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"The effect of use of stick by unaffected hand on electro-physiological parameters of median and ulnar nerves at wrist in post stroke patients : An Observational Study."

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ABSTRACT:
BACKGROUND: *Dysfunction of balance control is one of the most common physical impairment observed after stroke. The use of ambulatory assistive devices such as stick/cane can increase, maintain, or improve balance, mobility and functional capabilities of post stroke patients with balance impairments. The post stroke patients are not able to use the stick with the affected side due to paralytic effect of stroke and are tend to use it with unaffected hand for balance and mobility so the purpose of the study is to find out the effect of use of stick by unaffected hand on electrophysiological parameters of median and ulnar nerves at wrist in post stroke patients.*
OBJECTIVES OF THE STUDY: *(1) To assess the median and ulnar nerve at wrist joint of unaffected side by nerve conduction study in post stroke stick user patients and post stroke independent ambulatory patients without any kind of assistive device. (2) To compare the median as well as ulnar nerve conduction findings between post stroke stick user and independent ambulatory patients.*
METHODS: *A total number of 60 post stroke patients (30 independent ambulatory patients for group A & 30 stick user patients for group B) were selected for study by purposive sampling who fulfilled the inclusion and exclusion criteria. Written consent was taken from subjects after proper explanation about the purpose and procedure of the study. The electrophysiological data of median and ulnar nerves at wrist was collected from the unaffected side by performing nerve conduction study analysis using EMG-NCV instrument.*
RESULTS: *Results of unpaired t test shows significant increment in distal latency of Median motor nerve (p=0.000), latency of median sensory nerve (p=0.000), distal latency of ulnar motor nerve (p=0.0212) and latency of ulnar sensory nerve (p=0.022); significant decrement in median sensory amplitude (p=0.001) and sensory velocity of median nerve (p=0.000); No significant change in Distal amplitude of median motor nerve (p=0.072) Distal amplitude of ulnar motor nerve (p=0.168), amplitude of ulnar sensory nerve (p=0.105), and sensory velocity of ulnar nerve (p=0.159).*
CONCLUSION: *From the present study it can be concluded that prolonged use of stick by unaffected hand for independent ambulation and activities of daily living causes demyelinating neuropathy of median and ulnar nerve at wrist in post stroke stick user patients.*

KEYWORDS: *stroke; hemiplegia; stick; cane; nerve conduction study(NCV); assistive device; ambulation; electrophysiology; balance; wrist; carpal tunnel syndrome(CTS); guyon's canal syndrome.*

1. INTRODUCTION:

The World Health Organization (WHO) define stroke as a "Rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than a vascular origin." Stroke is a global health problem. Possible impairments are hemiplegia/hemiparesis, altered tone, muscle weakness, altered sensations and coordination, impaired balance, speech & swallowing difficulty, problems in cognition and perception.[1]

Dysfunction of balance control is one of the most common physical impairment observed after stroke. Balance problem is associated with reduced ambulatory function, restricted social interference. The high fall risk for individuals with stroke is not only present in the acute phase, but it remains a considerable health concern throughout the post stroke life span.[2]

The ambulatory assistive devices such as stick/cane can increase, maintain, or improve balance, mobility and functional capabilities of post stroke patients with balance impairments.[3] The stick acts to increase patient's stability during affected side single limb support and walking sticks may even improve hemiplegic gait.[4] Mostly tripod or quadrupod; one of these two types of stick is prescribed and used by the post stroke patients. Use of stick for ambulation requires appropriate grip of the hand to grasp the curved handle of the stick & to hold it between the palm and fingers

while transferring weight to wrist or forearm for walking. The patients who use stick for ambulation induces more stress on wrist due to weight transfer and also by faulty positioning.[5] It also causes repeated movement of wrist joint and pressure on the volar aspect of wrist to transfer the weight with hand which can induce nerve entrapment. There are mainly two nerves passing through the volar aspect of wrist joint; that are median nerve & ulnar nerve.[6]

Measurement of median and ulnar nerve function at wrist can be done by use of clinical assessment and electro-diagnostic investigation method for assessing degree of nerve damage which gives more accurate and quantitative readings. Electrodiagnosis plays a critical role in the assessment of nerve function and nerve damage. The Nerve Conduction Study (NCS) considered being the most objective non-invasive measure of electrodiagnosis by providing quantitative information about nerve function in a more sensitive and reliable way.

