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Conservative Interventions for Carpal Tunnel Syndrome

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The assessment and conservative interventions in patients with carpal tunnel syndrome (CTS) are described in this paper. Information about surgical procedures and postoperative care has also been included. It is difficult to make definitive conclusions about the literature regarding success of treatment for CTS due to variations in outcome measures, severity of CTS, and inconsistencies in duration, dosage, and follow-up time for interventions. Based on what is known to date, this author recommends that patients with mild or moderate CTS be provided with a conservative program of splinting the wrist in neutral for nocturnal wear. In addition, intermittent exercise (nerve-gliding exercises) and activity modification, including avoidance of protracted periods of sustained gripping activities and awkward wrist positions, can be useful. This conservative program may be complemented by pain-relieving modalities during times of activity and supplemental participation in other exercise such as yoga. If symptoms are not relieved to the satisfaction of the patient, or they recur, then it is incumbent upon the therapist to refer the patient to a hand surgeon for injection or possible surgical decompression. *J Orthop Sports Phys Ther 2004;34:589-600.*

Carpal tunnel syndrome (CTS) results from compression of the median nerve within the carpal tunnel in the wrist. CTS is a common upper extremity entrapment neuropathy[19] and is estimated in one study to occur in 1% to 3% of the general population.[26] Intervention strategies presently include attempts at prevention or recurrence of the disorder, conservative nonsurgical interventions, and surgical options.[31,43]

This paper will address (1) the signs and symptoms of CTS, (2) the selection of patients for conservative nonsurgical care, (3) outcome measures to determine treatment effectiveness and patient change, (4) the rationale for conservative nonsurgical intervention, and (5) management and expected recovery following carpal tunnel release (CTR). A companion paper by MacDermid discusses the tests and measures used to diagnose CTS. This commentary will not discuss diagnosis, but, rather, the outcome measures used to determine intervention effectiveness after the medical diagnosis of CTS has been established.

SIGNS AND SYMPTOMS OF CTS

The signs and symptoms associated with compression of the median nerve within the carpal tunnel usually include paresthesia, tingling, numbness, and/or pain within the cutaneous distribution of the median nerve to the thumb, index, middle, and radial half of the ring digits.[43] Nocturnal paresthesia is a frequent complaint; this tingling in the hand that interrupts sleep may be partially relieved by shaking the hand back and forth. Pain may radiate into the palm and up the forearm and arm. These primary complaints of paresthesia and pain typically cause the patient to seek medical attention.[40,49]

With compression of the median nerve in the carpal tunnel, the skin overlying the thenar eminence is usually spared because this area is innervated by the median nerve's palmar cutaneous branch. The branch originates from the median nerve before it enters the carpal tunnel and lies volar to the tunnel. Paresthesia in the distribution of the palmar cutaneous branch of the median nerve (skin overlying thenar eminence) should suggest a lesion of the median nerve proximal to the carpal tunnel. This requires further examination for a more proximal lesion, such as a brachial plexopathy or cervical radiculopathy.

PATIENT SELECTION FOR PHYSICAL THERAPY INTERVENTION

When planning examination, prognosis, and intervention for patients with CTS, knowledge of the severity of CTS is important. For example, a person with mild CTS may have symptoms successfully resolved with night use of splints and activity modification, while someone with moderate or severe CTS may be less likely to have

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CLINICAL COMMENTARY

TABLE 1. Some conditions associated with carpal tunnel syndrome. (More comprehensive lists can be found in the references cited in the text of this article.)

Local to upper quadrant
• Basal (thumb carpometacarpal) joint arthritis
• Distal radius fracture
• Dupuytren's contracture
• Proximal compression on median nerve
• Scaphotrapeziotrapezoid (STT) arthritis
• Trigger finger/thumb
Systemic condition
• Diabetes mellitus
• End-stage renal disease on renal dialysis
• Long-term haemodialysis
• Pregnancy
• Rheumatoid arthritis
• Thyroid disease (hypothyroidism)

splint usage be effective or efficacious. Categorizing CTS as mild, moderate, or severe[10] can provide a structural framework for intervention choices (see MacDermid's paper in this issue).

While many cases of CTS are idiopathic in nature, a recent report suggests that there may be a genetic predisposition for developing the disorder.[35] This may account for individual differences in the symptom threshold (ie, some individuals who do the same amount of repetitive activity that cause symptoms in others do not have symptoms themselves).

There are certain other hand disorders (Table 1) which occur concomitantly and/or are associated with CTS.[8,9,34,39,56,62,69,79,80,97] In this author's experience, patients have been referred to physical therapy with a diagnosis of CTS when other conditions coexist and these conditions must be taken into account if intervention strategies[16,94] are to be successful. In some instances, the diagnosis of CTS is made by inexperienced yet well-intentioned clinicians and other disorders must be recognized and properly addressed.

