MRI Assessment of Changes in Swelling of Wrist Structures Following OMT in Patients With Carpal Tunnel Syndrome

Kenneth A. Ramey, DO; Robert E. Kappler, DO, FAAO; Murthy Chimata, MD; John Hohner, DO; and Angelique C. Mizera, DO

FROM THE ARCHIVES

Abstract

We treated patients with carpal tunnel syndrome using OMT. Treatments were focused on the upper thoracic spine, lower cervical spine, and tenderpoints in the forearm muscles. OMT was not applied to the wrist in an attempt to stretch the transverse carpal ligament. MRI images were used to assess changes in fluid content in both the carpal tunnel and median nerve after OMT treatment. MRI measurements of median nerve area, carpal tunnel area and length of the transverse carpal ligament were also obtained. These measurements were correlated with changes in nerve conduction velocities (NCVs), pain ratings, wrist motion measurements, and somatic dysfunction information. The numeric data were compared and contrasted using Hest statistics. Significance probabilities of $P < 0.05$ were computed. Statistically significant changes were noted in pain ratings, wrist motions and nerve conduction (sensory amplitude). Five patients responded with improvement in symptoms and one did not. The responder group demonstrated a decrease in the amount of swelling of both the median nerve and carpal tunnel. The nonresponder demonstrated increased swelling in both the median nerve and carpal tunnel. Changes in the swelling of both the median nerve and carpal tunnel appear to more closely parallel changes in hand symptoms than nerve conduction results.[1] No statistically significant increases occurred in the length of the transverse carpal ligament or the carpal tunnel area. Minimal changes in both the length of the transverse carpal ligament and carpal tunnel area did occur despite no active attempts to stretch this region. All six patients had a predominance of acute changes in the upper thoracic spine and upper ribs. Most patients had tension in the flexor muscles of the forearm. Treatment of the upper thoracic spine, upper ribs, and forearms are all important in the management of carpal tunnel syndrome.

Methods

Seven patients were identified as having clinical signs and symptoms of carpal tunnel syndrome. Patients excluded from the study include those with rheumatoid arthritis, osteoarthritis, Paget's bone disease, gout, myxedema, multiple myeloma, acromegaly, current pregnancy, evidence of motor atrophy of the hands, diabetes, dialysis patients with A/V shunts, prior wrist fracture, hepatic disease, IV drug abuse, prior carpal tunnel release surgery, patients with impending litigation suits, and workman's compensation cases. The institutional review board approved the project. Written informed consent was obtained from each patient.

The following nerve conduction criteria were used to confirm the diagnosis of carpal tunnel syndrome: median nerve motor latency (MML) (8 cm) > 4.0 ms or median nerve sensory latency (MSL) (14 cm) > 3.7 ms or median nerve sensory velocity (MSV) (l4 cm) < 50 M/S.[2] Bilateral carpal tunnel MRIs were obtained on each patient.

Pretreatment pain and distress scales,[3] hand pain analog scales, and wrist motion measurements were obtained on each patient. Each patient underwent six OMT treatments. Each of the first four treat-

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Editor's note: Robert E. Kappler, DO, FAAODist, FCA, the AAO's 1980-81 president, died on Oct. 18. After graduating from the Chicago College of Osteopathic Medicine in 1958, Dr. Kappler spent his career on CCOM's faculty. He was instrumental in developing the Educational Council on Osteopathic Principles, a national group of OMM department chairs who meet to discuss ideas pertaining to the teaching of osteopathic principles and practices, and he established the undergraduate OMM fellow program. In addition, Dr. Kappler was a prolific writer, and he served on the editorial boards of *The Journal of the American Osteopathic Association, Osteopathic Physician,* and *Patient Care Magazine*. Read more about Dr. Kappler in the November issue of *AAO Member News*.

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ments were separated by a one-week interval. Each of the last two treatments were separated by a two-week interval. Treatments were focused on the upper thoracic spine, lower cervical spine and tender points in the forearm muscles. *OMT was not applied to the wrist in an attempt to stretch the transverse carpal ligament.* After the six treatments, the pain and distress scales, hand pain analog scales, wrist motion measurements, nerve conduction studies, and MRIs were repeated. One patient dropped out of the study after failing to keep several scheduled appointments due to work conflicts.

