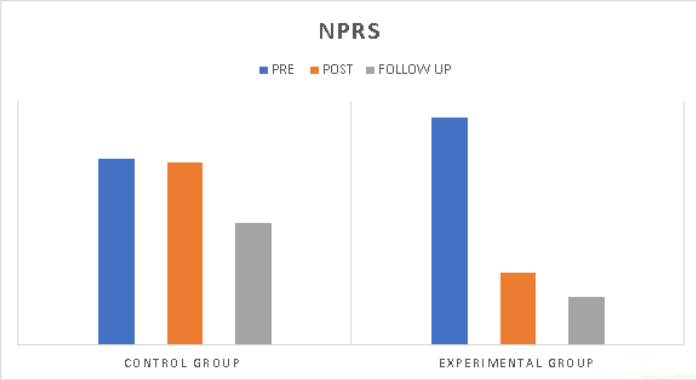

Figure 10: NPRS mean (pre, post, follow-up).

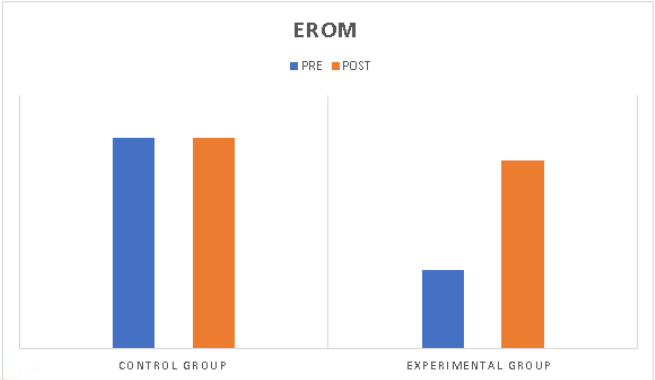

Figure 11: EROM mean (pre, post).

Table 7: Between group comparison for control and experimental group.

Outcome measure		Control group (Mean ± S.D)	Experimental group (Mean ± S.D)	p-value (post – post)	p-value (post-follow up)
NPRS (Left)	Post	5.73+_1.44	2.57±1.081	<0.01	<0.01
	Follow up	4±1.18	1.36 ± 0.49		
E.ROM (Left)		112.67+_14.09	125.57±4.7	.065**	--------
NPRS (Right)	Post	4.50±2.20	1.80 ± 0.83	0.025	0.36**
	Follow up	3.00±1.77	1.20±0.44		
E.ROM (right)		125±15.12	122.25±6.89	0.907**	--------

For right side, on comparing control group to experimental group. In control group, it was found that post intervention the NPRS Mean ± S.D was 5.73±1.44 while for Experimental group; it was 2.57±1.08, which was statistically significant. In control group, it was found that in follow up NPRS Mean± S.D was 4 ± 1.18 while for Experimental group, it was 1.36±0.49 which was statistically significant. In control group, it was found that post intervention the E.ROM Mean ± S.D was 112.67±14.09 while for Experimental group, it was 125.57 ± 4.7 which was statistically significant (p-value -0.065**).

In control group, it was found that in follow up SSS Mean± S.D was 19.47 ±7.86 while for Experimental group, it was 12±1.6 which was statistically significant. In control group, it was found that in follow up FSS Mean± S.D was 11± 3.58 while for Experimental group, it was 8.50± 2.09 which was statistically significant (p-value - 0.001).

For left side, on comparing control group to experimental group, in control group, it was found that post intervention the NPRS Mean ± S.D was 4.50±2.20 while for Experimental group it was 1.80±0.83, which was statistically significant. In control group, it was found that

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post intervention the E.ROM Mean ± S.D was 125±15.12 while for Experimental group, it was 122.25±6.89 which is statistically not significant (p-value -0.907). In control group, it was found that in follow up SSS Mean± S.D was 17.63±10.25 while for Experimental group, it was 11.60±0.89 which was statistically not significant (p-value -0.319). In control group, it was found that in follow up FSS Mean± S.D was 10.38±2.50 while for Experimental group, it was 8.20±0.45 which was statistically significant (p-value -0.079).

