Egyptian Journal of
Physical
Therapy (EJPT)

Egy. J. Phys. Ther. 2023; 14:29-34

Original article

https://ejpt.journals.ekb.eg

Changes in Median Nerve Excursion with Neurodynamic Techniques in Patients with Carpal Tunnel Syndrome and Healthy Adults: Influencing Factors

Hanaa Farghaly [1*], Hebatallah Rashed [2], Hanan Elgendy [3], Alyaa Mohamed[1]

[1] *Physical Therapy department for Neurology, Faculty of Physical Therapy, Cairo University, Giza, Egypt.*
[2] *Departement of Neurology, Ain Shams University, Egypt.*
[3] *Physical Therapy department for Neurology, Faculty of Physical Therapy, Cairo University, Giza, Egypt.*

***Correspondence to**
Hanaa Farghaly, Physical Therapy department for Neurology, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
Tel: 01097137499
Email:
Hanoonmahmoud118@hotmail.com

Abstract:

Background: Neurodynamic techniques are used for nerve entrapment rehabilitation, these techniques have a direct effect on median nerve excursion in patients with carpal tunnel syndrome and healthy adults. This narrative review clarifies how changes in upper limb positions and movements can change median nerve excursion magnitude and direction.

Aim of work: to determine the best neurodynamic techniques which increase median nerve excursion magnitude and detect the least effective ones and obtain how these techniques affect the excursion direction.

Methods: Google Scholar and PubMed were searched in English and utilized these Keywords: Carpal tunnel syndrome, Neurodynamic techniques, neural mobilization, median nerve excursion.

Results: 12 studies (systematic review, case-control, cross-sectional) studies were included in this review.

Conclusion: Median nerve excursion is influenced by upper limb and neck movements distally or proximally according to the moving joints and direction of movements. Wrist extension and full fist had the greatest effect on median nerve excursion, and MCP joint flexion had the least median nerve excursion.

Key Words: Carpal tunnel syndrome, Neurodynamic techniques, neural mobilization, median nerve excursion.

1.Introduction:

Carpal tunnel is the anatomic space that is located dorsal to the flexor retinaculum of the wrist. It is bounded medially by the pisiform and the hook of hamate bones and laterally by the scaphoid and trapezium tuberosities. It contains the flexor tendons, vessels, and nerves as they enter the hand (1). The median nerve runs dorsal to the flexor retinaculum through the carpal tunnel. It has a mean width of 6 millimeters (mm), which decreases from proximal to distal by 2.1-1.9 mm. Further, the nerve flattens out as it runs toward the palmar space of the hand. As the median nerve lies between the flexor retinaculum and tendons of the flexor digitorum superficialis muscle, the change in space between these structures affects its diameter (1). Specifically, the median nerve flattens out during wrist flexion as this space

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decreases and expands when the wrist is extended as the space increases (1).

This is also true regarding finger flexion and extension movements (2).

During movement, nerve function is influenced by its structure and relation to its neighboring tissues (3). For example, the magnitude of median nerve movement is dependent on the direction of the moving joint (4), and tensile stress elongates or glides the nerve in its bed (5). Longitudinal median nerve excursion is a mechanical description of nerve sliding movement relative to the adjacent tissues (6). This movement can be captured by real-time ultrasonography (US) and further quantified by video analysis (7). It can be quantified by measuring the difference in pixel gray levels between selected regions of sequenced images using US imaging analysis (8).

During various movements, the nerve is subjected to various physical forces or stresses (3); which direct tissue adaptive response based on the region where forces are applied and whether the nerve structure is normal or pathological (9). One of the most common nerve pathologies in this region is carpal tunnel syndrome (CTS), which is a compressive neuropathy of the median nerve at the level of the wrist. It is characterized by pain, numbness, and weakness of the lateral three and a half fingers of the hand (10).

