Evaluating the Effectiveness of Deep Transverse Frictional Massage Combined with Conventional Physiotherapy for Tendinopathies: A Systematic Review and Meta-analysis

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Background: Tendinopathies are common musculoskeletal disorders characterized by pain and functional impairment, often requiring therapeutic interventions for effective management. This systematic review and meta-analysis aimed to evaluate the effectiveness of deep transverse frictional massage (DTFM) combined with conventional therapy for the treatment of tendinopathies.

Methods: A study search of electronic databases including MEDLINE, Google Scholar, and PubMed databases, was conducted for randomized controlled trials, pilot study, and comparative study design comparing the combined application of DTFM with conventional physiotherapy (e.g., exercise, stretching, or modalities) to conventional therapy alone for the treatment of tendinopathies. Inclusion criteria were studies that reported clinical outcomes such as pain reduction and disability. Data extraction was performed independently by reviewers. A meta-analysis was conducted using random-effects models to estimate the pooled effect size, and heterogeneity was assessed using the I^2 statistic. The risk of bias was assessed using the Cochrane risk-of-bias approach.

Results: A total of 13 studies met the inclusion criteria. The combined treatment group (DTFM + conventional therapy) showed significant improvements in pain reduction (standardized mean difference (SMD) = −0.92, 95% confidence interval (CI): −1.70 to −0.14, $p < 0.05$) and disability in the shoulder (SMD = −15.05, 95% CI: −15.60 to −14.50, $p < 0.05$) and elbow (SMD = −2.67, 95% CI: −3.38 to −1.96, $p < 0.05$) compared to conventional therapy alone. No significant adverse effects were reported.

Conclusion: The findings suggest that DTFM, when combined with conventional therapy, offers significant benefits over conventional therapy alone in the management of tendinopathies, particularly in reducing pain and improving function. The exact physiological mechanisms through which DTFM works in combination with conventional therapies remain unclear. Research into how DTFM influences tissue healing, collagen remodeling, or pain reduction pathways could provide more insights into its effectiveness and guide its integration into treatment protocols.

KEYWORDS: Massage; disability; pain; randomized controlled trials; tendinopathies

INTRODUCTION

Tendinopathies are disorders impacting the fibrous tissues that attach muscles to bones. These disorders typically cause pain, swelling, and impaired tendon function. The most frequently affected anatomical areas include the patellar tendon, Achilles tendon, brachial biceps, the extensors and flexors of the wrist, the posterior tibial tendon, and the thigh adductors. Tendinopathy is an umbrella term used to describe any type of damage to a tendon, including

conditions such as tendinitis (inflammation) and tendinosis (degeneration). It often results from overuse, causing gradual wear and tear to the tendon, leading to painful symptoms.[1]

A unified theory of the pathogenesis of tendinopathy integrates various aspects of tendon biology, biomechanics, and pathology to provide a comprehensive understanding of tendinopathy development. A detailed exploration of a unified theory of tendinopathy pathogenesis is as follows: (i) Biological and structural factors, including tendon structure and composition, reveal that tendons are primarily composed of collagen fibers, proteoglycans, and tenocytes (tendon cells). The collagen fibers are organized in a hierarchical structure that provides tensile strength and flexibility. Tendinopathy often involves a breakdown of collagen fibers, leading to disorganized collagen bundles. This degeneration is thought to be a key feature of tendinosis, the chronic phase of tendinopathy. (ii) Mechanical overload explains that repetitive or excessive mechanical loading is a primary factor contributing to tendinopathy. This includes activities that involve repeated or high-intensity stress on the tendons, such as sports or repetitive occupational tasks. In load-bearing capacity the tendon's ability to withstand load can be compromised by both acute and chronic overload. This imbalance between loading and the tendon's capacity to repair can lead to microtrauma and subsequent degeneration. (iii) During cellular and molecular responses, tenocytes respond to mechanical stress by altering their production of extracellular matrix components. In tendinopathy, these cells may produce abnormal or excessive amounts of matrix proteins, contributing to disorganization. Although tendinopathy is not primarily an inflammatory condition, there is evidence that inflammatory mediators such as cytokines and growth factors play a role in the early stages of tendinopathy. These mediators can influence pain and tissue repair processes. Matrix metalloproteinases (MMPs) are enzymes that break down extracellular matrix components. In tendinopathy, elevated levels of MMPs may contribute to collagen degradation and matrix remodeling. During vascular and neurovascular changes tendinopathy often involves the formation of new, abnormal blood vessels within the tendon, a process known as neovascularization. This can lead to increased pain and altered tendon function. Increased nerve endings in tendinopathic tissue can contribute to pain perception. This neurovascular change is associated with the chronic pain experienced in tendinopathy. (iv) For biomechanical and functional factors, altered biomechanics, such as improper movement patterns or alignment issues, can exacerbate the stress on tendons. These factors may contribute to the development and progression of tendinopathy. Imbalances in muscle strength and flexibility around the affected tendon can affect the distribution of forces and contribute to tendinopathy. For example, weak or tight muscles can place additional strain on tendons. (v) Genetic and environmental factors: genetic factors may influence an individual's susceptibility to tendinopathy. Variations in genes related to collagen production or tendon structure can affect how tendons respond to mechanical stress. Environmental factors such as age, gender, and occupation can influence the risk of developing tendinopathy. For instance, aging tends to decrease tendon elasticity and repair capacity. (vi) Integrative model of pathogenesis: combining these factors, a unified theory of tendinopathy pathogenesis might propose the following model of initiation, progression, chronic phase, and functional impairment. This unified theory highlights the complex interplay of biological and biomechanical factors that contribute to the tendinopathy's etiology and progression, emphasizing the need for individualized treatment strategies.[2]

