
ORIGINAL ARTICLE

Physiotherapy, Steroid Injections, or Rest for Lateral Epicondylitis? What the Evidence Suggests

Ashok Nimgade, MD, MPH*[†]; Meaghan Sullivan, MSOT[‡];
Rose Goldman, MD, MPH*[†]

*Harvard School of Public Health, Occupational Health Program; [†]Harvard Medical School; Cambridge Health Alliance, Cambridge and Boston, Massachusetts; [‡]Tufts University, Boston School of Occupational Therapy, Medford, Massachusetts, U.S.A.

■ Abstract

Objective: To identify effective lateral epicondylitis interventions and assess the quality of research over time.

Methods: Relevant MEDLINE and EMBASE searches respectively yielded 226 and 187 potential studies. Additional citations were extracted from bibliographies. Thirty controlled trials met inclusion criteria. The Cochrane Collaboration guidelines "quality score" served to rate studies.

Results: In the short term (<2 to 3 months) steroid injections and physiotherapy outperformed relative rest. Physiotherapy appears efficacious regardless of time frame. After 3 months, active physiotherapy outperforms injections, but does not appear significantly better than rest. Evidence was neutral or insufficient regarding ultrasound, splinting, or manipulation. Nonsignificant correlations between publication year and study quality score were found.

Conclusions: Overall research quality has not improved with time. Steroid injections appear the most successful short-term intervention for pain relief. Active physiotherapy appears efficacious regardless of time frame. ■

Key Words: lateral epicondylitis (tennis elbow), ultrasound, steroid injections, physical therapy

Address correspondence and reprint requests to: Ashok Nimgade, MD, MPH, Harvard School of Public Health, 401 Park Drive, Landmark Center, PO Box 18697, Rm 3-111-11, Boston, MA 02215, U.S.A. E-mail: animgade@hms.harvard.edu.

INTRODUCTION

Lateral epicondylitis ("lateral epicondylitis" or "tennis elbow") is a relatively common musculoskeletal condition encountered by physicians. This condition peaks in the prime of work life with a prevalence in the mid-40s of almost 10% for females and about 3% for men.¹ The annual U.S. incidence is estimated to be 4/1000.^{2,3} A 7.4% prevalence was found in one survey of an industrial workplace population.⁴

Lateral epicondylitis is associated with continued stretching of forearm extensor musculotendinous structures (especially extensor carpi radialis brevis [ECRB]). Signs and symptoms include active or rest pain and tenderness at the musculotendinous junction about 1 cm distal to the lateral epicondyle, with discomfort during wrist extension or forearm supination. Focal pain can be noted with resisted wrist extension activities such as hammering or backhand tennis volleys. The association of this disorder with forceful work⁴ and repetitive strain leads to far more cases coming from the workplace than from tennis courts (even though the term "tennis elbow" has enjoyed usage since the 1880s⁵).

The pathophysiology of lateral epicondylitis has long been debated. Tears and granulation tissue have been observed in the ECRB tendon origin.^{6,7} Although evidence for more than transient inflammation is rarely found,⁸ some inflammatory cells have been observed adjacent to the tendon.⁶ Thus, the historic term "epi-

condylitis” is giving way to “epicondylitis” or “tendinosis,” referring to disruption or disarray of collagen fibers and other structural tissues, or even the more generic “tendinopathy.” The mechanisms and biochemical changes underlying tendonopathies are not yet fully understood. One hypothesis implicates a mismatch of metabolic supply and physiologic demand: tendons must sustain great loads (sometimes 10 times greater than bodyweight) and yet receive only about 13% oxygen uptake of muscle.^{9,10}

Although many conservative treatments have been proposed, in daily practice, most clinicians face the often baffling choice of whether to start patients with rest, physiotherapy, or steroid injections. The price tags associated with these interventions can prove substantial. Recent estimates place total direct and indirect costs of corticosteroid injections at 400 Euro, and for physiotherapy at 920 Euro.¹¹

Some biological basis for most common treatment exists. Steroid injections, for instance, help address any coexisting inflammation present with early stage tissue tears. Steroids, however, can lead to decreased collagen synthesis, tendon atrophy, and cell death.^{6,8} Ultrasound, through thermal and mechanical effects, is thought to increase local metabolism, protein synthesis, and fibroblast activation.⁸ Splinting/bracing may keep the tendon warm, add proprioceptive feedback, and reduce exacerbating stress on the ECRB. The natural history of spontaneous recovery within a year confounds treatment assessment.¹² Furthermore, recurrences can occur in up to 54%¹³ of “cured” patients within 6 months.

Unfortunately, many studies of lateral epicondylitis, including those labeled as “gold standard” randomized controlled trials (RCTs), are methodologically flawed (eg, insufficient power, poor reporting of data, lack of proper controls).¹⁴⁻¹⁸ Prior pertinent reviews also have not been consistently systematic,³ have admixed several conditions,^{14,19} or have focused on only single treatments.¹⁸⁻²² Furthermore, reviews have not always been written with the clinician in mind.³ Boyer and Hastings¹⁷ noted that most lateral epicondylitis treatments “are unproven at best or costly and time-consuming at worst . . . to have such a common clinical condition have such a paucity of peer-reviewed published data of acceptable scientific quality is disappointing.” The Agency for Healthcare Research and Quality (AHRQ) drew similar conclusions.³

Because steroid injections are amenable to standardization, they are relatively well-studied, with several reviews indicating their efficacy for lateral epicondylo-

sis.^{21,23,24} Physiotherapy, however, has proven harder to study, because it consists of a varying mixture of exercise—stretching, concentric strengthening, and eccentric strengthening (which combines strengthening and stretching)—and modalities such as ultrasound, manipulation, and massage. The role of exercise has rarely been studied in isolation. Although ultrasound is widely used,²⁵ and is relatively easy to isolate and standardize, only equivocal evidence exists for its efficacy as a sole treatment.²⁶ One would hope for better evidence for massage and manipulation, treatments dating back decades.^{12,27} In the 1930s, Cyriax reported using manipulation to provide “full relief” to 19 out of 20 patients.¹² This success, however, has not been convincingly duplicated.

The purpose of our review is to systematically identify, review, and rate the well-performed RCT studies to assist health care providers in utilizing the best available evidence for clinical management of lateral epicondylitis, particularly regarding the use of physiotherapy, steroid injections, or relative rest. A secondary goal is to see whether, in the modern environment of evidence-based medicine, the quality of studies has improved over time.

METHODOLOGY

A literature search was conducted using PubMed (MEDLINE) for papers in English involving controlled trials (1966 to November 2004, using terms: “epicondylitis,” “epicondylitis,” “lateral epicondylitis,” “tennis elbow,” “massage,” “splinting,” “bracing,” “physical therapy,” “injection,” and “steroid injection”). A similar search was also conducted in EMBASE. A few additional pertinent citations were found from the Cochrane Database of RCTs (Issue 2, 2000), from the AHRQ report,³ as well as from bibliographies from retrieved articles.