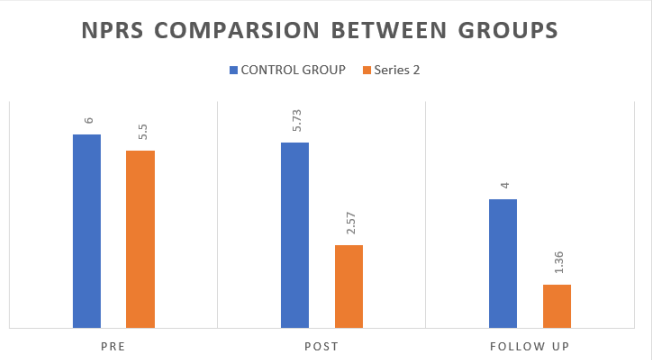

Figure 12: NPRS comparison between groups (Right Side).

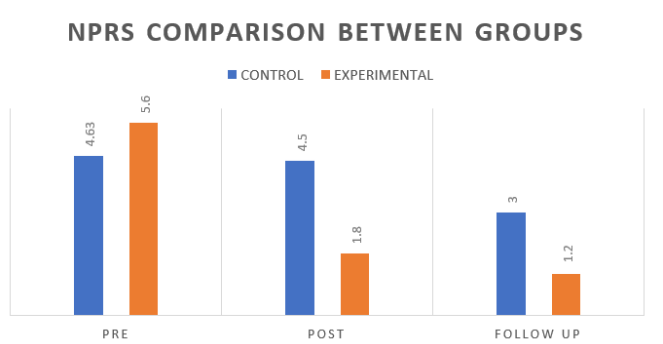

Figure 13: NPRS comparison between groups (Left Side).

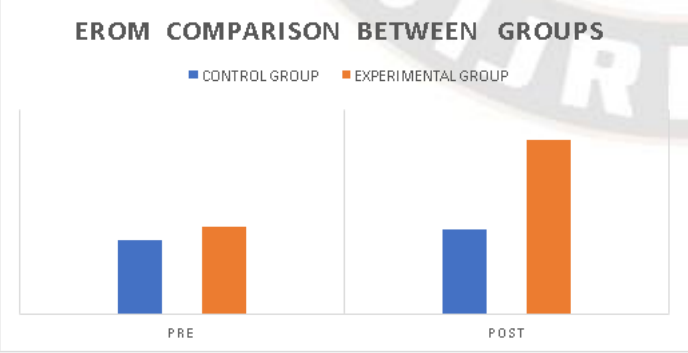

Figure 14: EROM comparison between groups (Right side).

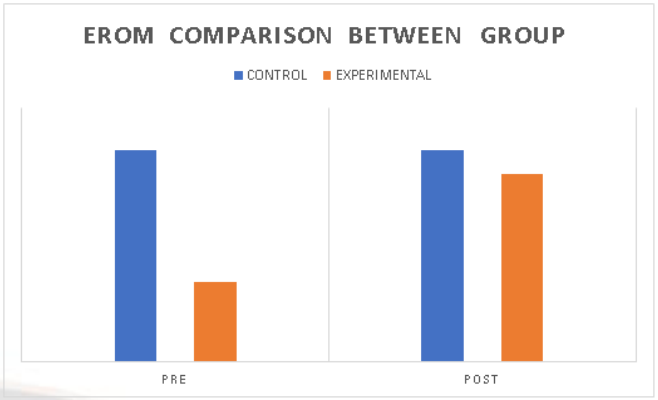

Figure 15: EROM comparison between groups (Left side).

