CME

Chronic occupational repetitive strain injury

Barbara A. O'Neil, MD Michael E. Forsythe, MD William D. Stanish, MD, FRCS

abstract

OBJECTIVE To review common repetitive strain injuries (RSIs) that occur in the workplace, emphasizing diagnosis, treatment, and etiology of these conditions.

QUALITY OF EVIDENCE A MEDLINE search from January 1966 to June 1999 focused on articles published since 1990 because RSIs are relatively new diagnoses. MeSH headings that were exploded using the thesaurus included "cumulative trauma disorder," "overuse injury," and "repetitive strain injury." The search was limited to English articles only, and preference was given to randomized controlled trials.

MAIN MESSAGE Repetitive strain injuries result from repeated stress to the body's soft tissue structures including muscles, tendons, and nerves. They often occur in patients who perform repetitive movements either in their jobs or in extracurricular activities. Common RSIs include tendon-related disorders, such as rotator cuff tendonitis, and peripheral nerve entrapment disorders, such as carpal tunnel syndrome. A careful history and physical examination often lead to the diagnosis, but newer imaging techniques, such as magnetic resonance imaging and ultrasound, can help in refractory cases. Conservative management with medication, physiotherapy, or bracing is the mainstay of treatment. Surgery is reserved for cases that do not respond to treatment.

CONCLUSION Repetitive strain injury is common; primary care physicians must establish a diagnosis and, more importantly, its relationship to occupation. Treatment can be offered by family physicians who refer to specialists for cases refractory to conservative management.

résumé

OBJECTIF Passer en revue les microtraumatismes répétés qui surviennent couramment en milieu de travail, en insistant sur le diagnostic, le traitement et l'étiologie de tels états.

QUALITÉ DES DONNÉES Une recension effectuée dans MEDLINE de janvier 1966 à juin 1999 portait surtout sur les articles publiés depuis 1990 car les microtraumatismes répétés sont des diagnostics relativement nouveaux. Les rubriques MeSH explorées incluaient, à l'aide du dictionnaire de synonymes, les équivalents en anglais pour «trouble de traumatisme cumulatif», «blessure d'utilisation excessive» et «blessure de tension répétée». La recherche s'est limitée aux articles en anglais et la préférence a été accordée aux essais aléatoires contrôlés.

PRINCIPAL MESSAGE Les microtraumatismes répétés résultent d'une tension répétitive exercée sur les structures de tissus mous du corps, notamment les muscles, les tendons et les nerfs. Ils se produisent souvent chez les patients qui exécutent des mouvements répétitifs dans le contexte de leur travail ou de leurs loisirs. Au nombre des microtraumatismes répétés courants figurent les troubles liés aux tendons, comme la tendinite du sus-épineux et les syndromes des défilés ostéo-ligamentaires, comme le syndrome du canal carpien. Une anamnèse et un examen physique rigoureux aboutissent souvent au diagnostic, mais les plus récentes techniques d'imagerie, comme l'imagerie par résonance magnétique et l'échographie, peuvent être utiles dans les cas réfractaires. Une prise en charge conservatrice à l'aide de médicaments, de physiothérapie ou d'immobilisation se révèle la principale thérapie. La chirurgie est réservée aux cas qui ne répondent pas aux traitements.

CONCLUSION Les microtaumatismes répétés sont fréquents; les médecins de première ligne doivent établir le diagnostic et, avant tout, leur relation avec les occupations. Le traitement peut être dispensé par les médecins de famille qui aiguilleront les cas qui sont réfractaires à une prise en charge conservatrice.

This article has been peer reviewed.

Cet article a fait l'objet d'une évaluation externe.

Can Fam Physician 2001;47:311-316.

← FOR PRESCRIBING INFORMATION SEE PAGE 380

Repetitive strain injuries (RSI) can be defined as injuries caused or aggravated by repetitive or sustained submaximal exertion of the body's soft tissue structures including muscles, tendons, ligaments, and nerves.[1] Of particular concern is the increasing prevalence of RSI in the workplace. Not only are these injuries associated with personal morbidity and direct costs to the health care system, but considerable loss of productivity and disability claims are associated with substantial indirect costs to society.[2]

According to the 1995 United States Bureau of Labor Statistics, approximately 60% of all occupational injuries were caused by repetitive strain.[2] Further, the average number of workdays lost because of RSI is three times the average number of workdays lost for all other types of work-related injuries, and total direct and indirect costs to society were estimated at $1 trillion in 1995.[3] The rate of upper extremity disorders in the United States has tripled between 1986 and 1993,[4] and during a similar period in Ontario, the rate doubled.[5] This paper aims to review current diagnosis and treatment of common chronic RSIs related to occupation. The paper focuses on the common tendon injuries and peripheral nerve entrapment syndromes seen and managed by family physicians.