The assessment of median and ulnar nerve at wrist using Nerve Conduction Study (NCS) help to know whether there is presence of any changes in nerve function or not due to use of stick by unaffected hand in post stroke patients, which gives more accurate and quantitative readings.[7,8]

1.1 NEED OF THE STUDY:

There are many studies have done on affected upper limb in post stroke patients but very few studies on unaffected hand and none of them had taken the effect of specific ambulatory device such as stick on the nerves passing through the wrist joint. As the post stroke patients cannot use the assistive device such as stick with the affected side due to paralytic effect of stroke and are tend to use it with unaffected hand for balance & mobility; this study will provide the effect of use of stick by unaffected hand on the nerves passing through the volar aspect of wrist joint for post stroke stick user patients in terms of electrophysiological parameters of the nerves which can help to guide the patients as preventive measures.

1.2 AIM OF THE STUDY:

The aim of the study is to find out the effect of use of stick/cane by unaffected hand on electrophysiological parameters of median and ulnar nerves at wrist in post stroke patients.

1.3 OBJECTIVES OF THE STUDY:

(1) To assess the median and ulnar nerve at wrist joint of unaffected side by nerve conduction study in post stroke stick user patients.

(2) To assess the median and ulnar nerve at wrist joint of unaffected side by nerve conduction study in post stroke independent ambulatory patients without any kind of assistive device.

(3) To compare the median as well as ulnar nerve conduction findings between post stroke stick user and independent ambulatory patients.

1.4 HYPOTHESIS OF THE STUDY:

NULL HYPOTHESIS: There is no significant effect of use of stick by unaffected hand on electrophysiological parameters of median and ulnar nerve at wrist joint in post stroke ambulatory patients.

EXPERIMENTAL HYPOTHESIS: There is significant effect of use of stick by unaffected hand on electrophysiological parameters of median and ulnar nerve at wrist joint in post stroke ambulatory patients.

2. MATERIALS AND METHODOLOGY:

STUDY SETTING: Shri K. K. Sheth Physiotherapy College, Rajkot.
SOURCE OF DATA: Physiotherapy centres in and around Rajkot.
STUDY DESIGN: A cross-sectional observational study.

METHOD OF COLLECTION OF DATA:

Study population & sample size: Total 60 post stroke patients. 30 Post stroke ambulatory patients who are using stick by unaffected hand for ambulation and 30 post stroke independent ambulatory patients who are not using any kind of assistive device.
Sampling method: Purposive sampling.

2.1 CRITERIA OF SELECTION:

INCLUSION CRITERIA:

INDEPENDENT AMBULATORY GROUP (GROUP A):

- post stroke independent ambulatory patients; not using any assistive devices for ambulation.
- Age group between 50 to 65 years.
- Gender: both male and female patients.

- Ability to understand and follow instructions.

STICK USER GROUP (GROUP B):

- Post stroke ambulatory stick user patients.
- Age group between 50 to 65 years.
- Gender: both male and female patients.
- Ability to understand and follow instructions.
- Subjects who are using tripod or quadrupod stick by unaffected hand as an ambulatory device for ambulation for at least 1 hour a day for ambulation from more than 3 months.

2.2 EXCLUSION CRITERIA:

- Patients with other form of neurological dysfunction for example Parkinsonism, Multiple sclerosis etc.
- Patients with history of any recent musculoskeletal injuries like fractures, dislocation, joint instability or any soft tissue injuries of cervical spine and unaffected upper extremity in past 6 months.
- Patient having open ulcer at wrist or hand or any infection at wrist or hand of unaffected side. Acute inflammation at wrist joint of unaffected side.
- Treatment with vitamin B1, B2, or B12, or steroid hormones during the study period.
- Clinical or electrophysiological evidence of accompanying conditions that could mimic entrapment neuropathy or interfere with its evaluation, such as cervical radiculopathy, proximal median neuropathy, significant polyneuropathy, or marked orthopedic abnormalities on unaffected side.
- Systemic diseases known to cause neuropathy, such as hypothyroidism, rheumatoid arthritis, or chronic renal failure.
- Any surgical history of cervical spine or unaffected upper limb.
- Thoracic outlet syndrome.
- Non consent.