A few reviews investigated changes in nerve excursion associated with CTS. Evidence supports that median nerve excursion magnitude is reduced in CTS patients compared with asymptomatic participants (11). Numerous manual techniques may restore or even increase neural mobility. Among these is the neurodynamic techniques. These procedures have shown to be superior compared to other manual techniques and exercises in enhancing nerve function, the strength of innervated musculatures, as well as in decreasing neuropathic pain (12).

For example, Silva and her colleagues (2014) emphasized the relationship between neural mobilization exercises, joint movement position, lesion proximity, range of motion (ROM) as well as nerve lesion location from the moving joint, the number, and positioning of the adjacent moving joints and effect of moving joints on sliding the nerve bed had an impact on increasing median nerve excursion (13). Specifically, neural tissue mobilization techniques showed evidence of significantly improving symptoms, restoring function, and decreasing pain in patients with mild and moderate CTS (14). However, how these techniques affect the magnitude of median nerve excursion in specific is not clear. Further, how joint position and movement direction influence nerve excursion magnitude needs further critical review.

As existing evidence supports neural mobilization techniques, efficacy is inconsistent, due to varying methodological quality (15), there is a need for high-quality research to establish the effectiveness of neural gliding techniques (16). This is particularly important to guide treatment selection, especially for different CTS severity (17). Therefore, this study critically reviews relevant literature that investigated the effects of neurodynamic mobilization techniques on longitudinal median nerve excursion during different joint movements and positions in asymptomatic participants and patients with CTS.

2. Literature Search:

An English literature search was conducted in Google Scholar and PubMed using the following keywords: “Carpal tunnel syndrome, median nerve excursion, neurodynamic techniques, neural mobilization”. Cross-sectional studies, randomized clinical trials, and comparative and systematic reviews were included whether the testing was performed on humans or cadavers.

Twelve studies that used the US to assess nerve excursion were found eligible for this review, one systematic review (13), two case-control studies (18,19), and nine cross-sectional studies (4,7,20–26) (table 1 supplementary). Among these 12 clinical studies, two studies were conducted on cadavers (20,21), and the remaining ten enrolled participants with or without CTS. Specifically, five studies were conducted on asymptomatic participants (4,7,22–24), three studies on patients with CTS and asymptomatic participants (18,19,25), and one study on asymptomatic participants, wheelchair users, and patients with cumulative trauma disorders (CTD) (26). Measurement sites varied among studies and included the wrist (19,20,25,26), wrist and forearm (23), wrist and arm (24), distal forearm (18,21), and proximal forearm (22), forearm and arm (4), and elbow and neck (7).

Median excursions ranged between 0.0037 mm (25) to 56.5 mm (26). The greatest excursion was associated with wrist extension and full fist closure (26), while the lowest excursion was associated with metacarpophalangeal (MCP) joint flexion and extension of distal and proximal interphalangeal (IP) joints in patients with CTS (25).

Following is a brief description of the twelve reviewed studies. These methods and results of reviewed articles are further summarized in (**tables 1 & 2 supplementary**).

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2.1. Studies conducted on human participants

Dilley and colleagues (2003) examined median nerve excursion at the forearm and arm in 34 asymptomatic participants during combined movements of the wrist, elbow, shoulder, and neck joints at different angles. They described that the median nerve moved distally when the wrist and elbow were extended. They explained this movement as a coping response to maintain intraneural blood supply and nerve conduction (4).

Erel and colleagues (2003) measured the longitudinal median nerve sliding associated with MCP joint movements in 17 patients with CTS and 19 asymptomatic control participants. They reported normal sliding of the median nerve in the wrist of the CTS patients. Median nerve sled distally as the MCP joints extended from 90º flexion to neutral, whereas the nerve moved proximally during flexion in all participants (18).

Hough and his peers (2007) quantified median nerve excursion in 19 patients with CTS and 37 asymptomatic participants during thumb and fingers extension. They reported reduced median nerve excursion in CTS patients compared to asymptomatic participants. Further, nerve excursion was greater when the elbow was flexed with the fingers and thumb extended (19).

