Stretching and strengthening exercises are key components of care

Overuse syndromes of the upper extremity: Rational and effective treatment

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ABSTRACT: Histologic studies from patients with various overuse tendinoses reveal a pattern of tissue disorganization consistent with metabolic stagnation, associated edematous reaction, and failure to repair at the injury site. Some persons are more prone to overuse syndromes than others. Risk factors are better defined for carpal tunnel syndrome (CTS) than other overuse tendinoses; they include pregnancy, obesity, and workplace activities. Electrodiagnostic studies are useful to confirm a diagnosis of CTS, but results bear little influence on outcome. Overuse syndromes are managed in four phases; after controlling pain, the goal is to reduce adhesion formation and restore mobility through stretching and strengthening exercises. Prevention of recurrence requires individualized environmental and lifestyle modification. Active release therapy, a new treatment, appears promising. (J Musculoskel Med. 1998;15(8):11-18)

This is the first in a series of special overview articles on major areas of musculoskeletal medicine that members of our Editorial Board have prepared to celebrate the 15th anniversary of The Journal of Musculoskeletal Medicine.

One of the more dubious distinctions of our mechanized and technically advanced age is an increase in overuse syndromes of the upper extremity. Included in the group of occupational disorders are the epicondylitis syndromes, fibrositis, tendinitis, and carpal tunnel syndrome (CTS) (Figure 1). All of these chiefly involve soft-tissue abnormalities, leading to the speculation that they all may share a common pathology.

The computer is perhaps the biggest culprit underlying the increase in overuse syndromes probably because, compared with a typewriter, its use involves less force and joint amplitude. According to the US Department of Labor, 60% of new occupational disorders that occurred in 1992 were associated with repetitive motion. 1

Because occupational syndromes depend on subjective pain complaints and associated tenderness for recognition, the diagnosis tends to be vague and treatments are varied. In this article, I discuss what we currently know about the pathophysiology of these problems and suggest some rational treatment programs that can be varied according to the anatomic site involved.

PATHOPHYSIOLOGY

Our understanding about the pathology underlying the various types of overuse tendinoses is limited. Unfortunately, there is no clear explanation of why overuse disorders occur in some people and not others. However, histologic analysis of biopsy samples from patients with different types of overuse syndromes reveals several consistent features.

Epicondylitis

A recent book on repetitive motion disorders published by the American Academy of Orthopaedic Surgeons cites a histologic study in which Nirschl proposed that overuse syndromes are not an inflammatory process but instead represent failed repair of disrupted connective tissue.2 Supporting this theory were biopsy samples from tendons of patients with epicondylitis that showed disorganized collagen; pale, haphazardly arranged mesenchymal cells; an excessive amount of matrix tissue; and vascular buds with an incomplete lumen and insufficient elastin. This disorganized mesenchymal tissue has poor potential for healing.

Based on these observations, a reasonable goal for healing would be to stimulate an inflammatory-mediated process with appropriately oriented fibroblasts (laying down parallel fibers in the tendons, which would increase their strength) and to reduce the amount of matrix tissue through the use of appropriate exercises.

Tendinosis

Rolf and Movin 3 recently reported their opportunity to obtain biopsy samples from patients with Achilles tendinosis related to overuse. Their findings confirm what Nirschl found in elbow tendons. The surgeons were able to ultrasonically determine the exact location of pain and swelling and obtain a punch biopsy without destroying the tendon. As in Nirschl's epicondylitis study, the tissue had disorganized collagenous tissue and no inflammatory cells.

An additional finding was a consistent increase in proteoglycan content – up to 40 times more than normal. Besides interfering with normal collagen organization, proteoglycan molecules absorb water; this creates the swelling and distention that causes persistent pain. (Pain resulting from local muscle spasm and mechanical tissue damage, in contract, is not persistent.)

Thus, it appears that patients with tendon overuse injuries lack the normal process of inflammation and repair, with associated increased vascularity and parallel fibroblastic proliferation. Evidence of an inflammatory repair process is consistently absent.

