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Original Article

A Systematic Review of Kinesiology Taping in Patients With Lymphedema

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Key Words
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Background: The compression therapy, which is the standard treatment for lymphedema patients, may be difficult to implement and contraindicated to some patients depending on their health condition.

Objects: The purpose of this study is to investigate whether kinesiology taping (KT) can be used effectively and safely in the management of lymphedema as an alternative treatment through systematic review and meta-analysis.

Methods: In February 2023, the literature was systematically collected through eight search engines with a combination of terms, 'lymphedema' and 'kinesiology taping.' We qualitatively analyzed the differences and safety of KT methods, and quantitatively meta-analyzed the effects of volume reduction in edema, range of motion (ROM), and pain improvement using Review Manager ver. 5. 4. To assess the risk of bias in the randomized controlled trial (RCT) studies, Risk of Bias was used.

Results: A total of 616 articles searched and 20 studies were selected, including 12 RCTs and eight case studies. KT intervention could not replace multilayer compression bandage (MLB), but it demonstrated similar or better results compared to compression garment (CG), with reduced pain and improved intervention comfort. Studies reported skin adverse events ranging from 2.5% to 20.68%, with a total adverse event incidence of 7.7%. There was no significant difference in the application method of KT. As a result of the meta-analysis from the 8 RCTs, the KT intervention showed a mean difference (MD) of –7.18 with a 95% confidence interval (CI) [–12.64 to –1.72] in the volume change of lymphedema, while the pain difference was MD 0.82 with CI 95% [0.50 to 1.15], in comparison to the MLB and CG intervention.

Conclusion: KT therapy led to a reduction in edema size, volume, pain, and improved ROM and quality of life. KT may be a viable option for lymphedema patients who have trouble applying traditional compression therapies.

INTRODUCTION

1. The Need for Research

Lymphedema is a progressive chronic disease characterized by abnormal accumulation of protein-rich fluid in tissues and occurs when lymphatic vessels or lymph nodes that are supposed to function normally are damaged or disturbed, resulting in lymph obligatory load exceeding the reduced lymphatic transport capacity [1]. There are two types of lymphedemas: primary (genetic and congenital) lymphedema, which manifests due to an inadequate development of the lymphatic system, and secondary lymphedema, which develops when lymphatic drainage fails because of lymphatic system damage, being the most prevalent type [2].

Lymphedema can be present in the extremities, trunk, abdomen, head and neck, external genitalia, and internal organs, and is a serious problem that, if left untreated, causes long-term physical deformities and adverse social and psychological effects for patients [3]. The accumulation of protein-rich fluids can lead to frequent inflammation. Patients with lymphedema describe a lower quality of life because of the permanent discomfort associated with edema, such as pain, pressure, heaviness, soreness, tightness, numbness, and stiffness, as well as feeling unable to carry out daily activities. This is accompanied by emotional distress such as anxiety and depression due to social stigma, which interferes with interpersonal relationships, and affects employment status [4-6].

The purpose of lymphedema treatment is to interrupt the

cycle by alleviating symptoms, halting progression, and lowering the risk of inflammation [6,7]. Treatment of lymphedema includes surgery, medication, and complete decongestive therapy (CDT). When CDT is ineffective, surgical therapy is used; nevertheless, CDT should be done after surgery. CDT, which is the core of lymphedema management, was first developed in the mid-20th century and consists of four components: compression, manual lymph drainage (MLD), skin care, and exercise [1,8].

Treatment of lymphedema is divided into an intensive phase and a maintenance phase. The former aims to reduce the volume and the latter maintains it [9]. The compression therapy requires daily use of a low-elastic multilayer compression bandage (MLB) for the intensive phase and a compression garment (CG) for the maintenance phase for 23–24 hours a day. During the transition period until the size and volume of the edema area stabilizes, CGs should be worn during the day and compression bandages should be applied at night. Patients are also advised to perform self-CDT at home every day to prevent the edema from worsening [1,3,9]. However, acute inflammation or malignant tumors, severe peripheral arterial disease with an ankle brachial pressure index of 0.5 or less, arterial insufficiency, uncontrolled chronic heart failure, cellulitis or acute dermatitis, diabetic complications or paralysis causing sensory function deficits are contraindications to compression [10-12]. As the temperature rises, blood permeability increases, resulting in more tissue interstitial fluid, which tends to intensify edema, and the hot and humid weather in summer is a factor that reduces the performance of compression therapy and increases the risk of secondary inflammation [13,14]. Furthermore, compression therapy affects quality of life and makes it difficult for many patients to sustain application since they find it unappealing and uncomfortable. During a one-year prospective cohort study in France, 537 individuals with breast cancer related lymphedema (BCRL), 56.2% reported maintenance failures [15].

As an alternative for patients who fall under these contraindications or who have difficulty performing compression therapy daily, kinesiology taping (KT) therapy has recently been actively employed in many countries [9,16]. Since its creation in 1973 by Kenzo Kase in Japan, KT therapy has gained worldwide recognition, and it has been utilized to treat lymphedema patients in the United States and Europe since the late 1990s [17].

Following application, the tape raises the skin and creates convolutions. They elevate the epidermis, making space in the dermis. It relieves pressure on the skin, fascia, and area beneath the skin, consequently enhancing blood and lymph microcirculation. It stimulates the skin's proprioceptors while moving and serves as an interstitial fluid conductor, transferring fluid from a high-pressure area to a low-pressure area, alleviating swelling, and pain [17-19]. The tape is made of 100% cotton fiber, stretching only along the longitudinal axis, and an acrylic thermally active hypoallergenic adhesive is applied in a wavy pattern. The tape, which is made to mimic the characteristics of the skin, is made of a material that is the same thickness and elasticity as the skin it is also well ventilated and dries [20,21]. This is very important for applications in hot and humid areas and can remain on the skin for several days after showering [17,22]. The most important thing to note when using taping is skin allergies caused by the adhesive component of the tape. And wounds must also be considered, as even a small wound can be a trigger that can worsen edema [17,20].

