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A systematic review of randomized controlled trials on the effect of transverse friction massage in lateral epicondylitis

Transvers friksiyon masajının lateral epikondilit üzerindeki etkisi randomize kontrollü çalışmaların sistematik derlemesi

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ABSTRACT

Background: Inter-specialist correlation of modalities employed in the management of lateral epicondylitis is poor and the number of review studies in this area is insufficient in the literature.

Aim: The present study aimed to review the literature on randomized controlled trials of transverse friction massage in patients with lateral epicondylitis.

Methods: A literature search was conducted in electronic databases "ScienceDirect, PubMed, Scopus and Web of Science (WoS)". A total of 3,615 studies were accessed via the identified keywords. According to the inclusion and exclusion criteria, a total of 17 articles were included. The "PEDro scale" was used to assess the methodological quality of the included studies.

Results: Seventeen studies were included in the systematic review. The included studies were of "good" quality based on the mean PEDro score. Visual Analog Scale, global improvement scale, Patient Rated Tennis Elbow Evaluation, Disabilities of Arm, Shoulder, and Hand Scale and algometer were among the most assessed outcomes. There were 8 studies in which the transverse friction massage plus other combined interventions group showed significantly better results than the other group. There were 4 studies in which the transverse friction massage plus other combined intervention group did not show a significant difference against the other group.

Conclusion: In conclusion, the current evidences are limited to moderate level and suggest that transverse friction massage may be an effective and suitable option for the treatment of lateral epicondylitis. We suggest that a better result can be obtained by combining transvers friction massage with Mills manipulation, stretching, and eccentric exercises in patients with lateral epicondylitis.

ÖZ

Giriş: Lateral epikondilit tedavisinde kullanılan modalitelerin uzmanlar arası korelasyonu zayıftır ve bu alandaki derleme çalışmalarının sayısı literatürde yetersizdir.

Amaç: Bu çalışmanın amacı lateral epikondilitli hastalarda transvers friksiyon masajı ile ilgili randomize kontrollü çalışmalar hakkındaki literatürü gözden geçirmektir.

Gereç ve Yöntemler: "ScienceDirect, PubMed, Scopus ve Web of Science (WoS)" elektronik veri tabanlarında literatür taraması yapıldı. Belirlenen anahtar kelimeler aracılığıyla toplam 3.615 çalışmaya ulaşıldı. Dahil edilme ve dışlanma kriterlerine göre toplam 17 makale dahil edilmiştir. Dahil edilen çalışmaların metodolojik kalitesini değerlendirmek için "PEDro ölçeği" kullanılmıştır.

Bulgular: On yedi çalışma sistematik incelemeye dahil edilmiştir. Dahil edilen çalışmalar ortalama PEDro skoruna göre "iyi" kaliteye sahipti. Görsel Analog Skala, global iyileşme ölçeği, Hasta Değerlendirmeli Tenisçi Dirseği Değerlendirmesi, Kol, Omuz ve El Engelleri Ölçeği ve algometre en çok değerlendirilen sonuçlar arasındaydı. Transvers friksiyon masajı artı diğer kombine müdahaleler grubunun diğer gruba göre anlamlı derecede daha iyi sonuçlar gösterdiği 8 çalışma vardı. Transvers friksiyon masajı artı diğer kombine müdahale grubunun diğer gruba karşı anlamlı bir fark göstermediği 4 çalışma vardı.

Sonuç: Sonuç olarak, mevcut kanıtlar sınırlı ile orta düzeyde olup, transvers friksiyon masajının lateral epikondilit tedavisinde etkili ve uygun bir seçenek olabileceğini düşündürmektedir. Lateral epikondilitli hastalarda transvers sürtünme masajının Mills manipülasyonu, germe ve eksantrik egzersizlerle birleştirilmesiyle daha iyi bir sonuç elde edilebileceğini düşünüyoruz.

Key Words:	**Anahtar Kelimeler:**
Tennis Elbow, Friction, Review	Tenisçi Dirseği, Friksiyon, Derleme

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GİRİŞ

Lateral epicondylitis (LE), also known as tennis elbow, is a common musculoskeletal disorder characterized by pain and functional impairment around the lateral epicondyle of the elbow. LE is primarily a degenerative tendinopathy involving the extensor carpi radialis brevis (ECRB) tendon. Histopathological findings typically show collagen irregularity, fibroblast proliferation, neovascularization, and the absence of classic inflammatory cells; this process is often defined as tendinosis. Mechanical overload, microtrauma, and impaired tendon healing are considered important contributing factors to the pathophysiology of LE, leading to persistent pain, decreased grip strength, and functional limitations. The long sarcomere length of the ECRB muscle may cause it to be exposed to increased mechanical stress when working in a long position. This increased stress can lead to impaired microcirculation in the ECRB muscle-tendon complex, and the development of ischemia associated with it, which can increase the production of immature Type III collagen in the tendon tissue. As a result, collagen organization is disrupted, neovascularization and degenerative changes accelerate, the tendon's load-bearing capacity decreases, and the healing process is delayed. When these mechanisms are considered together, it is thought that the structural characteristics of the ECRB muscle may significantly contribute to the development and persistence of the tendinopathic process in lateral epicondylitis (Bazancir & Fırat, 2019). LE, may develop through excessive and repetitive stress on the extensor muscle tendons in the lateral epicondyle of the elbow joint (Sayampanathan et al., 2020). LE is a common tendinopathy with a prevalence of 0.3% to 12.2% in the adult population and causes limitations such as pain and reduced grip strength (Chen et al., 2023; Park et al., 2021). The most frequent incidence of LE is between 30 and 55 years of age. Hence, LE is a serious cause of labor loss in this population (Aben et al., 2018).

General treatment procedures for LE include patient education, rest, activity modifications, splinting, corticosteroid injections, and physiotherapy interventions. Physiotherapy modalities include ice massage, laser, ultrasound (US) therapy, manipulative treatments, transverse friction massage, and exercise therapy (Ma & Wang, 2020). Transverse friction massage (TFM) is a physiotherapy method recommended for tendinopathies for long years (Chaves et al., 2017). Popularized by James Cyriax, TFM is one of the first treatments recommended for tendon disorders among manual therapies. Increased blood flow to the tissue, traumatic hyperemia, reduction of adhesions, and mechanoreceptor stimulation are the positive effects of TFM on the tendon (Joseph et al., 2012).

TFM has been practiced in tendinopathies such as tennis elbow, iliotibial band syndrome, and supraspinatus tendinitis. Evidence for the effect of TFM in managing tendinopathies has been demonstrated (Brosseau et al., 2002; Joseph et al., 2012). Yi et al. have shown that TFM has a sustained therapeutic effect in LE, whereas the effect of splinting or cortisone injection is not sustained in the long term (Yi et al., 2018). Moreover, physiotherapy intervention including TFM was more cost-effective (Struijs et al., 2006).

The correlation of the modalities employed in the management of LE among specialists is poor and the number of review studies in this field is currently insufficient in the literature (Amar et al., 2014). Despite the widespread clinical use of TFM in the treatment of lateral epicondylitis, the current literature presents conflicting and insufficient findings regarding the effectiveness of TFM. While TFM is frequently applied in conjunction with exercise or other manual therapy techniques, its independent contribution to clinical outcomes remains unclear. To date, no systematic review has comprehensively synthesized evidence from randomized controlled trials

to evaluate the effects of TFM in lateral epicondylitis. Therefore, a systematic review focusing on randomized controlled trials is necessary to clarify the current evidence base, identify methodological limitations, and provide clinicians and researchers with a clearer understanding of the role of TFM in evidence-based rehabilitation strategies for lateral epicondylitis. To the best of our knowledge, no review has specifically focused on studies examining the effects of TFM alone in LE. The present review illuminates the effect of TFM in LE and contributes to the literature. Therefore, the present study aimed to review the literature on randomized controlled trials of TFM in patients with LE.