Eligible papers had to have at least one “experimental” group and one “control” or “comparison” group (consisting of minimal, commonplace clinically relevant interventions such as relative rest, ergonomic advice, vitamins, or nonsteroidal anti-inflammatory drugs [NSAIDs][†]). The study design had to be either a RCT or a clinical controlled trial (CCT).[‡] Quality ratings of RCT studies that fulfilled the criteria were

†Although ergonomic advice, vitamins, or NSAIDs may have therapeutic effects of their own, in practice they are generally considered minimal interventions.

‡In RCTs, a subject is assigned through an entirely random selection process to either experimental group or control group; in CCTs the selection process occurs systematically through alternation or rotation.

conducted independently by two reviewers (A.N. and M.S.) with a third reviewer (R.G.) serving as tie-breaker. The Cochrane Collaboration guidelines²⁸ for grading-controlled trials was utilized. This system uses 11 items for internal validity, 6 for external validity, and 2 for statistical criteria (Table 1). Summation of internal validity scores yields a “quality score,” which was used primarily as an initial screen (Table 2). Sole reliance on this quality score, however, can prove problematic—for instance, it does not penalize for low number of study subjects (which, after all, depends on desired study power, a somewhat subjective determination).

Outcomes used for demonstrating efficacy varied across studies, but generally included improvement in one or more of the following categories: pain, strength, flexibility, or function (Table 3). Some authors also developed composite indices consisting of outcomes from several of these categories. Given the possible difference in outcomes studied, confidence in a particular intervention is bolstered when several studies of high methodological quality consistently show one intervention outperforming another.

Table 1. Cochrane Collaboration Criteria List for Methodological Quality Assessment²⁸

<i>Patient selection</i>	
a.	Were eligibility criteria specified?
b.	Treatment allocation
	(1) Was bona fide randomization performed?
	(2) Was treatment allocation concealed?
c.	Were groups similar at baseline regarding most important prognostic indicators?
<i>Interventions</i>	
d.	Were index and control interventions explicitly described?
e.	Was care provider blinded to intervention?
f.	Were cointerventions avoided or comparable?
g.	Was compliance acceptable in all groups?
h.	Was patient blinded to intervention?
<i>Outcome measurement</i>	
i.	Was outcome assessor blinded to intervention?
j.	Were outcome measures relevant?
k.	Were adverse effects described?
l.	Was withdrawal/dropout rate described and acceptable?
m.	Timing follow-up measurements
	(1) Was short-term follow-up measurement performed?
	(2) Was a long-term follow-up measurement performed?
n.	Was timing of outcome assessment in both groups comparable?
<i>Statistics criteria</i>	
o.	Was sample size for each group described?
p.	Did analysis include an intention-to-treat analysis?
q.	Were point estimates and measures of variability presented for primary outcome measures?
Internal validity criteria: b1, b2, e, f, g, h, i, j, l, n, p	
External/descriptive criteria: a, c, d, k, m1, m2	
Statistical criteria: o, q	

A “best evidence” approach was used here rather than meta-analysis, which prior reviewers have found untenable given the presence of grossly dissimilar data.¹⁶ Although a semiquantitative approach involving standardized mean differences has also been used to review relevant physiotherapy literature,¹⁹ we decided against such a course because of the large variety of treatment definitions, protocols, and outcomes in the studies reviewed. Statistical analysis was performed using Statistical Package for the Social Sciences (version 12). All conclusions were based on statistical significance of $P < 0.05$.

RESULTS

Most articles were identified through PubMed and EMBASE, which respectively yielded 228 and 187 potential papers. After initial review of abstracts and papers only 36 studies met inclusion criteria. Six of these were ineligible due to insufficient reporting, or admixture of multiple, inseparable diagnoses or treatments.

The internal validity “quality score” among the remaining 30 studies varied greatly from 2 to 9 (out of 11 possible). To select studies that offered “best” evidence, we chose only those studies that met over 50% of the internal validity criteria (ie, scoring 6 or over) (Table 2). The correlation between internal validity quality score and external validity score was 0.454 ($P = 0.013$), indicating that papers scoring high on internal validity also did fairly well regarding other quality measures. See Table 3 for study summaries, including details on outcomes utilized by each study.

Steroid Injections

Three studies found injection groups outperforming comparison groups in the short term (Table 4). Smidt et al.²⁹ found markedly greater improvement in the injection group over an exercise group after 6 weeks. After a year, however, the exercise group fared better. Hay et al.³⁰ similarly found injection to outperform placebo, but only in the short term. Price et al.³¹ found that up to 8 weeks, steroid injections outperformed anesthetic injections. These results mirrored a previous study by Murley.³²

Only one study³³ failed to find short-term advantages to steroid injections over conservative therapy, but here too decreased pain in the corticosteroid group was noted from 2 to 6 months. In just two studies, no benefits to steroid injections were noted over either NSAIDs³⁴ or local anesthetics,³⁵ but these studies both were blemished by small study size.

Table 2. Rating Scores for Randomized (RCT) and Clinical (CCT) Controlled Trials Reviewed Using Cochrane Collaboration Scoring System

