ORIGINAL ARTICLE

Radial Nerve Mobilization Decreases Pain Sensitivity and Improves Motor Performance in Patients With Thumb Carpometacarpal Osteoarthritis: A Randomized Controlled Trial

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ABSTRACT. Villafañe JH, Silva GB, Bishop MD, Fernandez-Carnero J. Radial nerve mobilization decreases pain sensitivity and improves motor performance in patients with thumb carpometacarpal osteoarthritis: a randomized controlled trial. Arch Phys Med Rehabil 2012;93:396-403.

Objective: To examine the effects of radial nerve mobilization on pain sensitivity and motor performance in subjects with secondary thumb carpometacarpal osteoarthritis.

Design: Randomized controlled trial. Treatment and placebo were given for 4 weeks. Measurements were taken before intervention, after 1 month (first follow-up), and after 2 months (second follow-up).

Setting: Patients from the Department of Physical Therapy, Azienda Sanitaria Locale 3, Collegno (Italy).

Participants: Participants (N=60; age range, 70–90y) with right-dominant hand secondary thumb carpometacarpal osteoarthritis without other motor-related pathology. All patients completed the study. No patients were withdrawn from the study.

Interventions: Sliding mobilization of the proximal-distal radial nerve or intermittent ultrasound therapy, used as placebo.

Main Outcome Measures: We hypothesized that radial nerve mobilization induces hypoalgesia and increases strength in secondary thumb carpometacarpal osteoarthritis. We measured pressure pain threshold (PPT) at the trapeziometacarpal joint, the tubercle of the scaphoid bone, and the unciform apophysis of the hamate bone by algometry. Tip pinch strength and tripod pinch strength were measured by a mechanical pinch gauge.

Results: Treatment increased PPT by $3.33\pm.24\text{kg/cm}^2$ ($P<.001$) in the trapeziometacarpal joint and was maintained until first follow-up and second follow-up. Also, PPT in the scaphoid bone and hamate bone was increased ($P<.001$ and $P<.02$, respectively). Variables in the placebo group remained unchanged. Tip pinch strength increased by $2.22\pm.22$kg ($P<.04$) and tripod pinch strength by $2.83\pm.24$kg ($P<.019$).

Conclusions: Radial nerve mobilization decreases pain sensitivity in the trapeziometacarpal joint and increases tip pinch strength.

Key Words: Hand strength; Osteoarthritis; Radial nerve; Rehabilitation; Thumb.

THUMB CARPOMETACARPAL osteoarthritis (OA) constitutes a major cause of upper limb–related disability in Europe and the United States. In fact, 30% to 40% of postmenopausal women and 40- to 50-year-old men have this condition.[1,2] Thumb carpometacarpal OA contributes to the largest number of OA-related surgical procedures conducted in the United States.[2,3] The main cause of thumb carpometacarpal OA is the degenerative alteration of the trapeziometacarpal joint. This includes chronic deterioration of superficial surfaces of the joint and ectopic bone regeneration.[3-5] These characteristics of thumb carpometacarpal OA result in increased pain at the base of the thumb.[2,5]

Thumb carpometacarpal OA can be managed using surgical procedures; however, the results usually are only partially successful. Because the trapeziometacarpal joint permits tweezers-like movements for precision grip and is involved in the gripping capabilities of the hand, this joint has a functional importance. In fact, any alteration of its function results in a major cause of chronic sociolabor incapacity.[4,5]

One of most common symptoms for people with OA is pain,[6] and sensitization may contribute to the pain severity. Pain in OA has been related to the local degenerative changes[7,8] (eg, destruction of cartilage, synovial inflammation, and alteration of bone). But the pain intensity does not always correlate with the extent of joint damage or inflammation, raising the possibility that there may be a central component to the pain.[9] In a recent study,[10] 48 patients with knee OA had reduced pressure pain thresholds (PPTs) in both joints, and increased temporal summation when compared with 24 healthy subjects. Reported pain intensity was related to the degree of sensitization but not radiologic findings. Therefore, central sensitization may play an important role in OA pain. Furthermore, recent work[11] has demonstrated that long-term drug therapy with nonsteroidal anti-inflammatory drugs or acetaminophen does not decrease pain to a clinically significant level. Similar results with demonstrated peripheral or central sensitization in knee OA were showed by Farrell et al[12,13] when

List of Abbreviations

ANOVA	analysis of variance
ICC	intraclass correlation coefficient
OA	osteoarthritis
PPT	pressure pain threshold
SEM	standard error of the mean

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mechanical, electrical, and thermal hyperalgesia were identified over the trapeziometacarpal joint of the thumb in patients affected with hand OA.