MATERIALS AND METHODS

Search Strategy

The present review was conducted by searching all fields in electronic databases (PubMed, Science Direct, Scopus, Web of Science) on December 2023 using a combination of the following keywords without limiting the years of research: "tennis elbow", "elbow tendinopathy", "lateral epicondylitis", "lateral elbow pain", "deep friction massage", "transverse friction massage", "cross friction massage", "friction". The detailed usage of keywords and search strategy is given in Appendix 1.

Eligibility Criteria

Studies were included if they met the following criteria: (1) randomized controlled trial design; (2) adult participants (≥18 years) diagnosed with lateral epicondylitis based on clinical assessment; (3) interventions including transverse friction massage (TFM), either as a standalone intervention or combined with other conservative physiotherapy approaches; (4) comparison groups receiving other conservative interventions used as comparators to TFM, such as exercise therapy, manual therapy, physical agents, sham treatment, or no intervention; (5) full-text articles published in peer-reviewed journals in the English language. Studies were excluded if they met any of the following criteria: (1) non-randomized study designs, including quasi-experimental studies and observational studies; (2) academic theses, dissertations, or unpublished manuscripts; (3) articles whose full text was not available in English or Turkish; (4) studies for which the full text could not be accessed; (5) studies in which transverse friction massage (TFM) was applied in all intervention and comparison groups, thereby preventing the evaluation of its comparative effects; (6) articles not indexed in PubMed, ScienceDirect, Scopus, or Web of Science, the databases used for the literature search.

Study Selection and Data Extraction

The current review was conducted following PRISMA guidelines (Moher et al., 2015). Rayyan (QCRI, Qatar) software was used for the search process. The results from the databases using relevant keywords were uploaded to this software. In the first stage, the titles and abstracts of the studies were read by two researchers with notes in different colors to include or exclude studies. At this stage, the researchers did not know which decision each other had made (include, exclude, or maybe). Articles whose titles and abstracts were not relevant to the topic of the systematic review were excluded. In the second stage, the two researchers reached a consensus by reviewing the articles on which the researchers had made different decisions or marked as "could be" under detailed consultation. In the third stage, the third researcher checked the articles with disagreements and selected the articles to be included in the review. A total of 3.615 studies

[PubMed (n=140), Science Direct (n=1.520), Scopus (n=1.807), Web of Science (n=148)] were retrieved from the database. Finally, seventeen studies were included in the current review. This process and its details are presented in Figure 1 with numerical data in line with the PRISMA flowchart. The content of the included studies is shown in Table 1. The following information was collected for each included study: authors, year of publication, sample size, participant characteristics, intervention and comparison details, outcome measures, and follow-up periods. Data extraction was performed independently, and inconsistencies were resolved through discussion and re-review to ensure accuracy and consistency. Information about the author, year of publication, study objective, symptom duration, age and number of participants, details of the intervention, outcome measures used in the study and post-intervention results are presented.

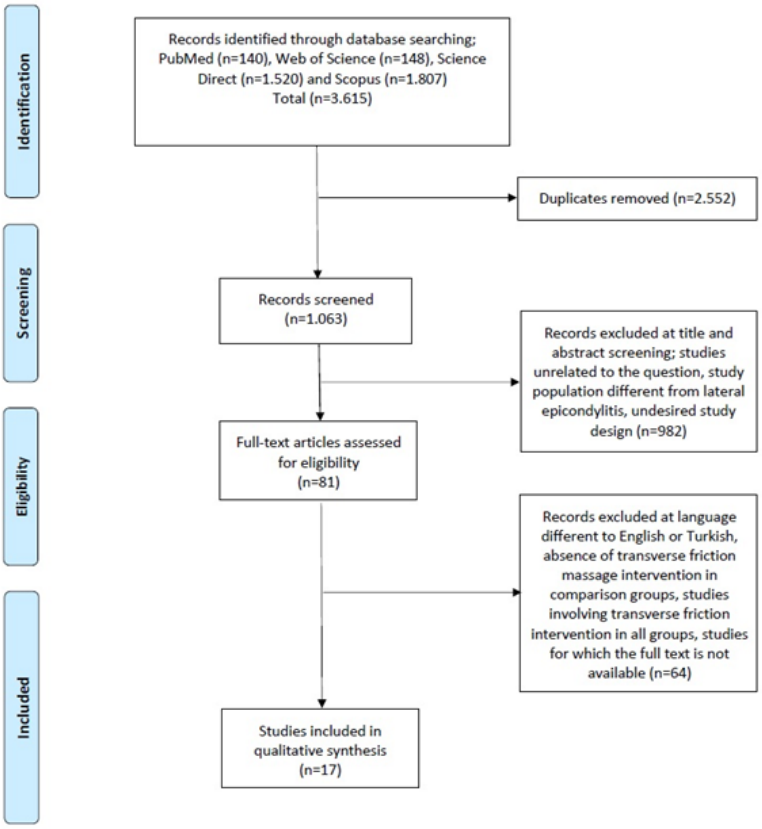

Figure 1. Flow diagram of study selection

Methodological Quality Assessment

The methodological quality of the included randomized controlled trials was assessed using the Physiotherapy Evidence Database (PEDro) scale. Quality assessment was conducted independently, and any disagreements were resolved through consensus. The PEDro scale evaluates key methodological criteria, including random allocation, concealed allocation, blinding, and completeness of follow-up, with total scores ranging from 0 to 10. The PEDro scale consists of 11 items, one of which reflects external validity and is not included in the total PEDro score. Eight items relate to internal validity, and two relate to statistical reporting. These items were: "eligibility criteria, randomization of groups, concealment of distribution, comparability of groups

at baseline, blinding of therapists-evaluators and participants, obtaining at least one key outcome measure >85% of participants, intent-to-treat analysis, statistical comparisons between groups to assess interpretability, reporting point measurements and variability measures". The total PEDro score is scored from 0-10 by calculating items 2-11. PEDro scores are categorized as <4 "poor", 4-5 "fair", 6-8 "good", and 9-10 "excellent" (Özden et al., 2023). Table 2 shows the PEDro scores of the included articles.

RESULTS

Search Outcome

The literature search was conducted on December 18, 2023, 11:11 pm with the keyword combinations identified. The search yielded a total of 3,615 studies (PubMed=140, ScienceDirect=1,520, Web of Science=148, Scopus=1,807). After excluding duplicates and studies that did not meet the inclusion criteria, 17 articles were selected for inclusion in the review. A detailed flow diagram is shown in Figure 1.

Participants and Study Characteristics

A summary of data from the 17 included studies is presented in Table 1. The articles included in the present study were conducted between 1992 and 2023. The total number of participants in the 17 reviewed articles was 1,113. The sample size of the studies included a minimum of 18 participants and a maximum of 198 participants. Subjects in the included articles had either chronic or acute duration of symptoms. Symptom durations were: mean 3.6 months (Vasseljen, 1992), not available (Dedes et al., 2020; Drechsler et al., 1997; Koch et al., 2015), more than 6 months (Smidt et al., 2002), 6 to 48 weeks (Struijs et al., 2003), mean 5 months (Stasinopoulos & Stasinopoulos, 2006), group means 12.5 weeks and 14.5 weeks (Nagrale et al., 2009), 8 to 10 weeks (Shridhar Thakare et al., 2014; Viswas et al., 2012), less than 3 months (Gündüz et al., 2012), 4 to 10 weeks (Olaussen et al., 2015), more than 6 weeks (Yi et al., 2018), mean 3.7 months (Alrawaili, 2019), more than 2 months (Büker et al., 2020), mean 8.82 months (Aldajah et al., 2022), group means 5.6 months and 6.2 months (Nambi et al., 2023), respectively.