For tendinopathies, massage therapy provides multiple advantages, such as enhanced range of motion, decreased discomfort and inflammation, and improved blood circulation. Deep transverse frictional massage (DTFM) utilizes short back-and-forth motions on the affected area, which assist in restoring mobility and reducing scar tissue. Additionally, deep tissue massage combines firm pressure with slow strokes, targeting deeper muscle layers and facilitating overall recovery. Massage therapy is often recommended as part of a comprehensive treatment plan rather than as a standalone therapy. Combining massage with conventional interventions tends to yield the best outcomes.

Conventional interventions for this condition involve activity modification (rest or cross training, such as cycling instead of running), a combination of exercise, electrotherapy, soft-tissue treatments, use of braces or splints, and cryotherapy. Prolonged stretching, in particular, has been found to decrease pain and the use of nonsteroidal anti-inflammatory drugs.[3–16] The main objectives of this systematic review and meta-analysis are to evaluate the effectiveness of deep frictional massage technique compared with various conventional physiotherapy over tendinopathy pain and improving function.

METHODOLOGY

Research Question

Is DTFM combined with conventional physiotherapy beneficial for tendinopathy pain and improving function?

PICO criteria

To obtain the research question, PICO criteria were used.

Population: patients with tendinopathy.

Intervention: Conventional therapy and DTFM.

Comparison: Conventional therapy.

Outcomes: Pain, disability.

Selection criteria

The selection criteria for the study are as follows: only open-access and full-text articles are included to ensure availability and transparency of the research. Articles published between 2000 and 2023 are considered to ensure the relevance of data to recent developments in the field. Only articles published in the English language are included to ensure comprehensibility and accessibility. Only randomized controlled trials, pilot studies, and comparative studies are selected to ensure robust study designs. Studies must report on outcome measures related to pain and disability, as these are central to understanding the effectiveness of interventions for tendinopathies. Research involving tendinopathies of all sites is included, ensuring comprehensive coverage of the condition across various anatomical locations. Systematic reviews and meta-analysis studies are excluded as they synthesize existing data and do not present new primary research. Studies involving post-operative tendinopathy patients are excluded to focus on non-surgical management and intervention approaches for tendinopathies.

Ethical Approval and Protocol

The research has been recorded at PROSPERO under the registration number CRD42024540738. Throughout the course of the research the PRISMA-CI (Preferred Reporting Items for Systematic Reviews and Meta-Analyses For Complex Interventions) guidelines were followed (Figure 1).[3]

Search strategies

The study searched the following databases: MEDLINE, Google Scholar, and PubMed. Search terms used to find open-access articles in the database are as follows: “Tendinopathies, Tendinitis, Eccentric Exercise, Transverse Frictional Massage (or) Deep Friction Massage (or) Cyriax, Effectiveness (or) Efficiency (or) Efficacy”, and “Conventional therapy.” The articles were independently searched in June 2023 by the author using the title, author name, and abstract of the research that met the criteria. Only English-language articles were selected based on language constraints.

Data Extraction

The following data were extracted from each article independently by three researchers (SS, PS, SV, SP, JT) (i) characteristics of the study—study design, total “n” participants, study location, gender, interventions, and types of tendinopathy; (ii) Measures of outcome of pain and disability (Table 1).