Neurodynamic techniques are a form of manual therapy directed to the neural structures through positioning and movement of multiple joints.[14] Although there is only limited evidence to support their use in therapeutics, researchers have found small advantages in patients treated by this method[15]—for example, in patients with certain neuropathic conditions[16] and musculoskeletal pain disorders.[17] There are 2 general methods used to apply neurodynamic techniques: sliding and tensioning.[14] Sliding techniques, the focus of this study, consist of alternating combinations of movement of at least 2 joints in which one movement loads the peripheral nerve, thus increasing tension in the nerve, while the other movement simultaneously unloads the nerve, which decreases the tension of the nerve.[18]

Sliding techniques are a very useful way to apply the neurodynamic techniques. In contrast, tensioning techniques that produce strain in the nerve may induce ectopic discharges from mechanosensitive abnormal impulse–generating sites,[19] and sustained elevated intraneural fluid pressure may reduce the intraneural blood flow.[20]

Prior work[21,22] has examined the neurophysiologic effects of this type of neurodynamic intervention in another peripheral wrist disorder, carpal tunnel syndrome. Those studies suggested that neurodynamic interventions result in changes in pain sensitivity.

Consequently, our purpose in this study was to examine the effects of a neurodynamic intervention on pain sensitivity and motor performance in patients with secondary thumb carpometacarpal OA of the dominant hand. Increasing life expectancy will increase the prevalence of this thumb carpometacarpal OA, and the polyanalgesic therapy these patients receive often is ineffective. In addition, complications of surgical interventions are common. Therefore, research of alternative treatments involving this population is needed.[4,14,23] Our primary intent in this study was to confirm that neurophysiologic changes occur in response to this intervention, and to extend these findings to a different peripheral musculoskeletal pain condition. We expected decreased pain sensitivity and increased strength to the tip pinch and tripod pinch.

METHODS

Participants

The study was a double-blind, randomized controlled trial. Informed consent was obtained from all participants, and all procedures were conducted according to the Declaration of Helsinki and supervised by the Department of Physical Therapy, Occupational Therapy, Rehabilitation and Physical Medicine, Universidad Rey Juan Carlos, Spain. The protocol (N°93571/c) was approved by the Ethical Committee in Azienda Sanitaria Locale 3, Collegno, Italy, and trial registration was done at Current Controlled Trials ISRCTN81771317. The complete protocol can be accessed at http://www.controlled-trials.com/ISRCTN81771317.

Sixty participants aged 70 to 90 years volunteered for the present study. All subjects were right-hand dominant.

Inclusion and Exclusion Criteria

Inclusion criteria included patients who used the dominant hand systematically, such as ex-factory workers and home workers, and who received a diagnosis of stage III or IV secondary thumb carpometacarpal OA in the dominant hand confirmed radiographically according to the Eaton-Littler-Burton Classification.[24] Patients were excluded if they scored more than 4 on the Beck Depression Inventory,[25] more than 30 on the State Trait Anxiety Inventory, or both.[26] Patients with a medical history of carpal tunnel syndrome, arthritis, surgical interventions on the trapeziometacarpal joint, or de Quervain's tenosynovitis were also excluded, as well as patients who had degenerative or nondegenerative neurologic conditions in which pain perception was altered.