Quality of evidence

The search strategy for this paper included a MEDLINE search using the thesaurus to explode the heading "cumulative trauma disorders" and the key words and phrases "repetitive strain injury" and "overuse injury." The search was narrowed to English-language articles in which RSI was the major subject. Bibliographies of articles were used to find additional articles. Preference was given to articles based on randomized controlled trials and clinical trials published since 1990.

The level of evidence upon which this paper is based is predominantly level 1 for diagnosis and treatment of RSIs. Few available level 1 studies examined etiology of RSIs. When no randomized controlled trials were available, recommendations were based on level 2 and 3 evidence. Overall, this paper concentrated on disorders for which there were published randomized controlled trials of treatment; however, some papers were anecdotal case reports. Many other RSIs exist, but they are rarely discussed in the literature.

Dr O'Neil *is a Research Fellow in the Orthopaedic and Sport Medicine Clinic of Nova Scotia in Halifax.*
Dr Forsythe *is a resident in Orthopaedic Surgery at Dalhousie University in Halifax.* **Dr Stanish** *is a Professor of Surgery at Dalhousie University and is Director of the Orthopaedic and Sport Medicine Clinic of Nova Scotia.*

Common repetitive strain injuries

Diagnosis of occupational RSI is a great challenge to physicians, because some patients present with few objective findings. Also, the injury must be caused by patients' occupations in some way. When making a diagnosis, it is often helpful to classify RSI in terms of the tissue involved and the underlying pathophysiologic mechanism of injury (**Table 1**[1-4,6]).

Table 1. Common repetitive strain injuries

DISORDERS	COMMENT
TENDON-RELATED DISORDERS	
Tendonitis and tenosynovitis	Most common tendon disorders involve inflammation of tendon and sheath
De Quervain's stenosing tenosynovitis	Pain and tenderness along anatomical snuffbox
Epicondylitis (medial epicondylitis or golfer's elbow; lateral epicondylitis or tennis elbow)	Pain and tenderness over unsheathed tendons of either flexor (medial) or extensor (lateral) compartment of the forearm
Rotator cuff tendonitis	Impingement of the supraspinatus tendon (usually) on the acromion causing pain during overhead activities
PERIPHERAL NERVE ENTRAPMENT DISORDER	
Carpal tunnel syndrome	Most common; compression of median nerve; pain, paresthesia on lateral aspect of palm with mild weakness, usually worse at night
Cubital tunnel syndrome	Second most common; similar symptoms to carpal tunnel; due to compression of ulnar nerve in cubital tunnel at elbow
Guyon tunnel syndrome	Impingement of ulnar nerve as it passes through Guyons canal in wrist, producing numbness and tingling in ulnar nerve distribution distal to wrist

Data from Schwartz,[1] Downs,[2] Melhom,[3] Yassi,[4] and Millender and colleagues.[6]

Diagnosis. Diagnosis of RSI should be made from a careful occupational history, physical findings, and accurate diagnostic testing when possible. Onset of symptoms and signs of RSI should always follow and not precede repetitive motion in the workplace. Onset of pain or numbness should be noted in relation to any change in work habits or other behaviours. Details of the patient's occupation should be listed including the ergonomic situation and the task performed, along with the frequency, duration of exposure, and forces or vibrations experienced. Any sports or hobbies should also be noted.[6]

Physical examination focuses on the soft tissues, beginning with inspection for signs of inflammation or muscle wasting, such as thenar wasting seen in advanced carpal tunnel syndrome (CTS). Both passive and active range of motion should be assessed, and palpation will reveal areas of tenderness. Detailed neurologic examination (particularly in cases of peripheral nerve entrapment disorders) is necessary and should involve muscle strength testing, sensory examination, and investigation of deep tendon reflexes.[7] Some special tests aid in diagnosing these disorders (**Table 2**[8,9]).

