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Kinesio tape reduces pain in patients with lateral epicondylitis: A meta-analysis of randomized controlled trials

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ABSTRACT

Background: The efficacy of Kinesio tape (KT) in *lateral epicondylitis* (LE) is widely discussed, but the results of these studies are conflicting. We perform this meta-analysis from randomized controlled trials (RCTs) in order to evaluate the efficacy and safety of KT in the treatment of LE.

Methods: A comprehensive search of the published literature in PUBMED, EMBASE, and Cochrane Library databases was implemented. Only English RCTs were included in this study. The outcome measures included visual analogue scale (VAS), grip strength, modified Mayo performance index, Disabilities of the Arm, Shoulder and Hand (DASH) score and adverse events. The Cochrane risk of bias tool was also utilized to evaluate the risk of bias. Data analysis was performed with STATA version 13.0 (Statacorp, college station, Tex).

Results: Five studies with a total of 168 patients were included. The present meta-analysis demonstrated that KT yielded statistically superior pain scores, grip strength, Modified Mayo performance index and DASH score. There was no significant difference between the two groups in terms of adverse events.

Conclusion: KT is effective in relieving pain, restoring grip strength, and improving functionality in patients with LE undergoing rehabilitation.

1. Introduction

Lateral epicondylitis (LE), is a condition in which the forearm muscles become damaged from overuse, and it involves the degeneration of the extensor carpi radialis brevis tendon near the attachment site to the LE [1,2]. The most common symptoms are recurring pain and a loss of joint motion. The incidence rate of LE is 3–8 per 1000 patients per year in general practice and it is as high as 15% among workers who perform highly repetitive work with their hands [3,4]. Although this condition is generally self-limited, several individuals may experience chronic pain and nonsurgical and surgical treatment options are necessary. The goal of treatment is to decrease the load to the forearm, reduce the severity of pain and facilitate the rapid return to daily activities.

Numerous treatments, including rest, physical therapy (ice massages and muscle stimulating techniques), the use of topical nonsteroidal anti-inflammatory drugs and steroid injections have been implemented [5–8]. However, it is unclear which treatment is the most effective. Recently, Kinesio tape (KT) has been extensively used for the treatment of musculoskeletal disorders, and was first introduced by Dr. Kenzo Kase in the 1970's. It is a relatively new form of elastic therapeutic tape (Fig. 1) and is effective in reducing pain, increasing muscle strength, and improving range of motion. Several clinical studies have reported that the use of KT is associated with improved outcomes in individuals with knee osteoarthritis and sports injuries [9,10].

Recently, the efficacy of KT in treating LE has been widely discussed, but the results of these studies are conflicting. Some experts have reported that KT may increase the risk of skin irritation. However, no reliable conclusions have been reached and it is not clear whether the potential advantages outweigh its disadvantages. Consequently, we performed this meta-analysis on randomized controlled trials (RCTs) to evaluate the efficacy and safety of KT in the treatment of LE; we hypothesized that KT may reduce pain and improve joint function in individuals with LE.

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Fig. 1. The application of true (A) and sham taping (B).

2. Methods

The work has been reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines.

2.1. Search strategy

The following search terms were used in PubMed, Medline, EMBASE, and Cochrane Library databases on December 2019, as the search algorithm: (lateral epicondylitis) OR (tennis elbow) AND (Kinesio tape) OR (Orthotic Tape). No time limit was given for the publication date. References were reviewed to include articles that were not included within our literature search.

2.2. Eligibility criteria

Studies that were included in our meta-analysis had to meet all of the following inclusion criteria in the PICOS order [1]: population: patients had LE [2]; intervention: patients received KT for treating LE [3]; comparison intervention: sham taping or physiotherapy [4]; outcome measures: at least one of the following outcome measures was reported: pain score, functional outcome, pain-free grip strength and adverse events [5]; study design: RCT. Articles with no assessment of