2.3 NERVE CONDUCTION STUDY MEASUREMENT PROCEDURE:

After the ethical approval from committee; A total number of 60 post stroke patients (30 independent ambulatory patients for group A & 30 stick user patients for group B) were selected for study from Out Patient Department (OPD) who fulfilled the inclusion and exclusion criteria. After proper explanation about the purpose and procedure of the study, written consent was taken from subjects who will fulfil both the criteria and willing to participate in the study.

The selection of subjects was done by purposive sampling. The data measured were recorded in the data collection form which included name, age, gender, dominance, side involved, post stroke duration, duration of stick use etc. Before testing commencement, all patients have been asked to rest on the bed with shoes removed for 5 minutes and remain comfortable and relaxed. All the patients were asked to empty their bladder prior to testing. To provide a quiet testing environment, all tests have been performed in a close quiet room with natural light from windows.

The room was electrically shielded and earth grounded for nerve conduction study measurements. The electrophysiological data was also collected from the unaffected side using EMG-NCV instrument (RMS EMG EP MK-II, Version 1.1).

The motor nerve conduction study of median and ulnar nerve at wrist was performed first using supramaximal stimulation to get the maximum compound motor action potential and to get the best stimulating site. The sensory nerve conduction study of median and ulnar nerve was performed than using sub-maximal stimulation. For both motor and sensory nerve conduction study, median and ulnar nerve is stimulated at the same distance from the recording active electrode. Compound Motor Action Potential (CMAP) & Sensory Nerve Action Potential (SNAP) of median and ulnar nerves at unaffected wrist were measured with EMG-NCV instrument.

2.4 METHOD FOR MEDIAN & ULNAR MOTOR NERVE CONDUCTION STUDY MEASUREMENT:

- For median nerve; Patient position Supine lying, upper limb supported with elbow extended and forearm in supination. Recording active electrode is positioned close to motor point of abductor pollicis brevis. Recording reference electrode is positioned 3 cm distal to recording active electrode at first MCP joint.
- For ulnar nerve; Patient position Supine lying, upper limb supported with elbow flexed and forearm in supination. Recording active electrode is positioned close to motor point of abductor digiti minimi. Recording reference electrode is positioned 3 cm distal to recording active electrode at first MCP joint.

- Ground electrode placed between the recording and stimulating electrodes and by using Bipolar stimulating electrode, supramaximal stimulation is given at wrist (3cm proximal to distal wrist crease) until the maximum compound motor action potential (CMAP) is received.
- Instrumentation Parameters for motor nerve conduction study of median & ulnar nerve: Sweep speed: 2-5 ms/div; Sensitivity: 0.5–1.0 mV/div; Filter setting: 5 Hz- 10 kHz.

2.5 METHOD FOR MEDIAN & ULNAR SENSORY NERVE CONDUCTION STUDY MEASUREMENT:

- Patient position Supine lying, upper limb supported with elbow extended and forearm in supination.
- For median nerve; Recording active electrode is positioned over proximal interphalangeal joint of index finger. Recording reference electrode is positioned 3 cm distal to recording active electrode.
- For ulnar nerve; Recording active electrode is positioned over proximal interphalangeal joint of little finger. Recording reference electrode is positioned 3 cm distal to recording active electrode.
- Ground electrode placed between the recording and stimulating electrodes and by using Bipolar stimulating electrode, submaximal stimulation is given at wrist (3cm proximal to distal wrist crease).
- Instrumentation Parameters for sensory nerve conduction study of median & ulnar nerve: Sweep speed: 1- 2 ms/div; Sensitivity: 1-5 µV/div; Filter setting: 10 Hz- 2 kHz.