Analysis: Bilateral carpal tunnel MRIs were obtained on each patient. T2-weighted axial images were assessed using General Electric's image analysis software. The hydration of the carpal tunnel was assessed by generating a line plot between the distal aspect of the hook of the hamate and the base of the trapezium. The computer will graph the pixel intensity of every structure along the line. The pixel intensity correlates with the level of hydration. A higher pixel intensity correlates with a higher level of hydration while a lower pixel intensity correlates with a lower level of hydration. If the cursor is moved along the line plot, the computer will generate the pixel intensity every 0.4 mm. The hydration of the structures located in the entire tunnel can be obtained by averaging the pixel intensities generated between the hook of the hamate and the base of the trapezium. The hydration of the carpal tunnel only (entire tunnel with median nerve removed) can be obtained by removing the pixel intensities for the median nerve when calculating the mean pixel intensity for the entire tunnel.

The hydration of the median nerve can be assessed by using the region of interest software. A 1.0 cm pixel box was placed around the median nerve. This function generates the mean and standard deviation for 121 separate pixel points within the box *(See Figure 2)*.

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Figure 1. *MRI of the distal carpal tunnel. A line plot is generated between the hook of the hamate and the base of the trapezium. The computer generates the pixel intensity for every structure along the line. The cursor (long vertical line through center of median nerve) is positioned to obtain the pixel intensity every 0.4 mm along the line. Note the pixel intensity of 312 generated through the center of the median nerve.*

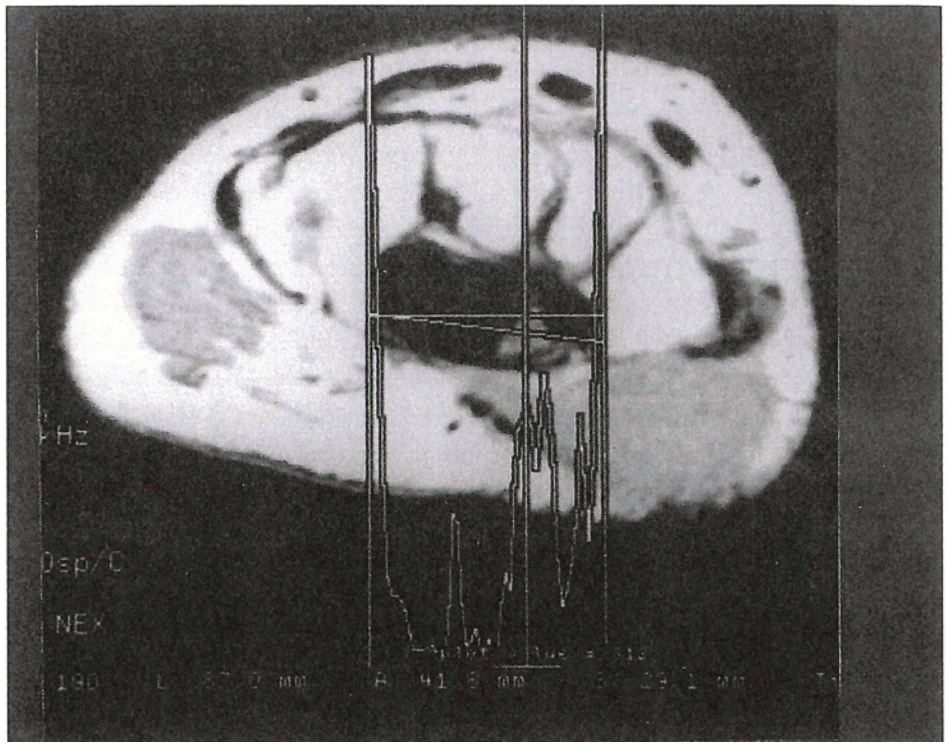


Figure 2. *A 1.0 cm pixel box is placed around the median nerve. The computer generates the mean and standard deviation for 121 separate pixel points within the pixel box.*