Outcome Measures

Mechanical pain sensitivity. Pain sensitivity was determined by measuring PPT. Measurements were performed with a mechanical pressure algometer[a] with a 1-cm^2 rubber-tipped plunger mounted on a force transducer.[27,28] Pressure was applied at a rate of 30kPa/s. The mean of 3 measurements was calculated and used for the main analysis. Previous articles have reported an intraexaminer reliability of this procedure ranging from 0.60 to 0.97, while the interexaminer reliability ranged from 0.40 to 0.98.[29] The following points were evaluated: trapeziometacarpal joint at the bottom of the anatomic snuffbox, tubercle of the scaphoid bone, and unciform apophysis of the hamate bone. Three measurements were made with a 1-minute pause between them. Although pain from deep tissue is difficult to assess precisely, PPTs have been found useful in assessing pain reactions in patients with OA.[30]

Motor performance: pinch strength. The pinch strength was evaluated with a mechanical pinch gauge[b] in the sitting position with the shoulder adducted and neutrally rotated and the elbow flexed at 90°.[31-33] Two different measurements were taken. First we measured the tip pinch between index and thumb fingers. Then we measured tripod pinch, between index and middle fingers and the thumb. The reliability of pinch strength has been found to be high (intraclass correlation coefficient [ICC]=.93).[34]

Interventions

Radial nerve mobilization (treatment group). Treatment was performed in 6 sessions over 4 weeks and was applied to the dominant hand 3 times during a 4-minute period, with 1-minute pauses between periods. The technique (fig 1) consisted of a sliding mobilization of the proximal-distal radial nerve.

To begin the technique, the patient was positioned supine and the physiotherapist was seated. The physiotherapist depressed the patient's shoulder girdle, extended the patient's elbow, and then internally rotated the arm. The patient's wrist, thumb, and all the fingers were flexed. Finally, ulnar deviation of the hand was added. This combination of movements is hypothesized to stress the radial nerve.[14,23] Once the upper extremity was positioned, 2 movements were done as follows: (1) shoulder depression was applied simultaneously with elbow flexion and wrist extension; and (2) shoulder elevation was performed with elbow extension, wrist flexion, and ulnar deviation. These motions are alternated at a rate of approximately 2 seconds per cycle (1s into extension and 1s into flexion).

Placebo technique. All subjects were treated by the principal investigator (J.H.V.). Participants in the placebo group received the same number and length of visits as those in the treatment group but received only inactive and nontherapeutic doses of pulsed ultrasound with an intensity of 0W/cm^2 and gentle application of an inert gel to the hypothenar area of the dominant hand.[35-37] We have successfully used this same placebo protocol in previous studies.[38] As for many procedural interventions, it is difficult to design a placebo treatment that

Fig 1. Radial nerve mobilization technique: mobilization of the radial nerve with an experimental sliding technique.

completely mimics a physiotherapy program. In this case, we aimed to completely avoid even possible tensions of the radial nerve.

Study Protocol

Each subject attended 6 intervention sessions scheduled on separate days, at least 48 hours apart and at the same time of day. Participants were not allowed to take any analgesic or anti-inflammatory drug for approximately 24 hours before each session.

Pretreatment measurements were collected by an assessor (R.M.) blinded to the subjects' intervention assignment. The pretreatment measurements were taken in the following order: PPT and pinch strength. Three measurements were done with a 1-minute pause between measurements. The mean of these 3 trials was used for analysis. The order of assessment was randomized between participants.

After pretreatment measurements, subjects were assigned randomly into the 2 groups, using GraphPad Software.[c] Subjects received the 6 treatments from a manipulative physiotherapist (J.H.V.) with 7 years of experience who was blinded to the subjects' pretreatment measurements. Posttreatment testing for PPT, pinch strength, and grip strength were performed 5 minutes after the application of the procedure. The first and second follow-ups were completed at 1 month and 2 months posttreatment by the same assessor who obtained the pretreatment measurement, and who remained blinded to the treatment allocation of the subject. The present document was prepared according to the editorial form of medical publishing and Consolidated Standards of Reporting Trials publishing rules.[39]

Statistics

Normal distribution of the sample was assessed by using the Kolmogorov-Smirnov test. Postrandomization assessment of baseline characteristics was performed using independent *t* tests or chi-square tests, as appropriate. ICC and standard error of the mean (SEM) were calculated to assess intraexaminer reliability of PPT data.