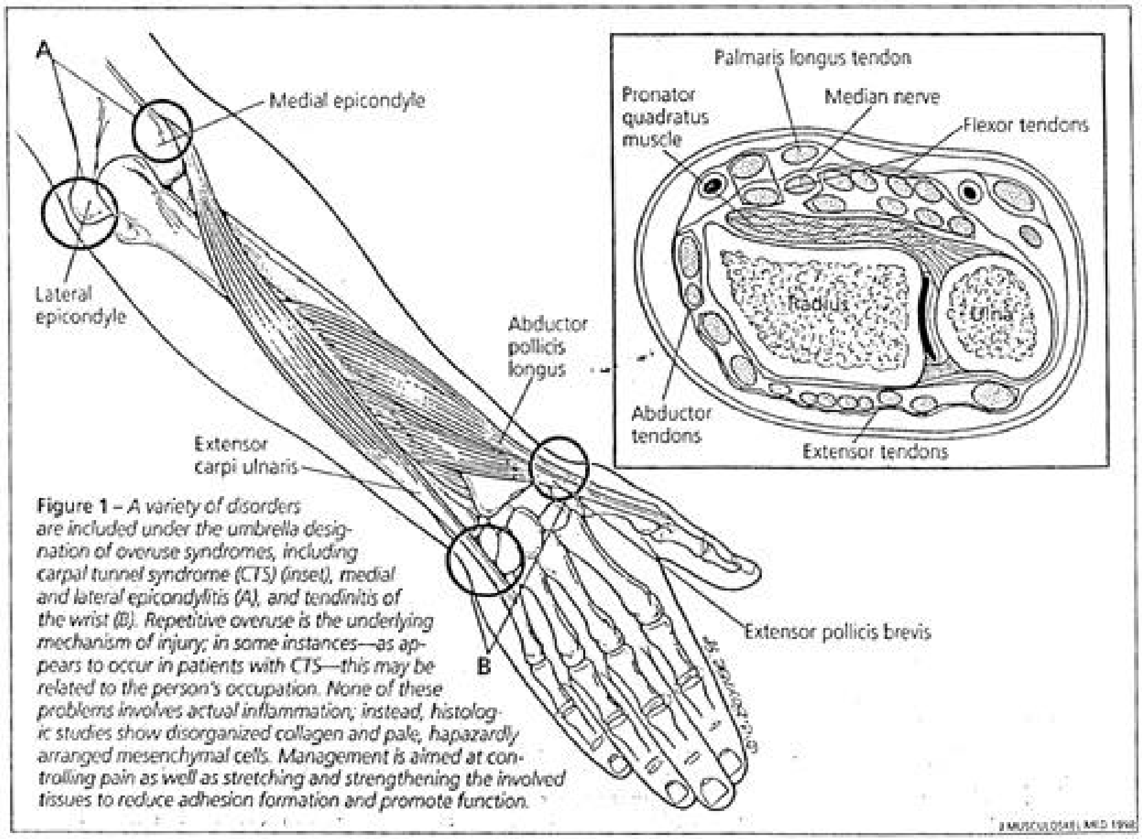

Figure 1 – *A variety of disorders are included under the umbrella designation of overuse syndromes, including carpal tunnel syndrome (CTS) (inset), medial and lateral epicondylitis (A), and tendinitis of the wrist (B). Repetitive overuse is the underlying mechanism of injury; in some instances—as appears to occur in patients with CTS—this may be related to the person's occupation. None of these problems involves actual inflammation; instead, histologic studies show disorganized collagen and pale, hapazardly arranged mesenchymal cells. Management is aimed at controlling pain as well as stretching and strengthening the involved tissues to reduce adhesion formation and promote function.*

Carpal tunnel syndrome

As in other overuse syndromes, histologic evaluation of carpal tunnel tenosynovium in symptomatic patients reveals swelling and edema in the synovium and a relative lack of inflammatory cells.4 The role of edema and deficient fluid exchange is also emphasized in studies showing a resting pressure within the carpal tunnel that is higher in patients with CTS than in normal controls.5 Increased swelling within the carpal tunnel constricts the median nerve and associated tendons.