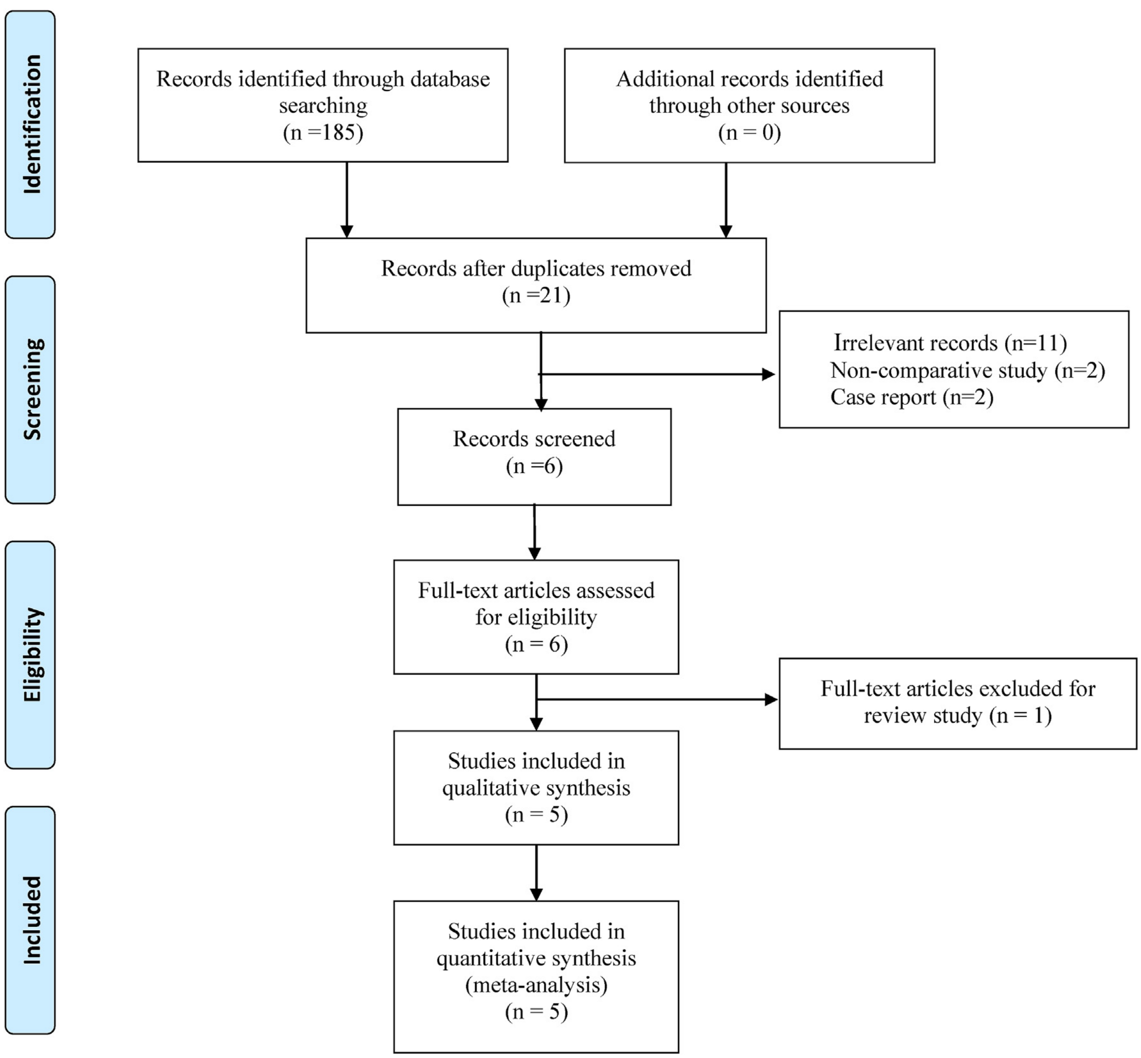


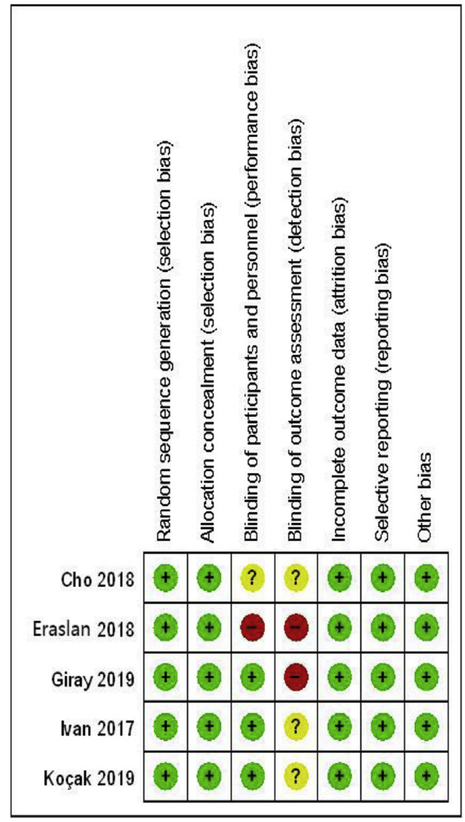
Fig. 2. Flow chart detailing inclusion and exclusion of the relevant articles.

Table 1
Characteristics of the included participants.

Study	Year	Design	Sample size		Age		Gender (Male)		Intervention	Follow up
			KT	Control	KT	Control	KT	Control		
Ivan et al.	2017	RCT	15	15	55	52	10	9	KT group: KT was applied from the direction of insertion (radial styloid process) to origin (lateral epicondyle) with 125% of its original length, which was proposed to provide muscle inhibition effects Control group: sham KT	3 months
Cho et al.	2018	RCT	15	15	52	50	8	8	KT group: two Y-shaped Kinesio strips for the KT procedure for lateral epicondylitis, with the main strip applied along the extensor muscles and the second strip vertical to the first one on the proximal forearm Control group: sham KT	2 months
Eraslan et al.	2018	RCT	17	15	47	49	10	7	KT group: Taping was performed according to the guidelines given by Kase[a] Control group: physiotherapy	6 months
Giray et al.	2019	RCT	10	10	47	45	4	5	KT group: Short tails of the X-strip were applied to dorsal side of hand without any tension, crossing part was applied to dorsal wrist with maximum tension and long tails were fixed along the muscles of extensor carpi radialis and extensor carpi ulnaris to lateral epicondyle. Y-strip was applied by using fascia correction method. Control group: sham KT	3 months
Koçak et al.	2019	RCT	28	28	43	41	14	16	KT group: An X-band, which was cut as a donut hole, was used. The space in the middle was placed on the lateral epicondyle with a stretch of 15–25%. The endings were taped without stretching (Figure- 2a). Then, a Y band was prepared by measuring the distance between the hand dorsum and the lateral epicondyle to perform the „muscle inhibition technique. The tip of the Y tape was placed onto the radial side of the wrist without stretching. Control group: sham KT	3 months

RCT: randomized controlled trial, KT: Kinesio tape.
[a] Kase K, Wallis J, Kase T (2003) Clinical therapeutic applications of the Kinesio taping methods. Kinesio Taping Association, Albuquerque.

Table 2
Risk of bias summary.



outcomes mentioned above or no comparison of two groups were not included into the meta-analysis. Duplicate reports and abstracts were also excluded, while reports, letters and reviews were removed.