Study (Interventions)	Study Design	Internal Validity											Quality Score	External Validity						Statistics				
		b1	b2	e	f	g	h	i	j	l	n	p		a	c	d	k	m1	m2	o	q			
Price et al., 1991 (I) ³¹	RCT?	?	+	+	?	+	+	+	+	+	+	+	+	+	9.0	+	+	+	+	+	+	+	+	+
Hay et al., 1999 (I) ³⁰	RCT	+	?	?	+	+	0.5	+	+	+	+	+	+	+	8.5	+	+	+	+	+	+	+	+	+
Smidt et al., 2002 (I, PT) ²⁹	RCT	+	+	-	+	0.5	-	+	+	+	+	+	+	+	8.5	+	+	+	+	+	+	+	+	+
Haker & Lundeberg, 1991 (U) ⁴⁰	RCT?	?	?	+	+	+	+	+	+	+	+	+	+	-	8.0	+	+	+	+	+	+	+	+	0.5
Halle & Karalfa, 1986 (I, U) ⁴³	RCT	+	+	+	+	?	+	+	+	+	-	+	?	?	8.0	+	?	0.5	-	+	-	+	+	0.5
Lundeberg et al., 1988 (U) ⁴¹	RCT?	?	+	+	?	+	+	+	+	+	+	+	+	NA	8.0	+	?	+	-	+	+	+	+	+
Zachrisson-Forsell, 1982 (U) ³⁹	RCT?	?	?	+	?	+	+	+	+	+	+	+	+	N/A	8.0	+	+	+	-	+	-	+	+	0.5
Altay et al., 2002 (I) ³⁷	CCT	-	+	?	?	+	+	+	+	+	+	+	?	?	7.0	+	?	+	+	+	+	+	+	0.5
Newcomer et al., 2001 (I) ³³	RCT?	?	+	+	?	?	?	+	?	+	+	+	+	+	7.0	+	+	+	-	+	+	+	+	+
Binder et al., 1985 (U) ⁴²	RCT?	?	+	+	?	?	?	+	+	+	0.5	+	?	?	6.5	+	+	+	-	+	+	+	+	0.5
Solveborn et al., 1995 (I) ³⁶	RCT?	?	?	+	-	+	+	?	+	0.5	+	+	+	N/A	6.5	+	+	+	0.5	+	+	+	+	0.5
Stratford et al., 1989 (M, U) ⁴⁶	RCT	+	?	-	+	?	0.5	+	+	?	+	+	+	NA	6.5	+	+	+	-	+	-	+	+	+
Freeland & Gribble, 1954 (I) ³⁵	RCT?	?	?	?	?	?	+	+	+	+	+	-	+	N/A	6.0	+	?	+	-	+	-	+	+	0.5
Haahr & Andersen, 2003 (PT) ⁵²	RCT	+	?	-	-	+	-	-	+	+	+	+	+	+	6.0	+	+	+	-	+	+	+	+	+
Murley, 1954 (I) ³²	RCT?	?	?	?	?	?	+	?	+	+	+	+	N/A	+	6.0	?	?	+	+	+	-	+	+	0.5
Saartok & Eriksson, 1986 (I) ³⁴	RCT?	?	?	-	+	+	+	?	+	+	+	+	-	+	6.0	+	+	+	0.5	+	-	+	+	+
Struijs et al., 2003 (M, PT) ⁴⁴	RCT	+	+	-	-	+	-	+	+	+	+	+	-	+	6.0	+	+	+	-	+	-	+	+	+
Verhaar et al., 1996 (I, M) ⁴⁵	RCT	+	+	-	?	?	-	?	+	+	+	+	+	N/A	6.0	+	?	+	+	+	+	+	+	+
Clements, 1993 (B) ⁵³	CCT	-	?	-	+	+	-	?	+	+	+	+	-	+	5.0	0.5	0.5	+	+	+	-	+	+	-
Korthals-de Bos et al., 2004 (I, PT) ¹¹	RCT?	?	N/A	-	+	+	-	?	+	+	+	+	+	+	5.0	+	?	+	-	-	+	+	+	+
Pienimäki et al., 1996 (E, U) ³⁸	RCT?	?	?	-	+	?	-	+	+	+	+	+	+	+	5.0	+	+	+	-	+	-	+	+	+
Bailey, 1957 (I) ⁵⁴	CCT	-	?	-	?	-	?	+	+	+	?	+	+	+	4.0	-	?	+	+	+	-	+	+	0.5
Burton, 1988 (B) ⁵⁵	RCT?	?	?	-	?	+	-	?	+	+	+	+	?	?	4.0	+	+	+	-	+	-	+	+	+
Day & Patnaik, 1978 (I) ⁵⁶	CCT	-	?	?	?	?	+	+	?	?	?	?	?	N/A	4.0	+	?	+	0.5	+	+	+	+	0.5
Haker, 1993 (B, I) ⁵⁷	CCT	-	?	-	+	?	-	?	+	+	+	+	?	?	4.0	+	+	+	+	+	+	+	+	0.5
Holdsworth, 1993 (U) ⁵⁸	RCT?	?	?	-	?	?	-	+	+	0.5	+	-	+	+	3.5	+	0.5	+	-	+	+	+	+	+
Pienimäki et al., 1998 (E, U) ⁵⁹	RCT?	+	?	-	?	?	-	?	+	-	0.5	?	?	?	2.5	+	+	+	-	+	+	+	+	+
Erturk et al., 1997 (B) ⁶⁰	RCT?	?	?	?	?	?	?	?	+	?	+	?	?	?	2.0	+	+	0.5	-	+	-	+	+	0.5
Kivi, 1982 (B, I) ⁶¹	CCT	-	?	?	?	?	-	?	+	?	+	?	?	?	2.0	-	-	+	-	+	+	+	+	0.5/-
Xingfeng, 2001 (M) ⁵¹	RCT?	?	?	-	?	?	-	?	-	?	+	+	+	NA	2.0	-	0.5	+	-	+	-	+	+	0.5

+, meets Cochrane standard; -, fails standard; 0.5, partially meets standard; ?, insufficient information; N/A, not applicable. *Interventions:* B, brace/splint; E, exercise; I, injections; M, massage/manipulation; PT, multimodal therapy; U, ultrasound.

Does nature of steroid injectate matter? Price et al.³¹ found no significant difference in efficacy between 10 mg of triamcinolone and 25 mg of hydrocortisone. The triamcinolone group did trend toward better outcome, however, perhaps serving as a reminder that dosage and potency should be taken into account when comparing steroid agents. Little evidence was found that the nature of adjunctive local anesthetic alters outcome.³⁶ Most patients appeared to improve regardless of anesthetic coinjectate. Injection technique may also be important as one study³⁷ found substantial relief, regardless of injectate, using a “peppering technique” (multiple, small injections) for all patients. No controlled trials of traditional vs. “peppering” technique have been reported.

Physiotherapy

Physiotherapy Including Exercise. One of the highest-rated studies for quality²⁹ compared physiotherapy with

steroid injection and “wait-and-see.” The physiotherapy regimen consisted of progressive arm stretching and strengthening mixed with ultrasound and massage. After 6 weeks, the injection group progressed the most (although with a higher recurrence rate), followed by the physiotherapy group. After 1 year, however, physiotherapy outperformed steroid injection, but did not differ significantly from “wait-and-see.”

Incidentally, only one study³⁸ examined isolated effects of exercise and found that after 6 to 8 weeks of treatment, exercise outperformed ultrasound regarding pain, strength, and return to work. Unfortunately, a borderline quality score of 5 rendered this study ineligible for inclusion.

Ultrasound. Four studies utilized “sham ultrasound” control groups (ie, with ultrasound insonation turned off). Two studies^{39,40} found no advantage to ultrasound. In both cases, all groups improved, which may merely