Thus far, the systematic reviews and meta-analyses published to date using KT as an intervention in the treatment of lymphedema have focused primarily on BCRL [23]. There is only one case study in Korea that applied KT to lymphedema management [24].

2. Objectives of the Study

The purpose of this study is to systematically analyze the application of KT intervention to patients with lymphedema to assess whether it can be used safely and effectively as an alternative or complementary therapy to baseline treatment. This study is 1. to compare the effectiveness of KT intervention in symptom relief management in patients with lymphedema with various problem such as contraindications from compression therapy, 2. to investigate the differences and safety of taping methods through qualitative analysis, and 3. to determine the effect size of the intervention between the KT intervention group and the control group using compression bandages and CGs using meta-analysis.

MATERIALS AND METHODS

1. Study Design

This study is a systematic review and meta-analysis to assess whether the effect of KT intervention applied to patients

with lymphedema can replace or complement conventional compression therapy. Systematic reviews and meta-analysis of studies that have used KT as an intervention in the treatment of lymphedema, are limited to breast cancer patients. In order to investigate the various applicability of KT in this study, we included randomized controlled trial(RCT)s and case studies of lymphedema in various databases.

2. Inclusion and Exclusion Criteria of Systematic Review

1) Inclusion criteria

(1) Patients diagnosed with lymphedema, regardless of race, sex, age, duration of illness, history of surgery, primary, or secondary

(2) KT intervention

(3) RCT

(4) Cross-over study

(5) Case studies

2) Exclusion criteria

(1) Foreign languages other than Korean and English

(2) Full text is not available

(3) Research is ongoing or there are only abstracts

(4) Interventions are not equitable between groups (multiple interventions or no interventions in either the control group or the KT group)

(5) The data on the intervention evaluation and outcomes are not adequately described

(6) There are no descriptions or photographs of the tape application method in the text

(7) A short intervention period of less than a week

(8) The control group is not the standard treatment (CDT)

3. Inclusion and Exclusion Criteria of Meta-analysis

1) Inclusion criteria

(1) RCT

(2) BCRL

(3) Pre-post design with a control group (CG, compression bandages)

(4) Studies with pre-post changes of the intervention that used same units of the measurement: changes in volume of edema, range of motion (ROM), pain scale

2) Exclusion criteria

(1) Case studies

(2) Head and neck lymphedema

(3) Control group is not compression therapy

4. Search Strategy

This study was conducted in February 2023 according to the Participants, Intervention, Comparison, Outcome, Study Design (PICO-SD) format, which is the key question for a systematic review. As a search term, 'kinesio tape,' 'kinesiology tape,' 'tape,' 'taping,' 'athletic tape,' 'lymph tape,' 'elastic tape,' etc., were combined in various ways according to the characteristics of the search engine using 'AND' and 'OR,' focusing on the MeSH language called 'lymphedema' (refer to Appendix 1). The literature published up to February 2023 was collected by two researchers using eight search engines, including CINAHL, Cochrane Library, Embase, Google Scholar, RISS, PEDro, PubMed, and Web of Science.

This analysis involved an initial search and selection of eligible articles according to the above inclusion and exclusion criteria. When there was disagreement in the selection of literature, it was repeatedly discussed and re-examined.

5. Data Extraction and Analysis

The extracted data were evaluated qualitatively and quantitatively. Individual characteristics (study design, type, and stage of edema in participants, control group, intervention protocol, intervention assessment tools and outcomes) and method of KT applied (site and shape of tape, anastomosis, tape elongation, skin test and adverse events, difference in effect from control group) were extracted for qualitative analysis. Data on changes in lymphedema volume, ROM, and pain before and after intervention were extracted separately for meta-analysis.

The meta-analysis using the random effects model by the Review Manager (RevMan) ver. 5.4 program, was conducted to account for the heterogeneity of the data: we only collected and estimated the results showing the measurement tool, units, method and the region are consistent. Heterogeneity indicates dissimilarity in the individual study results. I^2 quantifies the effect of heterogeneity; that is, the proportion of interstudy variability [25].

6. Evaluation of the Quality of the Literatures

The quality of the literature selected for this study was assessed using the Risk of Bias (RoB) of the RevMan ver. 5.4 for

12 RCT studies, with reference to the Cochrane collaboration handbook and systematic review manual of National Evidence-based healthcare Collaborating Agency.

RESULTS

A total of 616 literatures were searched, from which 362 remained after deduplication. Through the titles and abstracts of the literatures, papers for which KT is not an intervention in the management of lymphedema were excluded. Three studies were added by hand search after the reference search. In the process of searching for the original texts of the selected studies, eight studies written in a foreign language other than English, four studies with only abstracts, and three studies for which the original text could not be obtained were excluded, leaving 36 papers. For papers for which the original text was not available, we sent an e-mail directly to the author to request the original text but did not receive a response. After reading and reviewing the original texts and applying the exclusion criteria, 20 literatures remained. Of the 20 literatures, eight met the eligible criteria for meta-analysis (Figure 1).