2.6 OUTCOME MEASURE:

- Nerve conduction study parameters:
- Motor nerve conduction amplitude and latency of median and ulnar nerves.
- Sensory nerve conduction amplitude, latency and velocity of median and ulnar nerves at wrist joint.

3. STATISTICAL ANALYSIS:

- Statistical analysis was done by Statistical Package for the Social Sciences (SPSS) statistical software version 20.0 for windows. Microsoft excel was used to generate graphs and tables.
- Mean and standard deviation were calculated as measure of central tendency and measure of dispersion respectively. Normality of data was checked by using **Shapiro Wilk Test** which shows that data is of parametric type.
- Between groups comparison of the electrophysiological parameters of post stroke patients of independent ambulatory group and stick user group was assessed by **Unpaired t test**. Level of significance (p value) was set to 0.05 level.

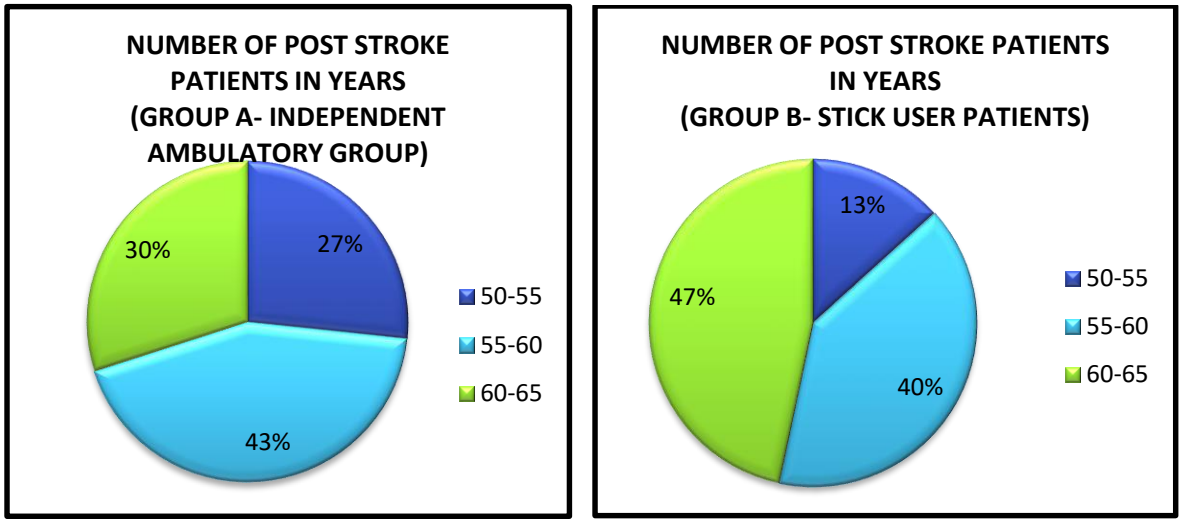
4. RESULTS:

- Results of unpaired t test for median nerve shows significant increment in distal latency of Median motor nerve (p=0.000) and latency of median sensory nerve (p=0.000), significant decrement in median sensory amplitude (p=0.001) and sensory velocity of median nerve (p=0.000), no significant change in Distal amplitude of median motor nerve (p=0.072).
- Results of unpaired t test for ulnar nerve shows significant increment distal latency of ulnar motor nerve (p=0.0212) and latency of ulnar sensory nerve (p=0.022), no significant change in Distal amplitude of ulnar motor nerve (p=0.168), amplitude of ulnar sensory nerve with p=0.105, and sensory velocity of ulnar nerve with (p=0.159).

Table 1: Age distribution of post stroke patients in group A (Independent ambulatory) and group B (stick users).

AGE GROUP (IN YEARS)	NUMBER OF SUBJECTS			
	GROUP A		GROUP B	
	N	%	N	%
50-55	8	26.67	4	13.33
55-60	13	43.33	12	40
60-65	9	30	14	46.67
TOTAL	30		30	

Graph 1: Pie Chart for Age Distribution of post stroke patients in GROUP A (Independent ambulatory) and GROUP B (stick users).