The underlying cause of this swelling is not always apparent but may relate to deficient vascularization and anoxia. However, in a series of more than 34,000 hands, such lifestyle factors as body mass index (obesity) and sedentary pursuits appeared to contribute more significantly to CTS than anatomic factors.6 (Lack of physical activity contributes to CTS by reducing metabolic exchange and potentiating edema.) Wrist dimension was a risk factor in only about 17% of study participants. In another study involving more than 14,000 workers, CTS claimants used tobacco and caffeine more often (26% and 5%, respectively) than nonclaimants.7 Obesity and lack of aerobic exercise also showed a statistically significant increased association with CTS.

RISK FACTORS

Intrinsic

Overuse tendinoses. No specific intrinsic risk factors for overuse tendinoses have been demonstrated yet. Nirschl 8 first proposed that these disorders all be categorized as part of a “mesenchymal syndrome,” which he defined as multiple sites of tendon pain or alteration secondary to some systematic constitutional factor.9

Consistent with this, approximately 15% of persons with medial or lateral elbow tendinosis have other overuse syndromes as well.10 It is also notable that 25% of tennis elbow cases affect the nondominant arm.10 Certain anatomic sites place tendons at greater risk for increased friction and reactive edema than others. The best example of this is de Quervain’s disease, which occurs where the extensor pollicis brevis and the abductor longus pass under the extensor retinaculum. It is inappropriate to call this tendinitis, since there are no inflammatory cells, but rather it is a lethargic (characterized by little cellular activity) fibrocyte/collagenous response to tissue irritation.11 De Quervain’s disease is two to three times more common in women and primarily occurs in middle age, suggesting an underlying metabolic problem.

CTS. Intrinsic risk factors for CTS are more specific than for other overuse syndromes. The most significant are conditions that cause edema such as pregnancy, obesity, and myxedema. Other intrinsic factors are anatomic features that constrict the sides of the carpal tunnel. CTS is more likely to occur in persons with abnormally long lumbrical muscles (in which the muscle mass invades the carpal tunnel).12 However, even a physiologically narrowed carpal tunnel canal can be a predisposing feature.13 The anatomy of the wrist is such that the flexor tendons displace more than the median nerve during flexion and extension movements. Frequent repetition of these movements creates significant opportunities for unusual friction between the nerve and tendons.14

Extrinsic

Overuse tendinoses. The role of the workplace as a contributing factor in overuse syndromes other than CTS is less clear-cut.

Workplace politics influence overuse complaints. Witness the well-documented, enormous increase in the annual prevalence of repetitive strain injuries (from 762 to 2,263) that occurred in the year following liberalization of workers' compensation awards in Australia.15 It is also clear that within the same industry, some companies have a higher incidence of claims than others because of the corporate culture and its tendency to neglect employee relationships.16

CTS. While reports of up to a 20% prevalence of CTS in chain saw operators, meat cutters, and poultry processors clearly implicate work-related activities as a culprit,17 other studies find little evidence that occupation contributes to CTS.18,19 Some consider that psychosocial factors play a major role instead. Hadler,20 for instance, states that merely perceiving pain versus a self-limited ache varies the incidence of complaints among workers doing the same job. This is because an ache is usually tolerated, regarded as self-limited, and controlled by physical activity. Pain, however, is perceived as a threatening medical condition requiring serious evaluation and treatment. The customary position of the hand in the workplace is a factor: flexion postures provide less room in the carpal canal than neutral postures.21

Societal differences also appear to contribute to CTS. In a cross-sectional study of 101 Japanese furniture factory workers, sensory conduction times of the median nerve were found to be slow in 18%, but only 2.5% had carpal tunnel complaints.22 A similar study of 316 American workers showed that 22% had slow median nerve conduction times, but 18% had carpal tunnel complaints – a statistically significant difference.22

DIAGNOSIS

Clinical presentation

CTS. Patients usually present with numbness and tingling in the median nerve distribution of the hand that is aggravated by repeatedly moving the hand and fingers. Often, there is pain in the wrist, fingers, and median nerve. One of the most significant points in the history is nocturnal pain, numbness, or tingling along the distribution of the nerve. The patient often can relieve this discomfort by shaking his hand.