1. General Characteristics of the Literature

As shown in Table 1, the 20 (total seven countries) included in this study were published between 2010–2022 and included 12 RCTs and eight case studies. The total number of partici-

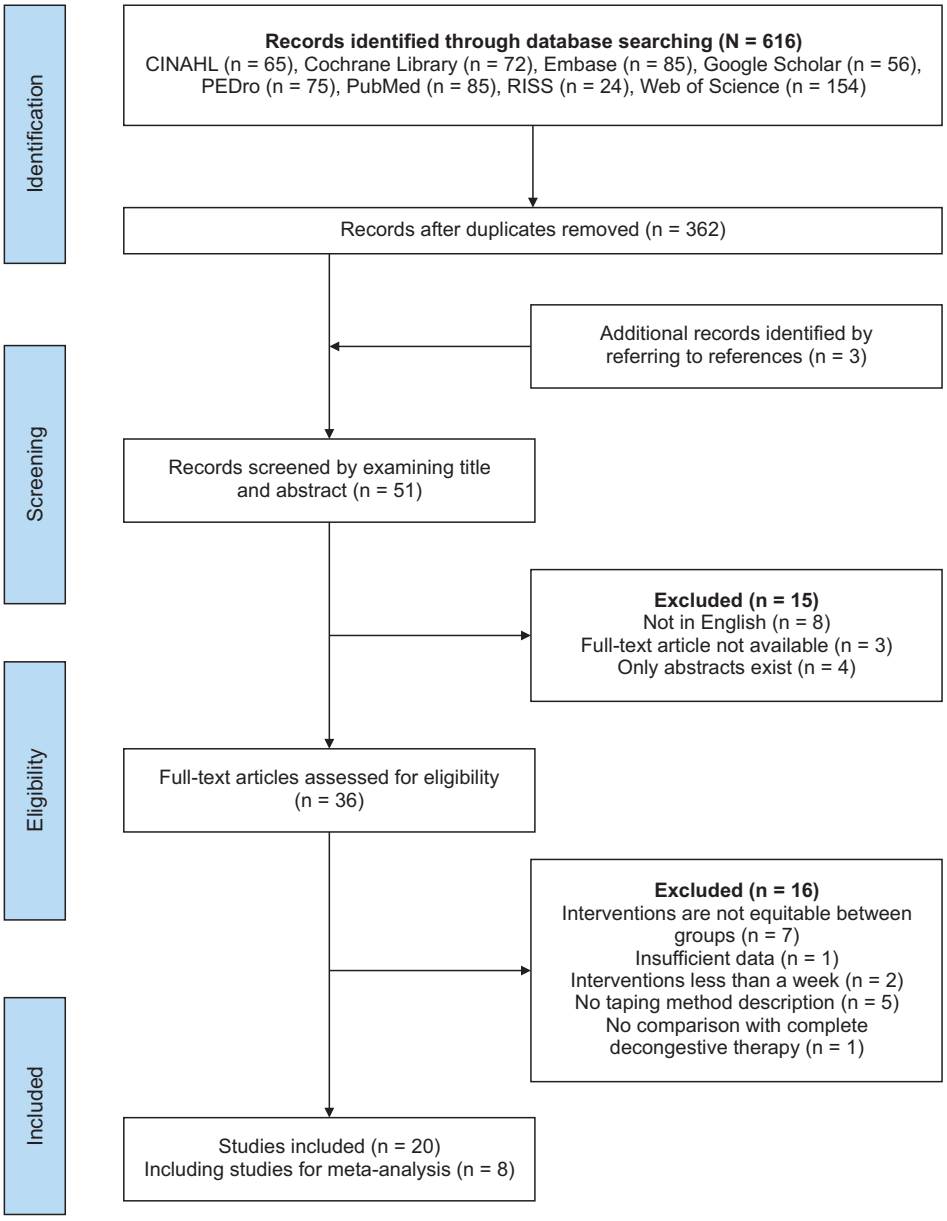

Figure 1. Flow chart of study selection.

Table 1. Characteristics of included studies

Study	Study design	Diagnosis LE status	Participants description	Treatment protocol & *intervention of control group	Evaluation tool	Outcome
Atar et al. [32]	RCT double blind sham control	HNL stage I & II	51.3 years (female: 23/male: 35) KT (n = 30) SKT (n = 28)	4 weeks (11 times) 5/w (1st week) & 2/w (2–4th week) with MLD 45 min & home exercise *sham KT	① Circumference of face and neck & edema scale by MDACC HNL ② Fiberoptic endoscopic images ③ VAS: comfort conception ④ EORTC QLQ-C30: QOL	① Significant reduction in both groups (p < 0.01) edema scale: KT = 76.7% ↓ , control = 57.1% ↓ ② No difference in both group (p = 0.860) ③ No difference between groups in discomfort but significant improvement of global health status & swallowing in the KT ④ Decrease of pain scale in the KT only
Selcuk Yilmaz and Ayhan [31]	RCT	BCRL stage II	54.7 years (female) KT (n = 15) MLD (n = 15) LLLT (n = 15)	3 weeks, KT = 2/w, MLD = 5/w, LLLT = 5/w with MLB + lymphedema remedial exercise + education/CCL2 flat knit CG after the intervention *MLD/LLLT	① Circumference & PDV ② DASH ③ LYMQoL-Arm: QOL ④ PDQ: pain	① Significantly higher PDV measurement in the KT group compared to the MLD group at every measurement time (p = 0.009, p = 0.039, p = 0.042) ② Improvements across all three measurements in both KT and LLLT groups ③ No difference between groups ④ Decrease in all three groups
Torres-Lacomba et al. [28]	RCT	BCRL stage I & II	58.4 years (female) KT (n = 29) MLB (n = 28) S.MLB (n = 30) Cohesive (n = 29) Adhesive (n = 30)	3 weeks, 5/w (1–2nd week) & for 3-day interval/w with CDT intensive: MLD + IPC 30 min + exercise 15 min + education *4 different bandages types of bandages	① % excess volume change via Frustrum formula ② Heaviness and tightness ③ 11 point numerical scale perceived comfort	① Volume reduction most effective in SMLB (59.5%), least effective in KT (4.9%) Difference between two groups' vol. reduction & access vol. %: 107.7 ml & 54.6% ② No difference in heaviness & tightness ③ KT: Most comfortable (1.4) / MLD: most uncomfortable (6.7)
Pajero Otero et al. [26]	RCT cross-over	BCRL stage II	67 years (female) KT (n = 15) CG (n = 15)	Wash out 4 weeks & 4 weeks, 1/w & wash out 4 weeks & 4 weeks, 1/w with self-care education: skin care & exercise *compression garment	① Relative Volume (change & difference) ② ROM ③ Self-perception of comfort ④ LE related symptoms	① RVC: KT = 5.7% ↓ /CG = 3.4% ↓ ② ROM: only improved in KT 5.8°–16.7° ↑ (p < 0.05) ③ KT: more comfortable (p < 0.001) ④ KT: more improved LE symptoms (p < 0.05)
Ozsoy-Unubol et al. [22]	RCT	BCRL stage I	52.7 years (female) KT (n = 16) CG (n = 19)	4 weeks, every 3–4 days with skin and nail care education + home exercise 20 min 2/d *compression garment	① Circumference measurement ② ROM ③ VAS: pain, heaviness, tightness	① Arm circumference differences at all levels decreased in both groups ② Similar effects between groups ③ Pain score: KT improves over CG
Tantawy et al. [19]	RCT	BCRL stage II & III	54.7 years (female) KT (n = 30) CG (n = 29)	3 weeks, 2/w with home exercise *compression garment	① Sum of limb circumference ② SPADI: shoulder pain & disability ③ Hand grip strength ④ QLQC30: QOL	① KT: 177.5 → 153.5 (24 cm ↓), CG: 172.2 → 163.4 (8.8 cm ↓) ② Significant improvement only at KT ③ KT: 23.43 kg ↑ , CG: 2.18 kg ↑ ④ Significant improvement only at KT