OUTCOMES MEASURES

Tests and measures used for determining a medical diagnosis may not always be useful to judge patient change as a result of intervention. For example, the median nerve compression test is used in the diagnosis of the pathology of CTS but can not be quantified in a way that would help determine if a patient was getting better, worse, or not changing as a result of an intervention. Therefore, we must select measures that are responsive to change and that reflect the changes in impairments, functional limitations, and disability that may be attributed to therapy intervention. Outcome measures of interventions can include the Boston Carpal Tunnel Scales questionnaires,[49] grip and pinch strength, manual muscle testing (particularly of the thenar muscles), light touch with monofilaments, and various timed tests of hand function requiring manipulation of objects. These measures are employed during examination at the initiation of therapy and during follow-up re-examinations.

There has been an emphasis over the last decade on the importance of patient self-administered questionnaires for report of pain and disability. It is particularly important to include a self-report measure with good psychometric properties to best capture the essence of the patient's complaints and difficulties. For example, with CTS, severe symptoms of paresthesia may not be associated with deficits in grip or complaints of weakness,[66] impairments traditionally measured during a physical therapist's examination. In addition, there is not a good correlation between results of electrophysiological studies and symptoms the patient reports.[20] As the CTS progresses, the symptoms of paresthesia may decrease and be replaced with actual muscle atrophy and weakness. If the disorder has progressed to the point of thenar muscle atrophy, then nonsurgical treatment may not be appropriate or effective.

The Boston Carpal Tunnel Scales questionnaires[49] are commonly used to assess individuals with CTS and include the Symptoms Severity Scale (SSS) and the Functional Status Scale (FSS). These scales take about 5 minutes for a patient to complete.[41] The SSS questionnaire is composed of 11 questions related to the severity of nocturnal pain and paresthesia, frequency of wakening at night, pain in the hand and wrist during the day, presence of numbness or weakness in the hand, and difficulty manipulating small objects. Each question is rated from 1 to 5, with 5 being the most severe. The scores for each question are then added and divided by 11. The reported score is a number out of a total of 5.00. The FSS asks about 8 activities, including writing, buttoning, holding a phone, carrying groceries, holding a book to read, opening jars, household chores, and bathing and dressing. This is scored in a similar fashion to the SSS questionnaire. This author uses information obtained from administration of these scales to assist in formulating functional intervention goals.

The SSS and FSS questionnaires capture aspects of sensation, pain, and function, and have been validated for use in individuals with CTS and following CTR. Amadio et al[2] have reported outcomes following CTR using these scales. Katz et al[41] reported that the SSS and FSS were 2 and 4 times more responsive, respectively, to clinical improvement than measures of neuromuscular impairment, such as grip strength, manual muscle test, 2-point discrimination, and light touch with monofilaments. Atroshi et al[4] reported similar findings. These authors recommend that these self-report measures should serve as primary outcomes in clinical studies of therapy for CTS. The SSS and FSS questionnaires are more sensitive to clinical

change produced by surgical treatment for CTS than other health status questionnaires such as the Arthritis Impact Measurement Scale and the Short-Form 36.[2] In addition, in the postoperative cases, there did not seem to be a relationship between wrist range of motion, pinch and grip strengths, monofilament pressure sensibility, and patient satisfaction.[2,41] These scales are valid as self-report measures for both recipients and nonrecipients of worker's compensation.[5,41]

Maximum grip strength is frequently measured in patients with CTS. Patients with CTS frequently complain of lack of ability to sustain activities (eg, cannot type for more than a few minutes without discomfort from paresthesia). In this author's opinion a measure of the ability to carry out activity requiring light prehension, rather than maximum grip strength, may be a better choice of test to reflect the symptoms common to patients with CTS and assess the outcomes of therapy intervention. This is certainly an interesting area for future research.

Outcome measures must also appropriately capture the severity of the disorder. For example in mild and moderate CTS, primary complaints are of tingling and pain. If median nerve degeneration has progressed to the point to include thenar muscle atrophy, then using measures of tingling and pain may be less relevant. In these cases tests of muscle performance (eg, manual muscle testing) and functional activity (eg, Jebson test of hand function[38]) may be more appropriate.

Return to work, while used as an outcome in many studies, may not accurately reflect the true outcome.[36] Some patients do not work, while others may not intend to return to work for reasons other than disability from CTS. Other socioeconomic factors or workers' compensation state regulations may also influence return-to-work decisions.[6]

CONSERVATIVE NONSURGICAL INTERVENTION OPTIONS FOR CTS

With entrapment neuropathies, the microcirculation of the nerve is compromised, venous congestion occurs, and axoplasmic transport is reduced.[18,52] The neutral (0°) wrist position minimizes pressure within the carpal tunnel, while wrist flexion and extension increase pressure.[29,46,48,50,52,93] Other factors that increase pressure within the carpal tunnel include external pressure on the palm,[15] incursion of the lumbricals into the carpal tunnel,[14] forearm position of full supination,[71] sustained grip,[76] and isolated finger flexion against resistance.[76] Lower pressures have been recorded with the forearm in 45° of pronation and the metacarpophalangeal (MCP) joints flexed to 45°, as compared to forearm supination and 0° or 90° of MCP joint flexion.[71]

Therefore, interventions that alter nerve compression by altering wrist and forearm position, activity levels, repetitive gripping, and pressure on the volar aspect of the wrist, could ameliorate the symptoms related to CTS. The focus of intervention techniques is to lower the pressure within the carpal tunnel and enhance neural circulation and nutrition. Conservative treatment has focused on splint wear, modality application (eg, heat, laser, ultrasound), exercise, activity modification, and corticosteroid injection. Alternative therapies, such as yoga and application of magnets, have also been attempted with varying success.