All measures fitting a normal distribution were tested using 2-way (within-time; between-group), mixed-model analyses of variance (ANOVAs). Significant interactions and main effects were decomposed using *t* tests with Bonferroni corrections to maintain type 1 error at 5%. Data were analyzed using SPSS for Windows (version 15.0).[d]

RESULTS

Two men and 28 women aged 70 to 90 years (mean, 80.87y; SEM, 2.93y) formed the radial mobilization group; 4 men and 26 women aged 70 to 90 years (mean, 81.73y; SEM, 2.93y) formed the placebo group. Figure 2 shows the flow diagram of subject progress through the study and the criteria followed. No significant differences for sex ($P>.05$) or age ($P>.05$) were noted. All subjects were right-hand dominant. No significant differences between the groups ($P>.05$) were found in key demographic variables or baseline levels of PPT, tip pinch, and tripod pinch. The demographic and clinical data of each group are detailed in table 1. A normal distribution was confirmed with the Kolmogorov-Smirnov test ($P>.05$). No subjects dropped out during the different phases of the study, and no adverse effects were detected after the application of the treatments. None of the subjects began drug therapy during the course of the study.

Mechanical Pain Sensitivity

Trapeziometacarpal joint. The intraexaminer reliability of PPT measurements of the trapeziometacarpal joint was determined as an ICC of .89, and the SEM was 3.07kg/cm^2. Regarding the results of the PPT of the trapeziometacarpal joint, the ANOVA revealed a significant group $\times$ time interaction ($F=8.82$; $P<.001$; partial $\eta=.14$). The post hoc analysis re-

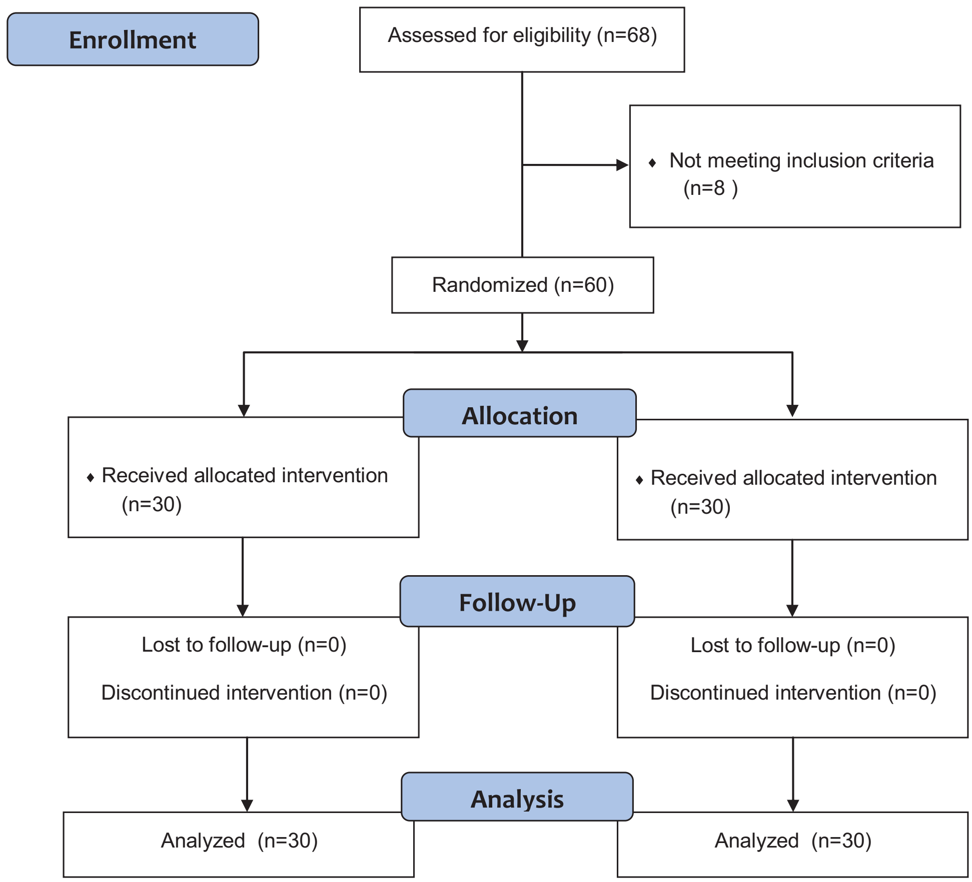

Fig 2. Flow diagram of subject progress and criteria in the study.

vealed significant differences between the 4 sessions for the treatment group ($P<.001$) but not for the placebo group (fig 3A).