Table 1. Continued

Study	Study design	Diagnosis LE status	Participants description	Treatment protocol & *intervention of control group	Evaluation tool	Outcome
Ergin et al. [34]	RCT	BCRL significant (≤ 250 ml & marked (250–500 ml)	56.24 years (female) KT + CDT (n = 18) CDT (n = 14)	4 weeks (20 times), 5/w (1 hr/d) with CDT: MLD + MLB + exercise + skin care/ KT is maintained for 3 days and then reapplied. *CDT	① Each 5 cm, 7 points circumference measurement & limb volume	① Reduced circumference & volume at all points in both group ($p \leq 0.001/p \leq 0.001$) No difference between groups
Hassan and Ismail [27]	RCT	BCRL	54.1 years (female) KT (n = 15) CG (n = 15)	4 weeks (12 times), 3/w with MLD 45 min + exercise *compression garment	① Circumference of arm and forearm ② ROM: flexion and abduction	① Arm: KT = 18.6% ↓ , CG = 13.7% ↓ /forearm: KT = 12.28% ↓ , CG = 18.62% ↓ ② ROM: flexion, KT = 75.4% ↑ CG = 19.6%/abduction, KT = 72.52% ↑ , CG = 47.51% ↑
Taradaj et al. [11]	RCT	BCRL stage II & III	62 years (female) KT (n = 22) qKT (n = 23) MLB (n = 25)	4 weeks (12 times), 3/w with MLD 50 min + IPC 45 min Tape on every Monday and take it off on Friday *quasi-KT/bandages	① Optoelectronic perometer 40T ② ROM ③ Hand grip strength	① % of volume decreased in all groups (MLB = 45.02% ↓ , KT = 22.45% ↓ , qKT = 24.04% ↓) ② Similar results in ROM ③ KT: 128.34 N → 140.23 N, qKT: 130.45 N → 138.93 N, MLB: 128.88 N → 168.76 N
Pekyavas et al. [29]	RCT	BCRL grade 2, 3	54.6 years (female) KT (n = 14) MLB + KT (n = 13) MLB (n = 14)	2 weeks (10 times), 5/w with CDT: MLD 30 min + skin care + exercise 20 min/KT daily application *bandages/combination of bandages and KT	① VAS: LE symptoms & itching and wound formation ② Circumference & volume ③ SF-36: QOL	① Reduced lymphedema related symptoms in all groups ($p < 0.05$) pain reduced only in KT ② After 1 month of the intervention: KT + MLB = 547.94 ml ↓ , KT = 379.04 ml ↓ , MLB = 358.31 ml ↓ , only KT + MLB ($p < 0.05$) ③ No difference between groups
Pop et al. [33]	RCT preliminary study	BCRL soft oedema	62 years (female) ownKT (n = 22) KT (n = 22)	3 weeks (3 times), 1/w with home exercise 2/d *KT with different directions	① Circumference & volume ② ROM ③ Hand grip strength ④ Self-prepared questionnaire about the therapy	① ownKT = 55% ↓ , KT=27% ↓ ② More improved in ownKT (between 0°–15°) ③ ownKT: 14 kg → 22 kg, KT: 13 kg → 18 kg ④ Very good: ownKT (n = 10), KT (n = 4) good: an equal number of 9 each, bad: no one
Smykla et al. [30]	RCT single blind pilot study	BCRL stage II & III	66.3 years (female) KT (n = 20) qKT (n = 22) MLB (n = 23)	4 weeks (12 times), 3/w with MLD 1 hr + IPC 45 min + skin care *quasi-KT/bandages	① Optoelectronic perometer 40T	① KT: 9410.01 cm^2 → 8051.15 cm^2 (19.36 ↓)/ qKT: 9621.33 cm^2 → 8041.02 cm^2 (19.19% ↓)/ MLB: 10089.41 cm^2 → 5021.22 cm^2 (54.48% ↓) ($p = 0.005/0.005/0.000003$)
Özçete and Eyigör [36]	Case study	BCRL	57 years Female (n = 1) A-V fistula	4 weeks (12 times), 3/w (+3 extra sessions) with LLLT + self MLD, home ex.	① Tape measurement & difference of arm volume	① Volume difference: 691 ml → 461 ml (230 ml ↓)/ 3 months later: 454 ml from baseline (237 ml ↓)/ 17 months later: 267 ml from baseline (424 ml ↓)
Tantawy [41]	Pilot experimental study	BCRL stage II & III	52.7 years Female (n=7)	3 weeks (6 times), 2/w with home exercise 2/w	① Sum of limb circumference	① 174.8 cm → 155.6 cm ($p = 0.02$)
Özçete et al. [39]	Case study	HNL stage II	58 years Male (n = 1)	1/w (12 times) with self MLD + exercise keep KT for 4–5 days	① Földi scale edema assessment ② ROM	① Edema scale II → 0 ② Extension: 20° → 35°/right rotation: 40° → 45°/ left lateral flexion: 25° → 35°/right lateral flexion: 30° → 35°