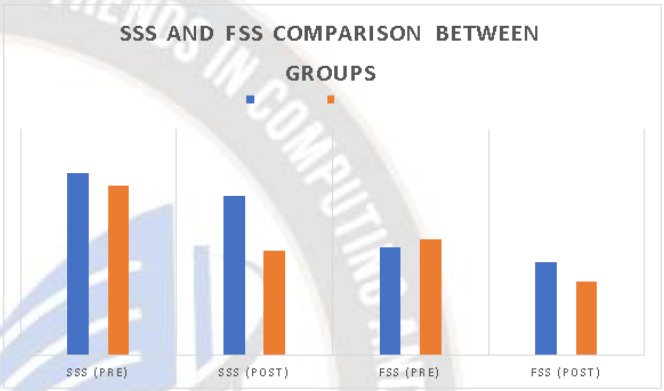

Figure 16: SSS and FSS comparison between groups (Right side).

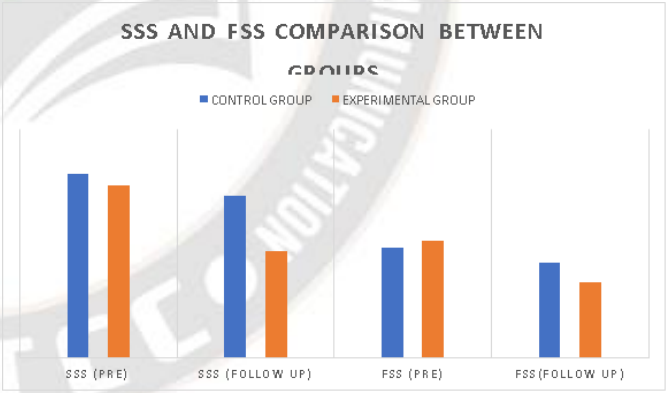

Figure 17: SSS and FSS comparison between groups (Left side**).**

The study conducted analysed the effects of neurodynamic in carpal tunnel syndrome in pain and disability. Previously, studies have seen effect of neurodynamic in contrast to various therapies but in a study conducted by Hamzeh et al, it was the first time that neurodynamic was combined with home exercise.2 In consideration, the effect of static opener, sliders and four levels of tensioners with home exercise have not been analysed. The protocol stated in our study is based totally on neurodynamic, but no study so far has used this

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protocol ever. Along with that, no study has ever seen effect of neurodynamic on Elbow extension ROM in CTS

The present study found out that both Neurodynamic with general exercises and Exercise therapy (general exercises) performed in experimental and control groups is effective in Carpal Tunnel Syndrome (CTS) after intervention and maintained the therapeutic effects at 2 weeks follow up. Although, the post intervention results for control group were pleasing but experimental group showed exponentially better results in almost every outcome measure. The outcome measures taken in this study were Numerical Pain Rating Scale (NPRS), Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ) and Elbow flexion Range of Motion (E.ROM) in accordance with the side involved whether right, left or bilateral involvement.

To precise the results, the subjects having bilateral involvement that is both right and left involvement, the hands listed under right and left side respectively. The NPRS, E.ROM and BCTSQ taken as a pre assessment measure followed only with the post assessment of NPRS and E.ROM after 5 days. After 2 weeks, a follow up was taken in which NPRS and BCTSQ were taken. The upper limb tension test performed to see whether the test is positive for sliding or tensioning dysfunction and in which E.ROM, measured and noted. In this study, the treatment protocol received by the patient in experimental group involved 5 sessions of neurodynamic technique, which involved static opener, sliders, and tensioners, for a week followed by the general exercises as home programme, found to be more effective over control group intervention, which only received general exercises. With this protocol, no patients restrained from having any pharmacotherapy, night splinting and following ergonomics advice. NPRS, when analysed for both the sides after intervention and at 2 weeks follow up both control and experimental group found to be statistically significant. Both the groups showed significant effects but the mean differences after intervention at 2 weeks follow up explained that neurodynamic with general exercises are more beneficial than general exercises in reducing pain.