Table 3. Summary of Studies, Arranged from Higher to Lower Quality Scores

Study Design Interventions [Quality Score]	Study Population	Intervention	Outcomes	Results	Comments
Price et al., 1991 ³¹ RCT? Injection [9]	Rheumatology clinic. Total n = 88, mean age 47 (43% female). Duration not specified	Group 1: anesthetic injection (n = 29); Group 2: hydrocortisone steroid injection (n = 29); Group 3: triamcinolone steroid injection (n = 30)	Pain VAS score, tenderness, grip strength	Up to 8 weeks: triamcinolone group fared better than anesthetic group. No significant difference between both steroid groups. At 6 months: no significant difference between all three groups. "More rapid relief of symptoms was achieved with triamcinolone than with hydrocortisone or lidocaine alone and there was less need to repeat injections"	Randomized method not specified. In a follow-up study presented here, no differences noted between 10 mg vs. 20 mg of triamcinolone. Injection side-effects: skin atrophy in 17% anesthetic group, 21% in hydrocortisone group, 18% in triamcinolone 10 mg, 27% in triamcinolone 20 mg
Hay et al., 1999 ³⁰ RCT Injection [8.5]	Primary care clinics. Total n = 164, ages 18–70 (41% female). 30% had symptoms > 3 months	2-week intervention period: Group 1: steroid injection (n = 53); Group 2: NSAID (n = 53); Group 3: vitamin C placebo tablets (n = 58)	Function impairment rating, pain rating, patient's global assessment, disability, pain-free grip strength	At 4 weeks: injection group did best with recovery/improvement in 92% with no difference between NSAID (57%) and placebo (50%). At 1 year: 84% of all patients "better" with no inter-group differences	Authors conclude: "Early epicondylitis treatment is effective ..." Injection side-effects: local elbow skin atrophy in 3 placebo patients
Smidt et al., 2002 ²³ RCT Injection, massage [8.5]	Referred by family doctors. Total n = 185, ages 18–70 (48% female). Symptom duration > 6 weeks	6-week program: Group 1: up to 3 steroid injections (n = 62); Group 2: exercise + US + deep friction massage (n = 64); Group 3: ergonomic advice + NSAIDs (n = 59)	General improvement, elbow pain-free function and disability, grip strength, elbow pain, self-assessment of treatment success ("success rate")	At 6 weeks: "Success rates": injections = 92%; PT = 47%; wait-and-see = 32%. But high recurrence rate in injection group At 52 weeks: "Success rates": injections = 69%; PT = 91%; wait-and-see = 83% (significant difference between PT and injections; but neither intervention differed significantly from "wait-and-see")	Were it possible to blind patients to treatments this study would have had the highest internal score rating. Injection side-effects: skin irritation seen in 5% of injected, and 5% of controls; skin color change seen in 11% of injected, and 5% of controls
Haker & Lundeberg, 1991 ⁴⁰ RCT US [8]	Referred by physician or therapist. Total n = 45, ages 33–67 (47% female). Median symptom duration 8–9 months	10 sessions over 3–5 weeks: Group 1: pulsed US (n = 21); Group 2: sham US (n = 22)	Grip strength, lifting, pain rating	No improvement over placebo	Injection side-effects: pain flare up in 2 patients

Table 3. Cont.

Study Design Interventions [Quality Score]	Study Population	Intervention	Outcomes	Results	Comments
Halle & Karalfa, 1986 ⁴³ RCT US, injection [8]	Physical therapy clinic. Total n = 48, ages 20–59 (54% female). Symptom duration not specified	5-day treatment period for each patient: Group 1: US (n = 12); Group 2: phonophoresis (n = 12); Group 3: transcutaneous electrical stimulation (n = 12); Group 4: steroid injection (n = 12)	Modified McGill Pain Questionnaire	All regimens showed some pain reduction; but no significant difference between 4 treatment regimens (P < 0.05)	Each group also received home program: elbow cuff, relative rest, ice massage. Compliance not mentioned. Should have a true placebo group and larger N; treatment details not given; duration too short? Injection side-effects: no report provided
Lundeberg et al., 1988 ⁴¹ RCT US [8]	Physiotherapy clinic. Total n = 99, mean age 38 (43% female). Symptom duration > 1 month	10 sessions over 5–6 weeks for each patient: Group 1: continuous US; Group 2: sham US; Group 3: rest	Pain VAS score, pain on resisted dorsiflexion, lifting, grip strength	“Significant improvement” (full functional recovery or 75–100% decrease in pain) found in: 36% in US; 30% in sham US; 24% in rest group. Difference between US and sham US not significant	Baseline comparisons and compliance not mentioned
Zachrisson-Forsell, 1982 ³⁹ RCT? US, exercise [8]	Physical therapy clinic. Total n = 63, mean age 40 (50% female)	10 treatment sessions during 1 month for each patient. n = roughly 15 for each group: Group 1: US + exercise; Group 2: sham US + exercise; Group 3: US; Group 4: sham US	Self-assessment of improvement (“considerable,” “slight,” or “no improvement”)	No statistically significant differences between the groups	How improvement was measured was not reported. N is likely small. Results incomplete
Alkay et al., 2002 ³⁷ CCT Injection [7]	Orthopedic clinic. Total n = 120, mean age 44. Mean symptom duration 8 months	All patients got 1–2 injections using “peppering technique”: Group 1: hydrocortisone steroid injection (n = 60); Group 2: procaine anesthetic injection (n = 60)	Global score encompassing pain relief, patient satisfaction, subjective grip strength, pain with provocation/function	Both groups improved (93–95%) in first 2 months, with no significant inter-group difference. Results not changed at 6, 12 months. “The peppering technique seems to be a reliable method of treatment”	Randomization method: alternation. “Peppering” technique involves about 50 small injections during one injection session. A saline injection control group was discontinued early due to patient discomfort. Injection side-effects: none
Newcomer et al., 2001 ³⁸ RCT? Injection [7]	Sports clinic. Total n = 39, ages 18–65 (51% female). Duration < 4 weeks	8-week program: Group 1: rehabilitation + sham injections (n = 20); Group 2: rehabilitation + steroid injections (n = 19)	Grip strength, VAS pain score, pain with functional activities	More than 80% of all subjects improved from baseline to 6 months for all scales. “No significant differences between the two groups with the exception of an improvement in the VAS pain in the corticosteroid group from 8 weeks to 6 months.” In acute patients, “Rehabilitation should be first line of treatment . . .”	Randomized method not specified. Injection side-effects: none specifically noted (report of 3 dropouts in controls, 1 in injection group—all claim pain flare up)