Scaphoid bone. The intraexaminer reliability of PPT measurements of scaphoid bone was determined as an ICC of .79, and the SEM was 6.37kg/cm^2. The PPT outcomes for scaphoid bone demonstrated a significant time factor (F=4.87; P=.003). All participants in both groups demonstrated changes (increases) over the first month (fig 3B). The group × time interaction was not significant (F=2.44; P=.066; partial η=.042).

Hamate bone. The intraexaminer reliability of PPT measurements of hamate bone was determined as an ICC of .94, and the SEM was 3.98kg/cm^2. The PPT outcomes for hamate bone demonstrated a significant time factor (F=5.41; P=.001; partial η=.043), but not for the interaction group × time (F=2.52; P=.06) (fig 3C).

Table 1: Baseline Demographics for the Studied Groups

Characteristic	Radial Mobilization Technique (n=30)		Placebo Technique (n=30)		
	Mean	SEM	Mean	SEM	*P*
Age (y)	80.87	2.93	81.73	2.93	.62
Sex (M/W), n	2/28 (92.86% W)		4/26 (84.62% W)		
STAI	24.47	0.29	23.17	0.28	.28
BDI	2.47	0.98	2.03	0.29	.13
PPT (kg/cm^2)					
Trapeziometacarpal joint	3.33	0.24	3.42	0.24	.79
Scaphoid bone	4.78	0.36	4.66	0.35	.80
Hamate bone	6.17	0.46	6.13	0.41	.95
Pinch strength (kg)					
Tip pinch	2.14	0.22	2.30	0.25	.80
Tripod pinch	2.83	0.24	2.80	0.27	.92

Abbreviations: BDI, Beck Depression Inventory; M, men; STAI, State Trait Anxiety Inventory; W, women.