Qualitative Evaluation

The Cochrane risk-of-bias approach was used to assess the quality of the articles that were chosen for the study by two independent researchers. Each individual article selected for the studies was examined based on the reviewer’s classifications of high, low, and unclear risk of bias. The following quality evaluation standards were applied: random sequence generation, allocation concealment, selective reporting, participants and personnel blinding, incomplete data outcome, blinding of out-

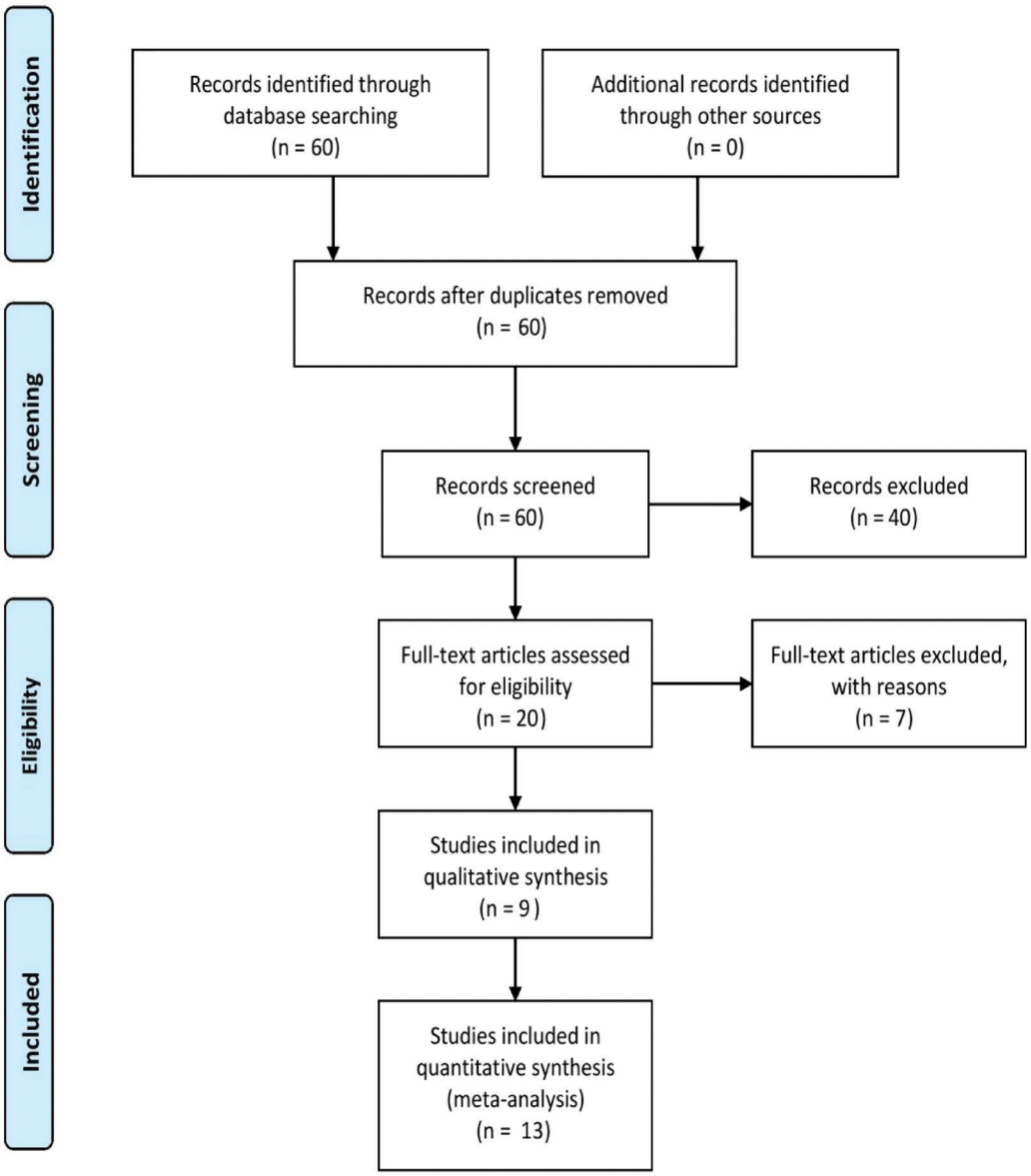


Figure 1. PRISMA flow chart.

come assessment, and other biases. Finally the percentage (Figure 2) and summary (Figure 3) of the reviewed articles were obtained by the researchers (SS, SP and JT).