The reported ages of the subjects were: mean 45.5 (Vasseljen, 1992), mean 46 (Drechsler et al., 1997), 41 to 54 (Smidt et al., 2002), 26 to 60 (Struijs et al., 2003), 30 to 60 (Koch et al., 2015; Nagrale et al., 2009; Stasinopoulos & Stasinopoulos, 2006), 30 to 45 (Shridhar Thakare et al., 2014; Viswas et al., 2012), group means 45.7 years 44.9 years and 43.6 years (Gündüz et al., 2012), mean 46.9 (Olaussen et al., 2015), mean 48 (Yi et al., 2018), mean 34.8 (Alrawaili, 2019), more than 18 years (Dedes et al., 2020), 33 to 67 (Büker et al., 2020), mean 42.28 (Aldajah et al., 2022), 18 to 60 (Nambi et al., 2023). The minimum age was 18 and the maximum age was 70.

Intervention Characteristics

Intervention details of the included articles appear in Table 1. Among the included articles, there were 8 studies in which TFM plus other combined interventions showed a significantly better result in terms of a few parameters (Büker et al., 2020; Nagrale et al., 2009; Nambi et al., 2023; Shridhar Thakare et al., 2014; Smidt et al., 2002; Stasinopoulos & Stasinopoulos, 2006; Vasseljen, 1992; Yi et al., 2018). The number of studies that did not show a significant difference against TFM plus other combined interventions was 4 (Drechsler et al., 1997; Gündüz et al., 2012; Koch et al., 2015; Olaussen et al., 2015). The number of studies with significantly better results

in a few parameters against TFM plus other combined interventions is 5 (Aldajah et al., 2022; Alrawaili, 2019; Dedes et al., 2020; Struijs et al., 2003; Viswas et al., 2012).

As reported treatment durations; one study continued the intervention program for 3, 4, 5, 10 sessions (Dedes et al., 2020), one study for 5 sessions (Aldajah et al., 2022), one study for 10 sessions (Gündüz et al., 2012), two studies for 3 weeks (Büker et al., 2020; Vasseljen, 1992), five studies for 4 weeks (Koch et al., 2015; Nagrale et al., 2009; Shridhar Thakare et al., 2014; Stasinopoulos & Stasinopoulos, 2006; Viswas et al., 2012), one study for 4+4 weeks (Nambi et al., 2023), five studies for 6 weeks (Drechsler et al., 1997; Olaussen et al., 2015; Smidt et al., 2002; Struijs et al., 2003; Yi et al., 2018) and one study for 8 weeks (Alrawaili, 2019). The TFM group also included US, laser, stretching, progressive strengthening, Mills' manipulation, hot pack, eccentric exercise, placebo injection, range of motion exercises, lidocaine injection, brace, local NSAIDs application, cold therapy, activity modification and corticosteroid injection interventions employed with different combinations

OUTCOME MEASUREMENTS

Patient Reported Outcome Measures

In the outcome measures reported in the included studies; thirteen studies Visual Analogue Scale (VAS) (Aldajah et al., 2022; Alrawaili, 2019; Büker et al., 2020; Gündüz et al., 2012; Koch et al., 2015; Nagrale et al., 2009; Nambi et al., 2023; Olaussen et al., 2015; Shridhar Thakare et al., 2014; Stasinopoulos & Stasinopoulos, 2006; Vasseljen, 1992; Viswas et al., 2012; Yi et al., 2018), three studies algometer (Büker et al., 2020; Smidt et al., 2002; Struijs et al., 2003), one study patient assessment (Vasseljen, 1992), one study self-report questionnaire (Drechsler et al., 1997), four studies global improvement scale (Alrawaili, 2019; Nambi et al., 2023; Smidt et al., 2002; Struijs et al., 2003), two studies patient-reported general improvement questionnaire including questions such as main symptom severity (Smidt et al., 2002; Struijs et al., 2003), one study modified pain free function questionnaire (Smidt et al., 2002), one study general severity of elbow complaints (Smidt et al., 2002), one study patient satisfaction (Smidt et al., 2002), two studies Tennis Elbow Function Scale (Nagrale et al., 2009; Viswas et al., 2012), three studies Patient Rated Tennis Elbow Evaluation (Koch et al., 2015; Nambi et al., 2023; Shridhar Thakare et al., 2014), one study treatment success scale (Olaussen et al., 2015), one study pain on dorsiflexion wrist and third finger scale (Olaussen et al., 2015), one study Pain Free Function Index (Olaussen et al., 2015), three studies Disabilities of Arm, Shoulder, and Hand Scale (DASH) (Aldajah et al., 2022; Büker et al., 2020; Yi et al., 2017), one study University of Peloponnese Pain Functionality and Quality of Life Questionnaire (Dedes et al., 2020), one study the Beck Depression Scale (Büker et al., 2020), one study the Short Form-12 (SF-12) (Büker et al., 2020), one study the Tampa Scale for Kinesiophobia (Nambi et al., 2023), one study the Hospital Anxiety and Depression Scale (HADS) (Nambi et al., 2023), one study used the EuroQol EQ-5D (Nambi et al., 2023). The most commonly used outcome measures are VAS, global improvement scale, Patient Rated Tennis Elbow Evaluation, DASH and algometer.

Strength

In terms of the strength outcome measures reported in the included articles; one study vigorimeter (Vasseljen, 1992), twelve studies dynamometer (Aldajah et al., 2022; Alrawaili, 2019; Drechsler et al., 1997; Gündüz et al., 2012; Koch et al., 2015; Nagrale et al., 2009; Nambi et al., 2023; Olaussen et al., 2015; Smidt et al., 2002; Stasinopoulos & Stasinopoulos, 2006; Struijs et

Table 1. Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Vasseljen (1992) (Vasseljen, 1992)	To compare low-level laser therapy versus conventional physiotherapeutic treatment for tennis elbow	3.6 months (mean)	25-70 45.5 (mean)	n=15	n=15	IG: Ultrasound with a frequency of 1 MHz and an intensity of 1.5 W/cm^2 was applied for 7 minutes in pulsed mode with 2 ms on and 8 ms off. Transverse friction massage was applied continuously to the teno-periosteal junction of the extensor carpi radialis brevis muscle for 10 minutes. CG: GaAs laser with 904 nm wavelength was used. The repetition frequency from the laser was 880 Hz, the pulse duration 175 ns and the average peak effect 10 W. A dose of 5 J/cm^2 was delivered with 10 minutes of treatment. Treatments were provided for a total of 8 sessions for 3 weeks.	Vigorimeter, weight test, goniometric measurements of wrist flexion, VAS, patient assessment were evaluated at baseline, end of treatment and 4 weeks follow up	VAS improved significantly more in IG than CG ($p<0.01$) In IG, more patients rated themselves as much better or pain-free at the final assessment. A significant improvement in grip strength was found in favour of CG from the end of treatment to the last evaluation ($p=0.03$). The weight test showed a significantly greater improvement in IG compared to CG from baseline to the end of treatment ($p<0.01$).
Drechsler et al. (1997) (Drechsler et al., 1997)	To compare the effectiveness of two physiotherapy treatments (neural tension and standard treatment) for tennis elbow	N/A	30-57 46 (mean)	n=8	n=10	IG: Continuous ultrasound was performed at 1.5 w/cm2, 5 minutes to the common extensor tendon using a 3 MHz head. Transverse friction massage to the extensor tendon area for 1 minute three times per treatment. Stretching and strengthening exercises were applied to the wrist extensors. A home exercise program consisting of stretching and strengthening exercises was also included. Treatment was carried out twice a week for 6 weeks. CG: Mobilisation of the radial nerve and surrounding interface was performed with the subject supine and the affected arm placed in full supination with elbow extension and approximately 50 degrees of shoulder abduction. Anteriorposterior mobilisations of the radial head were also included when judged to be hypomobile. Initially, 10 repetitions once a day. No more than twice a day.	Hydraulic hand-held dynamometer, third finger extension test, self-report questionnaire, upper limb tension test and radial head mobility were evaluated at baseline, end of treatment and 3 months follow up	No significant difference was found between the groups for any of the variables tested.