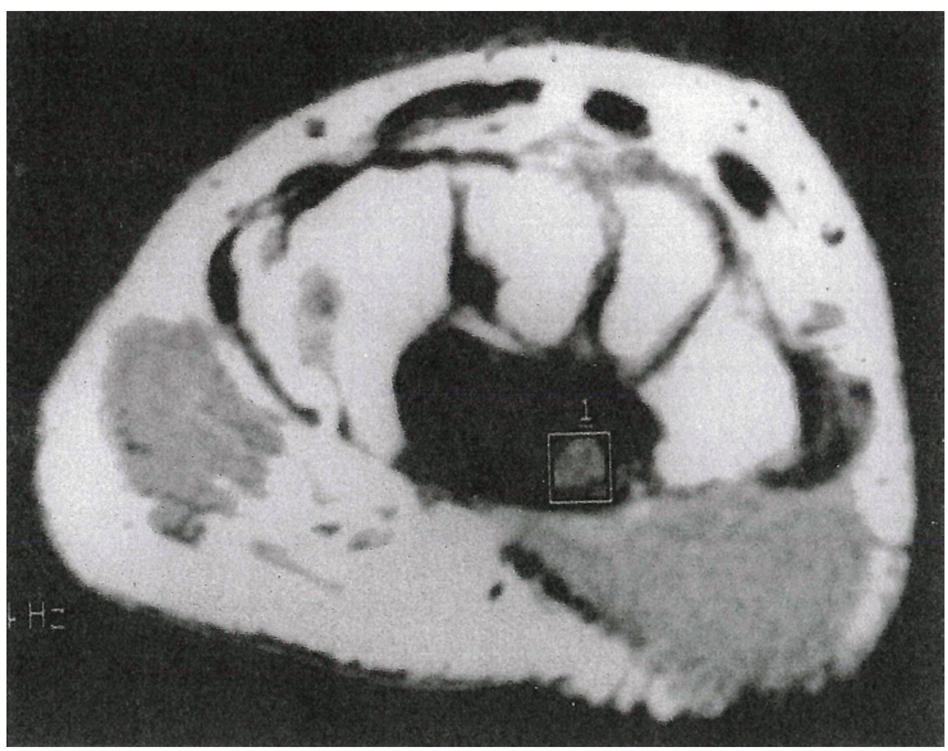
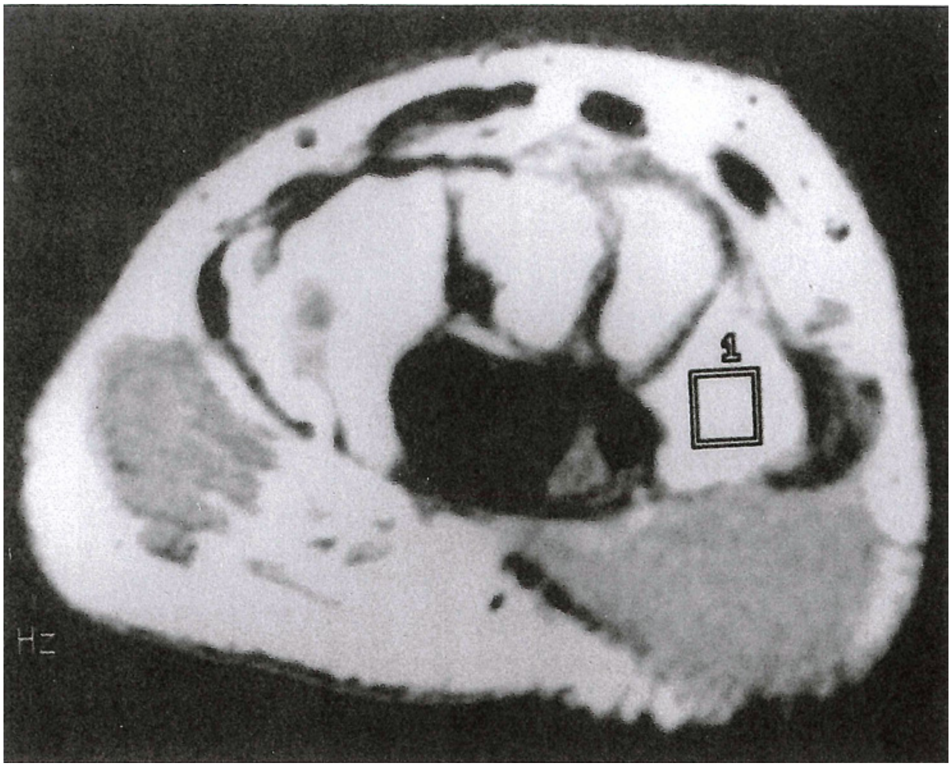


Figure 3. *A 1.0 cm pixel box is placed over the trapezium. The computer generates the mean and standard deviation for 121 separate pixel points within the pixel box. The pretreatment pixel intensity of the trapezium is chosen as the standard. All posttreatment pixel measurements are adjusted based on the pretreatment trapezium pixel intensity.*



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The pretreatment and posttreatment MRI images require standardization because the overall pixel intensity of the picture can vary depending on where the controls on the console are set. This standardization necessitates the identification of a structure that has a relatively consistent pixel intensity pre- and posttreatment. The trapezium was chosen for this purpose. Pretreatment and posttreatment pixel intensities of the trapezium were obtained *(See Figure 3)*. The pretreatment measurement of the trapezium's pixel intensity was chosen as the standard. The posttreatment values for each individual patient were adjusted by a factor that would make the posttreatment pixel intensity of the trapezium consistent with the pretreatment value.