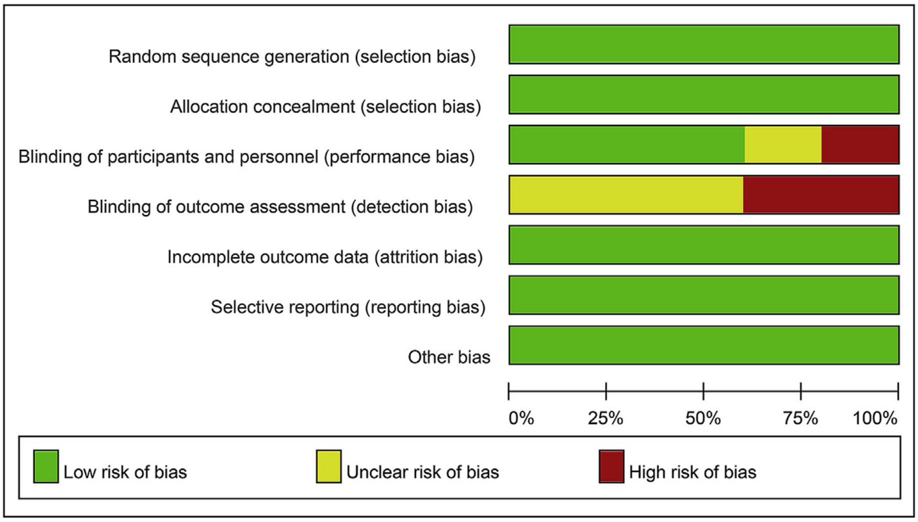
2.3. Data extraction

Two authors independently extracted the data while another author checked the consistency between the two sets of extracted data. When there were disagreements, the final decisions were made by discussion. The basic information included: the authors, publication date, study design, sample size (the ratio of males to females), mean age of the participants and follow-up duration. The clinical outcomes included the following: visual analogue scale (VAS), grip strength, modified Mayo performance index, Disabilities of the Arm, Shoulder and Hand (DASH) score and adverse events. If data were missing or could not be extracted directly, we contacted the corresponding authors to ensure that the information was retrieved.

2.4. Risk of bias

The Cochrane risk of bias tool was applied by two independent reviewers to evaluate the risk of bias of the included RCTs. The quality of each RCT was assessed according to the following 7 items: random sequence generation, allocation concealment, blinding of the participants and personnel, blinding of the outcome assessment, incomplete outcome data, selective reporting and other bias. Each item was classified as having low, unclear and high-risk bias. Disagreements between authors about the risk of bias in certain studies were resolved by discussion and another author was involved in the discussion when necessary.

Table 3
Risk of bias graph.



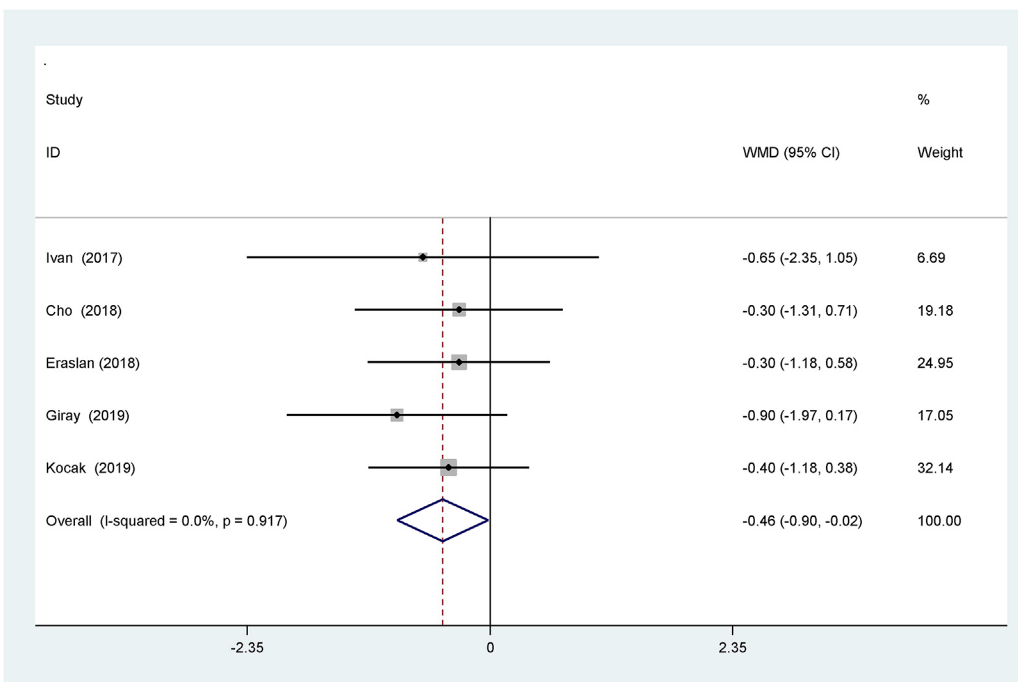


Fig. 3. Forest plot of pain score at rest.

2.5. Statistical analysis

The continuous variables were pooled using the weighted mean differences (WMD) and 95% confidence interval (CI). Statistical heterogeneity between the studies was evaluated with the P and I^2 values, where $P < 0.1$ and $I^2 > 50\%$ demonstrated high heterogeneity and a random-effects model was used. A fixed-effects model was applied when the level of heterogeneity was not significant. We performed a sensitivity analysis or subgroup analysis to investigate the potential source of heterogeneity. A funnel plot was used to evaluate the risk of publication bias in the studies. Additionally, data analysis was performed with STATA version 13.0 (Statacorp, college station, Tex).