<p>Binder et al., 1985⁴² US RCT [6.5]</p>	<p>General population. Total $n = 76$, ages 29–59 (32% female, 28% workers). Mean symptom duration 4–5 months</p>	<p>4- to 6-week course. 12 treatment sessions each patient: Group 1: pulsed US ($n = 38$); Group 2: sham US ($n = 38$)</p>	<p>Pain VAS score, pain on resisted dorsiflexion, lifting, grip strength</p>	<p>63% US patients improved (“satisfactory outcome”) vs. 29% placebo ($P < 0.01$) No mention of withdrawals</p>	<p>Insufficient details on compliance. No comments on baseline attributes (pain level, etc.). No mention of withdrawals</p>
<p>Solveborn et al., 1995³⁶ RCT? Injection [6.5]</p>	<p>Orthopedic clinic. Total $n = 113$, mean age 44 (35% female). Mean symptom duration 8–9 months</p>	<p>Group 1: steroid + lidocaine injection ($n = 54$); Group 2: steroid + bupivacaine injection ($n = 55$)</p>	<p>VAS pain scale, tenderness, provocation test, lifting strength, work days missed</p>	<p>At 2 weeks: in both groups combined, 37 were “much better,” 38 “evidently better,” 23 “somewhat better.” Bupivacaine more effective. At 1 year: no significant difference between groups</p>	<p>Randomization method not specified. Injection side-effects: no report provided</p>
<p>Stratford et al., 1989⁴⁶ RCT US, massage [6.5]</p>	<p>Sports injury clinic, Total $n = 40$, mean age = 43 (50% female). Mean symptom duration ~4 months</p>	<p>3- to 5-week course: Group 1: US + placebo ointment ($n = 9$); Group 2: US + Cyriax frictions ($n = 11$); Group 3: phonophoresis ($n = 10$); Group 4: phonophoresis + Cyriax frictions ($n = 10$)</p>	<p>Advancement in therapy: pain and function VAS; pain-free function and grip strength</p>	<p>No advantage found for friction massage or phonophoresis. Conclusions: “Most cost-effective method of treating . . . is by US alone”</p>	<p>Lacks true placebo group; despite good power, factorial design may limit ability to detect differences in treatment</p>
<p>Freeland & Gribble, 1954³⁵ RCT? Injection [6]</p>	<p>Physical medicine clinic. Total $n = 14$ (16 injection sites). Ages, sex, symptom duration not specified</p>	<p>1–2 injections: Group 1: hydrocortisone steroid injection ($n = 9$); Group 2: procaine anesthetic injection ($n = 7$)</p>	<p>Physician’s subjective assessment of patient improvement</p>	<p>“Despite the small numbers it is difficult to escape the conclusion that hydrocortisone is no more effective . . . than procaine” No report provided on side-effects</p>	<p>Low N. Scant details provided: randomization method not specified; timing of evaluation unclear. No report provided on side-effects</p>
<p>Haahr & Andersen, 2003⁵² RCT Rest [6]</p>	<p>Referred by general practitioners. Total $n = 266$, ages = 18–66 (57% female). Symptom duration < 1 year</p>	<p>6- to 8-week course: Group 1: “minimal intervention” provided reassurance; moderate activity encouraged; ergonomics ($n = 141$); Group 2: treatment as usual by general practitioner ($n = 125$)</p>	<p>Self-rating of overall progress, pain; function. Work absence, visits for PT and medical care, filing for workman’s compensation</p>	<p>No differences found between either group at 3 months, 6 months, and 12 months. In all patients “overall improvement” in pain-function: 69% at 3 months; 83% at 12 months</p>	<p>In an attempt to mirror practice realities no rigid, well-defined protocol used for either group. Both groups received some PT, US, injections, bracing although overall group 2 received more</p>

Table 3. Cont.

Study Design Interventions [Quality Score]	Study Population	Intervention	Outcomes	Results	Comments
Murley, 1954 ³² RCT? Injection [6]	Population not specified. Total $n = 37$, mean age 42 (19% female). Duration not specified	Injection × 1: Group 1: hydrocortisone injection ($n = 19$); Group 2: procaine anesthetic injection ($n = 18$)	Physician's subjective assessment of patient improvement	After 1 week and 4 weeks: significantly more patients "much improved/improved" in steroid group. "Local injection of hydrocortisone acetate causes relief of symptoms in a high proportion of cases"	Baseline characteristics of patient groups not provided. Randomized method not specified. Injection side-effects reporting: "No patients were made worse . . ."
Saartok & Eriksson, 1986 ³⁴ RCT? Injection [6]	Primary care physician referrals. Total $n = 21$, mean age 45 (25% female). Symptom duration not specified	2-week program: Group 1: NSAIDs ($n = 10$); Group 2: steroid (betamethasone) injections ($n = 11$)	Grip strength, pains scores during provocative maneuvers, tenderness, patient's global assessment, physician's global assessment	After 2 weeks: about half the patients improved, but "there were no significant differences between the two treatment groups"	Small N—but authors describe this as a pilot study. Randomized method not specified. Injection side-effects: transient injection site pain
Struijs et al., 2003 ⁴⁴ RCT Manipulation, therapy [6]	Referred by general practitioners. Total $n = 28$, mean age 47 (46% female)	Group 1: manipulation of wrist ($n = 13$); Group 2: traditional therapy (massage, exercise, US) ($n = 15$)	Self-rating of overall progress, pain; strength, range of motion	At 3 weeks: manipulation group showed greater overall progress. At 6 weeks: manipulation group had less pain	This was pilot study; hence small N
Verhaar et al., 1996 ⁶⁵ RCT Injection, massage, manipulation [6]	University hospital outpatients. Total $n = 106$, ages 16–65 (44% female). Mean symptom duration 33 weeks	Group 1: PT (deep transverse massage + Mill's maneuver) 12 sessions over 4 weeks; after 6 weeks 29 received further PT ($n = 56$); Group 2: up to 3 steroid injections over 6 weeks. After 6 weeks 13 got more injections and 3 got PT ($n = 53$)	Pain severity, pain on resisted wrist dorsiflexion, RTW, grip strength, patient satisfaction	At 6 weeks: injection group significantly improved vs. PT regarding: overall pain free, patient "satisfied," RTW, pain free resisted wrist dorsiflexion, grip strength, "Excellent-Good" results. At 1 year: no significant differences/equivalocal results re: grip strength, pain, RTW. Surgery underwent by 17 in injection group, 14 in PT	Lacks true placebo group. Multiple cointerventions: after 6 weeks, 30% of all patients had surgery and 20% got combination PT/injection treatment. Injection side-effects: no skin infections or hypopigmentation seen

?, insufficient information; CCT, clinical controlled trial; N, study population size; N/A, not applicable; NSAID, nonsteroidal anti-inflammatory drug; RCT, randomized controlled trial; RTW, return to work; US, ultrasound; VAS, Visual Analog Scale.

Table 4. Summary of Studies Comparing Steroid Injection (I) with Other Treatments

Study	Quality Score	Short-Term Results	Long-Term Results
Price et al., 1991 ³¹	9.0	I > anesthetic injection	I = anesthetic
Hay et al., 1999 ³⁰	8.5	I > placebo	I = placebo
Smidt et al., 2002 ²³	8.5	I > PT	I = PT = Rest
Newcomer et al., 2001 ³³	7.0	I = sham injection	I > sham injection (for pain only)
Murley, 1954 ³²	6.0	I > anesthetic	
Saartok & Eriksson, 1986 ³⁴	6.0	I = NSAID	

PT, multimodal physical therapy. "I > X" indicates that I outperformed X. Short term is <2 months.