Two recent systematic reviews have indicated there is support for short-term benefits from splinting, ultrasound, yoga, and carpal bone mobilization.[59,63] This does not mean that other treatments are ineffective. Rather, in many cases, it suggests that these other interventions have not yet been carefully studied or have not been studied at all, or that outcomes measures have been used that are not responsive for this patient population.

Splinting

Wrist splinting is a commonly employed intervention[24,40,64] to relieve symptoms of digital paresthesia due to CTS. The majority of studies on interventions for CTS that would fall within the domain of physical therapy have reported on the use of splints for symptom control, hence, emphasis on splinting in this article. In this author's opinion, a properly fitted splint can assist in controlling symptoms of CTS and should be offered to most patients as a first line of care. Splints should also be considered for recurrence of symptoms. Gerritsen et al[31] suggest that 2 prognostic indicators predict benefit from splint wearing: (1) CTS complaints of less than 1 year in duration, and (2) a score of 6/10 or less for severity of nocturnal paresthesia. Splinting the wrist in a neutral (0°) flexion/extension rotation position is generally agreed upon as the favored technique.[31] The recommendation for this position is supported by in vivo studies which have used indwelling catheters to measure carpal tunnel pressure while varying the wrist position. The consensus is that the lowest carpal tunnel pressure occurs with the wrist in a neutral (0°) anatomic position.[29,30,93] Kuo and associates[48] also used axial ultrasonographic imaging of the wrists of patients (n = 17) without evidence of CTS and reported that in most subjects (n = 13), the lowest compression to the median nerve is with the wrist in neutral, although some subjects had the lowest pressure in 15° of flexion. Positioning the wrist in neutral rotation is easily accomplished by fabricating a custom-molded thermoplastic splint or using a prefabricated splint that has an adjustable angle bar or

FIGURE 1. This commercially available wrist splint positions the wrist in extension. The desired position is neutral rotation. This splint can be modified by removing the metal bar and replacing it with a thermoplastic insert that holds the wrist in the proper position.

insert. Figure 1 depicts a commonly prescribed splint that holds the wrist in extension, rather than in a neutral position, and that splint should be modified for better wrist positioning.

Burke et al[11]compared the use of a wrist-neutral splint to a wrist-extended (20°) splint for 2 months of wear in patients who had symptoms of CTS for an average of 2 years. Wearing schedules were not reported. Subjective symptom relief using verbal descriptors (not at all, a little, a lot, completely) was determined by phone interview at 2 weeks and 2 months. There were more patients (n = 20) who reported "a lot/complete" relief with neutral angle splints than those splinted in extension (n = 6). The number of individuals who had no or little relief did not vary between the group wearing the neutral angle splint (n = 22) and the group wearing the extension splint (n = 22). The greatest relief occurred at night; some patients felt restricted in activity when wearing a splint during the day. Interestingly, in this study, it seems the extent of relief was not correlated with duration of symptoms of CTS. Manente et al[54] support the use of night splinting compared to no splinting in a group of patients with CTS, at least for the short-term follow-up. The group treated with a splint showed a reduction in SSS scores from 2.75 to 1.54 ($P<.001$) and FSS scores from 1.89 to 1.48 ($P<.001$) at 4 weeks, with no significant change in the control group that did not use a splint. There was no indication of follow-up longer than 4 weeks.

Wearing instructions for splints have varied. Splints have been recommended to be worn during the day for activity and at night. Walter et al[88] compared wearing a custom-molded wrist neutral splint for full-time use day and night to wearing the splint only at night for 6 weeks. About 50% of those tested had severe CTS, with about 42% taking nonsteroidal anti-inflammatory drugs (NSAIDS). Outcomes measures included the Boston SSS and FSS questionnaires and electrophysiological testing of the median nerve (motor and sensory distal latencies). Both the SSS and FSS questionnaire scores were lower for both groups after the 6 weeks, but were not significantly different in the 2 groups. There was no difference in changes in the scores of the SSS and FSS in comparing those with severe CTS versus mild/moderate CTS. The patients who had severe CTS faired better with improvement in sensory distal latencies (mean improvement, 0.59 milliseconds) compared to those who were classified as mild/moderate (mean improvement, 0.11 milliseconds). This study supports that after 6 weeks of splint wear, CTS symptoms, function, and electrophysiologic study results improve. It is not apparent that the addition of daytime wearing of splints further improves symptoms or function, but based on some study limitations, strong conclusions cannot be made. In addition, many of the subjects had bilateral CTS and each hand was included as an individual subject for the study, thus affecting the internal validity of the findings and inflating the apparent significance.