3. Result

3.1. Literature search

A total of 185 records were retrieved from the 4 databases and we excluded 164 of these records because they were duplicate publications or were not relevant to this study based on the titles and abstracts. Then, we excluded 16 studies after reading the abstracts. The reference lists of the relevant articles and reviews were searched for potentially eligible studies. Finally, 5 RCTs [11–15] were included in our meta-analysis after reading the full-text articles. A flow diagram of the number of records at each stage is shown in Fig. 2.

3.2. Patient characteristics

All included RCTs were published between 2017 and 2019. In each

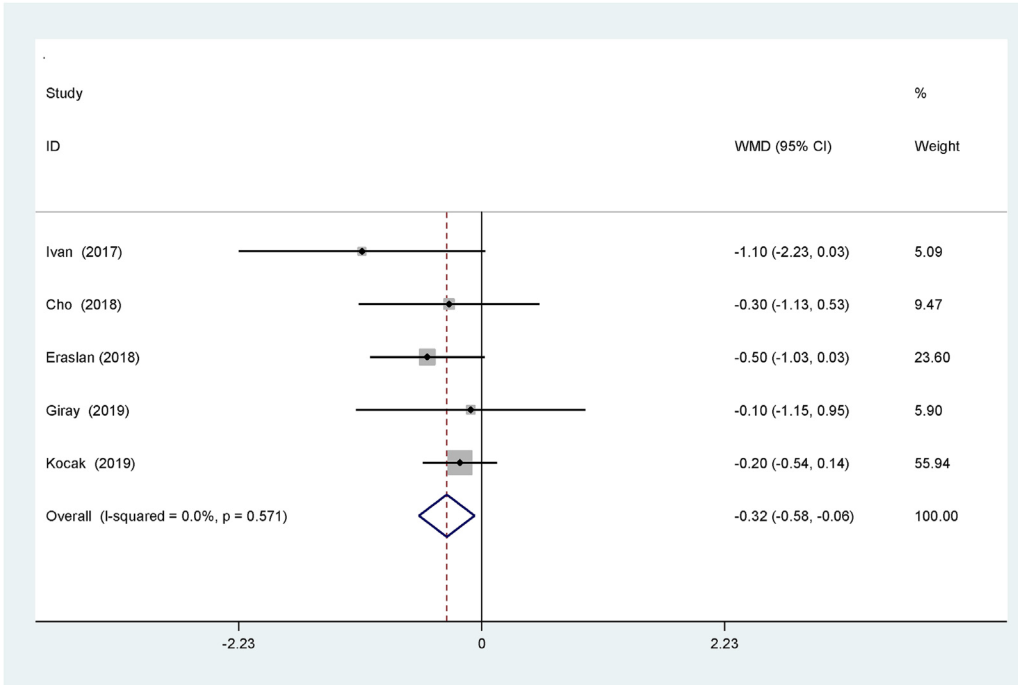


Fig. 4. Forest plot of pain score at movement.

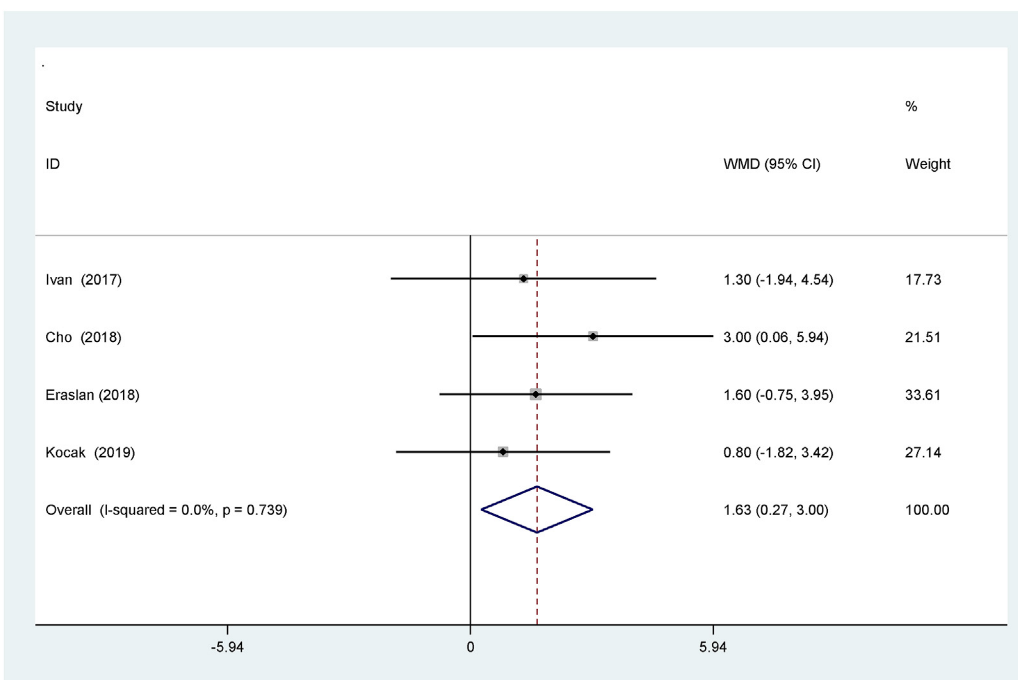


Fig. 5. Forest plot of grip strength at 1 month.

study, the demographic characteristics of the two groups were similar. A total of 168 patients were included, and the sample sizes of the studies ranged from 20 to 56. The experiential groups received KT for pain control and the control groups received sham KT or physiotherapy. The follow-up time ranged from 2 to 6 months and the baseline characteristics of the patients are indicated in Table 1.