Table 1 (Continue). Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Smidt et al. (2002) (Smidt et al., 2002)	To compare the effectiveness of the wait-and-see policy with physiotherapy, corticosteroid injections	>6 month	41-54	Wait and see n=59 Corticosteroid injection n=62	n=64	IG: Physiotherapy consisted of nine treatments consisting of pulsed ultrasound (20% duty cycle, intensity of 2 W/cm^2 for 7-5 minutes per session), transverse friction massage and an exercise programme (wrist and forearm stretching, muscle conditioning and occupational exercises) for 6 weeks. All patients received home exercise equipment and an instruction book. CG (wait and see): During the 6-week intervention period, patients visited their family doctor once. Ergonomic advice was discussed with the patients. Paracetamol or non-steroidal anti-inflammatory drugs were prescribed if necessary. The patient was encouraged to await further spontaneous improvement. CG (corticosteroid injection): Local infiltration of 1 mL triamcinoloneacetonide and 1 mL 2% lidocaine was applied. It was injected until the patient was pain-free during resistant extension. A maximum of three injections were given during the 6-week intervention period.	Patient-reported general improvement, severity of the main complaints pain and discomfort during the day as reported by the patient, modified pain-free function questionnaire, the general severity of elbow complaints as scored by the physiotherapist, Jamar hand dynamometer, algometer and patient satisfaction were evaluated at baseline, 3 weeks after randomization, 6, 12, 26 and 52 weeks	At 6 weeks, 92% of patients in the injection group, 47% in the physiotherapy group, and 32% in the wait-and-see group reported success. Success rates at week 52 were 69% for the injection group, 91% for the physiotherapy, and 83% for the wait-and-see group. At week 6, significant differences favoring corticosteroid injections were seen for all primary and secondary outcomes. At weeks 26 and 52, significant differences in favor of physiotherapy were noted in almost all outcome measures compared to the injection group.
Struijs et al. (2003) (Struijs et al., 2003)	To compare the effectiveness of wrist manipulation in the treatment of lateral epicondylitis with the effectiveness of an intervention consisting of friction massage, ultrasound, and muscle stretching and strengthening exercises.	6-48 week	26-60 CG: 46.3 (mean) IG: 47.5 (mean)	n=13	n=15	IG: Pulsed ultrasound (20% duty cycle, 2 W/cm^2 intensity) was delivered around the lateral humeral epicondyle for a total of 9 sessions over 6 weeks. Friction massage was applied for 10 minutes. When the pain subsided, the subjects were taught muscle strengthening and stretching exercises and were told to do the exercises at home twice a day. CG: Therapist holds the Subject's scaphoid bone between thumb and index finger. Therapist then extends the subject's wrist while simultaneously manipulating the scaphoid bone in a ventral direction. This intervention was performed twice a week for a maximum of 9 sessions for 6 weeks.	Global improvement scale, PROMs include severity of main complaint, pain during examination, pain during the day, and discomfort during daily activities, Jamar hand dynamometer, pressure threshold meter and goniometer measurement evaluated at baseline, 3 and 6 weeks	At 3 weeks after the intervention, global improvement showed a significant difference in favor of CG between groups, but the significance disappeared at 6 weeks. At the 6th week, the pain during day score was significantly different in favor of CG. There were no significant differences in other outcome measures.

Table 1 (Continue). Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Stasinopoulos & Stasinopoulos (2006) (Stasinopoulos & Stasinopoulos, 2006)	To compare the effectiveness of Cyriax physiotherapy, a supervised exercise programme, and polarized polychromatic non-coherent light in the treatment of lateral epicondylitis.	5 months (mean)	30-60 CG (Supervised exercise): 40.4 (mean) CG (Bioptron light): 40.1 (mean) IG: 40.4 (mean)	Supervised exercise n=25 Bioptron light n=25	n=25	IG: Cyriax physiotherapy consisted of a 10-minute deep transverse friction massage immediately followed by an intervention with Mill manipulation. CG (Supervised exercise): The supervised exercise program consisted of slowly progressive eccentric exercises of the wrist extensors and static stretching exercises of the extensor carpi radialis brevis tendon. CG (Bioptron light): The intervention was applied to three locations for 6 min at each location using the Bioptron 2 device (light wavelength= 480-3400 nm; degree of polarization= 95%; specific power density= 40 mW/cm^2; energy density= 2.4 J/cm^2). Each treatment was administered three times a week for four weeks.	VAS (pain), VAS (function) and Jamar hand dynamometer evaluated at baseline, 4, 8, 16 and 28 weeks	At weeks 4, 8, 16, 28, VAS (function), VAS (pain) and grip strength were significantly better on the supervised exercise program compared to Cyriax physiotherapy and polarized polychromatic non-coherent light. At week 28, there was a significant difference between Cyriax physiotherapy and polarized polychromatic non-coherent light in favor of Cyriax physiotherapy.
Nagrale et al. (2009) (Nagrale et al., 2009)	To compare the effectiveness of Cyriax physiotherapy with supervised exercise phonophoresis in patients with lateral epicondylitis	CG: 12.5 weeks (mean) IG: 14.5 weeks (mean)	30-60 38.6 (mean)	n=30	n=30	IG: Cyriax physiotherapy consisting of 10 minutes of deep transverse friction massage immediately following a single application of Mill's manipulation CG: Fhonophoresis (Voveran Emulgel, Novartis), supervised therapeutic exercise (static stretching of the extensor carpi radialis brevis followed by eccentric strengthening of the wrist extensors), ultrasound (100% duty cycle, frequency of 1 MHz, intensity of 0.8 W/cm^2 for 5 minutes) All participants received treatment 3 times a week for 4 weeks, for a total of 12 sessions.	VAS, hand-held dynamometer, Tennis Elbow Function Scale evaluated at baseline, immediately following the first treatment session, 2, 4 and 8 week	In between-group analysis, IG showed significantly better results than CG in all follow-up periods and all measurements