Several ancillary diagnostic tests help confirm diagnoses suspected during clinical examination. The most useful tests for diagnosing peripheral nerve entrapment syndromes are electrodiagnostic studies, such as electromyography (EMG).[10,11] Because soft tissues are involved, radiographs are often unhelpful, but arthrograms can reveal a full-thickness rotator cuff tear.[10] Magnetic resonance imaging has greatly enhanced our ability to view soft tissues. Research has shown sensitivity and specificity near 95% using MRI to diagnose epicondylitis and rotator cuff tendonitis,[12-16] but MRI is not universally available. Many Canadian centres have turned to ultrasound instead for diagnosing rotator cuff tears; its sensitivity is nearly 95% but specificity is only 70%.[15,17]

Etiology. There is considerable debate in the medical community regarding the causality or etiology and pathology associated with RSI.[18] Essentially, neuromuscular disorders have several possible influences, which include the amount of tissue damage and patients' age, health status, and psychosocial status.[19] The repetition, duration, and force of occupational tasks and the ergonomics of the work environment contribute to soft tissue damage. It is difficult, however, to separate the effects of factors outside the workplace from the cause.[20,21] Patients could have had previous injuries or have medical conditions predisposing them to RSI.[22]

Table 2. Special clinical tests for chronic repetitive strain injuries

TEST	DISORDER	TEST DESCRIPTION
Cozen's	Epicondylitis	Resistance to wrist extension and radial deviation while the forearm is pronated. Positive test if pain at lateral or medial epicondyle
Finkelstein's	De Quervain's disease	Ulnar deviation of hand with thumb flexed against palm, fingers flexed over thumb. Positive response is pain at radial styloid
Tinel's sign	Carpal tunnel syndrome	Tapping of the median nerve as it passes through the carpal tunnel. Positive test if pain and tingling in the median nerve distribution
Phalen's	Carpal tunnel syndrome	Flexing of both wrists 90° with dorsal aspects of hands held together for 60 s. Positive test if pain in median nerve distribution
Pressure and Flexion test[8]	Cubital tunnel syndrome	Maximum elbow flexion while applying pressure on the ulnar nerve just proximal to the cubital tunnel. Symptom response within 30 to 60 s

Data from Novak and associates[8] and Hoppenfeld.[9]

Repetition of movements does not allow muscles, tendons, or ligaments sufficient recovery time and, therefore, can damage these structures.[19-21] Local ischemia in the muscles of the upper limb and a resultant accumulation of lactic acid is believed to occur from holding the upper limb in a certain position for prolonged periods. Damage occurs when inflammation results in tissue remodeling and scar formation. Tendons can incur damage as a result of repeated failure at loads below their maximal tensile strength, which is probably the case in RSI.[19,20]

Flexed- or extended-wrist positions increase pressures applied to the median and ulnar nerves, and finger flexion places these nerves at risk of compression. Posture can increase pressure in nerves at entrapment sites or can shorten muscles to cause an adaptive short-

ening and secondary nerve compression. Also, muscles can be elongated into a weakened position, leading to overuse of other muscles, and ultimately contributing to the muscle imbalance cycle and to secondary nerve compression.[23]

Psychological and social factors (such as stress both at home and in the workplace) or mood disorders (such as depression) have key roles in RSI.[24-27] A study by Helliwell and colleagues[24] showed a significant relationship between both anxiety and depression scores and incidence of upper extremity pain in a group of factory workers who performed repetitive tasks. It remains unclear, however, whether increased anxiety and depression among RSI sufferers is due to their symptoms or is a predisposing factor to development of upper limb pain.[25,26] Other theories suggest that RSI results from a sensory dysfunction[27] rather than from pure tissue disorders or that it is a physiologically learned phenomenon.[28]

Prognosis and treatment. A retrospective follow-up study of a population-based case series showed that the mean duration of symptoms of CTS was between 6 and 9 months, with 22% of patients reporting symptoms for 8 years or more.[29] According to a meta-analysis of the literature, prognosis for RSI sufferers is poorer with longer duration of symptoms.[30]

Treatment of chronic tendon injuries: Treatment of chronic RSI includes both conservative and surgical interventions. Traditional treatment for chronic tendon injuries is similar to acute strain injuries with rest, ice, compression, and elevation (RICE) for the first 48 hours after an exacerbation. If there is minimal swelling, these modalities are of little aid in treating chronic injuries. Patients should reduce their workload, perhaps performing light duties or different tasks in the same workplace. Ergonomic adjustments should be made to decrease repetition of tasks and correct poor posture.[31-33] Limb immobilization is commonly prescribed but must be used with caution because it can result in muscle atrophy and joint stiffness. In fact, early initiation of eccentric exercises, those that allow the muscle-tendon unit to lengthen against resistance, have been described as a preferred method of treatment for refractory chronic tendonitis.[34] Adjunctive drug therapy with NSAIDS and analgesics can provide some symptom relief and make exercising more bearable.