3.3. Risk of bias

The Cochrane Collaboration for Systematic Reviews was adopted to assess the risk of bias (Table 2). All the included RCTs reported the use a computer-generated randomization sequence and demonstrated allocation concealment using the "envelope method". Two studies either did not use blinding methods or did not report it clearly. None of the studies described the blinding of the outcome assessment. All RCTs reported that some participants were lost to follow-up. For the missing data, we asked Ivan for the VAS scores for the movement and Cho for the adverse effects in their studies. All studies were considered to have a low risk of bias, including the incomplete outcome data and losses to follow-up. Each risk of bias item was expressed in terms of the

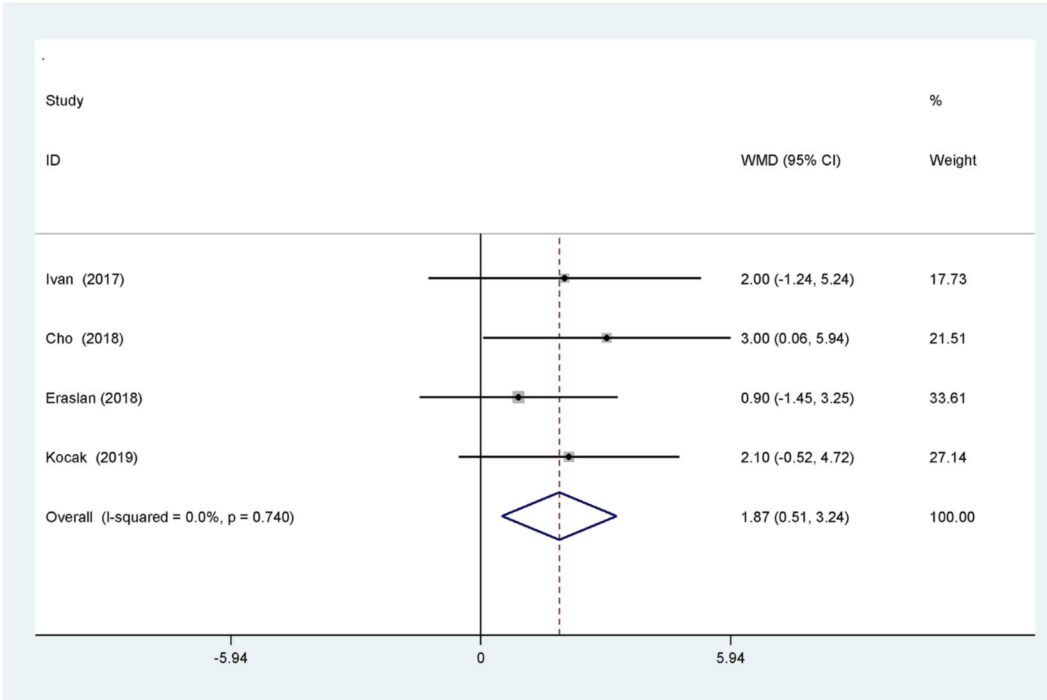


Fig. 6. Forest plot of grip strength at 3 month.

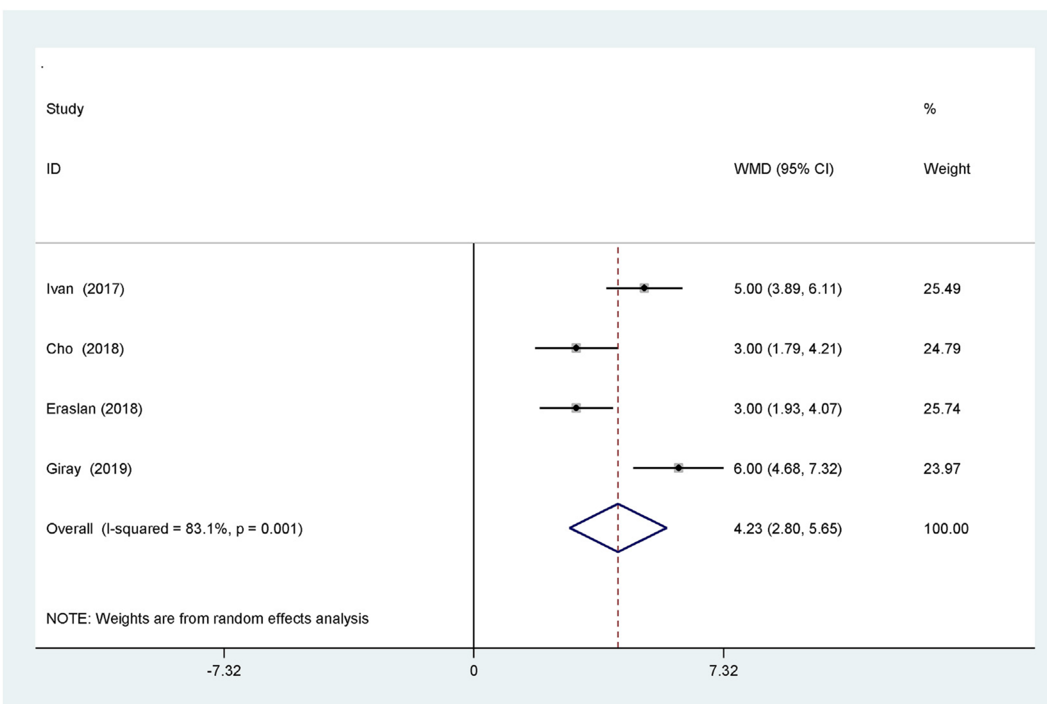


Fig. 7. Forest plot of Modified Mayo performance index.

percentage across all the included studies, which indicated the proportion of each risk level for each bias item (Table 3).