Table 1. (Continue) Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/ follow-up	Results
Viswas et al. (2012) (Viswas et al., 2012)	To compare the effectiveness of Cyriax physiotherapy and supervised exercise program in tennis elbow.	8-10 week	30-45 CG: 37.4 (mean) IG: 38.2 (mean)	n=10	n=10	IG: Cyriax physiotherapy consisting of a single Mill manipulation application immediately followed by a 10-minute deep transverse friction massage CG: Static stretching of the extensor Carpi Radialis Brevis (6 reps/ session) followed by eccentric strengthening of the wrist extensors (3 sets of 10 reps/session).	VAS and Tennis Elbow Function Scale evaluated at baseline and 4 week	VAS and Tennis Elbow Function Scale scores were significantly better between groups in favor of CG.
Gündüz et al. (2012) (Gündüz et al., 2012)2)	To compare clinically and ultrasonographically the therapeutic effects of physical therapy, local corticosteroid injection and extracorporeal shock wave therapy (ESWT) in lateral epicondylitis.	< 3 month	CG (injection): 45.7 years (mean) CG (ESWT): 44.9 years (mean) IG: 43.6 years (mean)	Corticosteroid injection n=20 ESWT n=20	n=19	IG: Hot pack (15 minutes), ultrasound therapy (1 W/cm^2, 5 minutes) and friction massage (5 minutes) for ten sessions CG (corticosteroid injection): Single injection of 20 mg methylprednisolone acetate and 1 ml prilocaine CG (ESWT): Ten sessions with ESWT (pressure 1.4 bar, frequency 4.0 Hz)	VAS, Jamar hydraulic dynamometer, pinch meter evaluated at baseline, after treatment first month, third month and sixth month Ultrasonography evaluated at baseline and after treatment sixth month	In general, changes in VAS, pinch and grip strength measurements were similar between groups in the first, third and sixth months of treatment. At the sixth-month ultrasonography control, extensor tendon thicknesses did not show a significant change in any group compared to the first measurements.
Thakare et al. (2014) (Shridhar Thakare et al., 2014)	To investigate the long-term effect of Cyriax physiotherapy in combination with a supervised exercise programme in people with tennis elbow	8-10 week	30-45 CG: 37.47 (mean) IG: 37.67 (mean)	n=15	n=15	IG: 4 weeks of Cyriax physiotherapy and supervised exercise programme. 10 minutes of deep transverse friction massage immediately followed by a single Mill manipulation application, static stretching of the Extensor Carpi Radialis Brevis followed by eccentric strengthening of the wrist extensors CG: 4 weeks of supervised exercise program only. Static stretching of the Extensor Carpi Radialis Brevis followed by eccentric strengthening of the wrist extensors	VAS, Patient Rated Tennis Elbow Evaluation evaluated at baseline, after 4 weeks of intervention and follow-up at 2 weeks	In the post-intervention and follow-up measurements, VAS and Patient Rated Tennis Elbow Evaluation scores were significantly better in IG than in CG.

Table 1. (Continue) Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Olaussen et al. (2015) (Olaussen et al., 2015)	To investigate the clinical short- and long-term effect of a combination of physical therapy with corticosteroid injection or placebo injection for acute lateral epicondylitis in comparison with a control group	4-10 week	46.9 (mean)	Wait and see n=60 Corticosteroid injection with physiotherapy n=59	Placebo injection with physiotherapy n=15	IG: Deep transverse friction massage for 15 minutes, Mills manipulation once per treatment session, and soft tissue treatment with stretching of the radial wrist extensors were performed twice a week for six weeks. Home exercises including eccentric exercise and isolated stretching of the radial wrist extensors were given daily for six weeks. A placebo injection was given at baseline and three weeks later. Naproxen 500 mg twice daily for two weeks CG (Corticosteroid injection with physiotherapy): At baseline and three weeks later, patients received 10 mg triamcinolone acetonide injection. naproxen 500 mg twice daily for two weeks. In addition, physiotherapy was performed as described above. CG (Wait and see): Naproxen 500 mg twice daily for two weeks. Paracetamol could be taken up to 4 grams per day according to the patient's request.	Six point Likert scale treatment success, VAS, Jamar Hydraulic Hand Dynamometer, a three-point scale for pain on resisted dorsiflexion of the wrist and third finger, Pain Free Function Index evaluated at baseline, 6, 12, 26 and 52 weeks	Wait and see and physiotherapy plus placebo injection showed similar improvement. The physiotherapy plus injection group showed a significant improvement at week 6 but a low success rate in the medium term. There was no difference between the groups in the long term. There was no significant difference between physiotherapy plus injection and physiotherapy plus placebo injection, suggesting no additional effect of steroid injection.
Koch et al. (2015) (Koch et al., 2015)	To compare the effect of Cyriax physiotherapy against eccentric strengthening and stretching exercises in chronic lateral epicondylitis	N/A	30-60	n=30	n=30	IG: Deep Transverse Friction for 10 minutes, Mill's Manipulation and laser (wavelength 632.8 nm, energy density 2-3 joules/point, 10 minutes per session) were applied 3 times a week for 4 weeks. CG: In addition to low-level laser therapy, eccentric strengthening and static stretching of the extensor carpi radialis brevis were applied.	VAS, Hand Held Dynamometer, Patient Rated Tennis Elbow Evaluation Questionnaire evaluated at baseline and 4 week later	There was no significant difference between the groups in VAS, Hand Held Dynamometer and Patient Rated Tennis Elbow Evaluation Questionnaire scores.

Table 1. (Continue) Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Yi et al. (2018) (Yi et al., 2018)	To compare 3 different clinical regimens (splinting and stretching, cortisone injection, transverse friction massage) for the nonoperative treatment of lateral epicondylitis	> 6 week	48 (mean)	Splinting and stretching n=11 Cortisone injection n=11	n=12	IG: 10 mL of 1% lidocaine was injected into the area of maximum tenderness at the lateral epicondyle followed by transverse friction massage. Lidocaine provided local anaesthesia so that patients could tolerate the friction massage. The massage was performed for a total of 5 minutes. Patients then wore a removable wrist splint for 3 to 5 days. After 1-2 rests, standard therapy was added. CG (Splinting and stretching): A removable cock-up wrist splint was applied to be worn full time for 6 weeks outside hygiene and treatment. Patients in group 1 received a standardised treatment protocol starting after 2 weeks of rest. The standardised treatment protocol was prescribed to all patients in all 3 groups and consisted of a supervised upper limb stretching programme for the wrist and finger extensors and flexors, as well as range of motion exercises for the elbow, forearm and wrist. CG (Cortisone injection): A total of 10 mL of cortisone injection containing 20 mg methylprednisolone and 1% lidocaine was administered. Removable wrist splint for 3 to 5 days. After 1-2 rests, standard therapy was added.	VAS, DASH, Jamar dynamometer evaluated at baseline, early follow- up between 6 and 12 weeks and late follow-up at 6 months	There was a significant difference in VAS pain score in all 3 groups at early follow-up. There was no significant improvement in DASH and grip strength score at early follow-up in the splint group. There was a significant improvement for the other two groups. At 6-month follow-up, VAS, DASH, grip strength score showed a significant improvement only in the friction group. ANOVA showed no significant difference in treatment effect between the 3 groups at early follow-up. However, at 6-month follow-up, the friction group showed significantly better results compared with the other groups.
Alrawaili (2019) (Alrawaili, 2019)	To evaluate the clinical effects on lateral epicondylitis with low-level laser therapy.	3.7 months (mean)	20-40 34.8 (mean)	n=15	n=15	IG: For 8 weeks, a lateral counterforce brace plus transverse friction massage and ultrasonic therapy were applied during the day. CG: Lateral counterforce brace plus low-level laser therapy (GaAlAs, the wavelength of 904 nm, continuous mode, frequency of 50 Hz, power density of 50 mW/cm^2, spot size of 0.5 cm^2, duty cycle of 0%, energy density of 1.5 J/ cm2, and the duration of irradiation was 30 sec for each point) was applied. During the 8-week treatment period, 10 sessions of laser treatment were performed.	Hand dynamometer, VAS, global assessment of improvement scale evaluated at baseline, 4, 8 week	At week 8, CG showed significantly better improvement than IG.