Table 1. Continued

Study	Study design	Diagnosis LE status	Participants description	Treatment protocol & *intervention of control group	Evaluation tool	Outcome
Taradaj et al. [37]	Case study	BCRL	62 years (female) Permanent nerve damage by DM	3 weeks, 1/w KT put it on Friday and keep it for 3 days with IPC + MLD 3/w	① Optoelectronic perometer 40T	① Volume: 627 cm^2 ↓ (2,733 cm^2 → 2,106 cm^2) The decrease in the period during which KT was applied is significantly larger (31 ↓ /194 ↓ /51 ↓ /206 ↓ /40 ↓ /105 ↓)
Chou et al. [35]	Case study	BCRL stage 2	48 years (female) AV-fistula	3/w (12 times) with MLD 45 min	① Circumference & volume ② PEV & PERV	① Circumference: 37.6 cm → 19.8 cm, excess volume: 992 ml → 536 ml ② PEV: 79.95% → 36.43%, PREV: 54% ↓
Simone [40]	Case study	HNL	52 years (male) Oropharyngeal cancer	9 weeks, 2–3/w, KT started from the 8th session with MLD + CG+ home exercise	① The sum of neck circumferences ② NDI: neck disability ③ FACIT-F ④ ROM ⑤ PIVM	① 129.9 cm → 121.9 cm ② 8% → 6% ③ 126 → 134 ④ Improvement between 4°–13° ⑤ Improvement in all directions
Van Wyk [42]	Case study	BCRL	37 years (female)	2 months, 1/w keep 5 days, remove for 2 days with exercise	① Circumference ② Assessment of skin texture	① Upper arm: 41.5 cm → 38.5 cm, forearm: 38.1 cm → 35.1 cm ② Softer to the touch and more flexible to use
Pyszora and Krajnik [38]	Case study	Lower limb LE	56 years (male) Malignant tumor of pancreas	1/3–5 days applied & 24 hours rest during palliative care	① Verbal evaluation of patient satisfaction ② Visual check by the therapist	① Reduced swelling, pain, and heavy symptoms, satisfied with the intervention ② Reduced skin tension, stripy marks on the skin

RCT, randomized controlled trial; KT, kinesiology taping; SKT, sham kinesiology taping; MLB, multilayer bandage; CG, compression garment; MLD, manual lymph drainage; LLLT, low level laser therapy; IPC, intermittent pneumatic compression therapy; MDACC, MD Anderson cancer center; BCRL, breast cancer related lymphedema; HNL, head and neck lymphedema; VAS, visual analog scale; CCL, compression class level; QOL, quality of life; EORTC QLQ-C30, the European organization for research and treatment of cancer's quality of life questionnaire consisting of 30 question; DASH, disability of shoulder and arm; PDQ, pain detect questionnaire; SMLB, simplified multilayer bandage; ROM, range of motion; PDV, percentage decrease of volume; RVC, relative volume change; SPADI, shoulder pain and disability; NDI, neck disability index; FACIT-F, functional assessment of chronic illness therapy and cancer; PIVM, passive intervertebral motion; PEV, percentage of excess volume; PREV, percentage reduction of excess volume; A-V fistula, arterio venous fistula. Age is estimated in mean number.

pants was 669 (females 632/males 37), with median age of 58.03 years. There are 16 studies on BCRL (n = 608), three on head and neck associated lymphedema (HNL) (n = 60), and one study of lower limb lymphedema due to pancreatic cancer surgery (n = 1).

Of all the studies, the stages of lymphedema varied from stage 1 (soft oedema) to 3 (severe), and of the 12 RCTs, 11 were in patients with BCRL and one was in patients with HNL [11,19,22,26-34].

2. Results of Qualitative Analysis

1) Comparison of included studies (n = 20)

Of all the 20 studies, 18 studies (including 12 RCTs and 6 case studies) evaluated the size and volume reduction of lymphedema. One study was for palliative care patients and did not measure the size because the primary outcome was pain relief, and the other study was for head and neck lymphedema and only measured the change in the scale of edema. The intervention used were mainly KT, MLB, CG, and additionally MLD, low level laser therapy (LLLT), intermittent pneumatic compression (IPC), and sham KT were compared.

The control group that received MLB intervention showed a volume change of around 50%, while the CG group showed a decrease of between 3.4% and 13.7%, which was less or like that of the KT group in the same study. In each study, the volume reduction rate in the KT intervention group varied from 4.9% to 55%. The reduction in volume in the edema area was greatest in the MLB group, but one study revealed that the effect was synergized when KT and MLB were used together [29]. Studies that showed a high reduction rate of about 50% in taping interventions were RCTs applied to soft edema in the early stages and case studies that included MLD in the KT intervention [33,35].