3.4. Meta-analysis outcome

3.4.1. VAS at rest

A total of 5 RCTs indicated VAS at rest. There was no significant heterogeneity and a fixed-effect model was used (I2 = 0%, P = 0.917). The present meta-analysis reflected that KT was associated with a significant reduction of VAS at rest (WMD = −0.458; 95% CI: -0.898 to −0.018; P = 0.042; Fig. 3).

3.4.2. VAS at movement

All RCTs provided VAS data at movement. Notably, a fixed-effect model was adopted because no significant heterogeneity was found (I2 = 0%, P = 0.571). The available data depicted that KT demonstrated significantly lower pain scores at movement compared with the placebo (WMD = −0.320; 95% CI: -0.576 to −0.065; P = 0.014;

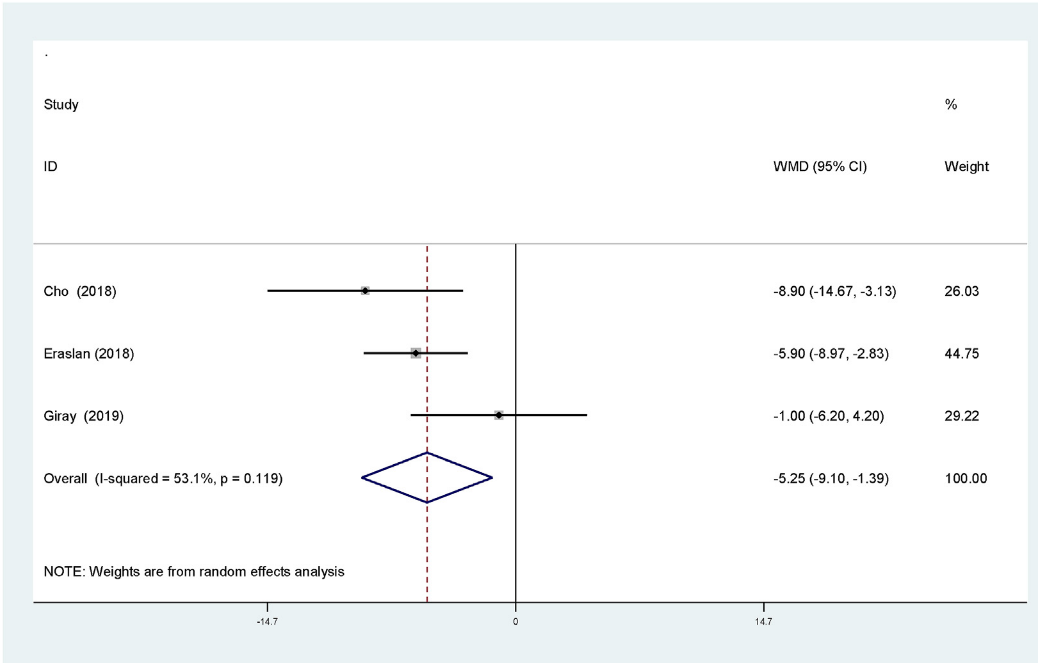


Fig. 8. Forest plot of Disabilities of the Arm, Shoulder and Hand (DASH) score.

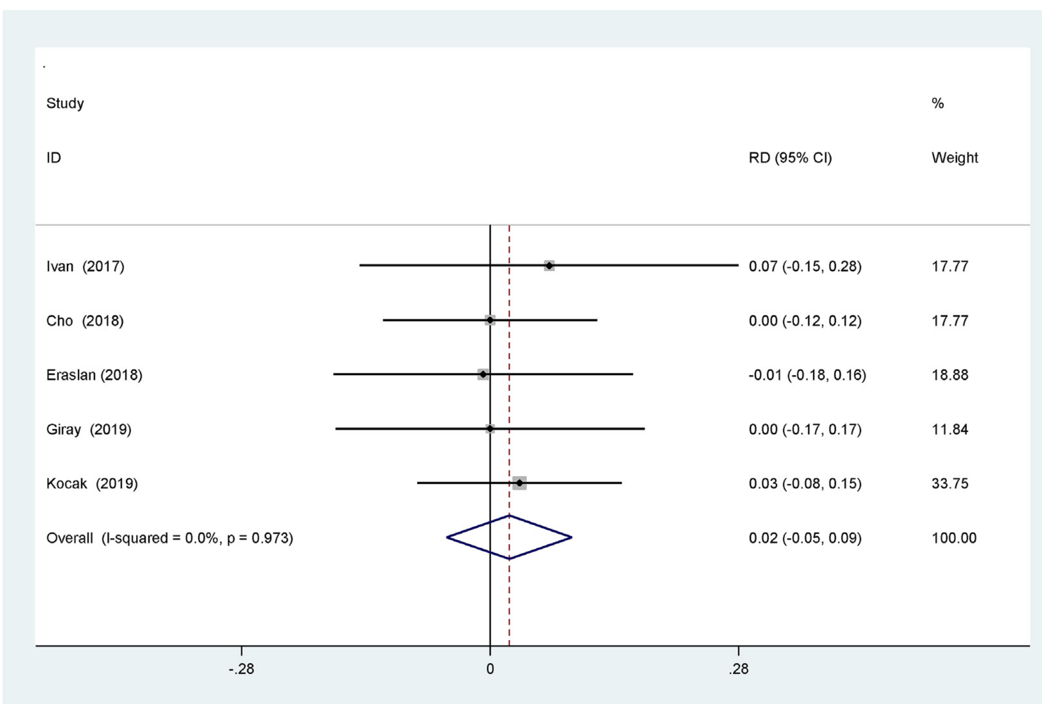


Fig. 9. Forest plot of adverse effect.

Fig. 4).