Rempel et al[72] studied the daytime wear of a flexible wrist splint versus no splint in subjects without CTS. The rationale for splint wearing was that if wrist motion was partially limited (from extremes of flexion or extension), carpal tunnel pressures would be lower when wearing the splint during activity. Repetitive activity of lifting light cans from a box for 5 minutes with and without a splint resulted in equivalent increases in carpal tunnel pressure. The likelihood of external contact from the splint on the volar aspect of the wrist while attempting to limit motion may have been counterproductive and increased carpal tunnel pressure.[15] It would be interesting to see a similar trial carried out in patients with CTS during a longer period of activity.

In an attempt to get CTS resolution with splinting, Evans[24] proposes extending the wrist splint distally to incorporate the proximal phalanges with the MCP joints splinted in 20° to 40° of flexion. The rationale of preventing MCP flexion is to prevent fisting and incursion of the lumbricals into the carpal tunnel, which by virtue of their origin from the flexor digitorum profundus tendons, increase carpal tunnel pressure[14] with gripping or fist clenching. The use of this type of splint would be an interesting concept to test in a controlled study.

Gerritson et al,[32] in a study of patients with idiopathic CTS, compared open CTR (n = 87) to night splinting for 6 weeks (n = 89). The investigators concluded that surgery was more effective because a greater percentage of patients who had surgery (80%), as compared to those who wore the splint (54%), had "general improvement" at 3 months; though it is unclear if CTS severity influenced these outcomes. By 18 months, 41% of the individuals in the group wearing a splint had gone on to have surgery.

Cortisone Injection

Steroid injection into the radial or ulnar side of the median nerve proximal to the wrist appears to be effective in the short term for those people who have mild symptoms of CTS.[29] For CTS occurring during the last trimester of pregnancy, this may be a viable alternative to control symptoms until after delivery, when many of the symptoms typically resolve.[10]

Weiss et al[92] did a prospective single-group study of patients with mild to moderate idiopathic CTS, examining the combined effects of 4 weeks of continuous splinting with the wrist neutral in addition to steroid injection using betamethasone. Short-term results at 1 and 2 months revealed symptom resolution for 50% of the 76 hands (a small number of patients were treated bilaterally). Forty-five hands of 33 subjects went on to CTR by long-term follow-up (6-18 months). Complete relief of symptoms occurred in 33 of the 45 hands that had CTR.

Celiker et al[13] in a prospective study compared oral anti-inflammatory plus splinting (neutral wrist, nocturnal use) to corticosteroid injection with methylprednisone acetate. Patients who had thenar muscle atrophy were not included in the study; so, perhaps, the assumption can be made that the study population of 33 hands in 23 subjects had mild or moderate CTS. Follow-up was for 8 weeks. Both groups had significant reduction in symptoms as measured by the Boston SSS questionnaire at 2 weeks, and improvement in motor and sensory distal latencies; but the chance for significant change again may have been inflated due to the use of both hands in 10 of the patients.

For further information on steroid injection effectiveness, the interested reader is referred to a recent review.[55]

Exercise

One of the first instincts of a physical therapist when presented with a patient who has pain and reported loss of function due to CTS is to reduce the pain and to give the patient exercises for mobility and strength. In the case of mild and moderate CTS, joint stiffness, muscle weakness, and altered muscle performance often times are not the primary complaints expressed by the patient. If the person works in awkward postures and does grip and strengthening activities, this may exacerbate rather than ameliorate symptoms.

Tendon gliding of the finger flexor tendons[90] and nerve gliding of the median nerve exercises (Figure 2) are recommended for conservative management of symptoms related to CTS. Seradge et al[76] have demonstrated via measurements of carpal tunnel pressure in vivo that intermittent exercise of active wrist and finger motion for 1 minute can lower pressure in the carpal tunnel. Based on his experi-