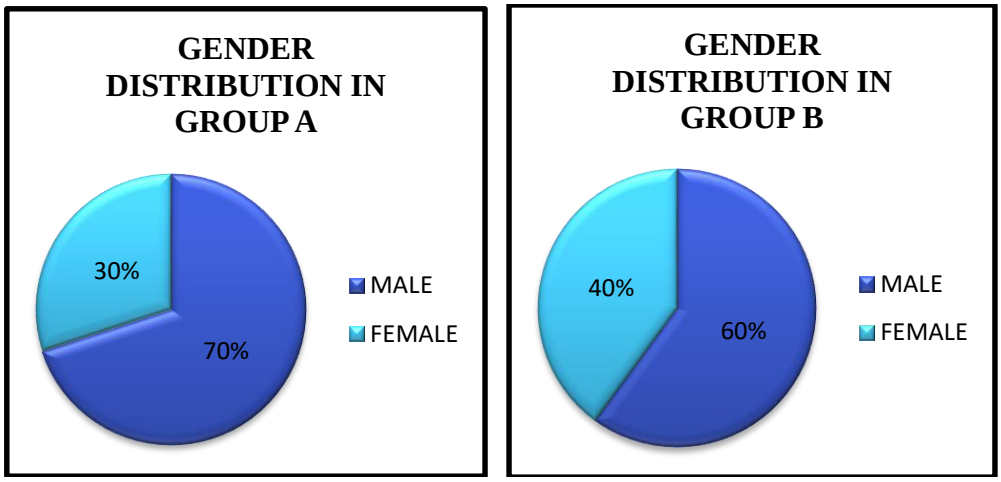


Interpretation: The above pie-charts show number of post stroke subjects and their Percentage according to age distribution.

Table 2: Gender Distribution of post stroke patients: GROUP A (Independent ambulatory) & GROUP B (stick users).

GENDER	GROUP A: INDEPENDENT AMBULATORY PATIENTS		GROUP B: STICK USER PATIENTS	
	N	%	N	%
MALE	21	70	18	60
FEMALE	9	30	12	40
TOTAL	30		30	

Graph 2: Pie Chart for Gender Distribution of post stroke patients: GROUP A (Independent ambulatory) & GROUP B (stick users).

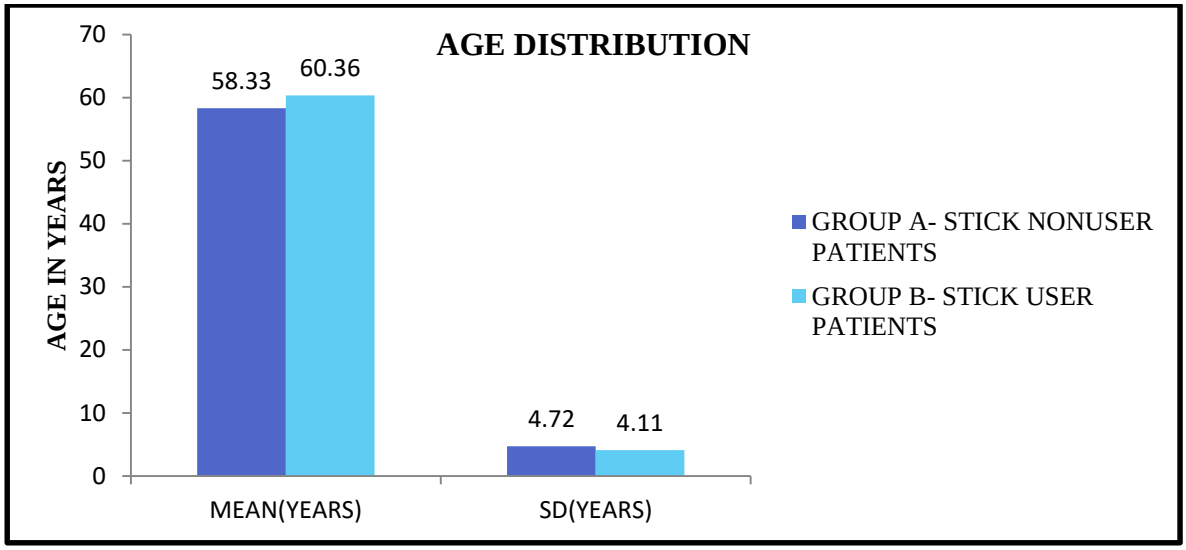


Interpretation: The above pie-charts show percentage distribution of gender of post stroke patients: GROUP A (Independent ambulatory group) & GROUP B (stick users).