Quantitative Evaluation

We pooled the continuous visual analog scale (VAS) data from each trial to generate a standardized mean difference (SMD) with a 95% confidence interval (CI) using a random-effects model for pain (Graph 1) and a fixed-effect model for the Shoulder Pain and Disability Index (SPADI) (Graph 2) and Patient-Rated Tennis Elbow Evaluation (PRTEE) questionnaire (Graph 3) functional outcomes. The heterogeneity between the studies was investigated using the I^2 statistic test, ranging from 0% to 100%, with a p-value of <0.05 considered significant. Using the RevMan software, a forest plot was generated to produce the quantitative analysis by a researcher independently (SS).

RESULTS

Out of 60 studies screened, 13 met the inclusion criteria. No articles were duplicates. Reasons for exclusion: 47 studies did not meet the eligibility criteria for

Table 1 (Part 1 of 3). Characteristics of the Included Studies

Authors	*N*	*Study Place*	*Study Design*	*Tendinopathy*	*Groups and Interventions*	*Outcome Measure*	*Outcome*
1. Hassan et al.[4]	40	Egypt	RCT	Tennis elbow	Group 1: deep frictional massage Group 2: stretching of wrist extensors	1. Goniometer Measurement 2. VAS 3. Squeezing sphygmomanometer	Stretching is more significant than DFM group.
2. Yi et al.[5]	41	Newark	RCT	Lateral epicondylitis	Group 1: stretching + splinting Group 2: a cortisone injection Group 3: lidocaine injection + DFM	1. VAS 2. DASH 3. Grip strength	DFM group is highly significant than the other group.
3. Blackwood and Ghazi[6]	14	UK	Pilot study	Infra patellar tendinopathy	Group A: exercise therapy, eccentric and proprioceptive exercise Group B: transverse frictional massage along with exercise therapy	1. VAS 2. VISA-P	TFM to an exercise is highly significant in reduction of pain and improving the functional.
4. Kousar et al.[7]	76	Pakistan	RCT	Achilles tendinopathy	Group A (n = 38): transverse frictional massage + eccentric exercise Group B (n = 38): ultrasound + eccentric exercise Eccentric exercise: standing on the steps (6 sets × 15 reps) Plantar flexion with knee extension (3 sets) Plantar flexion with knee flexion (3 sets) Ultrasound: 20% duty cycle 3 ms burst 1.0 MHz 0.5 W/cm^2 intensity	1. NPRS 2. VISA-A	TFM group is highly significant.
5. Lee et al.[8]	30	South Korea	RCT	Lateral epicondylitis	Taping group: non-stretching 3.8 cm thick tape 8–10 cm Shape: diamond Taping + deep frictional massage group: DFM and mill manipulation group for 15 min	1. VAS 2. PRTEE 3. Pain-free grip strength 4. Wrist extensor power 5. Electromyography of wrist extension	Taping with DFM is more effective.

TABLE 1 (Part 2 of 3). Characteristics of the Included Studies

Authors	*N*	*Study Place*	*Study Design*	*Tendinopathy*	*Groups and Interventions*	*Outcome Measure*	*Outcome*
6. Abd Elrahim et al.[9]	40	Egypt	RCT	Lateral epicondylitis	Group A: (n = 20): Mulligan mobilization with movement Group B (n = 20): deep frictional massage	1. VAS 2. Grip power: hand dynamometer 3. Patient-rated discomfort and disability 4. Functional specific activities 5. Functional usual activities	MMWM is less effective compared to deep frictional massage technique.
7. Stasinopoulos and Stasinopoulos[10]	30	Greece, Europe	RCT	Patellar tendinopathy	Group A: exercise program: static stretching Quadriceps and hamstring eccentric 3 sets × 15 rep Group B: Pulsed ultrasound Pulsed: 1:4 Ratio Duration: 2 ms Frequency: 1 MHz Group C: transverse frictional massage: 10 min 16 weeks	Pain (Self questionnaire)	Exercise program was more effective treatment than the ultrasound and transverse frictional massage.
8. Jindal and Moitra[11]	30	India	RCT	Supraspinatus Tendinitis	Intervention group: deep transverse friction massage + eccentric exercise Conventional group: ultrasound + eccentric exercise 5 days/week for 15–20 min	1. SPADI (Shoulder Pain and Disability Index) 2. NPRS 3. Goniometer	Compared to the conventional group, the intervention group showed noticeably greater improvement.
9. Nambi et al.[12]	60	Saudi Arabia	RCT	Lateral epicondylitis	Active MM group: corticosteroid injection + DTFM + Mills manipulation Sham MM group: corticosteroid + sham manipulation	1. VAS 2. MRI and ultrasound 3. Hand grip 4. Functional disability 5. Patient perception 6. Kinesiophobia 7. Quality of life	Corticosteroid injection + DTFM + Mills Manipulation group has greater significant improvement.