Meanwhile, when between group analysis was done for the same, experimental group showed better results contrary to control group with a p-value (0.025, <0.01) and (0.36**, <0.01) in post intervention and follow up respectively. EROM, when analysed for both the hands after intervention the experimental group was found to be more statistically significant than control group, which showed a slight difference only emphasizing that neurodynamic can increase elbow flexion range of motion. Meanwhile, between group analysis showed that experimental group was at benefit more than control group for right side (p –value -0.065**) and for left side experimental group was not favoured over control group (p –value -0.907**). The results may vary for both the hands but as stated above, neurodynamic with general exercises works exponentially better than control group having general exercises only. BCTSQ, an outcome measure that is valid, reliable and widely accepted evidence-based scale was used in this study which quantifies about the symptom severity and functional status in the patient. The components of BCTSQ, SSS and FSS showed significant improvement at 2 weeks follow up for both hands. Meanwhile, when in between group analysis was done, SSS for right hand improved in experimental group more than control group with a p-value of 0.001** and for left side control group was more beneficial with a p-value of 0.319**. The other component FSS showed better results in experimental group than control group for both the sides (p-value- 0.001**, right side) (p-value-0.079**, left side). Overall, outcome measures improved in both the groups but neurodynamic played a key role in decreasing pain and increasing the flexibility of elbow as nerve slides whether proximally or distally within its mechanical interface rather than just stretching at one end. On the other hand, tensioners were also effective as elasticity of the nerve affirmatively improved Findings of this study are suggestive of neurodynamic with general exercises can be used in the CTS patients as better results are being produced in outcome measures assessed and this protocol is effective in its own way.

5. LIMITATIONS

The study performed has small sample size and is not a blinded study. The study included mild to moderate CTS patients only.

6. FUTURE RESEARCH SCOPE

The study must carry out with large sample size. Further research can compare post intervention NCV findings to find out electrophysiological changes. As, no patient was restrained from splinting and pharmacotherapy future research can include the same.

7. CONCLUSION

Neurodynamics is an interdisciplinary approach which when combined with (home) general exercises is found to be beneficiary in reducing pain and disability along with increasing elbow extension range of motion in individuals with mild to moderate carpal tunnel syndrome over isolated (home) general exercises. Women are more likely than males to suffer from CTS, a common illness with a diverse clinical presentation that frequently includes motor and sensory symptoms that are distal to the location of the

lesion. It must be gradually learned with years of experience and observation. This is due to the fact that most clinical settings involve some degree of ambiguity. Superlatives such "never, rarely, sometimes, often, most of the time, and always" are frequently used by patients to characterize their symptoms during evaluation, and each individual symptom may also be assessed as "mild, moderate, or severe." Therefore, we draw the very encouraging conclusion that further research on the application of such a fuzzy expert system for medical opinion prediction and diagnosis is warranted. When included into regular clinical consultations and utilized sparingly, they can be beneficial, but they will never be able to fully replace the clinician.

REFERENCES

[1] Werner RA, Andary M. Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. *Clinical Neurophysiology*. 2002;113(9):1373–1381.

[2] Wipperman J, Goerl K. Carpal tunnel syndrome: diagnosis and management. *American family physician*. 2016 Dec 15;94(12):993-9.

[3] Bland JDP, Weller P, Rudolfer S. Questionnaire tools for the diagnosis of carpal tunnel syndrome from the patient history. *Muscle and Nerve*. 2011;44(5):757–762.

[4] Spindler HA, Dellon AL. Nerve conduction studies and sensibility testing in carpal tunnel syndrome. *Journal of Hand Surgery*. 1982;7(3):260–263.

[5] Jarvik JG, Comstock BA, Kliot M, et al. Surgery versus non-surgical therapy for carpal tunnel syndrome: a randomised parallel-group trial. *The Lancet*. 2009;374(9695):1074–1081.

[6] You H, Simmons Z, Freivalds A, Kothari MJ, Naidu SH. Relationships between clinical symptom severity scales and nerve conduction measures in carpal tunnel syndrome. *Muscle Nerve*. 1999; 22:497–501.

[7] Zadeh LA. The role of fuzzy logic in the management of uncertainty in expert systems. *Fuzzy Sets and Systems*. 1983;11(1–3):197–198.