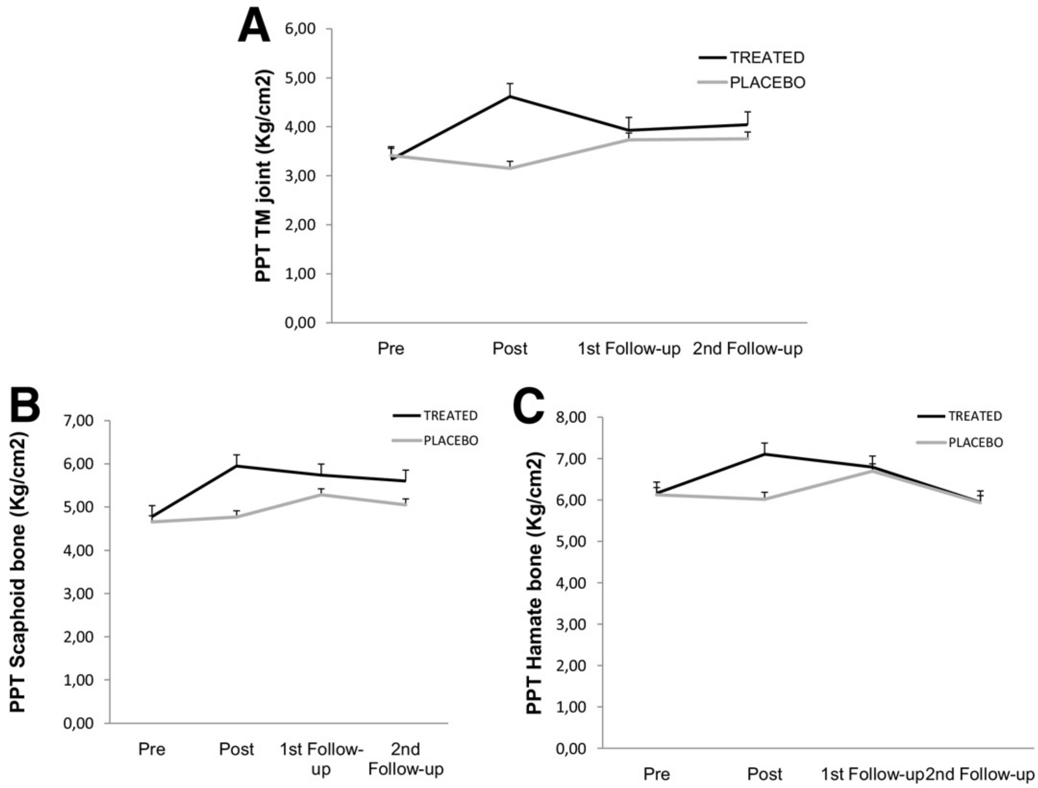

Fig 3. Changes immediately and by follow-up assessment in PPT. (A) PPT over trapeziometacarpal (TM) joint after radial nerve mobilization in posttreatment (Post), 1st follow-up, and 2nd follow-up compared with initial values (Pre). (B) PPT over scaphoid bone after radial nerve mobilization in posttreatment (Post), 1st follow-up, and 2nd follow-up compared with initial values (Pre). (C) PPT over hamate bone after radial nerve mobilization in posttreatment (Post), 1st follow-up, and 2nd follow-up compared with initial values (Pre).

Motor Performance

Tip pinch. The intraexaminer reliability of measurements of tip pinch was determined as an ICC of .82, and the SEM was 4.04kg. Regarding the tip pinch, the ANOVA revealed a significant interaction of group × time ($F=2.70$; $P=.047$; partial $\eta=.046$). Post hoc testing revealed significant differences between the pretreatment and posttreatment periods in the radial nerve mobilization group ($P=.04$). However, no significant difference was identified between the pretreatment and follow-up periods ($P>.05$) during the first and second month after treatment, between placebo and experimental group (fig 4A).

Tripod pinch. The intraexaminer reliability of measurements of tripod pinch was determined as an ICC of .93, and the SEM was 2.81kg. The ANOVA detected no interaction effects; however, a significant effect for time ($F=2.93$; $P=.035$; partial $\eta=.033$) was noted (fig 4B).

DISCUSSION

This study investigated the immediate and 1- and 2-month follow-up effects of a radial nerve mobilization on mechanical pain sensitivity and strength in patients with thumb carpometacarpal OA. On the whole our results, consistent with previous work by our group and others, showed that the intervention had an immediate effect on mechanical pain sensitivity. Moreover, radial nerve mobilization increased the tip pinch and tripod pinch in patients with dominant-hand secondary thumb carpometacarpal OA.

Neurophysiologic Effects of Intervention on Pain Sensitivity

Many studies[16,21,40-42] have suggested neurodynamic interventions for the treatment of neurogenic pain. However, few studies have studied thumb carpometacarpal OA, a common and debilitating monoarthritis. Several studies[43-45] have reported neurophysiologic effects of other forms of manual therapy, and recently the neurophysiologic effects of neurodynamic intervention have been investigated.[21,22] Our results demonstrate that neurodynamic sliding techniques had an immediate mechanical hypoalgesic effect in all the points measured around the wrist (trapeziometacarpal joint, scaphoid bone, and hamate bone), which is in agreement with previous studies[43,45-47] in which manual therapy produced immediate hypoalgesia determined by PPT.

There are differences between the findings of this current study and 2 recent studies[21,22] of neurodynamic intervention. Those studies did not identify immediate hypoalgesia to PPT; however, they did identify an immediate inhibition of thermal temporal summation in favor of the neurodynamic intervention group. The combination of these findings with the results of our study suggests that neurodynamic intervention affects nociceptive mechanisms.

Motor Effects

Radial nerve mobilization increased strength compared with the placebo in the tip pinch (12.2% vs –3% and 7.2% vs –7% in the first follow-up) and the tripod pinch (13.1% vs 0.4% and