Table 3: Mean Age and SD of post stroke patients in control group A(Independent ambulatory) and study group B(stick users).

GROUP	MINIMUM YEARS	MAXIMUM YEARS	MEAN(YEARS)	SD(YEARS)
A	52	65	58.33	4.72
B	50	65	60.36	4.11

Graph 3: Bar Diagram for Mean Age and SD of post stroke patients: GROUP A (Independent ambulatory) & GROUP B (stick users).



- **Interpretation:** The above bar chart displays the statistics of age distribution of post stroke patients of both groups: GROUP A (Independent ambulatory group) & GROUP B (stick users).

Table 4: Result of Unpaired-t test for between group Comparisons of NCV parameters of post stroke patients: GROUP A (Independent ambulatory) & GROUP B (stick users).

No.	VARIABLES	INDEPENDENT AMBULATORY GROUP		STICK USER GROUP		t VALUE	P VALUE	RESULT
		MEAN	SD	MEAN	SD			
1	MEDIAN MOTOR DISTAL LATENCY	3.51	0.55	4.38	0.65	-5.635	0	SIGNIFICANT
2	MEDIAN MOTOR DISTAL AMPLITUDE	10.38	1.61	9.61	1.66	1.834	0.072	NOT SIGNIFICANT
3	MEDIAN SENSORY LATENCY	2.61	0.59	3.79	0.77	-6.731	0	SIGNIFICANT
4	MEDIAN SENSORY AMPLITUDE	25.68	7.17	22.02	7.58	1.92	0.06	NOT SIGNIFICANT
5	MEDIAN SENSORY VELOCITY	51.56	7.69	37.96	7.57	6.904	0	SIGNIFICANT
6	ULNAR MOTOR DISTAL LATENCY	2.96	0.48	3.31	0.58	-2.599	0.012	SIGNIFICANT
7	ULNAR MOTOR DISTAL AMPLITUDE	10.89	1.56	10.36	1.38	1.396	0.168	NOT SIGNIFICANT
8	ULNAR SENSORY LATENCY	2.34	0.51	2.65	0.51	-2.351	0.022	SIGNIFICANT

9	ULNAR SENSORY AMPLITUDE	31.49	8.38	28.34	6.28	1.645	0.105	NOT SIGNIFICANT
10	ULNAR SENSORY VELOCITY	57.53	9.08	54.02	9.95	1.429	0.159	NOT SIGNIFICANT

Interpretation: Unpaired-t test for comparison between NCV parameters of post stroke patients of both groups: Independent ambulatory group and stick user group with p value.

5. DISCUSSION:

In the present study the results indicate that distal latency of Median motor nerve, latency of median sensory nerve, distal latency of ulnar motor nerve and latency of ulnar sensory nerve showed significant increment as well as median sensory amplitude and sensory velocity of median nerve showed significant decrement, thereby supporting experimental hypothesis. While distal amplitude of ulnar motor nerve, amplitude of ulnar sensory nerve, Distal amplitude of median motor nerve and sensory velocity of ulnar nerve did not show significant decrement thereby supporting null hypothesis. Thus, the results of the present study suggest the presence of demyelinating neuropathy of median and ulnar nerves at wrist in post stroke stick user patients who are using stick for independent ambulation and activities of daily living. Median nerve is more involved compared to ulnar nerve and median sensory fibers are more affected than median motor nerve.

The mechanism behind developing demyelinating neuropathy of median nerve due to prolonged use of stick based on the compressive forces and pressure at the volar aspect of the wrist while using stick for ambulation by post stroke patients. Use of stick for ambulation by post stroke patients requires a grip over the curved handle of the stick and repetitive movements of the hand and wrist for ambulation; gripping a cane/stick tightly would bring about direct pressure to the nerve branches in the palm, which can lead to compression.