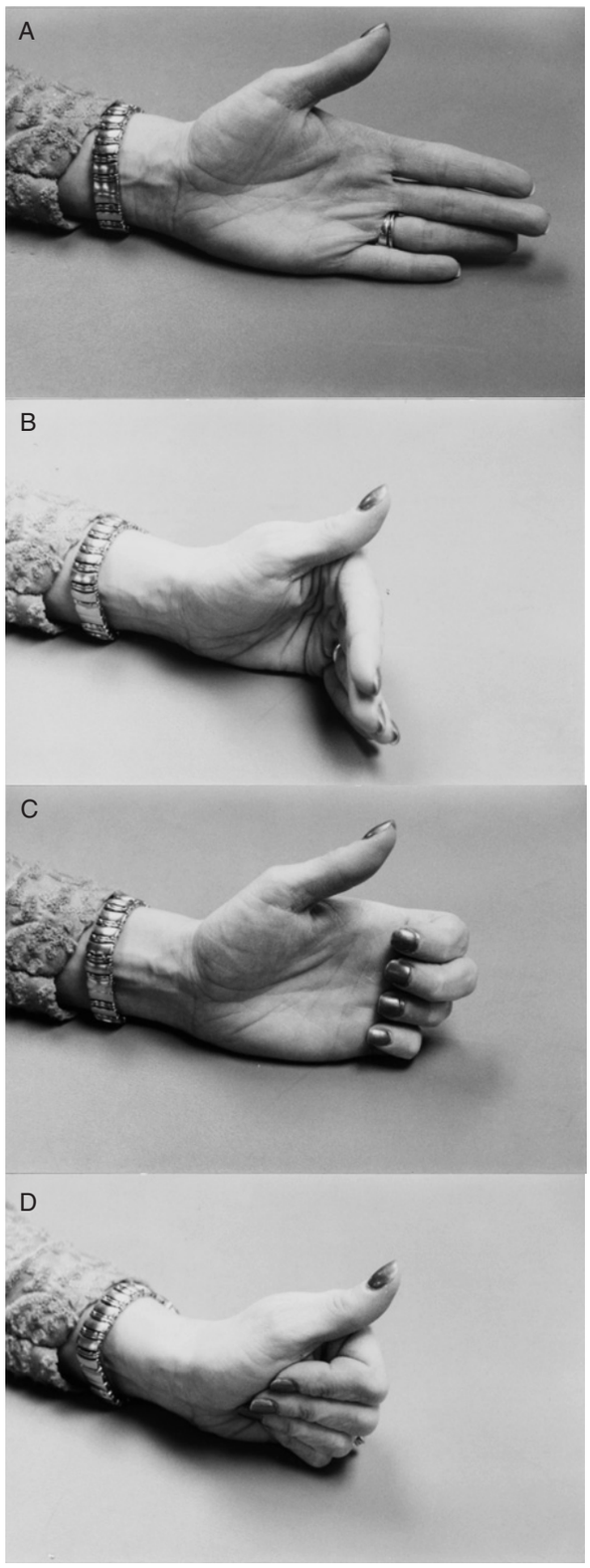

FIGURE 2A-D. The sequence of tendon- and nerve-gliding exercises recommended for carpal tunnel syndrome. Flexion and extension of the digits will glide the median nerve through the carpal tunnel.

ment, he recommends frequent 1-minute bouts of active motion throughout the day. This can serve as part of the basis for tendon- and nerve-gliding exercises so frequently utilized in managing CTS. These exercises may have a positive effect on CTS, in part, by facilitating venous return or edema dispersion in the median nerve.[10]

Seradge et al[77] used the Boston SSS and FSS questionnaires as baseline and outcomes measures for a group with CTS before, and at 1, 2, and 18 months after initiating an exercise program. The exercises, termed *carpal tunnel decompression exercises*, involved tendon- and nerve-gliding maneuvers of the upper extremity. The patients also were treated for the first week with oral methyl prednisolone, followed by 1 month of NSAIDs. Custom-fabricated volar wrist splints were worn for 8 hours during the day and at night for the first month, and solely at night during the second month. The investigators reported good outcomes as measured by reduced scores on the SSS and FSS questionnaires. About 65% of the individuals who entered the study were still participating in the study at 18 months. Of these, 7 went on to surgery. It is not possible to delineate the contribution of each treatment modality to the successes reported.

Seradge et al[75] also implemented the exercise program as a CTS preventative program in a meat packing plant. They reported that the company's reporting of CTS was reduced by 45% as a result of this program. Certainly, this would be an interesting concept to repeat in other industries noted to have a high incidence of individuals developing CTS. It would also be interesting to determine if this exercise program would prevent recurrence of CTS in a cohort of patients who have responded positively to conservative intervention for CTS.

Akalin et al[1] compared wrist-neutral splinting to a group that wore the same design of splint and also had a program of tendon- and nerve-gliding exercises in patients with CTS. Wrist splints were worn throughout the day and night for 4 weeks. Outcomes were determined using the Boston SSS and FSS questionnaires, physical measures (eg, provocative maneuvers, grip and pinch strengths, and 2-point discrimination), and a follow-up phone survey for patient satisfaction. There was improvement in all parameters except for 2-point discrimination in both groups, but the differences between the groups were not statistically significant. There was a trend for greater improvement in the patients who were instructed in tendon- and nerve-gliding exercises. It would be interesting to see a similar study repeated with a larger cohort and to consider matching splinting and tendon- and nerve-gliding exercises to a group who had surgical decompression. Rozmaryn et al[74] reported in a retrospective study that the inclusion of nerve- and tendon-gliding exercises to a plan of splinting, NSAIDS, and steroid injection resulted in a lesser number of patients ultimately going to surgery. It is unfortunately not possible to determine which part of the intervention yielded the improvement of the patients.

Grip-strengthening exercises with therapy putties or hand grippers are not appropriate in the conservative management of CTS.[24] This form of exercise increases pressure within the carpal tunnel.[76]

Modalities

Reduced circulation to the nerve can adversely affect nerve function.[52] Heat, therapeutic ultrasound, and laser to the wrist have been used to reduce the symptoms of CTS. Perhaps an effect of these modalities is to increase circulation or to provide an environment to decrease expression of tumor necrosis factor beta.[24] Michlovitz et al[58] studied the short-term benefits of wearing a continuous low-level heat wrap (maintains heat of 40°C for 8 hours) 8 hours per day for 3 consecutive days in a group of patients with CTS. This was compared to placebo analgesic drug. At a 5-day follow-up there was a greater and statistically significant improvement in pain relief, SSS, and FSS questionnaire scores, and improved grip strength in the group wearing the heat wrap as compared to the group taking the placebo drug. This heat wrap can be worn during activity to provide relief from symptoms.