For treatment of medial and lateral epicondylitis, randomized controlled trials have shown steroid injections at the site of inflammation to provide short-term relief.[35] Topical 2% diclofenac or 10% ketoprofen applied to the elbow has also been shown to provide effective short-term relief compared with placebo, and represent an alternative to oral NSAIDs.[36] Bands worn on the proximal forearm for epicondylitis could relieve or reduce symptoms, as they redirect contractile forces away from the muscle attachment to the humeral condyle.[37] Shock wave therapy has not been shown to improve epicondylitis.[38] Surgical treatment is considered only for refractory cases and includes newer surgeries, such as arthroscopic release of the extensor carpi radialis brevis tendon for lateral epicondylitis.[39]

Treatment for chronic rotator cuff tendonitis beyond RICE and NSAIDs can include local corticosteroid injections for short-term relief of pain.[40] Periarticular injection of 20 mg of tenoxicam, a relatively new treatment, was shown by a double-blind placebo-controlled trial to be as effective in relieving pain and improving shoulder mobility as a lidocaine-steroid injection.[41]

Injection of a steroid-lidocaine combination has been shown to provide complete relief of symptoms for most patients with de Quervain's disease, provided the injection is accurately placed between the tendons of abductor pollicis longus and extensor pollicis brevis (**Figure 1**).[42,43] Surgical management includes decompression of the extensor pollicis brevis tendon subcompartment. It provides relief to most patients but is reserved for refractory cases.[44]

Treatment of nerve entrapment syndromes: Treatment of CTS should include ergonomic adjustments in the workplace.[45] A randomized controlled trial by Rempel et al[45] showed that an alternative computer keyboard

Figure 1. Injection site for de Quervain's tenosynovitis within the first dorsal compartment (anatomical snuffbox) containing the tendons of extensor pollicis brevis and abductor pollicis longus: *Care should be taken not to inject the tendons directly.*

design, which differs in the force-displacement characteristics of the keys, significantly reduced hand, forearm, and arm pain.[35,45] Steroid injections have been shown to reduce pain in CTS.[46] A randomized controlled trial of oral therapies for CTS showed that corticosteroids provided greater benefit than NSAIDs and diuretics, which showed no improvement over baseline.[47]

Exercises have led to better outcomes than splinting.[46] Rozmaryn et al[48] showed that patients treated with nerve and tendon gliding exercises with the wrist held in six different positions for 7 seconds at a time helped tendons in the carpal tunnel and the median nerve function freely. Only 43% of patients performing these exercises underwent surgery compared with 71% of the group not performing the exercises.[48]

A randomized controlled trial by Spence et al[49] showed that both EMG biofeedback alone or applied relaxation training alone provided significant short-term reductions in pain and pain-related depressed mood among patients with chronic upper extremity RSIs.[49] Electromyographic biofeedback involved auditory feedback regarding muscle tension levels to train patients to minimize such tension. Relaxation training involved a psychologist teaching patients a range of relaxation techniques to be used when conducting activities that involve physical or emotional stress and muscle tension. Ultrasound therapy was shown by a randomized controlled trial to have no effect on RSI recovery compared with placebo.[50]

An elective surgical procedure successfully relieves pain in most patients within 6 weeks of surgery and has a high rate of patient satisfaction according to a prospective trial by Katz et al.[51] Improvement in function after carpal tunnel release can take up to 2 years.[51] Carpal tunnel release can be done using intraoperative ultrasonography to minimize exposure and dissection. Several randomized controlled trials, however, show no significant difference between conventional carpal tunnel release and ultrasonographically assisted surgery.[52]

Treatment of cubital tunnel syndrome is similar in principle to CTS treatment. Conservative treatments with proven efficacy include splinting and steroid injection.[53] Surgical management of proven benefit for severe and refractory cases includes partial medial epicondylectomy, cubital tunnel release, and anterior transposition of the ulnar nerve.[54-57]

Conclusion

Repetitive strain injury continues to be an important health problem, and the epidemic shows no signs of slowing down. It causes a dilemma for physicians and the general public because rising social and financial costs are associated with RSI. Preventing these injuries by ensuring ergonomically sound work environments