Overuse tendinoses. These present less distinctly than CTS. Pain and specific tenderness along the course of tendons and at muscle-tendon junctions are the defining features, as in the case of de Quervain's disease. Problems related to tendon constriction – the flexor carpi ulnaris, extensor pollicis, and extensor carpi ulnaris syndromes – cause pain and tenderness along the corresponding tendon sheaths at the wrist. Patients with lateral or medial epicondylitis often have pain and tenderness in areas other than the precise anatomic site of the epicondyle. This suggests that at least part of the pathology is located on the muscle surface (in the form of adhesions between muscle planes), rather than in the tendon or its attachment to the epicondyle.

Diagnostic studies

Overuse tendinoses. Suspicion of de Quervain's disease is confirmed with the Finkelstein test: the patient clenches the involved hand and deviates it sharply in the ulnar direction, which elicits intense pain at the styloid process of the radius. No specific tests other than pain on resisted activity (resisted wrist flexion to confirm medial epicondylitis and resisted wrist extension to confirm lateral epicondylitis) or specific types of tenderness have been described to diagnose lateral and medial epicondylitis.

CTS. An array of provocative tests and electrodiagnostic studies are available to diagnose CTS (Table 1).[23] The most common tests are Tinel's sign and Phalen's maneuver. Recently, Bronson and colleagues [24] proposed a variation of Phalen's maneuver. Using conduction studies of the median nerve across the wrist, the motor latency is measured in the four stress positions (radial and ulnar deviation, full flexion and extension) as well as neutral. Subtracting the least latency value from the greatest indicates the magnitude of the abnormal nerve function in the stressed positions. Normal is 0.24 ms, while patients with confirmed CTS average 0.44 ms. In this particular study, latency values returned to normal by 3 months after surgery.

Table 1

Test	Method	Condition measured	Positive Result	Interpretation of positive result
Moving two-point discrimination	As above, but with points moving	Innervation density of slowly adapting fibers	Failure to discriminate points more than 5 mm apart	Advanced nerve dysfunction
Vibrometry	Vibrometer head is placed on palmar side of digit; amplitude at 120 Hz increased to threshold of perception; compare median and ulnar nerves in both hands	Threshold of quickly adapting fibers	Asymmetry with contralateral hand or between radial and ulnar digits	Probable CTS (sensitivity, 0.87)
Semmes-Weinstein monofilament test	Monofilaments of increasing diameter touched to palmar side of digit until patient can tell which digit is untouched	Threshold of slowly adapting fibers	Value greater than 2.83 in radial digits	Median nerve impairment (sensitivity, 0.83)
Distal sensory latency and conduction velocity	Orthodromic stimulus and recording across wrist	Latency and conduction velocity of sensory fibers	Latency greater than 3.5 ms or asymmetry greater than 0.5 ms compared with contralateral hand	Probable CTS
Distal motor latency and conduction	Orthodromic stimulus and recording across wristLatency and conduction velocity of motor fibers of median nerve	Latency greater than 4.5 ms or asymmetry greater than 1 ms	Probable CTS	Electro-Myography
Needle electrodes placed in muscle	Denervation of thenar muscles	Fibrillation potentials, sharp waves, increased insertional activity	Very advanced motor median nerve compression	

Adapted with permission from Szabo RM, Madison M. Orthop Clin North Am. 1992. 23

Although electrophysiologic tests are the best tool for confirming the syndrome, the results do not necessarily predict therapeutic success. Braun and Jackson 25 recently compared the success of surgical carpal tunnel release in patients who had typical clinical findings and patients who had electrodiagnostic studies; the study results were positive in only half the patients (there were 75 in each group). Surgical outcome was the same regardless of electrodiagnostic findings. This study also compared functional test results (pinch, power, and static grasp) with typical CTS complaints. Again, the findings in the two groups were comparable. Positive electrodiagnostic studies were not predictive of clinical success. The most predictive functional test for CTS was the pinch test, which I have also found to be true in my patients.

MANAGEMENT

The efficacy of comprehensive treatment for overuse syndromes is not well documented in the literature, and usually the patient receives care without concern for an underlying conceptual framework that would provide a treatment rationale. There are four phases of management (Table 2).