The cross-sectional area of the median nerve, the cross-sectional area of the carpal tunnel, and the length of the transverse carpal ligament were obtained at the distal portion of the carpal tunnel (narrowest region and most likely site of compression).

The numerical data obtained from the MRI images, pain ratings, wrist measurements, nerve conduction studies, and osteopathic structural examinations were compared and contrasted statistically using the SPSS PC+ for WINDOWS program. This program employs Student's t-test statistics. Significance probabilities of $P < 0.05$ were computed.

Results

Five patients (cases 1-5) responded with improvement in symptoms, and one did not (case 6). Statistically significant changes were noted in pain ratings, wrist motions, and nerve conduction findings (sensory amplitude). Changes were also noted in pain and distress scale ratings, median nerve hydration and carpal tunnel area. The data and statistics are listed in *Tables 1-4*.

Discussion

Statistically significant changes were noted in pain ratings *(Chart 1)*, wrist motions *(Chart 2)*, and nerve conduction findings (sensory amplitude) *(Chart 3)*. Changes were also noted in pain and distress scale ratings *(Chart 4)*, median nerve hydration *(Chart 5)*, carpal tunnel hydration *(Chart 6)*, median nerve area, and carpal tunnel area.

Overall, five patients responded with improvement in symptoms (past week pain ratings) and one did not. The responder group demonstrated a decrease in the amount of swelling of both the median nerve and carpal tunnel. The nonresponder demonstrated increased swelling in both the median nerve and carpal tunnel. The nonresponder group did demonstrate improvement in pain and distress scale ratings and wrist motion measurements.

Changes in the hydration (swelling) of the median nerve and carpal tunnel appeared to more closely parallel changes in patient hand symptoms than nerve conduction studies. In the responder group, the amount of swelling in both the median nerve and carpal tunnel decreased; the nerve conduction findings improved, as did the hand symptoms. In the nonresponder group the amount of swelling in both the median nerve and the carpal tunnel increased; although the nerve conduction studies improved, the hand symptoms worsened. Perhaps more investigation in this area is warranted.

Changes in hydration in the carpal tunnel were two to nine times greater than in the median nerve. For years, the medical establishment has been dwelling on the point that there is not enough room underneath the transverse carpal ligament. The median nerve becomes compressed, ultimately leading to hand symptoms and debility.
The question that needs to be addressed is: Why isn't there enough

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room underneath the transverse carpal ligament? This study may indicate that there is increased swelling in both the carpal tunnel and median nerve in patients with carpal tunnel syndrome. OMT effectively reduces this swelling and results in improvements in both nerve conduction parameters and hand symptoms.

What is the role of the sympathetic nervous system in the development of carpal tunnel syndrome? All six patients had a predominance of acute changes in the upper thoracic spine and upper ribs. Cell bodies of preganglionic sympathetic neurons concerned with the upper extremity are located in the upper thoracic spinal cord segments.[6] The smooth musculature in the walls of lymphatic vessels contracts when sympathetic nerves are stimulated. This results in reduction in the size of the lumen, thereby impairing lymphatic drainage.[7] Increased sympathetic tone can close down lymphatic channels and lead to congestion in regions of the body. Upper thoracic dysfunction increases sympathetic tone to the upper extremity and decreases lymphatic drainage. This may lead to the increased swelling observed within the carpal tunnel (and possibly the entire upper extremity) and the subsequent production of symptoms.

Do these findings support the role of the "double crush" in the genesis of carpal tunnel syndrome. The double crush hypothesis proposed by Upton and McComas explains that compression of axons at one location may not impair axoplasmic transport enough to result in denervation changes in their target structures, but if a similar amount of compression is simultaneously applied at a second location, the threshold for denervation effects is exceeded.[8] The median nerve passes deep to the bicipital aponeurosis (the fibrous band connecting the biceps tendon to the forearm fascia). It then passes down between the two heads of the pronator teres and through the

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Table 1. *Changes in pixel intensity of the median nerve, and carpal tunnel (with median nerve removed). The t-test statistics were performed on the mean pretreatment and posttreatment values for cases 1-5.*