[8] Lozano-Zahonero S, Gottlieb D, Haberthür C, Guttmann J, Möller K. Automated mechanical ventilation: adapting decision making to different disease states. *Medical and Biological Engineering and Computing*. 2011;49(3):349–358.

[9] Milad Zarrin, Noureddin Nakhostin Ansari et al, A Pilot Study Into the Effects of Cervical Manual Therapy Plus Conventional Physical Therapy on Clinical Outcomes and Electrodiagnostic Findings in People With Carpal Tunnel Syndrome (2023).

[10] Alberto Tomás-Escolar, Javier Merino-Andrés et al, Short-term effectiveness of kinesio taping as therapeutic tool in conservative treatment of carpal tunnel syndrome: A systematic review and meta-analysis (2023).

[11] Sidrah Shabbir, Ayesha Rasheed et al, Comparing Effectiveness of Median Nerve Mobilization with and without Transverse Carpal Ligament Stretching in Patients with Carpal Tunnel Syndrome (2022).

[12] Sandra Jiménez-del-Barrio, Luis Ceballos-Laita et al, Diacutaneous Fibrolysis Intervention in Patients with Mild to Moderate Carpal Tunnel Syndrome May Avoid Severe Cases in Elderly: A Randomized Controlled Trial (2022).

[13] S.A. Raeissadat, V. Dinarvand et al, Carpal tunnel syndrome treatment: The effect of scaphoid and hamate mobilization (2022).

[14] Sergio Núñez de Arenas-Arroyo, Iván Cavero-Redondo et al, Short-term Effects of Neurodynamic Techniques for Treating Carpal Tunnel Syndrome: A Systematic Review with Meta-analysis. (2021).

[15] Hayat Hamzeh, Mohammad Madi et al, The long-term effect of neurodynamics vs exercise therapy on pain and function in people with carpal tunnel syndrome: A randomized parallel-group clinical trial (2020).

[16] Zhiyuan Bian, Jie Yu et al. Acupuncture and related therapies for carpal tunnel syndrome (2021).

[17] Ghadam Ali Talebi , Payam Saadat et al, Comparison of two manual therapy techniques in patients with carpal tunnel syndrome: A randomized clinical trial (2020).

[18] Josiah D. Sault, Dhinu J. Jayaseelan et al, The Utilization of Joint Mobilization As Part of a Comprehensive Program to Manage Carpal Tunnel Syndrome: A Systematic Review (2020).

[19] Wielemborek PT, Kapica-Topczewska K, Pogorzelski R, Bartoszuk A, Kochanowicz J, Kułakowska A. Carpal tunnel syndrome conservative treatment: a literature review. Postep Psychiatr Neurol. 2022 Jun;31(2):85-94. doi: 10.5114/ppn.2022.116880. Epub 2022 May 31. PMID: 37082094; PMCID: PMC9881572.

[20] Elseddik, M.; Alnowaiser, K.; Mostafa, R.R.; Elashry, A.; El-Rashidy, N.; Elgamal, S.; Aboelfetouh, A.; El-Bakry, H. Deep Learning-Based Approaches for Enhanced Diagnosis and Comprehensive Understanding of Carpal Tunnel Syndrome. *Diagnostics* 2023, 13, 3211. https://doi.org/10.3390/diagnostics13203211.

[21] Zhou, H., Bai, Q., Hu, X. et al. Deep CTS: a Deep Neural Network for Identification MRI of Carpal Tunnel Syndrome. J Digit Imaging 35, 1433–1444 (2022). https://doi.org/10.1007/s10278-022-00661-4.

[22] Gautam N, Shrivastava A. A Review on Carpal Tunnel Syndrome Various Terminologies. InProceedings of the Third International Conference on Information Management and Machine Intelligence: ICIMMI 2021 2022 Aug 4 (pp. 533-545). Singapore: Springer Nature Singapore.

[23] Lin TY, Chang KV, Wu WT, Özçakar L. Ultrasonography for the diagnosis of carpal tunnel syndrome: an umbrella review. *Journal of Neurology*. 2022 Sep;269(9):4663-75.