The results of comfort of treatment, quality of life, and symptoms associated with lymphedema were almost consistent with the volume reduction. However, in research that examined four different types of bandage groups in application of the methods as control groups, the KT experimental group received the highest marks for intervention comfort even though all bandage groups experienced better volume reduction [28]. In a cross-over study comparing CG as a control group to the KT group, the participants reported that KT was more comfortable, and the improvement in symptoms of edema was better in the KT intervention. The seven studies measured ROM with the patients presented limited movement, showed a substantial improvement after receiving the KT intervention.

2) Case studies (n = 8)

Of the eight case studies, all of them were in patients who had difficulty applying above compression method, MLB and CG [35-42]. All case studies reported that KT was effective regardless of the site or severity of edema, and KT was a suitable alternative method in cases where compression was difficult. For example, KT can be useful for patients who have an A-V fistula in the arm or permanent nerve damage for whom compression therapies are contraindicated [35-37], and in one study reported KT was effective for pain relief for advanced cancer patients suffer from lower extremity lymphedema [38].

In two case studies of head and neck lymphedema, patients who complained uncomfortable with MLB and CG, reported KT replacement was more comfortable [39,40]. Another study, a combination of KT, MLD, and IPC reduced the volume of swollen arm by 627 cm^2. During the week, the MLD and IPC were received daily in the clinic, and KT was applied only on weekends, and the volume reduction rate on weekends was 2.5 to 6 times higher than on weekdays [37].

3) Analysis of KT application method and skin adverse effect

In this study, the KT application method and any skin adverse effects of the method were investigated, as shown in Table 2. The Figure 2 shows some representative KT application methods. The results in Table 2 are described below.

(1) Use of anastomosis

In KT, anastomosis means transporting congested lymph fluid from the affected side to the unaffected side by applying KT in the opposite area of the affected side. Application of KT regarding anastomosis can be vary, for example, either KT on the anastomosis area or without KT on the area, and KT on the area either anterior or posterior side of the body.

As shown in Table 2, 11 of the 16 BCRL studies (68.75%) used anastomosis. Of those studies, unlike all the other studies that applied the KT tape at the edema region as well as the anastomosis area (unaffected side), Ergin et al. [34], applied KT only on the anastomosis area. Also, two studies applied KT only posterior anastomosis, although, it may avoid the skin adverse effect [26,35], none of the studies showed any additional ef-

Table 2. Methods of applying kinesiology taping

Study	Anastomosis	Style (number)	Application area	Direction	Stretching (%)	Skin adverse (n = drop out)	Patch test	Result
Atar et al. [32]	X	Fan (4)	Neck, face	Lymphatic	5–25	Temporary itching & redness 16.6% (n = 0)	○	KT > SKT
Selcuk Yilmaz and Ayhan [31]	X	Fan (6)	Arm, forearm, hand	Lymphatic	10–15	Drop out by allergy 16.66% (n = 3)	○	KT ≥ MLD, LLLT
Torres-Lacomba et al. [28]	X	Fan (4)	Arm, forearm, hand	Lymphatic	15–20	Drop out by irritation 3.4% (n = 1)	○	KT < B (comfortable KT > B)
Pajero Otero et al. [26]	Posterior 1 (A-A)	Spiral	Arm to wrist	Lymphatic	0	Skin peeling 20% (n = 0)	○	KT > CG
Ozsoy-Unubol et al. [22]	X	Fan (4)	Arm, forearm	Lymphatic	15	Drop out by allergy 2.5% (n = 1)		KT ≥ CG
Tantawy et al. [19]	Anterior 1 (A-A)	Fan (6)	Arm, forearm, hand	Lymphatic	5–25/15–20 (anastomosis)	No mention		KT > CG
Ergin et al. [34]	Anterior 2 Posterior 1 (A-A, I-A)	Fan (3)	Only on the anastomosis	Lymphatic	0–15	X		KT using anastomosis only, no effect
Hassan and Ismail [27]		Fan (5)	Arm, forearm, hand	Lymphatic	No mention	No mention	○	KT ≥ CG
Taradaj et al. [11]	Anterior 2 (A-A & A-I)	Fan (6)	Arm, forearm	Lymphatic	0–15	Drop out by allergy inflammatory 20.68% (n = 6)		KT < MLB KT ≒ qKT
Pekyavas et al. [29]	Anterior 1 (A-A)	Fan (6)	Arm, forearm, hand	Lymphatic	No mention	No mention		KT + MLB > KT (pain) KT >
Pop et al. [33]	Anterior 1 (A-A)	Fan (1) & spiral	Fingers to arm	*ownKT: reverse KT: lymphatic	10	No mention		ownKT > KT
Smykla et al. [30]	Anterior 2 (A-A, A-I)	Fan (6)	Arm, forearm	Reverse	5–15	Drop out by allergy 15.38% (n = 4)		MLB > KT KT = qKT
Özçete and Eyigör [36]	Anterior 2 Posterior 1 (A-A, A-I)	Fan (7)	Arm, forearm, hand	Lymphatic	No mention	No mention		Alternatives to pressure contraindications
Tantawy [41]	Anterior 1 (A-A)	Fan (6)	Arm, forearm hand	Lymphatic	15–20/5–25 (anastomosis)	No mention		Effective & comfortable
Özçete et al. [39]	X	Fan (2)	Neck	Cross application reverse	No mention	Pruritis but not wound	○	Very effective
Taradaj et al. [37]	Anterior 1 (A-A)	Fan (6)	Arm, forearm	Lymphatic	0–15	No mention		Safe & effective without side effects
Simone [40]	X	Fan (2)	Neck	Lymphatic	15	X	○	Safe & effective
Chou et al. [35]	Posterior 1 (A-A)	Fan (2)	Arm, forearm	Lymphatic	No mention	Itching & wound formation		Alternative for hospice management
Van Wyk [42]	X	Spiral	Arm, forearm	Lymphatic	No mention	X		Symptoms relief, patient satisfaction
Pyszora and Krajnik [38]	X	Fan (2)	Dorsum of foot to knee	Lymphatic	15	X	○	Suitable for palliative tx.