Editor's key points

- Diagnosis of repetitive strain injury (RSI) relies on a careful history of work and leisure activities and on physical examination checking for muscle strength, sensation, and deep tendon reflexes. Special physical tests for certain syndromes can also help.
- Magnetic resonance imaging is best for most RSIs but is not very accessible. Ultrasound is more readily available. Electromyography is best for nerve entrapment syndromes.
- Management strategies include modifying duties and ergonomic adjustments at work and eccentric exercises, which allow the muscle-tendon unit to lengthen against resistance.
- Oral and topical nonsteroidal anti-inflammatory drugs and forearm bands reduce symptoms, while steroid and tenoxicam injections are effective in certain cases. Surgery is reserved for refractory cases of nerve entrapment syndromes.

Points de repère du rédacteur

- Le diagnostic des microtraumatismes répétés se fonde sur une anamnèse rigoureuse des activités professionnelles et récréatives, et sur un examen physique portant sur la force des muscles, la sensation et les réflexes des tendons profonds. Des épreuves physiques spéciales peuvent aussi se révéler utiles pour certains syndromes.
- L'imagerie par résonance magnétique est la meilleure épreuve pour la majorité des microtraumatismes répétés, mais elle n'est pas facile d'accès. L'échographie est plus aisément disponible. L'électromyographie est à privilégier pour les syndromes des défilés ostéo-ligamentaires.
- Les stratégies thérapeutiques comportent la modification des tâches et les ajustements ergonomiques au travail, et les exercices excentriques qui permettent à la structure muscle-tendon de s'allonger contre la résistance.
- Les médicaments anti-inflammatoires non stéroïdiens par voie orale ou topique et les bandages de l'avant-bras réduisent les symptômes, tandis que les injections de stéroïdes et de tenoxicam sont efficaces dans certains cas. La chirurgie est réservée aux cas réfractaires de syndromes des défilés ostéo-ligamentaires.

and adequate time away from work is important for decreasing incidence.

Diagnosis of RSIs should be based on history and objective physical findings as well as electrodiagnostic tests when possible. Physicians might not be able to determine a work-related cause but might determine an association with tasks performed on the job. Initial treatment should involve conservative measures such as RICE, NSAIDs, steroid injections, appropriate exercises, and modification of the inciting repetitive tasks. Surgery is reserved for those with persistent symptoms despite maximal nonsurgical therapy.

Competing interests

None declared

Correspondence to: *Dr William D. Stanish, Department of Surgery, Dalhousie University, 5595 Fenwick St, Suite 311, Halifax, NS B3H 4M2*