3.4.3. Grip strength at 1 month

Four studies, including 148 patients, reported grip strength at 1 month after treatment. No significant heterogeneity was found and a fixed-effect model was used (I2 = 0%, P = 0.739). The pooled results indicated there was significant difference between groups in terms of grip strength at 1 month (WMD = 1.631; 95% CI = 0.266 to 2.995; P = 0.019, Fig. 5).

3.4.4. Grip strength at 3 month

Grip strength at 3 month was reported in 4 RCTs. There was no significant heterogeneity and a fixed-effect model was adopted (I2 = 0%, P = 0.740). Our meta-analysis demonstrated that KT was associated with a significant improvement of grip strength at 3 month (WMD = 1.873; 95% CI = 0.508 to 3.237; P = 0.007, Fig. 6).

3.4.5. Modified Mayo performance index

4 RCTs provided data on the Modified Mayo performance index. It was concluded that there was significant heterogeneity (I2 = 83.1%,

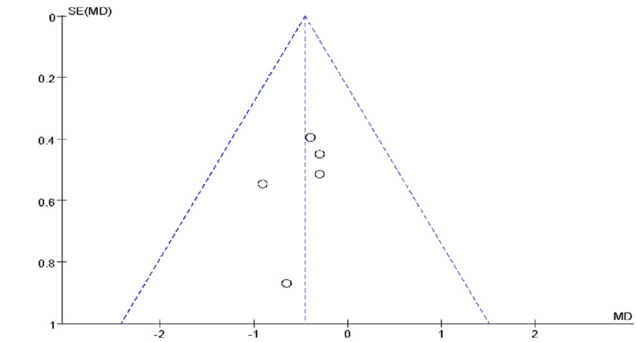


Fig. 10. Publication bias of VAS at rest.

P = 0.001) so a random-effect model was used. The overall pooled results indicated that there was significant difference between groups regarding the Modified Mayo performance index (WMD = 4.229; 95% CI = 2.805 to 5.653; $P < 0.001$, Fig. 7).

3.4.6. DASH score

The DASH score was reported in 3 RCTs and a random-effect model was used (I2 = 53.1%, P = 0.119). There was significant difference between groups in their DASH score (WMD = −5.249; 95% CI = −9.105 to −1.393; P = 0.008, Fig. 8).

3.4.7. Adverse effect

The most common adverse effect was skin irritation through the use of KT. All RCTs reported an adverse effect. The present meta-analysis reflected that the use of KT did not increase the risk of skin irritation (Risk difference (RD) = 0.022; 95% CI = −0.049 to 0.092; P = 0.549, Fig. 9).

3.4.8. Publication bias and sensitivity analysis

The symmetrical shape of the funnel plots (VAS at rest) indicated that there was a low risk of publication bias (Fig. 10). Sensitivity analysis was performed through omitting one study at a time and calculating the pooled outcomes for the remaining studies. The result of the sensitivity analysis concerning VAS at rest indicated that no significant effect was observed after excluding any single study, suggesting that the results was relatively robust (Fig. 11).

3.4.9. Subgroup analysis

We performed a subgroup analysis based on the different protocols of comparison intervention: sham taping or physiotherapy. We excluded the study by Eraslan et al. and the final result was shown in Table 4.

4. Discussion

To the best of our knowledge, this is the first meta-analysis of RCTs that evaluated the efficacy and safety of KT in reducing pain in individuals with LE. The most important finding was that KT is associated with a significant reduction in the VAS score, and KT was found to be effective in restoring grip strength and improving functionality during the rehabilitation process.

LE, or "tennis elbow", is generally self-limiting, but it may progress and cause persistent symptoms in some patients, which can be refractory to treatment [16]. The typical symptoms include lateral elbow pain, pain with wrist extension, and weakened grip strength [17]. Previously, LE was defined as tendinitis arising as inflammation of the tendon. Now however, it is considered to be a degenerative process because it is associated with a paucity of inflammatory cells, such as macrophages and neutrophils [18]. Traditionally, LE is treated by conservative treatments, including oral non-steroidal anti-inflammatory drugs, exercise therapy, or steroid injections. However, patients may endure pain for several months. Consequently, there is a need for effective temporary management, such as taping, which can potentially improve the quality of life and sport performance of patients.

KT normally involves a combination of applying appropriate tension along the elastic therapeutic tape and placing the target muscle in a stretched position. This treatment is widely used and is an interesting and relatively novel treatment for various clinical conditions [19,20]. It has been previously documented that KT enhances muscle activations and re-education by increasing the subcutaneous space, enhancing blood flow and providing tactile stimulation. Notably, Lu et al. [21] reported that KT is effective in relieving pain and improving joint function in patients with knee osteoarthritis. Yam et al. [22] demonstrated that KT can improve lower limb muscle strength in individuals