Table 2 – Phases of management for overuse syndromes

Phase	Goal
1	Control pain by improving local metabolism
2	Restore range of motion and soft-tissue compliance
3	Improve strength and endurance to restore muscle fitness
4	Institute prophylactic maneuvers, including ergonomic improvements on job

Phase 1: Control pain

Not surprisingly, the patient's first desire is for pain relief. Splinting the area is helpful. However, considering that overuse syndromes involve metabolic stagnation and a tendency toward adhesion formation, splinting must be tempered with gradual resumption of movement. The progression to gradual mobilization is very similar to that following an ankle sprain.

Such modalities as ultrasound, heat, and massage can help control pain by affecting the local metabolism of the involved sites. The best results in the literature occur in association with low-energy shock-wave therapy, which has the potential to resolve local edema by breaking up the proteoglycan bonds that hold water. Rompe and colleagues 26 randomly assigned 100 patients with epicondylitis to receive therapy (3,000 mJ/mm2) or to serve as a control (30 mJ/mm2). At 6-month evaluation, results were good to excellent in 48% and acceptable in 42% of the treatment group, compared with 6% and 24%, respectively, of the control group.

The goal of prescribing such medications as NSAIDs and corticosteroids is also to reduce reactive edema, rather than to control inflammation. However, corticosteroids appear to do this less effectively than shock-wave therapy. In a recent study, 109 patients with tennis elbow were randomized to treatment with triamcinolone plus either lidocaine or bupivacaine. 27 Regardless of the anesthetic, response to corticosteroid injection followed a patter of rapid improvement at 2 weeks (failure rate of only 16%), followed by deterioration at 3 months (failure rate of 41%). Patients who had no previous treatment or had been afflicted for 3 months or less responded best to corticosteroids.

In a recent study of patients treated for CTS with splinting and corticosteroid injection, only 10 of 76 hands were pain-free at final evaluation. 28 Corticosteroid injections produce a similar result in medial epicondylitis: improvement over the short term but not long term. A study of 106 patients who received either local corticosteroid injection or massage showed that at 6 weeks, 22 or 53 patients in the corticosteroid group were pain-free compared with 3 of 53 in the physiotherapy group. After a year, however, there were no significant differences between the groups – the outcome was successful in only half the patients treated with either approach. 29

Active release therapy is based on the observation that there are many areas in the forearm where traversing tissues are situated at oblique angles to one another. This means that local reactive changes can gradually produce adhesions with associated local edema. Any site of distention will create pain and associated tenderness.

Leahy 30 identifies 105 upper extremity symptom patterns, which can be depicted as pain patters and represented by pain diagrams. During active release therapy, patients choose which of these diagrams most resemble their pain pattern. Based on the diagram selected, the clinician applies a combination of deep digital pressure at the area of tenderness and passive tissue movement through the adhesion site (Figure 2).

Our experience with the active release technique in 29 patients who had either CTS or epicondylitis was a 75% success rate at 3 months, according to criteria that included functional testing, a pain questionnaire, and a pain drawing, followed by gradual deterioration unless the patient had repeated releases. 28 Thus, pain relief is generally only temporary and other prophylactic factors have to be initiated, such as workplace modification, occasional use of splints and braces, and strengthening programs. Nonetheless, our results were better than others reported in the literature.

Phase 2: Restore motion

Joint function must return to normal levels, which ensures that tissues are restored to full compliance (soft tissues able to move past each other).

Training, which is supervised by a physical therapist and reinforced at each visit, focuses specifically on stretching. It is important that the patient practice full range of motion stretches several times daily, to avoid recurrence of painful adhesions between traversing tissues. Forceful full extension of the wrist is appropriate for all overuse syndromes. Full flexion, pronation, and supination are additional stretching maneuvers that are particularly helpful for patients with extensor tendinoses.