Echigo and his colleagues (2008) compared median nerve longitudinal excursion at the forearm of 34 asymptomatic participants during forearm supination and pronation during elbow flexion and extension as well as during passive wrist and active fingers extension. They concluded that forearm supination was associated with the greatest distal median nerve excursion, whereas active fingers motion (Hook and Grasp) produced the greatest proximal median nerve excursion (22).

Coppieters and his team (2009) measured median nerve excursion at the elbow and neck in 15 asymptomatic participants during different nerve gliding exercises. They found that exercises that moved adjacent joints may intensely facilitate or limit the longitudinal nerve excursion magnitude. They concluded that elbow movement increases the median nerve excursion more than cervical movement (7).

Lopes and his colleagues (2011) measured median nerve excursion at the wrist during wrist and fingers motions of 16 asymptomatic participants and six subjects with CTD. They found that median nerve excursion is dependent on the angle of joint position. Specifically, the largest excursion was associated with wrist extension with full fist movement whereas the least excursion occurred during MCP joint flexion (26).

Brochwicz and colleagues (2013) measured longitudinal median nerve excursion at the forearms and wrists of 27 asymptomatic participants during neurodynamic techniques that included cervical lateral glide (CLG) and cervical lateral flexion (CLF). All tested movements affected longitudinal median nerve movement, CLG had a statistically significantly greater excursion compared to CLF (23).

Gonzalezsuarez and his co-workers (2016) measured median nerve longitudinal excursion at the wrist and arm of 20 asymptomatic participants to investigate the effect of wrist extension and cervical ipsilateral (ICLF) and cervical contralateral lateral flexion (CCLF). They concluded that the median nerve's highest excursion, regardless of CLF direction, occurred in the arm and the wrist when the wrist extension is the terminal movement in the neural mobilization technique whereas CCLF movement was associated with the least excursion when the wrist was positioned in extension (24).

Yao and his colleagues (2020) evaluated median nerve excursion at the wrist of 11 asymptomatic participants and 11 CTS patients during finger flexion from neutral to 90º flexion. They concluded that median nerve proximal excursion is directly proportional to increasing finger flexion angles (25).

2.2. Cadaveric studies

Meng and his colleagues (2015) measured median nerve longitudinal excursion at the wrist of 18 upper extremities from fresh cadavers while adding fingers movement to conventional nerve gliding techniques. They found that adding fingers adduction and abduction to conventional nerve gliding techniques resulted in greater excursion than applying conventional nerve gliding exercise alone (20).

Bueno-Gracia and his co-workers (2020) compared median nerve excursion measured in nine upper extremities from cadavers at the distal forearm while adding CCLF to upper limb neurodynamic test 1 (ULNT1) during different elbow flexion angles. These added movements applied at various elbow flexion angles created greater proximal median nerve excursion at the wrist when the elbow was bent to 30º of flexion, whereas no excursion was measured during 90º elbow flexion (21).

2.3. Systematic review

Silva and her colleagues (2014) reviewed eight studies that quantified median nerve excursion using the US during neural mobilization exercise. They concluded that the magnitude of nerve excursion is dependent upon moving joint range, distance from the moving joint to the site of the lesion, position of adjacent joints, number of moving joints, and whether joint movement the nerve bed (13).

3. Discussion:

This review summarizes median excursion values and influencing factors as reported in clinical trials, experimental studies, and systematic reviews. Median nerve excursion is dependent on the range of moving joints, the distance between joint and lesion site and the number of moving joints (13), the position of adjacent joints (13,19), and the number of joints involved in executing motion (7,13).

The reviewed studies showed that the median nerve may move proximally or distally based on joint movement direction (18). For example, CCLF and shoulder abduction at arm measurements (21), full finger fist (22), and finger flexion (25) were associated with increased proximal longitudinal median nerve excursion. On the other hand, distal nerve excursion increased in association with wrist and elbow extension at the forearm (4), and forearm supination (22).