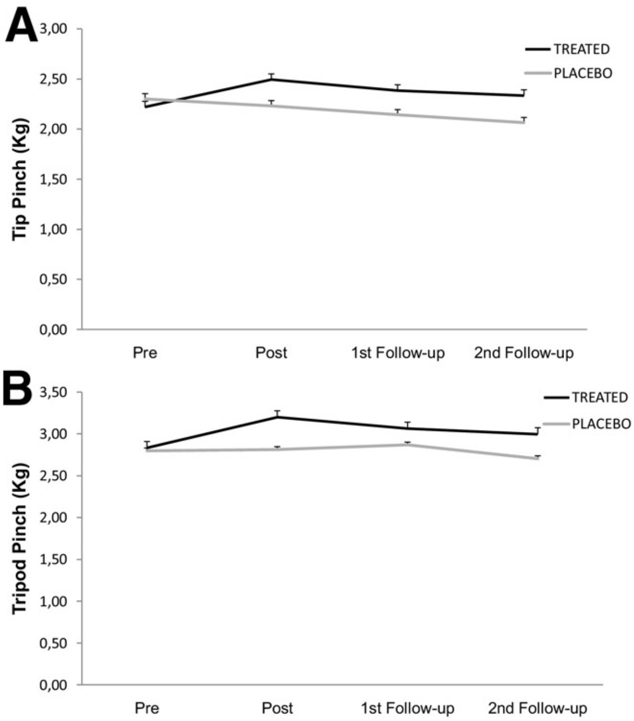

Fig 4. Changes immediately and by follow-up assessment in strength. (A) Tip pinch strength after radial nerve mobilization in posttreatment (Post), 1st follow-up, and 2nd follow-up compared with initial values (Pre). (B) Tripod pinch strength after radial nerve mobilization in posttreatment (Post), 1st follow-up, and 2nd follow-up compared with initial values (Pre).

8.1% vs 2.5% in the first follow-up), demonstrating a substantially increased motor control in tip pinch and tripod pinch in patients in whom radial nerve mobilization was applied.

Similarly, others have found that neural tests induce an increase of the muscle activity during the application.[48-51] According to other authors, the muscle response seems to be produced by a protective mechanism to prevent nerve injury.[52] This hypothesis is supported by studies that describe increased muscle activity during neural tests in asymptomatic subjects.

In the past, others have also examined the effects of several types of mobilizations on motor performance. For example, measurements of pain-free grip strength and maximum grip strength significantly improved after Mulligan mobilization with movement intervention for tennis elbow[53] was applied directly to the elbow. These types of findings emphasize the relevance of a local action of the mobilization. Such a mechanism may involve intraneural circulation, axoplasmic flow, or neural connective tissue viscoelasticity.[54] However, an increasing number of studies indicate that passive joint mobilization might also activate several areas within the central nervous system to produce a multisystem response that extends beyond the specific joints and spinal segments stimulated.[55]

Our results also differ from other studies of conservative interventions for thumb carpometacarpal OA reported in the past. After 16 weeks of home-based daily hand exercises, grip and strength modestly improved, and hand physical function or pain remained unchanged.[3] Other studies involving clinical trials in patients with thumb carpometacarpal OA treated with two 6-week splints and exercise did not show improvements in tip pinch.[5] The difference of our results may be due to the fact that the radial nerve mainly controls general motor skills of the hand. Therefore, maneuvers affecting intrinsic properties of the radial nerve may directly affect the thumb or finger movements.

Study Limitations

Our sample consisted of 90% women. Because thumb carpometacarpal OA is more common in women,[56] a higher frequency of women was expected. However, our results may not be generalizable to the male population. We also recognize that improvements were not quantified with pain or disability scales for the hand or upper extremity. We were primarily interested in the effects of the intervention on neurophysiologic function. The visual analog scale is one of the most common methods to evaluate pain intensity; however, it has been shown to have levels similar to those of manual algometry in the range of values we obtained in our subjects.[57,58]

In the present study we used ultrasound, instead of a sham mobilization technique, as a placebo. This was our preferred choice because sham neurodynamic tensioning techniques involve extensive therapist handlings.[47] Because we wanted to avoid this parameter completely, we chose a technique that would minimize the neural tension.

Other factors not collected include patient expectations for benefit from the interventions and the therapist's attitudes toward the interventions to be applied.

CONCLUSIONS

Radial nerve mobilization produces significant mechanical hypoalgesia and increases pinch strength in patients with dominant-hand thumb carpometacarpal OA. Because nerve mobilization was used previously as a treatment in patients with this pathology, this may serve as an alternative or complementary therapy with positive results. The sliding technique is suggested to be used for a chronic pain condition such as OA pain, in which central or peripheral sensitization has been found,[18] because the technique is less aggressive than more direct interventions.

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Suppliers

a. Wagner Instruments, PO Box 1217, Greenwich, CT 06836.
b. Baseline Corp, PO Box 1137, White Plains, NY 10602.
c. GraphPad Software, Inc, 2236 Avenida de la Playa, La Jolla, CA 92037.
d. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.