Table 1. (Continue) Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Dedes et al. (2020) (Dedes et al., 2020)	To compare the effectiveness of shockwave and ultrasound treatments in patients with lateral epicondylitis	N/A	> 18	Ultrasound n=63 Shockwave n=117	n=18	IG: Local application of NSAIDs, use of bracing, an exercise program, modification of activity levels, friction massage, and placing hot or cold packs on the injured area CG (Ultrasound): 3 MHz and intensity of 2 W/cm^2 CG (Shockwave): For the initial session, the frequency was set to 21 Hz, the pressure at 1.8 bar, and 2000 shocks to achieve analgesia. For all the remaining sessions, the frequency was set to 15 Hz, the pressure at 1.6 bar, and 1500 shocks to achieve therapy.	University of Peloponnese Pain, Functionality and Quality of Life Questionnaire evaluated at pre-treatment, post-treatment, 4 week follow up	Outcomes in the ultrasound group were significantly better compared to IG after treatment and at 4-week follow-up. The results in the shockwave group were significantly better compared to IG after treatment and at 4-week follow-up. The results in the shockwave group were significantly better than in the ultrasound group after treatment and 4-week follow-up.
Büker et al. (2020) (Büker et al., 2020)	To compare the short-term effects of deep transverse friction massage and extracorporeal shock wave therapy in patients with lateral epicondylitis and the costs of both treatment methods	> 2 month	33-67 CG: 33.55 (mean) IG: 47.08 (mean)	n=27	n=25	IG: Friction was applied for two sessions per week with at least two-day intervals. Cold application was performed for 10 minutes before the treatment and friction was applied for 15 minutes immediately afterwards. At the end of the treatment, 10 minutes of cold application was performed again. Cold pack at home for 10 minutes every 2 hours for the first 24 hours after the treatment session. CG: ESWT (5 Hz, 2.5 bar, 2,000 pulses) was applied in 3 sessions, one week apart. Patients in both groups were asked to perform stretching exercises and eccentric strengthening exercises as home exercise program. The treatments lasted for 3 weeks.	VAS, Algometer, grip strength with paediatric blood pressure cuff, Mayo elbow performance score, DASH, Beck Depression Scale, SF-12 evaluated at before treatment and after 3 weeks of treatment	When the groups are compared; significant difference was found in favor of IG in pain during activity and DASH total score. Total scores of rest pain, pain threshold, grip strength, Mayo elbow performance score, SF-12 and Beck Depression Scale were at similar levels. The treatment cost of IG was determined as 69.60 Turkish Liras, and the treatment cost of CG was determined as 124.0 Turkish Liras.

Table 1. (Continue) Summary of included articles

Article	Objective	Symptom Duration	Age (year)	Control Group (CG) (n)	Intervention Group (IG) (n)	Interventions	Outcomes/follow-up	Results
Aldajah et al. (2022) (Aldajah et al., 2022)	To evaluate and compare the effectiveness of ESWT and traditional physiotherapy intervention in the treatment of lateral epicondylitis.	8.82 months (mean)	42.28 (mean)	n=20	n=20	IG: 5 sessions of traditional physical therapy for 5 minutes. 1 minute of friction massage followed by 3 minutes of continuous therapeutic ultrasound at a frequency of 1.5 Hz and 1 minute of direct ice massage on the elbow common extensor tendon CG: 5 sessions of ESWT (2000 shock waves with 1.6 bar intensity and 16 Hz frequency) were applied.	VAS, DASH, Hydraulic Hand Dynamometer evaluated at baseline and end of the fifth session	Between groups, CG performed significantly better than IG in VAS, DASH, and grip strength
Nambi et al. (2023) (Nambi et al., 2023)	To investigate the effects of corticosteroid injection, friction and Mill manipulation on clinical and radiological changes in lateral epicondylgia.	CG: 5.6 months (mean) IG: 6.2 months (mean)	18-60 CG: 47.82 (mean) IG: 48.35 (mean)	n=30	n=30	IG: 1 ml Triamcinolone Acetonide (10 mg/ml) (Kenacort-A 10) and 1 ml Lignocaine (1%) were injected. One week after the injection, participants began physical therapy interventions (3 sessions per week for 4 weeks). Deep transverse friction massage (5 minutes) and Mill's manipulation were applied. CG: For the sham group, injection plus high-amplitude movement was performed at the elbow joint at a low speed that the study participants could not understand. Following corticosteroid injection, recommended physical therapy was administered for 4 weeks, and then participants were asked to exercise at home for an additional 4 weeks. The relevant intervention was applied to both groups three sessions a week for 4 weeks. Progressive resistance exercises and home exercises were applied to both treatment groups.	VAS, MRI, US imaging, The Patient-rated Tennis Elbow Evaluation, handheld dynamometer, Global perceived improvement questionnaire, Tampa Scale for Kinesiophobia, The Hospital Anxiety and Depression Scale, The EuroQol EQ-5D evaluated at baseline, after 4 weeks, 8 weeks and at 6 months follow up	IG improved significantly more than CG at all outcome measures and follow-up points.

CG: Control group; **IG**: Intervention group; **n**: Number of participants; **PROM**s: Patient-reported outcome measures; **ESWT**: Extracorporeal shock wave therapy; **DASH**: Disabilities of Arm, Shoulder, and Hand; **VAS**: Visual Analogue Scale; **NSAID**s: Nonsteroidal anti-inflammatory drugs; **SF-12**: Short Form-12; **MRI**: Magnetic Resonance Imaging; **US**: Ultrasound; **N/A**: Not Available

al., 2003; Yi et al., 2018), one study pinch meter (Gündüz et al., 2012), and one study used blood pressure cuff (Büker et al., 2020). The most commonly used result measure is the dynamometer.

Function

In terms of the function outcome measures reported in the included articles; one study weight test (Vasseljen, 1992), two studies goniometric measurement (Struijs et al., 2003; Vasseljen, 1992), one study third finger extension test (Drechsler et al., 1997), one study upper limb tension test (Drechsler et al., 1997), one study radial head mobility (Drechsler et al., 1997) and one study used Mayo elbow performance score (Büker et al., 2020). The most commonly used outcome measure is the goniometric measurement.

Imaging

Regarding imaging evaluations reported in the included articles, Magnetic Resonance Imaging (MRI) was used in one study (Nambi et al., 2023) and US imaging was used in one study (Nambi et al., 2023).

Quantitative Synthesis of Outcomes

In the included studies, pain intensity was most assessed using the VAS. Significant intra-group decreases in VAS scores after treatment were reported in many interventions, including low-level laser therapy, TFM, Cyriax physiotherapy, ESWT, supervised exercise programs, and multimodal physiotherapy approaches ($p<0.05$ to $p<0.001$). Specifically, some studies showed that including low-level laser therapy resulted in significantly greater pain reduction compared to traditional physical therapy or TFM techniques in the medium and long-term follow-up ($p<0.05$), while ESWT showed superior improvements in pain and function compared to traditional physical therapy and ultrasound therapy in the post-treatment and short-term follow-up ($p<0.001$). In contrast, some studies have reported no significant difference in pain outcomes between groups despite significant improvements within groups ($p>0.05$). Functional outcomes assessed using validated tools such as DASH, Patient-Rated Tennis Elbow Evaluation, Tennis Elbow Function Scale, and six-point general improvement scales have demonstrated significant improvements in many studies following treatment. Intergroup analyses have revealed significantly greater functional improvements in favor of Cyriax physiotherapy, TFM, supervised exercise, ESWT, and multimodal manual therapy compared to control, sham, or alternative conservative interventions in many studies ($p < 0.05$ to $p < 0.001$). Hand grip strength results showed mixed findings. Significant improvements in grip strength were reported within the group following low-level laser therapy, TFM, Cyriax physiotherapy, ESWT, and supervised exercise programs ($p < 0.05$). Several studies have shown statistically significant differences in favor of manual therapy-based or multimodal interventions involving TFM after treatment or during longer-term follow-up ($p < 0.05$).