Case No.	Median Nerve Intensity (mean)		Tunnel Intensity (mean)	
* = symptomatic hand	Pretreatment	Posttreatment	Pretreatment	Posttreatment
Case 1 Right*	295.1	263.1	34.0	120.0
Case 1 Left	286.7	267.9	78.0	63.8
Case 2 Right*	274.4	221.5	192.0	20.0
Case 2 Left*	278.4	222.7	87.0	1.0
Case 3 Right*	225.6	245.2	172.0	81.0
Case 3 Left*	248.6	235.0	112.0	19.0
Case 4 Right*	257.1	256.3	109.0	139.0
Case 4 Left*	251.8	222.8	125.0	113.0
Case 5 Right	317.8	287.2	103.0	153.0
Case 5 Left*	336.6	360.6	159.0	161.0
Right mean SD	274.0 31.6	254.6 21.5	122.0 56.0	102.6 47.9
Left mean SD	280.4 31.7	261.8 52.1	112.2 28.8	71.6 59.2
Case 1-5 mean SD	277.2 33.5	258.2 42.2	117.1 47.2	87.1 59.1
2-tail t-test sig	0.280		0.225	
Case 6 Right*	207.9	227.9	18.0	24.0
Case 6 Left*	160.6	171.4	29.0	43.0
Case 6 mean SD	184.3 23.6	199.6 28.2	13.5 4.5	33.5 9.5

Table 2. *Distal Carpal Tunnel Anatomic Measurements. The t-test statistics were performed on the mean pretreatment and posttreatment values for cases 1-5.*

Case No.	Median Nerve Area (mm^2)		Carpal Tunnel Area (mm^2)		Transverse Carpal Ligament Length (mm)	
* = symptomatic hand	Pretx	Posttx.	Pretx.	Posttx.	Pretx.	Posttx.
Case 1 Right*	20.0	8.0	416.0	207.0	27.0	25.0
Case 1 Left	12.0	10.0	X	X	X	X
Case 2 Right*	X	X	230.0	171.0	22.0	20.0
Case 2 Left*	X	X	180.0	170.0	18.0	18.0
Case 3 Right*	6.0	4.0	264.0	240.0	21.0	21.0
Case 3 Left*	8.0	10.0	264.0	240.0	19.0	20.0
Case 4 Right*	15.0	24.0	231.0	220.0	21.0	22.0
Case 4 Left*	X	X	253.0	220.0	20.0	22.0
Case 5 Right	6.0	15.0	207.0	220.0	24.0	22.0
Case 5 Left*	15.0	15.0	220.0	220.0	23.0	24.0
Right mean SD	11.8 6.0	12.8 7.6	269.6 75.4	211.6 22.9	23.0 2.3	22.0 1.7
Left mean SD	11.7 2.9	11.7 2.4	229.3 32.7	212.5 25.9	20.0 1.9	21.0 2.2
Case 1-5 mean SD	11.7 5.3	12.3 6.4	251.7 67.4	212.0 25.7	21.6 2.7	21.6 2.1
2-tail t-test sig	0.859		0.119		0.925	
Case 6 Right*	10.0	4.0	231.0	220.0	23.0	22.0
Case 6 Left*	10.0	10.0	230.0	207.0	23.0	24.0
Case 6 mean SD	10.0 0.0	7.0 3.0	230.5 0.5	213.5 6.5	23.0 0.0	23.0 1.0

Table 3. *Individual Pain and Distress (PAD) Scale ratings, past week analog pain ratings, and wrist range of motion (ROM) measurements. The t-test statistics were performed on the mean pretreatment and posttreatment values for cases 1-5.*

Case No.	PAD Scale		Past week Pain		Wrist ROM	
* = symptomatic hand	Pretx.	Posttx.	Pretx.	Posttx.	Pretx.	Posttx.
Case 1 Right*	46.0	38.0	3.0	2.0	133.0	147.0
Case 1 Left	X	X	1.0	1.0	140.0	167.0
Case 2 Right*	37.0	36.0	4.0	2.0	110.0	119.0
Case 2 Left*	X	X	4.0	3.0	107.0	118.0
Case 3 Right*	36.0	32.0	8.0	5.0	92.0	129.0
Case 3 Left*	X	X	8.0	5.0	118.0	133.0
Case 4 Right*	53.0	30.0	10.0	4.0	78.0	112.0
Case 4 Left*	X	X	5.0	2.0	120.0	125.0
Case 5 Right	46.0	46.0	1.0	0.0	120.0	128.0
Case 5 Left*	X	X	10.0	2.0	104.0	112.0
Right mean SD	43.6 6.3	36.4 5.6	5.2 3.3	2.6 1.7	106.6 19.6	127.0 11.8
Left mean SD	X	X	5.6 3.1	2.6 1.4	117.8 12.7	131.0 19.3
Case 1-5 mean SD	43.6 6.3	36.4 5.6	5.4 3.4	2.6 1.6	112.2 18.4	129.0 17.0
2-tail t-test sig	0.126		0.031		0.048	
Case 6 Right*	58.0	44.0	8.0	9.0	115.0	125.0
Case 6 Left*	X	X	8.0	10.0	105.0	112.0
Case 6 mean SD	58.0 X	44.0 X	8.0 0.0	9.5 0.5	110.0 5.0	118.5 6.5

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fibrous arch formed by the flexor digitorum superficialis.[9] Most of the patients in this study had tension in the flexor muscles of the forearm. It is possible that increased tension in the flexor muscles of the forearm is providing one part of the compression and making the median nerve more susceptible to compression distally. The increased swelling observed within the carpal tunnel may be providing the second portion of the compression, thereby leading to the production of carpal tunnel syndrome. Additional areas where the brachial plexus may become compressed include the interscalene triangle, the space between the clavicle and the first rib, and underneath the pectoralis minor muscle.