There is support in the literature to use therapeutic ultrasound in relieving symptoms of CTS. Ebenbicher et al[21] compared sham ultrasound to the use of 20% duty cycle pulsed ultrasound at 1 MHz, 1.0 W/cm^2, for 15 minutes, applied daily for 2 weeks, then twice a week for an additional 5 weeks. Treatments were given for a total of 20 times over a 7-week period. The patients in the study had mild to moderate idiopathic CTS and had symptoms on the average for 8 months. Using these parameters, the investigators demonstrated positive changes in symptoms, sensation, and nerve conduction in the group receiving pulsed ultrasound. The results reported by Oztas[65] in a trial of continuous-wave ultrasound do not support the use of ultrasound. The subjects treated in this study were exposed to continuous ultrasound rather than pulsed and had symptoms for a mean duration of 7 years. A comparison between ultrasound plus splinting versus splinting alone may be worthy of consideration to further delineate the role of ultrasound in managing CTS.

Using low-power gallium asrsenide (GaAs) laser for 10 minutes 3 times per week for 2 weeks in patients with mild to moderate CTS, Padua et al[67] reported a decrease in pain, numbness, and tingling, and an increase in function and improvement in sensory and motor conduction velocities, when compared to no treatment. Weintraub et al[91] reported similar improvement in patients with moderate to severe CTS, but had no comparison group. Naesar et al[60] studied

TABLE 2. Suggested Internet sites for patient education information on carpal tunnel syndrome. (This is not an all-inclusive list. All sites were last accessed on July 29, 2004.)

Organization	Web Site
American Physical Therapy Association	www.apta.org
Arthritis Foundation	www.arthritis.org
American Association for Hand Surgery	www.handsurgery.org
American Society for Surgery of the Hand	www.hand-surg.org
Mayo Clinic Foundation	www.mayoclinic.org

a small number of patients with CTS (n = 11) in a crossover design study using low-power laser and microamperage electrical stimulation (MENS) applied to acupuncture points, as compared to sham treatment applied over the same points. As a result of their findings, these investigators suggested that pain may be more effectively reduced with a combination of laser and MENS. Because both modalities were used in combination, it is difficult to tell which one would have caused the effects reported.

Activity Modification and Patient Education

Activities can be modified to maintain the wrist in neutral for as many activities as practical and to reduce repetitive and forceful gripping and pinching. Increases in carpal tunnel pressure have been measured during fingertip loading (eg, active flexor tendon loading during depression of keyboard keys).[46] As the wrist is moved from neutral during fingertip loading, pressures within the carpal tunnel increase. There is ongoing controversy of whether keyboard use causes CTS[3]; but if CTS is present in keyboard users, it would be prudent to advise activity modification to control symptoms. These modifications can include avoiding resting the wrist on a hard surface, such as a desk edge, regular breaks to perform nerve- and tendon-gliding exercises, and using a split keyboard to avoid full pronation while typing (see article on computer keyboards in this issue). Sustained-grip activities should be discouraged due to increases in carpal tunnel pressure.[76] Lumbrical incursion into the carpal tunnel can also occur during gripping activities.[14,78]

The physical therapist should spend time with the patient educating her/him about postures to avoid, factors that can influence circulation to, and those that can potentially compress, the median nerve. In a sample of persons with work-related musculoskeletal disorders who were heavy video display terminal users, changes in posture, as measured via video analysis and health status as rated by the Short Form-36,[89] were accomplished with a brief postural education program.[81] The program included a single 60-minute ergonomic educational session with a 15-minute follow-up session 1 week later.

Many patients with CTS will consult resources other than the therapist or physician to learn about their disorder and intervention options. Caution should be given to the patient about information found on the Internet. Beridjiklian et al[7] evaluated 250 Internet sites related to CTS. Unconventional or misleading information appeared on 23% of the web sites. An equal number of Internet sites were authored by a physician or an academic organization and the researchers found that information to be accurate. Some suggested sites the therapist can direct the patient to for information on CTS are listed in Table 2.

Alternative Therapies

The popularity of alternative therapies is increasing and is appealing to the patient who has a chronic painful disorder. There are many different alternative therapies and this article will confine comments to 2 options: magnet therapy and yoga. Results of studies using both of these techniques have been reported in the literature.