Table 5. Summary of Studies Comparing Relative Rest Group (R) with Other Treatments

Study	Quality Score	Control Group	Short-Term Results	Long-Term Results
Hay et al., 1999 ³⁰	8.5	Vitamin C	R < I	R = I
Smidt et al., 2002 ²³	8.5	Ergonomic advice, NSAID	R < I, R < PT	R = PT, R = I
Lundeberg et al., 1988 ⁴¹	8.0	Rest	R < U	R < U (3 months)
Haahr & Andersen, 2003 ⁵²	6.0	"Reassurance," Ergonomic advice	R = "Treatment as usual"	R = "Treatment as usual"
Saartok & Eriksson, 1986 ³⁴	6.0	NSAID	R = I	

I, steroid injection; PT, multimodal physical therapy; U, ultrasound alone; "R > X" indicates that R outperformed intervention X. Short term is <2 months.

reflect the natural course of recovery. Another study⁴¹ yielded mixed results: a significant improvement was found for ultrasound over rest but not over sham ultrasound. The authors and reviewers variously concluded that beneficial treatment effects of ultrasound could reflect benefits of careful supervision or compression effects from the head of the ultrasound device.⁴⁰ All these studies, however, had weaknesses such as small study population or insufficient elaboration of methodological details. One dissenting study⁴² found ultrasound beneficial. Patients receiving ultrasound for up to 6 weeks outperformed sham ultrasound recipients, and after 1 year ultrasound recipients had a lower incidence of recurrence. This study, however, provided relatively few methodological details.

Halle et al.⁴³ found no significant changes between ultrasound and phonophoresis (which utilizes ultrasound to enhance delivery of topical therapeutics): all groups improved, which could reflect a benign natural history or simply general beneficial effects of ultrasound. The study, however, had only 12 subjects in each group.

Other Physiotherapy Modalities. One relevant study,⁴⁴ although a small, short-term pilot study, found that manipulation outperformed multimodal physiotherapy. Two other studies with lower quality scores found that injection⁴⁵ or ultrasound⁴⁶ outperformed manipulation or massage in the short term. Five relevant clinical controlled studies pertaining to bracing/splinting were iden-

tified, but were of insufficient quality to include in the analysis.

Relative Rest

Although clinically relevant experiments probably cannot employ strict rest control groups, five studies (Table 5) did have "relative rest" groups receiving treatments such as ergonomic advice, NSAIDs, or vitamin C. Three of these^{29,30,41} demonstrated benefits of interventions such as steroid injections, physiotherapy, and ultrasound over relative rest in the short term (<2 months). In the longer term all patients improved; generally no difference was found between relative rest and the interventions studied. This is consistent with the natural history of lateral epicondylitis where most subjects improve within 1 year from onset of symptoms.

Has Overall Study Quality Improved Over Time?

No increase in study quality (ascertained by internal validity) was noted with the passage of time (Figure 1); a low Pearson product-moment correlation between publication year and quality score of 0.039 ($n = 30$, $P = 0.84$) was found. Using partial correlation to adjust for journal quality (2002 ISI journal impact factor), the correlation between publication year and quality score was 0.368, but remained insignificant ($df = 14$, $P = 0.161$).[§]

§Even after removing older outlier publications from the 1950s, the correlation between year and quality remained low ($r = 0.101$, $n = 28$, $P = 0.609$), and the partial correlation remained insignificant ($r = -0.244$, $df = 12$, $P < 0.40$).

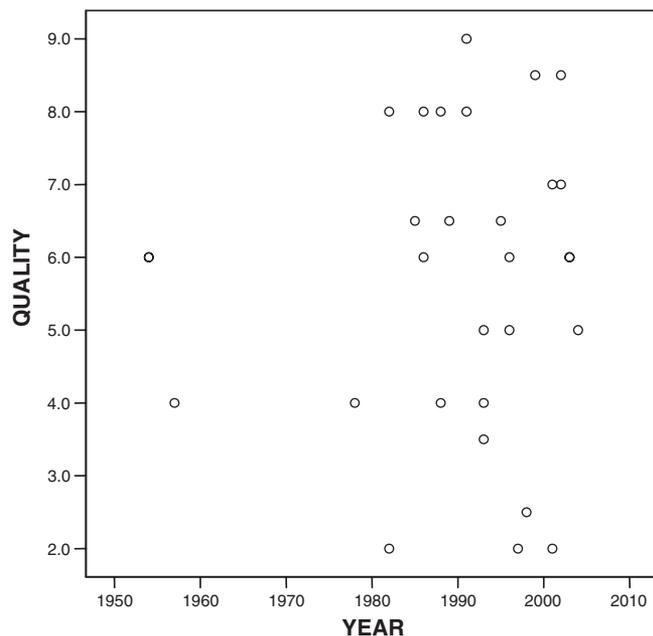


Figure 1. No increase in study quality (internal validity) score was noted with the passage of time ($r = 0.039$, $n = 30$, $P = 0.84$).

DISCUSSION

Steroid injection (16 of the 30 studies included) was overwhelmingly the most studied intervention. Evidence indicates that steroid injections provided more immediate relief than other nonsurgical interventions for pain and function when assessed during the first months of treatment. This mirrors results from other reviews.^{21,23,24} For workers, injections during the acute phase may allow earlier return to work (although care must be taken to prevent reinjury). Injections have a favorable side-effect profile with Smidt et al.²⁹ reporting no tendon ruptures. Sixty percent of patients, however, experienced minor problems such as pain flare ups or skin irritation. Most studies reported injecting approximately 1 mL of steroid, often with an equal volume local anesthetic, just distal to the lateral epicondyle, over the region of maximal tenderness, often with elbow bent and forearm resting in pronation.

Factors to be taken into account include patient preference and prior injections given reports of tendon rupture following steroid injection.⁴⁷⁻⁴⁹ No evidence²¹ favored any one steroid composition or any particular adjunctive local anesthetic. Quite possibly injection technique (peppering vs. single injections) does make a difference, although direct comparisons are lacking. The demonstrated short-term advantages to steroid injections, however, appear not to persist (at least without repeated injections).

In the longer term, Smidt et al.,²⁹ in the highest-quality paper of relevance, reported that multidisciplinary physical therapy outperforms steroid injection at 1 year. Physical therapy also provided more relief than relative rest for time periods less than 1 year. Therefore, if the pain is not severe and the patient is willing to devote the time to physical therapy, it may be a reasonable treatment option for improving pain and function more rapidly than expectant waiting and relative rest. Given its salutary effects for other repetitive strain injury conditions,¹⁴ it is unfortunate that more studies did not address exercise.

Overall, there is little evidence regarding beneficial effects of isolated ultrasound, with support coming from only one study. Unfortunately, insufficient evidence exists for the evaluation of massage or manipulation. The lack of evidence regarding passive physiotherapy components mirrors prior relevant reviews for ultrasound,^{18,20} bracing/splinting,⁵⁰ or massage therapy.²² At best, prior reviews found only “weak” evidence in favor of ultrasound (or evidence indicative of a “trend”).^{3,19} Clearly, additional high-quality studies will be required to compare efficacy of different physiotherapy components, especially exercise vs. passive modalities.

Based on the reviewed data, for patients that need to return to work or their usual activities more rapidly, practitioners can recommend a judicious number of steroid injections (usually one or two) for pain relief in the first few weeks or months and physiotherapy (including active exercise) at any stage. An advantage to exercise is that after proper training it can be self-administered, thus reducing the cost of this intervention.