No statistically significant increases occurred in the length of the transverse carpal ligament or the carpal tunnel area. Minimal changes in both the length of the transverse carpal ligament and carpal tunnel area did occur despite no active attempts to stretch this region. Changes in the length of the transverse carpal

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Table 4. *Nerve conduction examinations (median nerve).*

Case No.	Motor Latency (ms)		Motor Amplitude		Sensory Latency (ms)		Sensory Amplitude		Sensory Velocity (M/S)	
* = symptomatic hand	Pretx.	Posttx.	Pretx.	Posttx.	Pretx.	Posttx.	Pretx.	Posttx.	Pretx.	Posttx.
Case 1 Right*	5.8	4.6	5.0	11.0	5.2	4.9	10.0	14.0	26.9	28.6
Case 1 Left	3.7	3.9	8.0	11.0	3.9	3.7	18.0	34.0	35.9	37.8
Case 2 Right*	X	X	X	X	X	X	X	X	X	X
Case 2 Left*	X	X	X	X	X	X	X	X	X	X
Case 3 Right*	5.2	4.7	9.0	7.0	4.6	4.6	10.0	20.0	30.4	30.4
Case 3 Left*	5.3	5.3	7.0	8.0	5.3	5.5	8.0	12.0	26.4	25.5
Case 4 Right*	X	X	X	X	X	X	X	X	X	X
Case 4 Left*	X	X	X	X	X	X	X	X	X	X
Case 5 Right	X	X	X	X	3.4	3.5	15.0	37.0	41.2	40.0
Case 5 Left*	5.9	4.5	7.0	8.0	5.1	3.5	9.0	21.0	27.5	40.0
Right mean SD	5.5 0.3	4.6 0.1	7.0 2.0	9.0 2.0	4.4 0.7	4.3 0.6	11.7 2.4	23.7 9.7	32.8 6.1	33.0 5.0
Left mean SD	5.0 0.9	4.6 0.6	7.3 0.5	9.0 1.4	4.8 0.6	4.2 0.9	11.7 4.5	22.3 9.0	29.9 4.2	34.4 6.4
Case 1-5 mean SD	5.2 0.9	4.6 0.5	7.2 1.5	9.0 1.5	4.6 0.8	4.3 0.8	11.7 3.9	23.0 10.3	31.4 6.0	33.7 6.3
2-tail t-test sig	0.236		0.130		0.535		0.031		0.526	
Case 6 Right*	4.1	3.9	9.0	10.0	3.8	3.2	50.0	52.0	36.8	43.8
Case 6 Left*	4.1	3.9	12.0	13.0	3.6	3.0	45.0	64.0	38.9	46.7
Case 6 mean SD	4.1 0.0	3.9 0.0	10.5 1.5	11.5 1.5	3.7 0.1	3.1 0.1	47.5 2.5	58.0 6.0	37.8 1.1	45.2 1.4

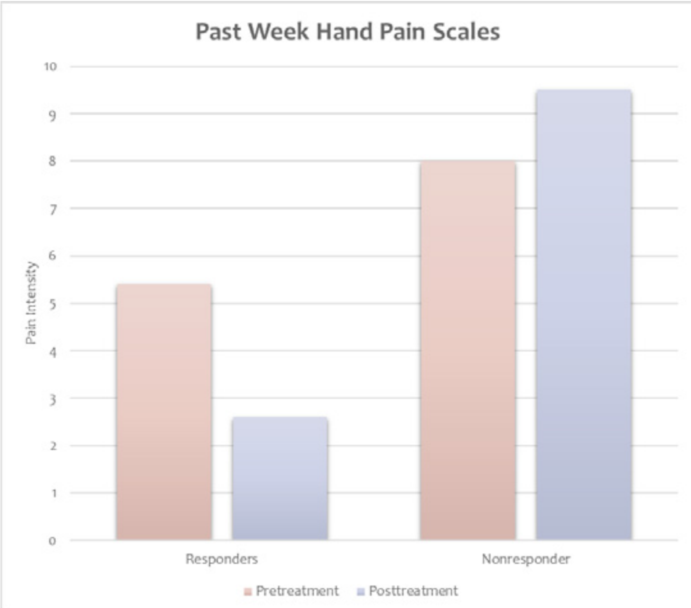

Chart 1. *Comparison of the changes in the past week hand pain analog scales for the responder group and the nonresponder (0=no pain, 10=unbearable pain).*