A-A, axillo-axillary anastomosis; A-I, axillo-inguinal anastomosis; CG, compression garment; KT, kinesiology taping; LLLT, low level laser treatment; MLB, multilayer bandage; MLD, manual lymph drainage; qKT, quasi kinesiology taping; SKT, sham KT; Lymphatic, from proximal to distal.

fects associated with the use of anastomosis.

(2) Shape of the KT

A total of 17 studies used fan-shaped tape, and three studies used spiral and independent I-shaped tape. Both fan-cut and I-cut techniques were successful in treating lymphedema management, but the research analyzed in this study did not conclude which technique was better.

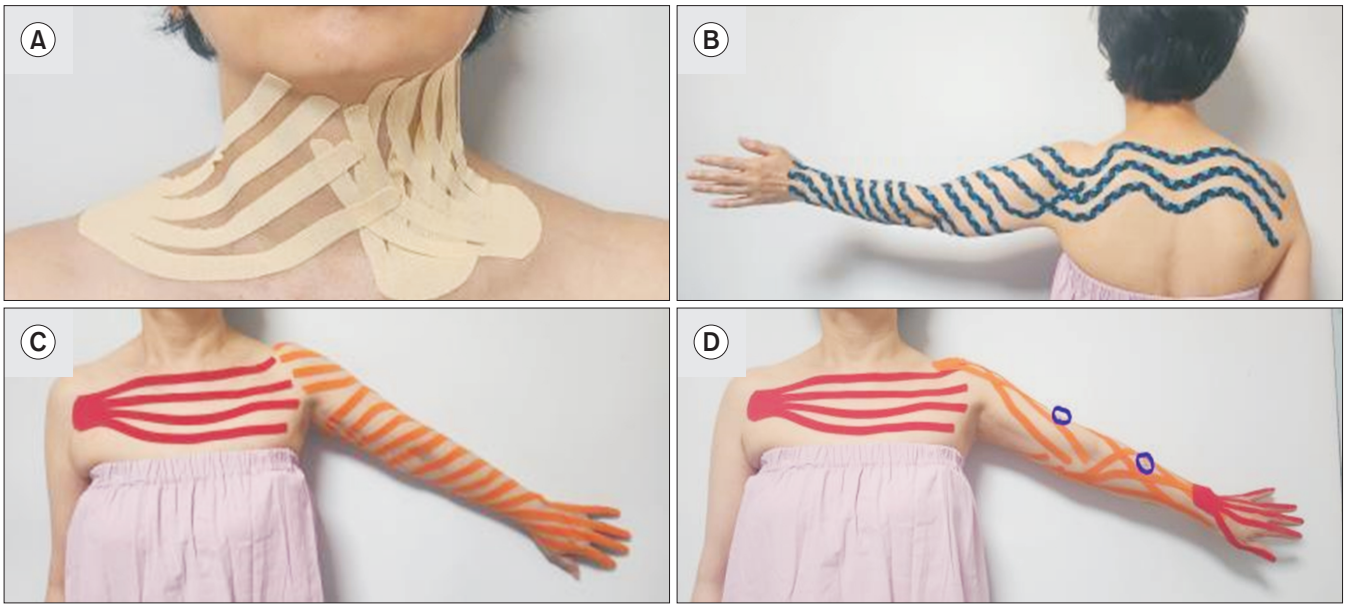

Figure 2. Examples of taping methods used in each study. (A) Fan-shaped taping for head and neck lymphedema. (B) Independent parallel long spiral I-shaped taping. (C) A combination of fan-shaped anastomotic tape and long I-shaped independent spiral taping. (D) Fan-shaped taping applied to arm and anastomosis with arteriovenous fistula for renal dialysis.

(3) Direction of the KT

Eighteen of the 20 studies followed lymphatic correction from proximal to distal of the central lymph node. On the other hand, in two studies, the KT was applied from the distal to the proximal part [33,39]. No difference in the effect by KT direction was observed. Pop et al. [33] compared their self-designed KT method in different directions and obtained better results in the reverse lymphatic direction (distal to proximal). However, the author states that there is a limitation of the movement of raising the arm for 20 minutes was added only before the application of the reverse lymphatic direction KT itself.

(4) Skin adverse effects caused by the KT

One of the objectives of this study was to see if the tape could be safely applied without skin adverse effects. There were nine reported cases of adverse skin reactions, and the incidence of adverse events ranged from 2.5% to 20.68%. In those studies, total 31 individuals experienced skin issues during the intervention procedure, which includes 15 patients reported mild side effects and the other 16 patients who discontinued the intervention due to skin side effects. In 20 studies, including sham KT, a total of 399 patients received taping interventions, the dropout rate due to tape allergies was 4%. And 7.7% of those reported experiencing skin adverse reactions, including mild skin allergies, while using tape. Otero et al. [26] stated that skin side effects were mainly concentrated in the latter part of the study, and that studies longer than 4 weeks were not recommended because they could strain the skin.

None of the studies specified which manufacturer of tapes was used. However, low-quality tapes may influence treatment outcomes and can also cause skin side effects [17].