A limited number of studies have reported effect sizes and confidence intervals. Moderate to large effect sizes supporting Cyriax physiotherapy or manual therapy interventions involving TFM have been reported in terms of pain reduction and functional outcomes in medium- and long-term follow-ups, with effect sizes ranging from 0.74 to 0.81. One study reported large effect sizes for pain intensity, functional disability, imaging results, and hand grip strength (η^2=0.55–0.99). Confidence intervals for treatment effects were reported inconsistently across the included trials.

Methodological Quality

Methodological quality assessment of the articles included in the present review was performed with the PEDro scale (Table 2). The PEDro scores of the studies ranged from 3 to 9, with a mean score of 6.29 ± 1.4. This shows that the present study can be classified as good. Only one study's PEDro score was rated poor (Koch et al., 2015). Three studies had a score of 5 (Drechsler et al., 1997; Vasseljen, 1992; Yi et al., 2018). Twelve studies were classified as having good methodological quality with a score between 6 and 8 (Aldajah et al., 2022; Alrawaili, 2019; Büker et al., 2020; Dedes et al., 2020; Gündüz et al., 2012; Nagrale et al., 2009; Olaussen et al., 2015; Shridhar Thakare et al., 2014; Smidt et al., 2002; Stasinopoulos & Stasinopoulos, 2006; Struijs et al., 2003; Viswas et al., 2012). A recent study was also classified as excellent, scoring 9 points (Nambi et al., 2023). All included studies were randomly allocated, and seven of them performed concealed allocation (Aldajah et al., 2022; Gündüz et al., 2012; Nambi et al., 2023; Olaussen et al., 2015; Shridhar Thakare et al., 2014; Smidt et al., 2002; Struijs et al., 2003). In ten of the included studies, the assessors were blinded to group allocations (Aldajah et al., 2022; Büker et al., 2020; Gündüz et al., 2012; Nagrale et al., 2009; Nambi et al., 2023; Smidt et al., 2002; Stasinopoulos & Stasinopoulos, 2006; Struijs et al., 2003; Viswas et al., 2012; Yi et al., 2018). In one study, participants were blinded to group allocations (Nambi et al., 2023). No studies were excluded based on their methodological quality.

Table 2. PEDro scores

Article	Q-1[a]	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7	Q-8	Q-9	Q-10	Q-11	Total
Vasseljen (1992) (Vasseljen, 1992)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Drechsler et al. (1997) (Drechsler et al., 1997)	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
Smidt et al. (2002) (Smidt et al., 2002)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Struijs et al. (2003) (Struijs et al., 2003)	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Stasinopoulos & Stasinopoulos (2006) (Stasinopoulos & Stasinopoulos, 2006)	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Nagrale et al. (2009) (Nagrale et al., 2009)	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Viswas et al. (2012) (Viswas et al., 2012)	Y	Y	N	Y	N	N	Y	Y	Y	Y	N	6
Gündüz et al. (2012) (Gündüz et al., 2012)	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Thakare et al. (2014) (Shridhar Thakare et al., 2014)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Olaussen et al. (2015) (Olaussen et al., 2015)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Koch et al. (2015) (Koch et al., 2015)	Y	Y	N	N	N	N	N	Y	N	Y	N	3
Yi et al. (2018) (Yi et al., 2018)	Y	Y	N	Y	N	N	Y	N	N	Y	Y	5
Alrawaili (2019) (Alrawaili, 2019)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Dedes et al. (2020) (Dedes et al., 2020)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Büker et al. (2020) (Büker et al., 2020)	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Aldajah et al. (2022) (Aldajah et al., 2022)	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Nambi et al. (2023) (Nambi et al., 2023)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Total	15	17	7	16	1	0	10	16	8	17	15	

Q-1: Eligibility criteria; Q-2: Random allocation; Q-3: Concealed allocation; Q-4: Baseline comparability; Q-5: Blind subjects; Q-6: Blind therapists; Q-7: Blind assessors; Q-8: Adequate follow-up; Q-9: Intention-to-treat analysis; Q-10: Between-group comparisons; Q-11: Point estimates and variability

[a] This item relates to external validity and therefore does not contribute to the total score.

DISCUSSION

This study, which aimed to review randomized controlled trials evaluating the effect of TFM in chronic or acute LE, provided evidence that TFM was effective in the majority of studies in this patient group. LE affects 1% to 3% of the population and middle-aged people, and may cause a social and economic burden. Unfortunately, there is still a lack of established standards in the treatment of LE (Ma & Wang, 2020). To our knowledge, there is no article in the literature that reviews randomized controlled trials comparing TFM therapy for LE. In our study, randomized controlled trials that included TFM in at least one group and did not include TFM intervention in the other group were reviewed in terms of their characteristics, intervention protocols, outcome measures, results and methodological quality.

A study comparing pulsed US plus TFM with low level laser reported that after 3 weeks of treatment, the TFM group was better on outcome measures (Vasseljen, 1992). Sample size in the study was only 30 people. This increases the probability of type 1 error. In addition, the effect of the 3-week treatment period on the results may be limited. However, patients were re-interviewed 5 months after treatment and concluded that patients with a high level of satisfaction were still satisfied. In this study, laser, which has a relatively high treatment cost, was not superior to TFM and US. Nevertheless, in another study with a similar design, laser intervention showed better results than the TFM group (Alrawaili, 2019). Similarly, a small sample size was used in this study. There is not sufficient data to compare TFM and laser procedures. A study comparing TFM with US and Extracorporeal Shockwave Therapy (ESWT) found US better than the TFM group and ESWT better than US (Dedes et al., 2020). However, the TFM intervention could not be compared in isolation in this study. The TFM group included many comprehensive applications such as NSAID application, brace, exercise, heat, cold. Moreover, the TFM group consisted of 18 participants, while the US group consisted of 63 participants and the ESWT group consisted of 117 participants. This limitation also affects the level of evidence.

Another intervention with relatively high treatment costs in these patients is ESWT. In the study mentioned above, ESWT showed better results than the TFM group, but we have serious concerns. There were two other studies comparing ESWT with TFM intervention (Aldajah et al., 2022; Büker et al., 2020). Büker et al. compared cold combined TFM intervention with ESWT in a sample of 52 patients and reported that TFM intervention was more effective and less costly (Büker et al., 2020). In a study with a similar design, Aldajah et al. reported that ESWT intervention provided better results in their study with a sample of 40 patients (Aldajah et al., 2022). In another study, hot pack TFM US group was compared with ESWT group and corticosteroid group (Gündüz et al., 2012). The sample size consisted of 59 participants in total and the interventions were delivered over 10 sessions. There was no difference between the groups in the findings of the study. Conflicting results have been reported in these studies comparing TFM and ESWT. However, studies with independent assessors, large sample sizes, long-term intervention and follow-up are needed.

Another intervention commonly used in the treatment of LE is corticosteroid injection. Four studies compared corticosteroid and TFM groups with different study designs (Gündüz et al., 2012; Olaussen et al., 2015; Smidt et al., 2002; Yi et al., 2018). In general, when the study results are summarized, the corticosteroid group seems to be effective in the short term, but in the medium and long term, the TFM group is better or there is no difference between them. The TFM group maintained the treatment effect in the long term.