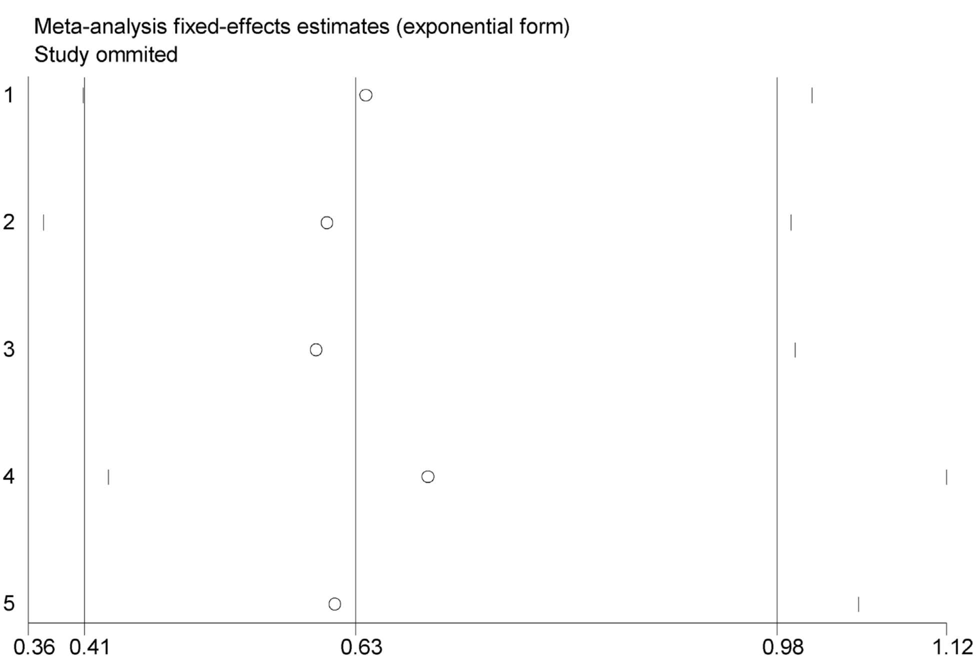


Fig. 11. Sensitivity analysis of VAS at rest.

Table 4
The outcome of subgroup analysis.

Variables	Studies (n)	Patients (n)	P	WMD or RD (95% CI)	Heterogeneity P-value (I^2)	Model
VAS at rest	4	136	0.049	−0.510 [-0.019, −0.002]	0.853 (0%)	Fixed-effect
VAS at movement	4	136	0.018	−0.352 [-0.645, −0.060]	0.505 (0%)	Fixed-effect
Grip strength at 1 month	3	116	0.021	1.967 [0.292, 3.642]	0.250 (27.8%)	Fixed-effect
Grip strength at 1 month	3	116	0.006	2.365 [0.690, 4.040]	0.875 (0%)	Fixed-effect
Modified Mayo performance index	3	80	< 0.001	4.655 [2.975, 6.336]	0.003 (82.7%)	Random-effect
DASH score	2	50	0.003	−7.356 [-12.131, −2.581]	0.174 (45.9%)	Fixed-effect
Adverse effect	4	136	0.474	0.028 [-0.049, 0.106]	0.931 (0%)	Fixed-effect

VAS: visual analogue scale, DASH: Disabilities of the Arm, Shoulder and Hand, WMD: weighted mean difference, RD: risk difference, CI: confidence interval.

with muscle fatigue and chronic musculoskeletal diseases. However, there is no reliable evidence for the management of LE because the present conclusions are inconsistent and controversial. The VAS, for which 0 corresponds to no pain and 10 corresponds to the worst possible pain, is a standard instrument used in chronic pain studies [23]. The present meta-analysis indicated that KT is associated with a significant reduction in VAS scores at rest and during movement in LE patients.

Several articles have reported that KT can potentially be used to modulate muscle activations. Hsu et al. [24] suggested that the elastic taping results in positive changes in scapular motions and muscle performance. The results supported its use as a treatment aid in managing shoulder impingement problems. However, Wong et al. [25] demonstrated that the application of KT did not alter the muscle peak torque generated by muscles or total work performed but rather shortened the time to generate the peak torque. Currently, the positive effect on KT in muscle strength in patients with LE remains controversial. Eraslan et al. [13] reported that KT is effective in restoring grip strength in LE patients undergoing rehabilitation. Notably, Cho et al. [12] found no difference between the KT and placebo groups regarding grip strength and the pain threshold. In the present meta-analysis, we found that the KT group showed improved grip strength. It has been hypothesized that KT may exert its effects by Ref. [1] increasing local circulation [2], improving circulation of blood by facilitating muscle [3], providing a positional stimulus to the skin, muscle, or facial structures, and [4] promote joint stability and movement.

Elbow joint function is a vital outcome measured that should be used to evaluate the efficacy of KT. The modified Mayo performance index is considered a valid and reliable measure that can be used to assess elbow joint function [26]. The DASH is a 30-item, self-report questionnaire designed to evaluate physical function and symptoms in patients with any musculoskeletal disorders of the upper limbs [27]. A total of 4 RCTs provided relevant data on functional outcomes. The overall pooled results indicated significant differences between groups in terms of the modified Mayo performance index and the DASH score, which is consistent with the findings of previous studies. To date, few studies have compared the efficacy of steroid injections and KT in treating LE. Only one article has focused on this issue and the authors indicated that KT alone was found to be as effective as steroid injections alone [15]. However, the co-administration of steroid injections and KT is more effective than each treatment alone.

Our meta-analysis still has the following limitations [1]. The sample size is relatively small, so the conclusions drawn on this basis still need to be verified by multi-centre studies with large sample sizes [2]. Heterogeneity among the included studies was unavoidable due to the different KT regimens reported. Additionally, heterogeneity was caused by a variety of other factors, such as racial and age differences in the participants [3]. Publication bias is unavoidable because the identified language was restricted to English [4]. Short-term follow-up data have an impact on the integrity of the study.

5. Conclusion

KT is effective in relieving pain, restoring grip strength, and improving functionality in patients with LE undergoing rehabilitation.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Data statement

All the data in our manuscript is available to access. Please contact the correspondence.

Ethical approval

Not required.

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Author contribution

Please specify the contribution of each author to the paper, e.g. study design, data collections, data analysis, writing. Others, who have contributed in other ways should be listed as contributors:

Ying Zhong: Methodology, Data curation, Writing.
Cheng Zheng: Reviewing and Editing.
Jiahui Zheng: Reviewing and Editing, Supervision.
Shanchun Xu: Data collections.

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Declaration of competing interest

None.

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