Compliance can be a problem. In our study of active release therapy, for instance, only half of our patients were still doing their exercises at 3-month follow-up. 28

Phase 3: Strengthening

Fatigue contributes to altered posture, which, in turn, can place an abnormal demand on muscles and tendons and cause discomfort. An example is the neck pain often experienced by persons who must hold their neck and torso in a steady position (the computer user and the supermarket checker are examples). No study has ever evaluated whether strength training diminishes fatigue in persons with overuse syndromes. Nonetheless, strength training appears to be a rational recommendation. Like the stretching regimen, this does require a significant amount of patient cooperation.

Finding protocols in which the patient competes against a previous record of accomplishment is the ideal way to transfer training from the treatment center to home. The goal is slow, steady joint movement under load rather than a large number of potentially irritating repetitions. Also keep in mind that eccentric training (muscle lengthening under load) is easier and more comfortable than concentric training (muscle shortening under load). For example, the patient with lateral epicondylitis who needs to improve the strength and endurance of the wrist extensors should lower a dumbbell gripped by his hand rather than extend his wrist. This exercise would be done with the pronated forearm supported on a table using a 2- to 5-lb dumbbell. Every other day is sufficient frequency; the patient can progress by doing the exercises for a longer time or using a heavier weight each session.
If all of these treatment approaches fail after several months, refer the patient for surgery. However, no surgery can restore normal anatomy, and the patient must expect some residual weakness or minor ongoing problems.

Phase 4: Prevention

This may be one of the most important aspects of managing overuse syndromes. Preventing recurrence depends on changing contributing factors in the patient's lifestyle and/or work environment. Modifications need to be individualized to the patient's biomechanical circumstances. In the workplace, for instance, can equipment be rearranged so that the wrist is not at extreme flexion or extension? Can the patient's chair be modified? Patients with tennis elbow might benefit by changing to a larger racket grip or a racket that has a larger sweet spot. Wearing a tennis elbow strap reduces the peak load placed on the wrist extensor origins.

Figure 1 - A variety of disorders are included under the umbrella designation of overuse syndromes, including carpal tunnel syndrome (CTS) (inset), medial and lateral epicondylitis (A), and tendinitis of the wrist (B). Repetitive overuse is the underlying mechanism of injury; in some instances – as appears to occur in patients with CTS – this may be related to the person's occupation. None of these problems involves actual inflammation; instead, histologic studies show disorganized collagen and pale, haphazardly arranged mesenchymal cells. Management is aimed at controlling pain as well as stretching and strengthening the involved tissues to reduce adhesion formation and promote function.

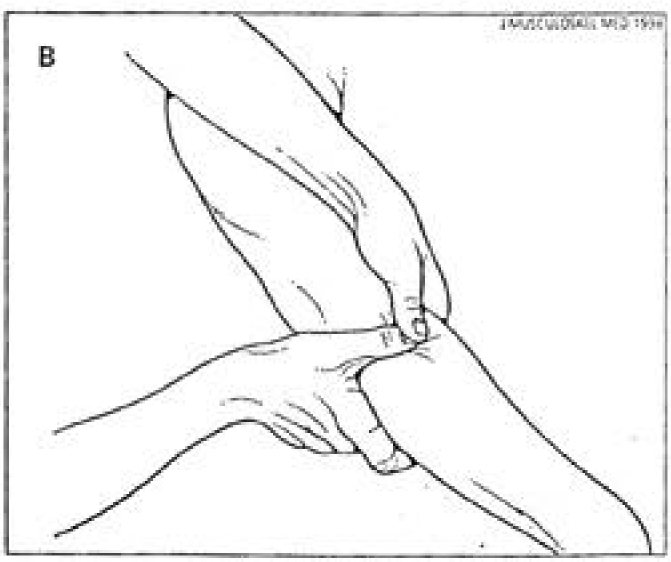

Figure 2 - In this illustration of active release therapy, the therapist is working on the extensor carpi radialis longus and brevis muscles by applying pressure to the muscles distal to their attachment at the elbow. The patient starts with the elbow bent and wrist straight (A). As the therapist holds the muscles, the patient extends the elbow and pronates and flexes the wrist while the therapist moves the pressure proximally (B), attempting to release adhesions around and between muscle planes. The patient can subsequently perform similar maneuvers at home.

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