One 45-minute trial of magnet therapy to the wrist (n = 15) was compared to placebo device treatment (n = 15) in patients with wrist pain attributed to CTS.[12] There was not a clear description of how the diagnosis of CTS was made by the investigators, other than mention of recruiting ''patients who had chronic wrist pain attributed to CTS by their primary care physician'' via the mail. Pain was rated on a visual analogue scale (VAS) during the 45-minute magnet treatment and by postcard after 2 weeks. Pain was slightly improved in both groups, actual magnet and placebo magnet, without any significant differences between groups. In a different study, with patients wearing wrist support wraps 24 hours per day, those patients with CTS and actual magnets had less numbness and tingling and improved nerve conduction after 8 weeks than those receiving sham treatment (nonactive magnets plus wrist support).[91]

A randomized controlled multicenter trial of Hatha yoga, emphasizing upper body postures and relaxation, was compared to wearing wrist splints for 8 weeks.[28] Participation in the yoga program was for 60 to 90 minutes, 2 times per week. Demographics of both groups were similar, with a mean age of 48 years. Outcome measures included pain, grip strength, and sensory and motor nerve conduction velocities. All parameters improved more in the group treated with yoga. Interestingly, sleep disturbances only improved in 4 of 17 individuals in the yoga group, and in 2 of 18 individuals in the splint group. The positive effects of yoga may be in part accounted for by changes in posture and in exercise capacity, both of which may produce changes in nerve function due to reduction of compressive stresses on the brachial plexus and median nerve and enhancement of microcirculation. In certain popula-

tions, yoga could be a viable addition to conservative management. The use of yoga to control symptoms of CTS warrants further testing. This author is curious to know if an ongoing program of yoga would prevent or decrease the frequency and intensity of recurrence of CTS.

Surgical Intervention

Surgical decompression, an option offered to the patient if conservative care fails involves transection of the transverse carpal ligament (TCL) to relieve pressure on the median nerve. There is some evidence to suggest that patients who choose to undergo surgery have histochemical changes consistent with fibrosis of tissues within the carpal tunnel.[23,27] Many patients who choose to go to surgery for CTS do so to have relief of nocturnal pain and numbness. Surgery is performed via an open carpal tunnel release (OCTR) or endoscopically assisted carpal tunnel release (ECTR).[85,96] A comparison of OCTR versus ECTR has been the topic of many studies and a detailed discussion is beyond the scope of this commentary. In some instances, ECTR has been reported to have better short-term effects than OCTR, in that return to work and function is faster, and incision and pillar pain are less than with OCTR.[86] MacDermid et al[56] found no differences in resolution of symptoms between the surgeries, but at short-term follow-ups (1 and 6 weeks) there was less pain and greater grip strength in the endoscopically treated group. The operation, whether it be open or endoscopic, is done under local or regional anesthesia and patients generally can use their hands the next day for light activities not requiring repetitive use or a tight grip.

Consequences of CTR: What to Expect Following Surgery

Ideal outcomes of CTR include resolution of preoperative symptoms and restoration of hand function to a premorbid level. The physical therapist should understand the natural course of recovery following a CTR for the purposes of (1) educating the patient regarding expectations for recovery and (2) notifying the surgeon if undue complications are present that may require further treatment.

Some patients experience pain from scar, pillar pain (pain at the bases of the thenar and hypothenar eminences), and a decrease in grip and pinch strengths following surgery.[57] Most of these symptoms are expected to resolve over time (eg, within 3 to 6 months following surgery). But, Higgs et al[37] found that 118 of 166 patients studied had some residual symptoms at 18 months following CTR.

Paresthesia and pain that was present before surgery may diminish within the first few days or over the first few weeks following surgery. An improvement of 1.20 to 1.60 points of a total possible score of 5.00 can be expected from surgery in the Boston Carpal Tunnel Scales questionnaire scores.[42] Light touch, if impaired, usually returns within the first 3 months after surgery.[95] Pain that occurs following CTR is usually due to the surgical incision and pillar pain or tenderness.[51] Pillar pain occurs at the bony pillars of attachment for the transverse carpal ligament (the hook of the hamate, pisiform, scaphoid tubercle, and the ridge of the trapezium). In this author's experience, this pain occurs when the patient begins to do activities that involve applying pressure over those bony prominences. Pillar pain may limit grip, thus accounting in part for decreased grip strength measured after surgery.[47,57] This pain often times is resolved within 3 months postsurgery or earlier.[57] Some authors have estimated the incidence of pillar pain at 6% to 10%.[61] The pillar areas correspond closely to the locations of the TCL insertions radially to the scaphoid tubercle and the trapezium tubercle, and ulnarly to the hamate hook and the pisiform. The cause of pillar pain is not known, but carpal arch widening, periostitis of the hamate hook and scaphoid tubercle, intrinsic muscle pain resulting from pulling of the released TCL, and sectioning of nerve fibers in the skin and subcutaneous tissue of the palm have been implicated.[25] It is this author's experience that low-intensity continuous-wave ultrasound (0.5 W/cm^2, 3 MHz) may assist in more rapid resolution from pillar pain. This notion may be worthy of further testing in a patient population that has functional difficulties due to pillar pain (eg, difficulty with activities that require weight bearing on the palm).