References

1. Schwartz RG. Cumulative trauma disorders. *Orthopedics* 1992;15(9):1051-3.
2. Downs SG. Nonspecific work-related upper extremity disorders. *Am Fam Physician* 1997;55(4):1296-302.
3. Melhom JM. Cumulative trauma disorders and repetitive strain injury. The future. *Clin Orthop* 1998;351:107-26.
4. Yassi S. Repetitive strain injuries. *Lancet* 1997;349:943-7.
5. Ashbury FD. Occupational repetitive strain injuries and gender in Ontario, 1986-1991. *J Occup Fam Med* 1995;37(4):479-85.
6. Millender LH, Louis DS, Simmons BP. *Occupation disorder of the upper extremity.* New York, NY: Churchill Livingstone Inc; 1992.
7. Katz JN, Larson MG, Sabra A, Krarup C, Stirrat CR, Sethi R, et al. The carpal tunnel syndrome: diagnostic utility of the history and physical examination findings. *Ann Intern Med* 1990;112:321-7.
8. Novak CB, Lee GW, Mackinnon SE, Lay L. Provocative testing for cubital tunnel syndrome. *J Hand Surg* [Am] 1994;19(5):817-20.
9. Hoppenfeld S. *Physical examination for the spine and extremities.* New York, NY: Appleton and Lange; 1992.
10. Glowaki KA, Breen CJ, Sachar K, Weiss AP. Electrodiagnostic testing and carpal tunnel release outcome. *J Hand Surg* [Am] 1996;21(1):117-21.
11. Cherniak MG, Moalli D, Viscolli C. A comparison of traditional electrodiagnostic studies, electroneurometry, and vibrometery in the diagnosis of carpal tunnel syndrome. *J Hand Surg* [Am] 1996;21(1):122-31.
12. Anderson MW, Kaplan PA, Dussault RG, Degnan GG. Magnetic resonance imaging of the wrist. *Curr Probl Diagn Radiol* 1998;27(6):187-229.
13. Martin CE, Schweitzer ME. MR imaging of epicondylitis. *Skeletal Radiol* 1998;27(3):133-8.
14. Steinbach LS, Fritz RC, Tirman PF, Uffman M. Magnetic resonance imaging of the elbow. *Eur J Radiol* 1997;25(3):223-41.
15. Bachmann GF, Melzer C, Heinrichs CM, Mohring B, Rominger MB. Diagnosis of rotator cuff lesions: comparison of US and MRI on 38 joint specimens. *Eur Radiol* 1997;7(2):192-7.
16. Jones AO. Magnetic resonance imaging of the supraspinatus tendon: the significance of signal intensity alterations at the 'critical zone'. *Austrlas Radiol* 1998;42(2):106-13.
17. Bonnel H, Stabler A, Schmitt R. Imaging in sports medicine. *Eur J Radiol* 1997;26(1):2-15.
18. Clevand LG. "RSI": a model for social iatrogenesis. *Med J Aust* 1987;147:236-9.
19. MacKinnion SE, Novak CB. Repetitive strain in the workplace. *J Hand Surg* [Am] 1997;22A:2-16.
20. Wigley RD. Repetitive strain syndrome, fact not fiction. *N Z Med J* 1990;103:75-6.
21. Hadler NM. Cumulative trauma disorders, an iatrogenic concept. *J Occup Med* 1990;32(1):38-41.
22. Vender MI, Kasdam M, Truppa KL. Upper extremity disorders: a literature review to determine work relatedness. *J Hand Surg* [Am] 1995;20A:534-41.
23. Novak CB, Mackinnon SE. Repetitive use and static postures: a source of nerve compression and pain. *J Hand Ther* 1997;10(2):151-9.
24. Helliwell PS, Mumford DB, Smeathers JE, Wright V. Work related upper limb disorder: the relationship between pain, cumulative load, disability, and psychological factors. *Ann Rheum Dis* 1992;51(12):1325-9.
25. DePalma MT, Weisse CS. Psychological influences on pain perception and nonpharmacologic approaches to the treatment of pain. *J Hand Ther* 1997;10(2):183-91.
26. Hess D. Employee perceived stress. Relationship to the development of repetitive strain injury symptoms. *Am Assoc Occup Health Nurses J* 1997;45(3):115-23.
27. Byl N, Wilson F, Merzenich M, Melnick M, Scott P, Oakes A, et al. Sensory dysfunction associated with repetitive strain injuries of tendinitis and focal hand dystonia: a comparative study. *J Orthop Sports Phys Ther* 1996;23(4):234-44.
28. Byl NN, Melnick M. The neural consequences of repetition: clinical implications of a learning hypothesis. *J Hand Ther* 1997;10(2):160-74.
29. DeStefano F, Nordstrom DL, Vierkant RA. Long-term symptom outcomes of carpal tunnel syndrome and its treatment. *J Hand Surg* [Am] 1997;22(2):200-10.
30. Cole DC, Hudak PL. Prognosis of nonspecific work-related musculoskeletal disorders of the neck and upper extremity. *Am J Ind Med* 1996;29(6):657-68.
31. Smith A. Upper limb disorders—time to relax? *Physiotherapy* 1996;82(1):31-8.