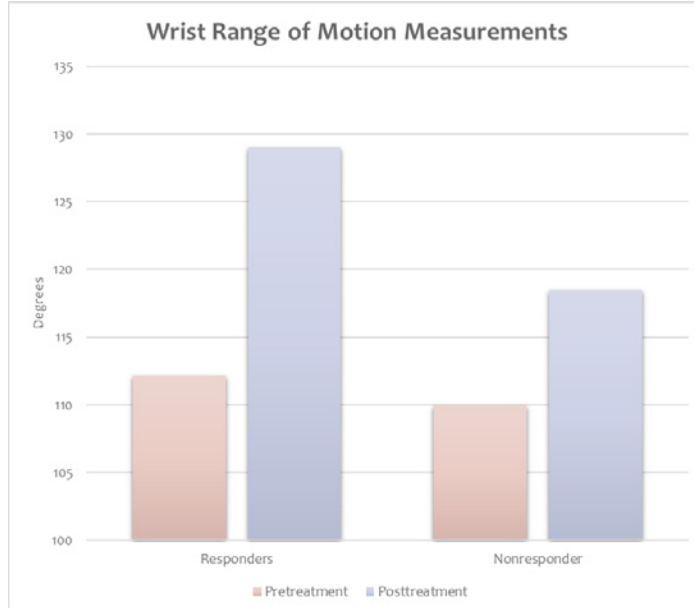

Chart 2. *Comparison of the changes in wrist motion measurements (combination flexion and extension) for the responder group and non-responder.*

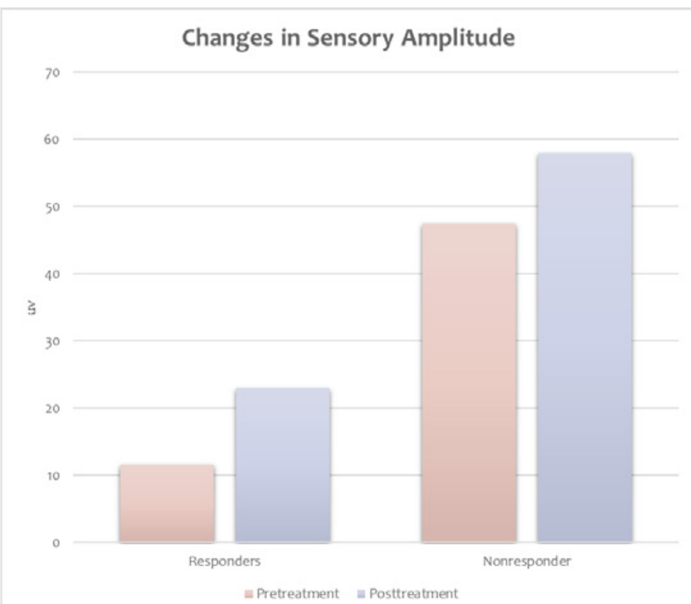

Chart 3. *Comparison of the changes in the sensory amplitude of the median nerve for the responder group and nonresponder.*

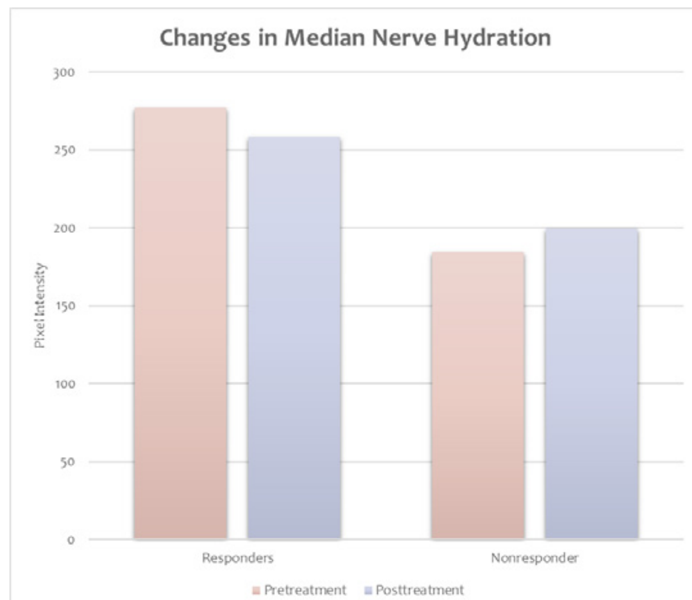

Chart 5. *Comparison of the changes in the hydration (swelling) of the median nerve for the responder group and the nonresponder.*

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ligament and cross-sectional area of the carpal tunnel did not conspicuously correlate with changes in the swelling of the median nerve and carpal tunnel, nerve conduction studies and patient symptoms. In the responder group, the transverse carpal ligament increased in length in 44.4% of the limbs, was unchanged in 22.2% of the limbs, and decreased in length in 33.3% of the limbs. In the nonresponder group, the transverse carpal ligament increased in length in one limb and decreased in length in the opposite limb.