Comment on Research Quality

A number of authors have noted methodological flaws in literature involving lateral epicondylitis treatment,^{3,14-17} and have called for methodologically rigorous studies. This is the first review to systematically track the quality of studies over time. Despite some high-quality studies, we found little evidence that overall quality of studies has improved over time, even when adjusting for journal quality (impact factor). This is especially surprising given recent emphasis on evidence-based medicine.

Common problems found in the studies reviewed included:

1. Low number of study participants (eg, one study spread 48 patients across four treatment groups⁴³).

2. Admixture of symptoms or cointerventions. Some studies mixed a wide variety of symptoms which makes isolating efficacy of any given intervention difficult.
3. Insufficient reporting. Failure to report crucial details such as treatment randomization method, for instance, led to down-grading of several self-termed RCT studies to CCT status.
4. Lack of a placebo group. Only 4 of 16 injection studies used something close to a true control such as placebo tablets³⁰ or sham injections.³³ Controls are important, because most studies showed improvement in both control and intervention groups. This may reflect either natural history of the condition or placebo effects.¹⁶

An important research challenge is whether outcomes should relate to pain, function, or both. Family practitioners, for instance, may emphasize pain reduction, while occupational clinics may emphasize returning patients to activity. Such differences in goals may also determine treatment aggressiveness. An additional challenge is how to compare intervention “dosing.” For instance, can six massage sessions be compared with one steroid injection?

Weaknesses of our review might include use of the Cochrane quality (internal validity) score, which does not take into account size of the study population. However, this score correlated fairly well with other quality criterion and, in any case, was used primarily as an initial screen. The English language restriction employed might present another potential weakness. However, this restriction likely did not alter findings. In one review of physiotherapy for lateral epicondylitis,¹⁹ only one of 15 “potentially eligible” non-English studies made the quality screening criteria utilized (Amsterdam–Maastricht criteria). English studies were over six times more likely to make the final cut. Allowing for a variety of control interventions such as relative rest, ergonomic advice, vitamins, or NSAIDs may also be construed as a weakness. These controls represent current clinically prevalent interventions.⁵¹

CONCLUSION

In the short term (<2 to 3 months), active interventions, especially steroid injections, appear more efficacious than relative rest. Multimodal physiotherapy that includes exercise appears efficacious in the short and long term. In the long term, active physiotherapy outperforms injections, although it does not appear signifi-

cantly better than relative rest after 1 year. Although patients on relative rest eventually improve, early active interventions such as injections and exercise therapy may help attain functional goals more quickly. Despite some excellent recent research,²⁹ there is still a need for more studies that address previous study design limitations.

ACKNOWLEDGMENTS

Dr. Nimgade is recipient of a Research Fellowship Award from the Department of Environmental Health at the Harvard School of Public Health.

REFERENCES

1. Allander E. Prevalence, incidence, and remission rates of some common rheumatic diseases or syndromes. *Scand J Rheum.* 1974;3:145–153.
2. Hamilton P. The prevalence of humeral epicondylitis: a survey in general practice. *J R Coll Gen Pract.* 1986;36:464–465.
3. *Diagnosis and Treatment of Worker-Related Musculoskeletal Disorders of the Upper Extremity.* Rockville, MD: Agency for Healthcare Research and Quality; 2002.
4. Dimberg L. The prevalence and causation of tennis elbow (lateral humeral epicondylitis) in a population of workers in an engineering industry. *Ergonomics.* 1987;30:573–579.
5. Morris H. The lawn tennis elbow. *Lancet.* 1882; 2:133–134.
6. Nirschl RP, Petrone FA. Tennis elbow. The surgical treatment of lateral epicondylitis. *J Bone Joint Surg Am.* 1979;61:832–839.
7. Coonrad R, Hooper WR. Tennis elbow: its course, natural history, conservative and surgical management. *J Bone Joint Surg.* 1973;55A:1177–1182.
8. Khan KM, Cook JL, Bonar F, Harcourt P, Astrom M. Histopathology of common tendinopathies. Update and implications for clinical management. *Sports Med.* 1999; 27:393–408.
9. Vailas A, Tipton CM, Laughlin HL, Tcheng TK, Matthes RD. Physical activity and hypophysectomy on the aerobic capacity of ligaments and tendons. *J Appl Physiol.* 1978;44:542–546.
10. Zernicke R, Garhammer J, Jobe FW. Human patellar-tendon rupture. *J Bone Joint Surg Am.* 1977;59:179–188.
11. Korthals-de Bos IB, Smidt N, van Tulder MW. Cost effectiveness of interventions for lateral epicondylitis: results from a randomised controlled trial in primary care. *Pharmacoeconomics.* 2004;22:185–195.
12. Cyriax J. The pathology and treatment of tennis elbow. *J Bone Joint Surg.* 1936;18:921–939.
13. Clarke A, Woodland J. Comparison of two steroid preparations used to treat tennis elbow. *Rheumatol Rehabil.* 1975;14:47–49.