The pathophysiology involves increased pressure within the carpal canal which leads to median nerve microcirculation injury followed by median nerve connective tissue injury associated with nonspecific flexor tenosynovitis. Similarly for ulnar nerve, repetitive trauma to hypothenar eminence and compressive forces are eventually leads injury to the ulnar artery and ulnar nerve which can lead to guyon's canal syndrome.

The post stroke patients are not able to use the stick with the affected side due to paralytic effect of stroke and are tend to use it with unaffected hand for balance and mobility; thus, the unaffected limb is more prone to secondary injuries due to the weight bearing and pressure over the volar aspect of the wrist. If an ambulatory assistive device stick is used incorrectly, secondary injuries would tend to occur in the unaffected upper extremity.

Frequent disorders caused by the use of assistive device or cane are reported; such as musculoskeletal problems and peripheral neuropathies. For example; Ginanneschi F(2009) reported guyon's canal syndrome caused due to excessive weight on the wrist in a patient using crutch for ambulation.[9] Tsai HC(2009) et al reported using a cane for ambulation were at increased risk of both median and ulnar neuropathy at wrist.[10] Similarly overuse of cane due to dependence on mobility assistive aid becomes a risk factor for entrapment neuropathy in post stroke patients.

Koichiro D(2015) also mentioned that excessive use of T cane or a Lofstrand crutch was hypothesized to induce entrapment neuropathies in the nonparetic upper extremity of post stroke patients.[11] To prevent these injuries, a well-balanced gait should be established to reduce the load on the walking device. The findings of this study are supporting the present study that excessive use of stick by post stroke patients for ambulation can induce entrapment neuropathies. thus, post stroke patients using a cane by unaffected hand for ambulation were at increased risk of both median and ulnar neuropathy at wrist.

Additional findings of this study include that in the post stroke stick user patients; female population was more suffering with entrapment neuropathy at wrist compared to male population. The entrapment neuropathy was mainly found in the patients who are using stick from longer than 8-12 months as an assistive ambulatory device. The post stroke patients who were wearing Ankle Foot Orthosis (AFO) along with use of stick for ambulation were less suffering compared to the stick user patients who are not wearing any kind of AFO.

6. LIMITATION OF THE STUDY:

The duration of stick use was considered minimum greater than three months in post stroke patients; The effect of different duration of use of stick was not considered. Functional status of the paretic upper limb and Associated orthotic device used by the post stroke patients such as ankle foot orthosis(AFO) was not considered.

7. FURTHER RECOMMENDATION:

Further research can be done by taking different electrophysiological outcomes with nerve conduction study parameters such as Electromyography (EMG) and also including other nerves of the upper limb.

8. CONCLUSION:

From the present study it can be concluded that prolonged use of stick by unaffected hand for independent ambulation and activities of daily living causes demyelinating neuropathy of median and ulnar nerve at wrist in post stroke stick user patients. Median nerve is more affected compared to ulnar nerve due to prolonged use of stick for ambulation by post stroke stick user patients.

9. CLINICAL IMPLICATION:

The present study suggests that prolonged use of stick for balance and mobility in post stroke patients causes demyelinating neuropathy of median & ulnar nerves at wrist, if it is not taken care it can lead to entrapment neuropathy, reduction in the muscle's strength, loss of joint position and movement sense and abnormal sensations. These all symptoms can hamper the quality of life of post stroke patients as they are more dependent on the unaffected upper limb to carry out the functions and activities of daily living. Proper emphasis should be taken to prevent these secondary injuries. To prevent these secondary injuries, while walking with a cane the wrist should be in a neutral position. The length of a stick must be adjusted properly to prevent overload on the upper extremity and to lower the energy cost of walking. The shape of a handle for grip must be designed to avoid excessive compression to the palm and forearm.

The stick user post stroke patients should be examined for peripheral neuropathy by regular interval to see the effect of use of this assistive device. Conservative management in the form of conventional physiotherapy should be started as early as possible to prevent these injuries. Protective splints or gloved pads while using stick should be advised according to the patient's need.

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