Table 1 (Part 3 of 3). Characteristics of the Included Studies

Authors	*N*	*Study Place*	*Study Design*	*Tendinopathy*	*Groups and Interventions*	*Outcome Measure*	*Outcome*
10. Shivakumar et al.[13]	60	Bangalore, India	Comparative study design	Supraspinatus tendinitis	Group A: UST + cryokinetics Group B: UST + deep friction massage	1. VAS 2. SPADI 3. ROM	Group B is more significant than Group A.
11. Puri and Ahmed[14]	50	N/A	RCT	Lateral epicondylitis	Group A: DFM + exercise Group B: UST + exercise	1. VAS 2. Grip strength	Group A is more effective than Group B.
12. Reddy et al.[15]	60	Bangalore, India	Comparative study design	Supraspinatus Tendinitis	Group A: UST and cryokinetics Group B: UST and deep friction massage	1. VAS 2. SPADI	Group B showed greater significant than Group A.
13. Jadhav et al.[16]	40	Bangalore, India	Comparative study design	Patellar tendinopathy	Group A: TFM (10 min/session 5 days in a week for 12 week) + quadriceps and hamstring stretching exercises (20 s hold for 3 rep) + eccentric squats on 25° decline board (3 sets of 15 rep in a session) Group B: Cryotherapy (10 min per session, 5 days per week followed for 12 weeks) + quadriceps and hamstring stretching exercises (20 s hold for 3 rep) + eccentric squats on 25° decline board (3 sets of 15 rep in a session)	1. VAS 2. VISA 3. ROM	Group A showed greater significant than Group B.

DFM = Deep frictional massage; DTFM = deep transverse frictional massage; MRI = magnetic resonance imaging; PRTEE = patient-rated tennis elbow evaluation; RCT = randomized controlled trials; ROM = range of motion; NPRS = numeric pain rating scale; SPADI = Shoulder Pain and Disability Index; TFM = transverse frictional massage; UST = ultrasound therapy; VAS = visual analog scale; VISA = Victorian Institute of Sport Assessment.

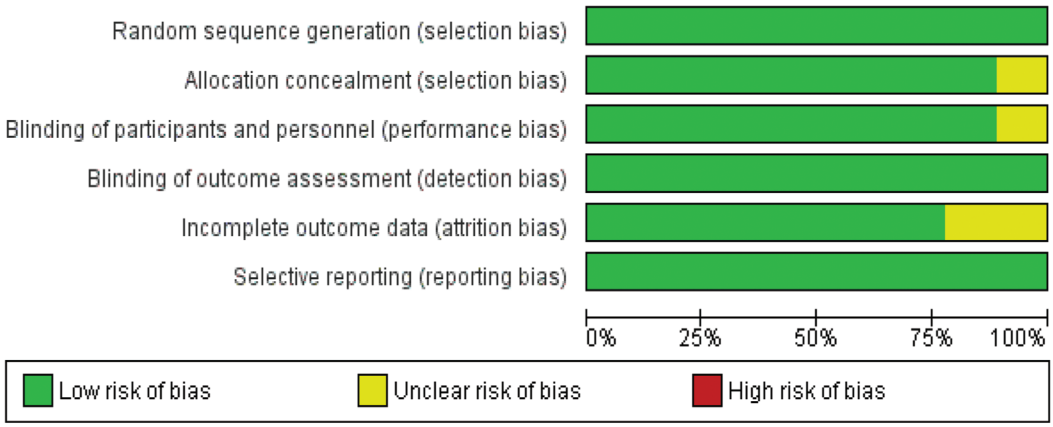


Figure 2. Percentage of risk of bias.

interventions and outcome measures. Of the 13 eligible articles, 9 articles underwent qualitative analysis, and all the 13 articles underwent quantitative analysis. Risk of bias was assessed using the Cochrane risk-of-bias tool. Six studies were judged to have a low risk of bias, while three studies had an unclear risk of bias. Quantitative analysis was assessed based on pain (VAS) and functional outcome (Patient-Rated Forearm Evaluation Questionnaire, SPADI). The overall estimates of the VAS outcome with SMD, 95% CI using a random-effects model, and the SPADI and PRTEE outcome measures with SMD, 95% CI using a fixed-effects model, were estimated for DTFM with conventional physiotherapy compared to conventional therapy group.