This implies that the effect of neurodynamic movements on median nerve excursion is dependent on the position of adjacent moving joints. For example, the increased median distal excursion was associated with MCP joints extension (18), fingers and thumb extension (19), abduction and adduction (20), and wrist extension (4,19,26).

Median nerve proximally excursion was associated with MCP joints flexion (18,25) and wrist flexion (4).

Fingers and wrist extension were associated with a greater excursion magnitude (24). This may be explained by the proximity of these joints to the carpal tunnel, and the ability of the wrist and fingers joints to freely move distally, thus nerve slide movement-compensation may occur distal to the site of compression *(6)*. Moreover, wrist extension increased median nerve excursion magnitude even when fingers were full-fisted compared with low excursion magnitude during just MCP joints flexion (26).

Increased excursion magnitude was not limited to sagittal direction movements, but also fingers abduction and adduction when added to conventional nerve gliding exercises, (20). Increased fingers flexion had a direct proportion to increasing the median nerve excursion magnitude (25). Thus, may explain as the wrist and fingers are terminal parts of the upper limb and have freely unrestricted movements distal to the carpal tunnel as an isolated motion which increased the opportunity for the median nerve to move more easily.

Elbow movements have a converse effect on median nerve excursion, it can increase median nerve excursion magnitude and affect the neurodynamic techniques as it slides the median nerve in its bed at the elbow during extension movement. Further, during combined joints movements including elbow joint increased median nerve excursion magnitude (7), which could be attributed to sliding the nerve at multiple locations. Thus, including the extension of the elbow joint during neurodynamic mobilization may be recommended to increase the excursion (19).

On the other hand, supination increased median nerve excursion more than pronation regardless of elbow flexion or extension position. This may be attributed to nerve movement restriction by pronator teres muscle during pronation (22), additionally, combined joints movements increased median nerve excursion regardless of elbow joint movements (4,7,19,22). This may be attributed to the free movement and slaking of the median nerve and long distance from the wrist during multiple joints movements.

The effect of cervical movements on median nerve excursion has a low magnitude, which could be due to the neck being the proximal part and the long distance from carpal tunnel and neck musculature tension which restrict the median nerve free movements. This was apparent during CCLF (24), both the CCLF and ICLF (7). CCLF created proximal excursion(7,24) and ICLF created distal excursion (24), thus leading the role of median nerve excursion direction following joints movements direction. Moreover, CLG had a larger effect on median nerve excursion than CLF (23) The difference in excursion may be explained by gliding neck joints that could increase median nerve excursion than stretching the neck muscles which restrict median nerve excursion.

3.1. Limitations

This narrative review included studies of different designs without considering the quality and/or risk of bias. It also included only two databases. No quantitative analysis was attempted. Further, included papers reported data from patients with various CTS severity, asymptomatic participants, and cadavers which may have influenced the amount of the excursion measured.

However, it should be emphasized that this review's aims are not to draw conclusive evidence but rather to map available studies that measured longitudinal median nerve excursion to identify gaps in knowledge and to guide further research studies.

3.2. Clinical implication:

Single or compound movements of different upper limb joints, different joint ROM, and adjacent joints positioning can generate different amounts of median nerve excursion. the largest impact moving joints are preferred to be used during neurodynamic mobilization techniques.

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4. Conclusion:

Median nerve excursion influenced by upper limb and neck movements distally or proximally according to the moving joints and direction of movements. Wrist extension and full fist had the greatest effect on median nerve excursion, and MCP joints flexion had the least median nerve excursion.

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Acknowledgments

I would like to express my gratitude to Professor Dr. Alyaa my research supervisor for her patient guidance, energetic encouragement, her knowledge and exacting attention to detail have been an inspiration and kept my work on track from the first beginning of my research work.

I should also thank Professor DR. Heba for her advice and encouragement, and professor Dr. Hanan for her support.

Finally, I wish I can gratefully thank my family for their support and for their belief in me.

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