Full return of presurgical grip and pinch strengths often does not occur until 3 to 6 months following surgery, but this should not impede return to full function prior to that time. There are a number of reasons that may account for these strength decreases, including altered morphology of the carpal tunnel,[9,73] decreased thenar muscle and digital flexor muscle strengths, inhibition of muscle by pain, and scar or pillar pain. After the TCL is cut, the stable point of anchor for the thenar muscles' origin changes. The intrinsic thenar muscles, which arise from the TCL and trapezium, may be at a length-tension disadvantage for force production.[10] This may contribute to the decrease in pinch strength following CTR.[57] This author has had a few patients, though, with hypersensitivity along the distribution of the palmar cutaneous nerve's innervation following open CTR surgery, where the incision has extended proximal to the wrist crease.[84]

It has been suggested that those who respond better to steroid injection preoperatively do better following surgery than those who do not.[22] Factors associated with poorer outcomes following CTR in-

clude alcohol use, decreased mental health status, and workers compensation cases with attorney representation.[43] The latter group has greater functional limitations than injured workers without attorney representation.

Care Following Surgery: To Splint or Not? Therapy or Not?

A bulky dressing is usually applied following surgery. Some patients, though, may have a wrist splint applied.[87] The rationale to splint the wrist in about 20° extension following surgery has been passed down over time and may have its origins during the days when an extensive surgical exposure was done during a CTR. The 2 cited reasons have been to protect the surgical incision and to prevent bowstringing of the flexor tendons following transection of the flexor retinaculum.[24] Cook et al[17] compared splinting of the wrist for 2 weeks postoperatively to no splinting. They reported that for those who wore the splint, there was less pain and scar tenderness, greater delay in return to activities, including work, and less strength as measured with grip and pinch dynamometers, as compared to those who did not wear splints.

Some patients are enrolled in formal hand therapy programs for scar desensitization and hand strengthening. Some patients are given no formal hand therapy, except for instruction in a home program and to use the operated hand as tolerated. Postoperative exercises usually include flexor-tendon-gliding and nerve-gliding exercises.[24,85] The finger flexion and extension exercises will also produce proximal and distal gliding, respectively, of the median nerve through the carpal tunnel and minimize risk of adherence to the nerve to surrounding tissues. The median nerve has a mean excursion of 1 cm after CTR with full finger flexion and extension.[82] Grip- and pinch-strengthening exercises begin 3 to 4 weeks after surgery.

Little has been reported in the literature about the necessity or effectiveness of postoperative therapy. Provinciali et al[70] suggested that the return-to-work interval may be shorter in patients who undergo postoperative therapy. In this author's opinion, patients can benefit from postoperative therapy if pain is preventing return to activity or, in the case of an injured worker who needs guidance to return to maximum activity.

Surgery as the First Option? Yes or No?

Verdugo et al[87] in a systematic review including 2 clinical trials reported that surgery resulted in better symptom relief than nonsurgical management. The work of Gerritsen et al[31] would support this conclusion. Verdugo et al,[87] though, conceded that there is insufficient data to determine if those with mild CTS would have similar results. Perhaps splinting, nerve-gliding exercise, and activity modification can control symptoms sufficiently to prevent surgery in some patients with mild and moderate CTS. Clearly this is an area for further exploration.

Summary and Recommendations

This article has reviewed concepts related to physical therapy assessment and intervention in patients with CTS. Information about surgical procedures and postoperative care has also been included. It is difficult to make definitive conclusions about the literature regarding success of treatment for CTS due to variations in outcomes measures, severity of CTS,

TABLE 3. Suggested conservative nonsurgical interventions for a patient with carpal tunnel syndrome.

Intervention	Rationale for Intervention	Clinical Suggestion
Wrist splint	• Lowest carpal tunnel pressure	• Splint with wrist in neutral rotation • Wear at night
Heat modality	• Enhance circulation, reduce pain and paresthesia	• Continuous low-level heat wrap during the day
Nerve- and tendon-gliding exercises	• Intermittent exercises reduce carpal tunnel pressure	• Instruct to do intermittently through the day • Suggest every hour if doing repetitive activity
Activity modification	• Reduce compression in carpal tunnel • Minimize external pressure on palm • Assess activities of the individual and modify	• Minimize lumbrical incursion
Yoga program	• Improve posture and reduce compression on median nerve	• For patients able to participate in a regular exercise program
Corticosteriod injection into carpal canal	• Reduce pain and inflammation • May be used as screening to determine candidates for surgery	• May be used in conjunction with other techniques

and inconsistencies in duration, dosage, and follow-up time for interventions. Based on what is known to date, this author recommends for the patient with mild or moderate CTS a conservative program of splinting the wrist in neutral for nocturnal wear. Intermittent exercise (nerve-gliding exercises) and activity modification, including avoidance of protracted periods of forceful gripping activities, may also be helpful. This conservative program may be supplemented by the use of continuous low-level heat wraps, pulsed ultrasound, or magnets during times of activity, and participation in a yoga program (Table 3). If symptoms are not relieved to the satisfaction of the practitioner, or they recur, it is then incumbent upon the therapist to refer the patient to a hand surgeon for injection or possible surgical decompression. The appeal for practitioners to select surgical interventions is that in the hands of a competent surgeon there are minimal to no associated risks and patients usually have good results. But conservative nonsurgical interventions may offer temporary relief or total relief in someone with mild CTS.

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