Characteristics of Included Studies

Thirteen studies were identified to fulfill the eligibility criteria. Of these, three were comparative studies,[13,15,16] one was a pilot study,[6] and nine were randomized controlled trials.[4,5,7–12,14] All of these studies were subjected to qualitative analysis. Three studies used the Patient-Rated Forearm Evaluation Questionnaire to measure elbow disability,[8,9,12] and three studies used SPADI to measure shoulder disability.[11,13,15] Ten studies used the VAS to measure pain[4–6,8,9,12–16] for quantitative analysis (Table 1).

The PRTEE is a self-reported 15-item test utilized for evaluating disability and pain in a person with tennis elbow. Pain, usual activities, and specialized activities constitute its three sub-scales.[8,9,12]

SPADI is a self-administered questionnaire with two dimensions—one for pain and the other for functional activities. Five questions on the degree of a person's pain constitute the pain dimension. Eight questions are used to evaluate functional activities. SPADI is developed to assess the difficulty a person experiences while performing several daily tasks required for upper-limb involvement.[11,13,15]

The VAS is used to quantify pain. The VAS comprises a line that is 10-cm long, with two end points that stand for 0 (i.e., "no pain") and 10 (i.e., "pain as bad as it could be").[4–6,8,9,12–16]

Pain

Based on a meta-analysis of the overall VAS outcome with SMD and 95% CI using a random-effects model (Graph 1), 10 out of 13 articles validate the finding that DTFM with conventional treatment significantly reduces pain on tendinopathies (SMD = −0.92, CI = −1.70 to −0.14, p = 0.02) compared to conventional treatment alone. The heterogeneity test result showed a significant difference in heterogeneity (I^2 = 93%; p ≤ 0.00001).

Disability

The outcome measure of SPADI and PRTEE was used to validate the disability of shoulder and elbow joints. The SPADI outcome measure was analyzed using SMD, 95% CI using a fixed-effects model. Three articles validate the finding that DTFM with conventional treatment significantly reduces shoulder disability when compared to conventional treatment alone (SMD = −15.05, CI = −15.60 to −14.50, p ≤ 0.00001). The heterogeneity test result showed significant heterogeneity (I^2 = 99%; p ≤ 0.00001) (Graph 2). The PRTEE outcome

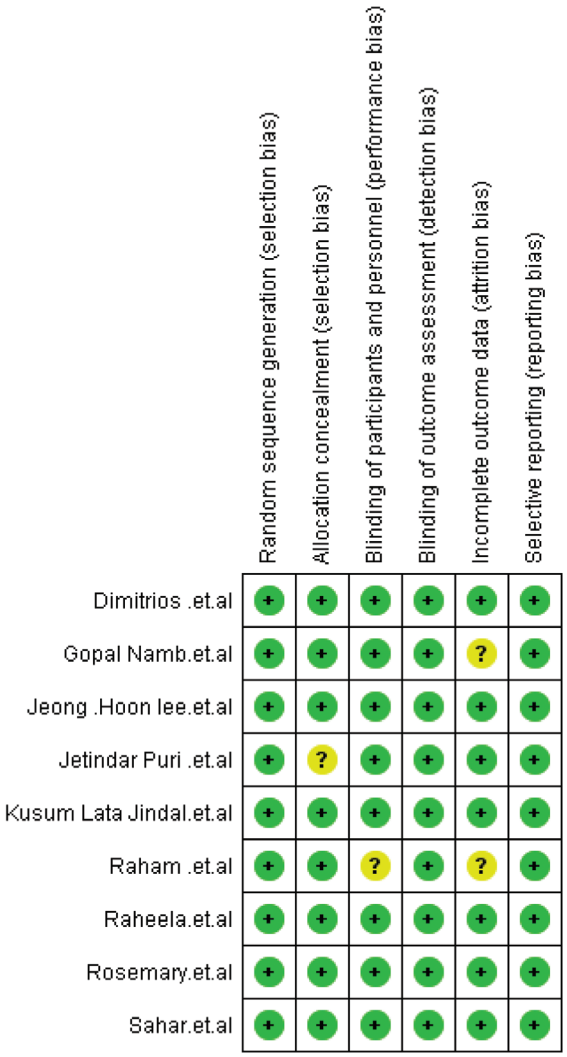
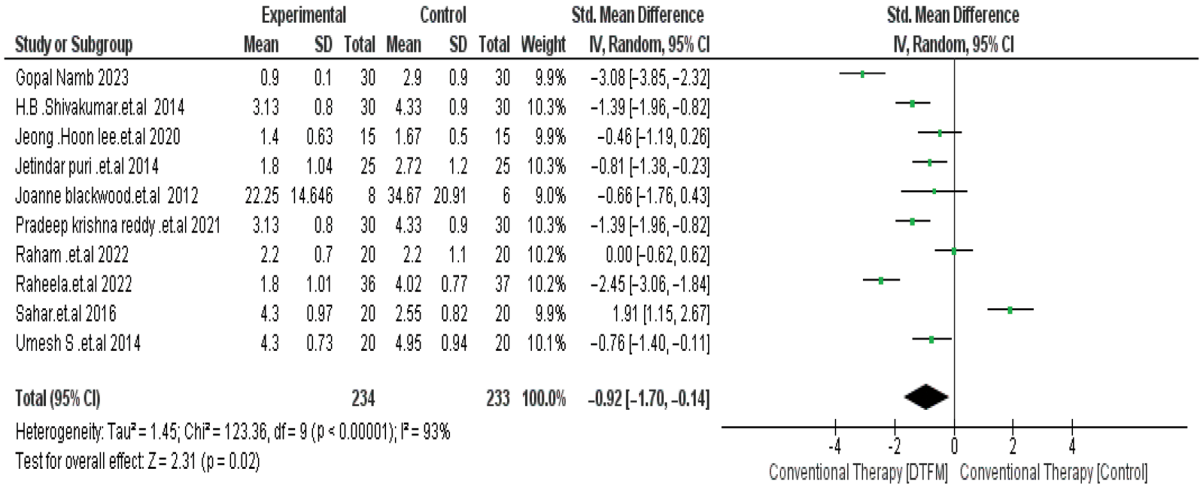