14. Konijnenberg HS, de Wilde NS, Gerritsen AA, van Tulder MW, de Vet HC. Conservative treatment for repetitive strain injury. *Scand J Work Environ Health*. 2001;27:299–310.
15. Hudak PL, Cole DC, Haines AT. Understanding prognosis to improve rehabilitation: the example of lateral elbow pain. *Arch Phys Med Rehabil*. 1996;77:586–593.
16. Labelle H, Guibert R, Joncas J, Newman N, Fallaha M, Rivard CH. Lack of scientific evidence for the treatment of lateral epicondylitis of the elbow. An attempted meta-analysis. *J Bone Joint Surg Br*. 1992;74:646–651.
17. Boyer MI, Hastings H. Lateral tennis elbow: “is there any science out there?” *J Shoulder Elbow Surg*. 1999;8:481–491.
18. van der Windt DA, van der Heijden GJ, van den Berg SG, ter Riet G, de Winter AF, Bouter LM. Ultrasound therapy for musculoskeletal disorders: a systematic review. *Pain*. 1999;81:257–271.
19. Smidt N, Assendelft WJJ, Arola H, et al. Effectiveness of physiotherapy for lateral epicondylitis: a systematic review. *Ann Med*. 2003;35:51–62.
20. Falconer J, Hayes KW, Chang RW. Therapeutic ultrasound in the treatment of musculoskeletal conditions. *Arthritis Care Res*. 1990;3:85–91.
21. Assendelft WJJ, Adshear R, Bouter LM. Corticosteroid injections for lateral epicondylitis: a systematic overview. *Br J Gen Pract*. 1996;46:209–216.
22. Brosseau L, Casimiro L, Milne S. Deep transverse friction massage for treating tendinitis. *Cochrane Database Syst Rev*. 2002;1: CD003528.
23. Smidt N, Assendelft WJ, van der Windt DA, Hay EM, Buchbinder R, Bouter LM. Corticosteroid injections for lateral epicondylitis: a systematic review. *Pain*. 2002;96:23–40.
24. Bernstein RM. Injections and surgical therapy in chronic pain. *Clin J Pain*. 2001;17(4 suppl):S94–S104.
25. Roebroeck ME, Dekker J, Oostendorp RA. The use of therapeutic ultrasound by physical therapists in Dutch primary health care. *Phys Ther*. 1998;78:470–478.
26. Gam AN, Johannsen F. Ultrasound therapy in musculoskeletal disorders: a meta-analysis. *Pain*. 1995;63:85–91.
27. Mills G. The treatment of “tennis elbow.” *BMJ*. 1928;i:12–13.
28. van Tulder MWA, Assendelft WJ, Koes BW, Bouter LM. Method guidelines for systematic reviews in the Cochrane Collaboration Back Review Group for spinal disorders. *Spine*. 1997; 22:2323–2330.
29. Smidt N, van der Windt DA, Assendelft WJ, Deville WL, Korthals-de Bos IB, Bouter LM. Corticosteroid injections, physiotherapy, or a wait-and-see policy for lateral epicondylitis: a randomised controlled trial. *Lancet*. 2002;359:657–662.
30. Hay EM, Paterson SM, Lewis M, Hosie G, Croft P. Pragmatic randomised controlled trial of local corticosteroid injection and naproxen for treatment of lateral epicondylitis of elbow in primary care. *BMJ*. 1999;319:964–968.
31. Price R, Sinclair H, Heinrich I, Gibson T. Local injection treatment of tennis elbow—hydrocortisone, traimecinolone and lignocaine compared. *Br J Rheumatol*. 1991;30:39–44.
32. Murley AHG. Tennis-elbow treated with hydrocortisone acetate. *Lancet*. 1954;2:223–225.
33. Newcomer KL, Laskowski ER, Idank DM, McLean TJ, Egan KS. Corticosteroid injection in early treatment of lateral epicondylitis. *Clin J Sport Med*. 2001; 11:214–222.
34. Saartok T, Eriksson E. Randomized trial of oral naproxen or local injection of betamethasone in lateral epicondylitis of the humerus. *Orthopedics*. 1986;9:191–194.
35. Freeland D, Gribble MD. Hydrocortisone in tennis elbow. *Lancet*. 1954;2:225.
36. Solveborn SA, Buch F, Mallmin H, Adalberth G. Cortisone injection with anesthetic additives for radial epicondylalgia (tennis elbow). *Clin Orthop*. 1995;316:99–105.
37. Altay T, Gunal I, Ozturk H. Local injection treatment for lateral epicondylitis. *Clin Orthop*. 2002;398:127–130.
38. Pienimaki T, Tarvainen T, Siira P, Vanharanta JHV. Progressive strengthening and stretching exercises and ultrasound for chronic lateral epicondylitis. *Physiotherapy*. 1996;82:522–530.
39. Zachrisson-Forsell M. *Ultrasound Therapy for “Tennis Elbow.”* Proceedings at WCPT. 1982.
40. Haker E, Lundeberg T. Pulsed ultrasound treatment in lateral epicondylalgia. *Scand J Rehabil Med*. 1991;23:115–118.
41. Lundeberg T, Abrahamsson P, Haker E. A comparative study of continuous ultrasound, placebo ultrasound and rest in epicondylalgia. *Scand J Rehabil Med*. 1988;20:99–101.
42. Binder A, Hodge G, Greenwood AM, Hazleman BL, Page Thomas DP. Is therapeutic ultrasound effective in treating soft tissue lesions? *BMJ (Clin Res Ed)*. 1985;290:512–514.
43. Halle JS, Franklin RJ, Karalfa BL. Comparison of four treatment approaches for lateral epicondylitis of the elbow. *J Orthop Sports Phys Ther*. 1986;8:62–69.
44. Struijs PA, Damen PJ, Bakker EW, Blankevoort L, Assendelft WJ, van Dijk CN. Manipulation of the wrist for management of lateral epicondylitis: a randomized pilot study. *Phys Ther*. 2003;83:608–616.
45. Verhaar JA, Walenkamp GH, van Mameren H, Kester AD, van der Linden AJ. Local corticosteroid injection versus Cyriax-type physiotherapy for tennis elbow. *J Bone Joint Surg Br*. 1996;78:128–132.
46. Stratford PW, Levy DR, Gauldie S, Miferi D, Levy K. The evaluation of phonophoresis and friction massage as treatments for extensor carpi radialis tendinitis: a RCT. *Physiother Can*. 1989;41:83–99.
47. Ford LT. Tendon rupture after local steroid injection. *South Med J*. 1979;72:827–830.

48. Lee H. Avulsion and rupture of the tendocalcaneus after injection of hydrocortisone. *BMJ*. 1957;2:395.
49. Kleinman M. Achilles tendon rupture following steroid injection. Report of three cases. *J Bone Joint Surg Am*. 1983;65:1345–1347.
50. Struijs PA, Smidt N, Arola H, van Dijk CN, Buchbinder R, Assendelft WJ. Orthotic devices for tennis elbow: a systematic review. *Br J Gen Pract*. 2001;51:924–929.
51. Xingfeng W. Seventy cases of external humeral epicondylitis treated by local blocking and massotherapy. *J Trad Chin Med*. 2001;21:52–53.
52. Haahr JP, Andersen JH. Prognostic factors in lateral epicondylitis: a randomized trial with one-year follow-up in 266 new cases treated with minimal occupational intervention or the usual approach in general practice. *Rheumatology (Oxford)*. 2003;42:1216–1225.
53. Clements LG, Chow S. Effectiveness of a custom-made below lateral counterforce splint in the treatment of lateral epicondylitis. *Can J Occup Ther*. 1993;60:137–144.
54. Bailey RA, Broch BH. Hydrocortisone in tennis elbow—a controlled series. *J R Soc Med*. 1957;50:389–390.
55. Burton A. A comparative trial of forearm strap and topical anti-inflammatory as adjuncts to manual therapy in tennis elbow. *Man Med*. 1988;3:141–143.
56. Day BH, Govindasamy N, Patnaik R. Corticosteroid injections in the treatment of tennis elbow. *Practitioner*. 1978;220:459–462.
57. Haker E, Lundeborg N. Elbow-band, splintage and steroids in lateral epicondylalgia (tennis elbow). *Pain Clin*. 1993;6:103–112.
58. Holdsworth LK, Anderson DM. Effectiveness of ultrasound used with a hydrocortisone coupling medium or epicondylitis clasp to treat lateral epicondylitis: pilot study. *Physiotherapy*. 1993;79:19–25.
59. Pienimäki T, Karinen P, Kemilä T, Koivukangas P, Vanharanta H. Long-term follow-up of conservatively treated chronic tennis elbow patients. A prospective and retrospective analysis. *Scand J Rehabil Med*. 1998;30:159–166.
60. Ertürk H, Celiker R, Sivri A, Cetin A, Cindas A. The efficacy of different treatment regimens that are commonly used in tennis elbow. *J Rheum Med Rehabil*. 1997;8:298–301.
61. Kivi P. The etiology and conservative treatment of humeral epicondylitis. *Scand J Rehabil Med*. 1982;15:37–41.