Another preferred treatment procedure among the included studies is eccentric stretching strengthening exercises. Four studies compared the TFM group versus the exercise group (Koch et al., 2015; Nagrale et al., 2009; Stasinopoulos & Stasinopoulos, 2006; Viswas et al., 2012). Two studies reported that exercise was better (Stasinopoulos & Stasinopoulos, 2006; Viswas et al., 2012), one reported that TFM was better (Nagrale et al., 2009) and one reported no difference (Koch et al., 2015). In the eight studies in which exercise and TFM were applied to the same group, TFM plus exercise showed better results in five studies (Büker et al., 2020; Nambi et al., 2023; Shridhar Thakare et al., 2014; Smidt et al., 2002; Yi et al., 2018), TFM plus exercise was not better in two studies (Dedes et al., 2020; Struijs et al., 2003) and there was no difference between the groups in one study (Drechsler et al., 1997). We provide limited to moderate quality evidence suggesting that TFM combined with exercise interventions may have a beneficial treatment effect. However, the other study groups included various treatment procedures (nerve mobilization, corticosteroid injection, wait and see, wrist manipulation, splinting, US, ESWT) compared with the TFM plus exercise treatment procedure, so it is not clear to arrive at a definitive judgment.

Finally, only two studies compared TFM in isolation. Thakare et al. (Shridhar Thakare et al., 2014) compared a control group that included stretching and eccentric exercise versus an intervention group in which they included stretching eccentric exercise plus TFM and Mills manipulation. Nambi et al. (Nambi et al., 2023) compared a control group of corticosteroid injection sham manipulation and strengthening versus an intervention group of corticosteroid injection strengthening plus TFM and Mills manipulation. Both studies demonstrated the TFM and Mills manipulation procedure as more effective. In addition, the methodological quality of the studies included in the present review is on average "good" indicating that the level of evidence in this review is high.

In general, conservative physical therapy interventions yield improvements in pain, function and grip strength in individuals with lateral epicondylitis, consistent with previous studies. However, the conflicting results observed in the included studies can be explained by various methodological and clinical factors. One reason for variability may be differences in intervention protocols between trials. Interventions have varied widely in terms of treatment method, intensity, frequency, and duration, which may have affected the response to treatment (Nagrale et al., 2009; Stasinopoulos & Stasinopoulos, 2006). Additionally, while some studies applied single-method interventions, others used multi-method treatment approaches combining manual therapy with exercise or electrotherapy, further contributing to inconsistent results (Büker et al., 2020; Viswas et al., 2012). Differences in outcome measures and follow-up duration also represent important sources of inconsistency. Studies with short-term follow-up often reported no significant difference between groups despite intra-group improvements, while studies with medium- and long-term follow-up more frequently showed differences supporting physiotherapy-based interventions (Smidt et al., 2002; Yi et al., 2018). This temporal effect, particularly in comparisons between physical therapy and corticosteroid injections, has been previously highlighted in the literature, where the benefits of injections tend to diminish over time. Patient-related factors may also have contributed to conflicting findings. Variations in symptom duration, initial severity, occupational demands, and activity modifications during treatment have not been consistently controlled for or reported across studies, and this may potentially affect treatment response. Furthermore, methodological limitations such as small sample sizes, inadequate blinding, and failure to report effect sizes and confidence intervals reduce statistical power and limit comparability between studies (Koch et al., 2015; Yi et al., 2018).

TFM stimulates the local inflammation response in healing problems due to degeneration and initiates the healing process of the tendon (Wang, 2012). TFM prevents abnormal fibrous adhesions by applying stress transversely to the collagen tissue. In addition, friction reorganizes collagen tissue, improving normal healing conditions and preventing abnormal scarring (Loew et al., 2014). TFM has also been used in various tendinopathy conditions and effectiveness has been reported (Joseph et al., 2012). TFM may contribute to the improvement of impaired microcirculation in the ECRB muscle-tendon unit, and the reduction of ischemic stress associated with the long sarcomere structure by creating local hyperemia through mechanical stimulation applied transversely to the tendon fibers. It is also suggested that it may increase the load-bearing capacity of tendinopathic tissue by supporting the mechanical realignment of disorganized collagen fibers. Exercise approaches, particularly through eccentric and stretching exercises, target the mechanical adaptation of the muscle-tendon unit; it is known that eccentric loading increases collagen synthesis and fibril organization, while stretching exercises reduce excessive local stress by regulating passive tension distribution in the ECRB muscle, which has a long sarcomere structure. Load-induced cellular signaling mechanisms triggered by repeated controlled loading also support the biological healing response, and these complementary pathways may explain why TFM and exercise together yield more consistent clinical outcomes.

Some limitations of this systematic review should be noted. First, heterogeneity was observed among the included studies in terms of intervention protocols, treatment duration, outcome measures, and follow-up periods. Another limitation is the lack of data pooling and meta-analysis. This has limited the direct comparability of results and prevented the quantitative pooling of data. In most of the included studies, effect sizes or confidence intervals were not reported consistently. Variability in methodological quality, including small sample sizes, limited blinding, and incomplete reporting, may have affected the internal validity of some studies. Furthermore, future high-quality randomized controlled trials with larger sample sizes, longer follow-up periods, and true control groups are needed to directly compare TFM with other interventions.

Clinical Implications

Evidences show that manual therapy techniques involving TFM, supervised exercise programs, low-level laser therapy, and multimodal treatment approaches are associated with significant improvements in pain and functional outcomes. The variability in treatment outcomes observed across studies indicates that no single physical therapy method can be universally considered superior. Interventions combining manual therapy with progressive exercise programs are generally associated with positive outcomes. Although short-term outcomes are similar across interventions, mid- and long-term follow-up generally supports physical therapy-based treatments, while corticosteroid injections have been associated with less favorable long-term outcomes; this emphasizes the importance of sustained exercise adherence and long-term management in clinical practice. These findings reinforce the role of TFM+exercise as an effective and flexible approach in the conservative management of lateral epicondylitis.

CONCLUSION

In conclusion, the available evidence is limited to moderate and suggests that TFM may have beneficial effects on pain and function in individuals with lateral epicondylitis. Many of the included studies reported improvements in pain and functional outcomes, particularly when TFM was combined with other physical therapy interventions such as Mills manipulation, stretching, and eccentric exercise programs. However, the overall level of evidence remains limited due to

methodological heterogeneity, small sample sizes, and inconsistent reporting of quantitative outcomes across studies. Therefore, while TFM-based multimodal approaches appear promising, the current evidence is insufficient to support the superiority of any single intervention. This review may assist clinicians and researchers in determining appropriate combinations of treatment components, outcome measures, and study designs, and highlights the need for future high-quality randomized controlled trials with larger sample sizes and longer follow-up periods.

Key Findings

• The studies included in the present review had good methodological quality (mean PEDro score: 6.29), indicating moderate to high levels of evidence.

• TFM, especially when combined with other interventions (e.g., Mills manipulation, stretching, and eccentric exercises), has demonstrated superior clinical outcomes in terms of pain reduction and functional improvement compared to control interventions.

• Pain intensity, functional outcomes, and grip strength were the most frequently assessed outcomes, and TFM demonstrated more consistent benefits compared to corticosteroid injection in long-term follow-up.

• Evidence indicates that TFM alone is not consistently superior as a standalone intervention, but its combination with manual therapy and exercise-based approaches increases clinical effect in patients with lateral epicondylitis.

• Due to heterogeneity in intervention protocols, outcome measurements, and follow-up periods, definitive conclusions about optimal TFM protocols cannot be reached, highlighting the need for high-quality studies with standardized methodologies.

• Based on the current evidence, transverse friction massage should not be used as a standalone treatment for lateral epicondylitis; however, when integrated into a multimodal rehabilitation program including manual therapy and eccentric exercise, it may contribute to clinically meaningful improvements in pain and function, particularly in the medium to long term.

• Future studies should include TFM as a standalone intervention and compare it with well-defined control or sham interventions to determine its independent therapeutic effect.

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