FIGURE 3. Summary of risk of bias.

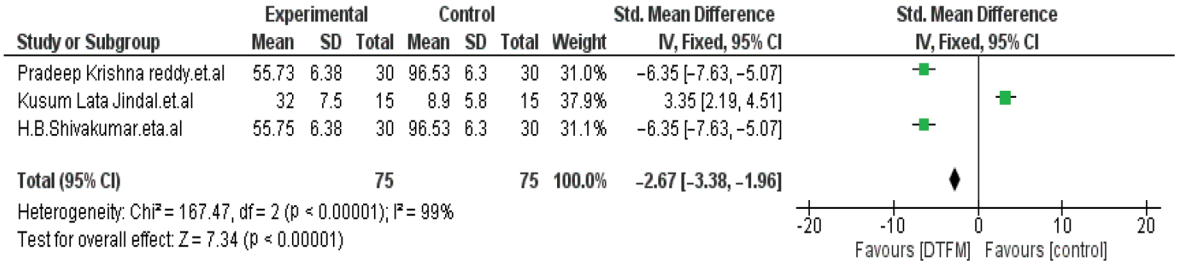
measure was analyzed using SMD, 95% CI using a fixed-effects model. Three articles validate the finding that DTFM with conventional treatment significantly reduces shoulder disability when compared to the conventional treatment alone (SMD = −2.67, CI = −3.38 to −1.96, $p \leq 0.00001$). The heterogeneity test result showed significant heterogeneity ($I^2 = 99\%$; $p \leq 0.00001$) (Graph 3).