Conclusion

OMT is effective in the treatment of carpal tunnel syndrome. OMT results in significant improvements in pain symptoms, wrist motions, and nerve conduction parameters. OMT also results in decreased swelling in both the median nerve and carpal tunnel. Changes in the swelling of both the median nerve and carpal tunnel appear to more closely parallel changes in hand symptoms than

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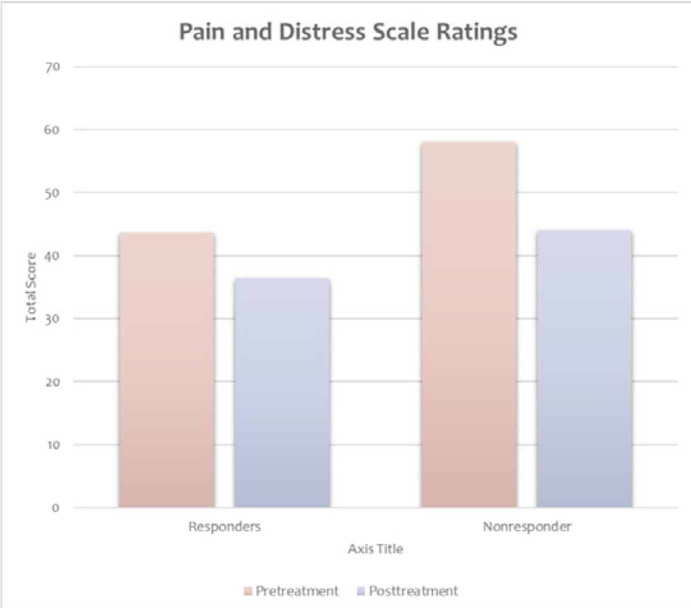

Chart 4. *Comparison of the changes in the pain and distress scale ratings for the responder group and the nonresponder. The scale is scored from 20-60. A higher score correlates with a greater level of disability.*

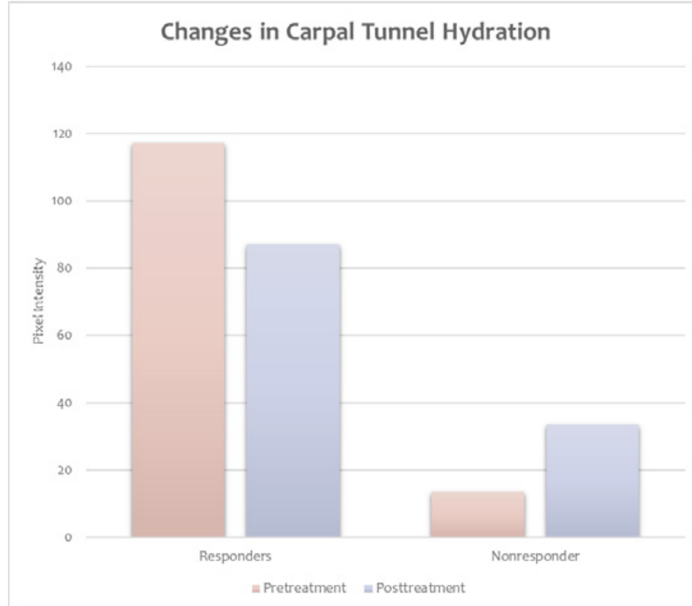

Chart 6. *Comparison of the changes in the hydration (swelling) of the carpal tunnel (with median nerve removed) for the responder group and the nonresponder.*

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with nerve conduction findings. Upper thoracic somatic dysfunction, acting by way of the sympathetic nervous system, may play a role in the development of swelling in the carpal tunnel and the development of carpal tunnel syndrome. Somatic dysfunction involving the forearm flexor muscles may be contributing to the "double crush" and the subsequent production of symptoms. Treatment of the upper thoracic spine, upper ribs, lower cervicals, and release of forearm dysfunctions are all crucial in the treatment of carpal tunnel syndrome.

Acknowledgments

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