32. Furth HJ, Holm MB, James A. Reinjury prevention follow-through for clients with cumulative trauma disorders. *Am J Occup Ther* 1994;48(10):890-8.
33. Lawler AL, Tomlin G. Educational techniques used in occupational therapy treatment of cumulative trauma disorders of the elbow, wrist, and hand. *Am J Occup Ther* 1997;51(2):113-8.
34. El Hawary R, Stanish WD, Curwin SL. Rehabilitation of tendon injuries in sports. *Sports Med* 1997;24:347-58.
35. Stahl S, Kaufman T. The efficacy of an injection of steroids for medial epicondylitis. A prospective study of sixty elbows. *J Bone Joint Surg* Am 1997;79(11):1648-52.
36. Burnham R, Gregg R, Healy P, Steadward R. The effectiveness of topical diclofenac for lateral epicondylitis. *Clin J Sport Med* 1998;8(2):78-81.
37. Sheon RP. Repetitive strain injury. *Postgrad Med* 1997;102(4):53-56,62,68,72,75,77-81,85,88.
38. Krischek O, Hopf C, Nafe B, Rompe JD. Shock-wave therapy for tennis and golfer's elbow—1 year follow-up. *Arch Orthop Trauma Surg* 1999;119(1-2):62-6.
39. Kuklo TR, Taylor KF, Murphy KP, Islinger RB, Heekin RD, Baker CL Jr. Arthroscopic release for lateral epicondylitis: a cadaveric model. *Arthroscopy* 1999;15(3):259-64.
40. Goupille P, Sibilia J. Local corticosteroid injections for treatment of rotator cuff tendonitis (except for frozen shoulder and calcific tendonitis). Groupe Rhumatologique Français de l'Épaule (G.R.E.P.). *Clin Exp Rheumatol* 1996;14(5):561-6.
41. Itzkowitch D, Ginsberg F, Leon M, Bernard V, Appelboom T. Peri-articular injection of tenoxicam for painful shoulders: a double-blind, placebo controlled trial. *Clin Rheumatol* 1996;15(6):604-9.
42. Rankin ME, Rankin EA. Injection therapy for management of stenosing tenosynovitis (de Quervain's disease) of the wrist. *J Natl Med Assoc* 1998;90(8):474-6.
43. Zingas C, Failla JM, Van-Holsbeeck M. Injection accuracy and clinical relief of de Quervain's tendinitis. *J Hand Surg* [Am] 1998;23(1):89-96.
44. Yuasa K, Kiyoshige Y. Limited surgical treatment of de Quervain's disease: decompression of only extensor pollicis brevis subcompartment. *J Hand Surg* [Am] 1998;23(5):840-3.
45. Rempel D, Tittiranonda P, Burastero S, Hudes M, So Y. Effect of keyboard keyswitch design on hand pain. *J Occup Environ Med* 1999;41(2):111-9.
46. Feuerstein M, Burrell LM, Miller VI, Lincoln A, Huang GD, Berger R. Clinical management of carpal tunnel syndrome: a 12-year review of outcomes. *Am J Ind Med* 1999;35(3):232-45.
47. Chang MH, Chiang HT, Lee SS, Ger LP, Lo YK. Oral drug of choice in carpal tunnel syndrome. *Neurology* 1998;51(2):390-3.
48. Rozmaryn LM, Dovelle S, Rothman ER, Gorman K, Olvey KM, Bartko JJ. Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. *J Hand Ther* 1998;11(3):171-9.
49. Spence SH, Sharpe L, Newton-John T, Champion D. Effect of EMG biofeedback compared to applied relaxation training with chronic, upper extremity cumulative trauma disorders. *Pain* 1995;63:199-206.
50. Oztas O, Turan B, Bora I, Karakaya MK. Ultrasound therapy effect in carpal tunnel syndrome. *Arch Phys Med Rehabil* 1998;79(12):1540-4.
51. Katz JN, Fossel KK, Simmons BP, Swartz RA, Fossel AH, Koris MJ. Symptoms, functional status, and neuromuscular impairment following carpal tunnel release. *J Hand Surg* [Am] 1995;20(4):549-55.
52. Nakamichi K, Tachibana S. Ultrasonographically assisted carpal tunnel release. *J Hand Surg* [Am] 1997;22A(5):854-66.
53. Hong CZ, Long HA, Kanakamedala RV, Chang YM, Yates L. Splinting and local steroid injection for the treatment of ulnar neuropathy at the elbow: clinical and electrophysiological evaluation. *Arch Phys Med Rehabil* 1996;77(6):573-7.
54. Tsai TM, Chen IC, Majd ME, Lim BH. Cubital tunnel release with endoscopic assistance: results of a new technique. *J Hand Surg* [Am] 1999;24(1):21-9.
55. Asami A, Morisawa K, Tsurata T. Functional outcome of anterior transposition of the vascularized ulnar nerve for cubital tunnel syndrome. *J Hand Surg* [Br] 1998;23(5):613-6.
56. Kaempffe FA, Farbach J. A modified surgical procedure for cubital tunnel syndrome: partial medial epicondylectomy. *J Hand Surg* [Am] 1998;23(3):492-9.
57. Glowacki KA, Weiss AP. Anterior intramuscular transposition of the ulnar nerve for cubital tunnel syndrome. *J Shoulder Elbow Surg* 1997;6(2):89-96.