DISCUSSION

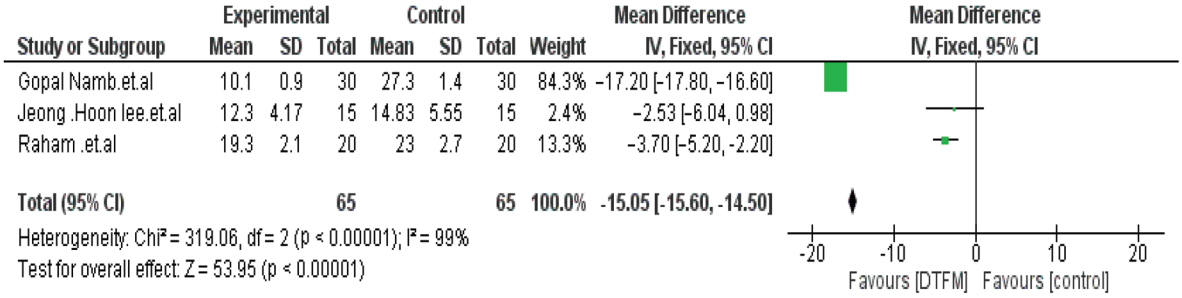
This study reveals that DTFM combined with conventional physiotherapy provides a remarkable effect on pain reduction and enhancing function. However, the forest plot exhibits high heterogeneity of VAS ($I^2 = 93\%$), SPADI ($I^2 = 99\%$), and PRTEE ($I^2 = 99\%$). Higher heterogeneity in the study can be due to multiple factors such as variations in treatments or interventions used in the studies in terms of dose, duration, or type. Variations in population characteristics (e.g., age, gender, comorbidities, disease stage) and outcome measures (different time points for follow-up) can contribute to variations in outcomes. DTFM combined with conventional therapy provides a synergistic benefit that enhances the healing process. While DTFM can directly improve local conditions by fostering blood circulation and reducing scar tissue, conventional therapy can work on broader functional improvements, ensuring that the tendon is not only healing but also becoming stronger and more resilient against future injuries.[17] According to Stasinopoulos and Johnson, DTFM is frequently used in therapeutic settings and often results in instantaneous pain alleviation. During the session, the patient feels numb, and a quick post-treatment evaluation reveals less pain and a gain in strength and mobility.[18] In a study that compared TFM and Mill's manipulation with phonophoresis and exercises for treating tennis elbow, it was shown that after 8 weeks, the TFM/Mill's manipulation group's results dramatically improved.[19] When combined with eccentric exercises, DTFM proved to be more beneficial than ultrasonic therapy in reducing the severity of tendinopathy pain and increasing ankle range of motion.[7] Lee et al. demonstrated that tennis elbow patients' pain, function, strength, and activity are all influenced by taping and DTFM treatments. The findings demonstrated that both the taping-with-DTFM and the taping-alone groups significantly reduced elbow pain and boosted muscle activation. After the intervention, taping and DTFM were found be effective treatment approaches for tennis elbow patients.[8] DTFM enhances the muscles' viscoelastic qualities, improves their function, and reduces pain. A technique known as deep friction or soft-tissue massage works by realigning normal soft-tissue fibers in an effort to lessen abnormal fibrous adhesions and increase the mobility of scar tissue in acute, subacute, and chronic inflammatory disorders.[20–23] In patients with lateral epicondylalgia, corticosteroid injection combined with DTFM and Mill's technique was more effective than the sham group in terms of reducing pain, injury percentage, functional disability, kinesiophobia,



Graph 1. Comparison of conventional management with DTFM and conventional management without DTFM with outcome of VAS. CI = confidence interval; DTFM = deep transverse frictional massage; SD = standard deviation; VAS = visual analog scale.



Graph 2. Comparison of conventional management with DTFM and conventional management without DTFM with outcome of SPADI. CI = confidence interval; DTFM = deep transverse frictional massage; SD = standard deviation; SPADI = Shoulder Pain and Disability Index.



Graph 3. Comparison of conventional management with DTFM and conventional management without DTFM with outcome of PRTEE. CI = confidence interval; DTFM = deep transverse frictional massage; PRTEE = Patient-Rated Tennis Elbow Evaluation Questionnaire; SD = standard deviation.

and depression, and improving handgrip power and quality of life.[12] The study had proven that splinting, cortisone injections and deep friction massage all resulted in significant improvements in pain in the early follow-up period (6–12 weeks). Specifically, patients who received either a cortisone injection or deep friction massage showed improvements in both their DASH (disabilities of the arm, shoulder, and hand) score and grip strength during this period. These results imply that deep friction massage can be an effective treatment for lateral epicondylitis.[5]

CONCLUSION

This systematic review and meta-analysis reveals that DTFM, when combined with conventional therapy, significantly improves function and reduces pain. Importantly, no adverse effects of DTFM have been identified, supporting its safety and efficacy. Based on these findings, DTFM combined with conventional therapy should be considered a first-line therapeutic option for the management of tendinopathies in clinical practice, offering a promising and effective intervention to improve patient outcomes.

CONFLICT OF INTEREST NOTIFICATION

The authors declare there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Sathya Siva: wrote the paper, worked on qualitative (Cochrane risk of bias) and quantitative (forest plot) analysis, data extraction, and PRISMA guidelines. Prathap Suganthirababu: wrote the paper, worked on search strategies, data extraction, and qualitative analysis. S. Vignesh: worked on PRISMA guidelines, qualitative analysis. Kishoremoy Das: wrote the paper, worked on PROSPERO Registration Trail. K. Priyadharshini: revised for grammatical correction. S. Dhanusia: reference formatting. S. Santhana Lakshmi: manuscript preparation. J. Vanitha: analyzed for plagiarism. J. Titus: wrote the paper, manuscript formatting. V. Surya Prakash: wrote the paper, revised for grammatical errors. Mohammed Arifullah Mohamed Fazulah: revised for grammatical errors and overall manuscript formatting.

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