3. Meta-analysis

In view of the heterogeneity of the studies, out of 11 breast cancer related RCT studies, 8 studies with bandages and CG were included in the analysis. The commonly measured items, such as volume reduction of edema, improvement of ROM and pain, were analyzed and shown in Figure 3.

First, six studies were included in the meta-analysis of volume reduction of edema, except for two studies that used other indicators that measured % of volume changed after the intervention. Volume changes were analyzed by dividing the control group into MLB & CG, MLB, and CG, respectively. Second, four studies that measured changes in ROM were included in the analysis, which looked at changes in shoulder flexion and abduction. Third, four studies that measured changes in pain before and after the intervention were included in the analysis.

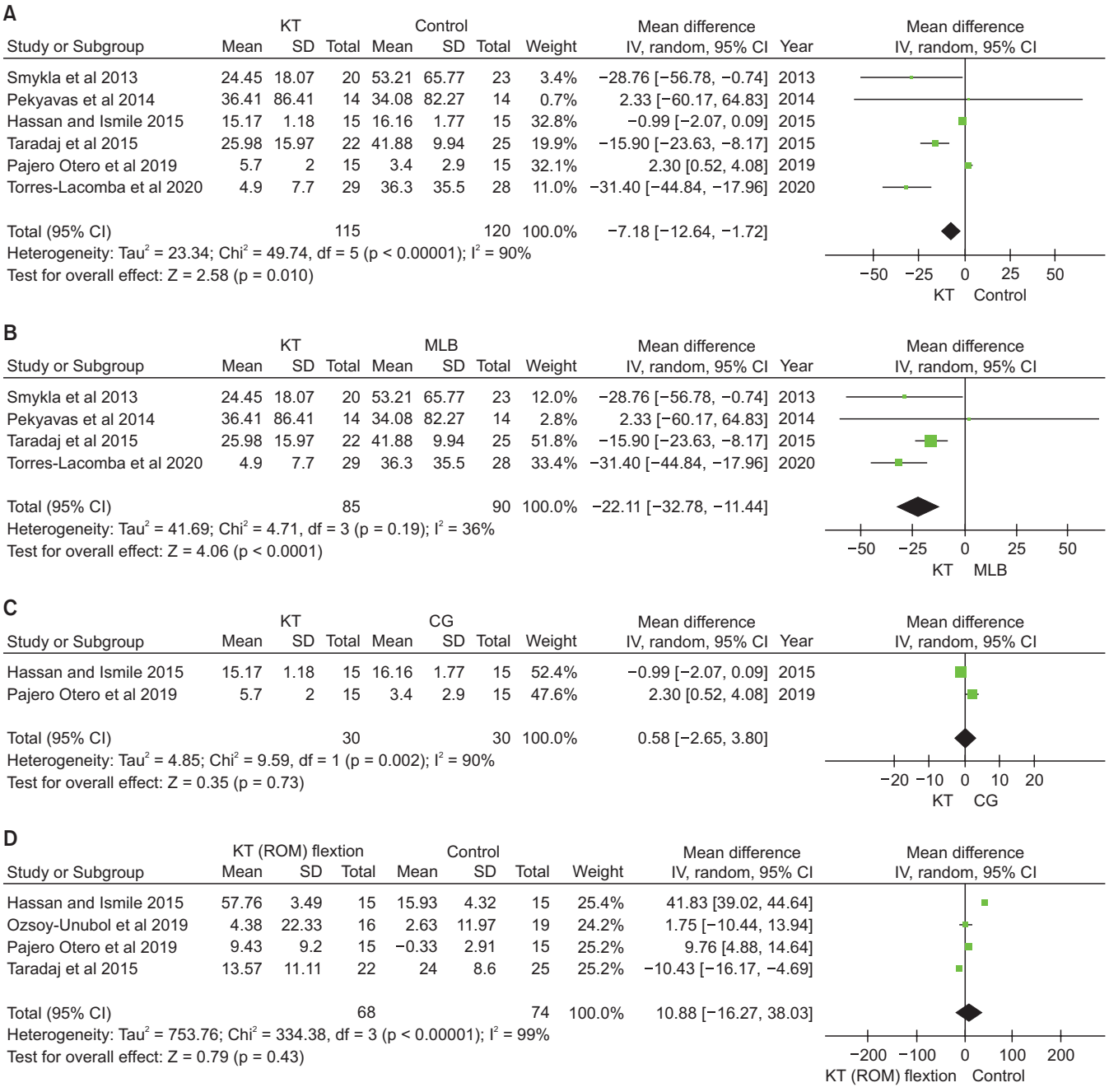

Figure 3. Forest plot of the intervention effect of the intervention group and the control group in order from above. (A) Volume change: KT vs. control group (MLB & CG). (B) Volume change: KT vs. MLB. (C) Volume change: KT vs. CG. (D) ROM of flexion: KT vs. control (MLB & CG). (E) ROM of abduction: KT vs. control (MLB & CG). (F) Pain: KT vs. control (MLB & CG). KT, kinesiology taping; SD, standard deviation; IV, weighted mean difference; CI, confidence interval; MLB, multilayer compression bandage; CG, compression garment; ROM, range of motion.

1) Changes in volume

(1) KT vs. control group (MLB & CG)

The effect size was statistically significant ($p < 0.05$), with an effect size mean of –7.18 (95% confidence interval [CI] = 12.64 to –1.72) across the six literatures, but there was heterogeneity between the literature ($I^2 = 90\%$).

(2) KT vs. control group (MLB)

There was a statistically significant difference in effect size with an average of –22.11 (95% CI = –32.78 to –11.44) in the four literatures ($p < 0.001$), and the heterogeneity between the literature was less than 50%, indicating that there was no significant difference in effect size between the results ($I^2 = 36\%$).

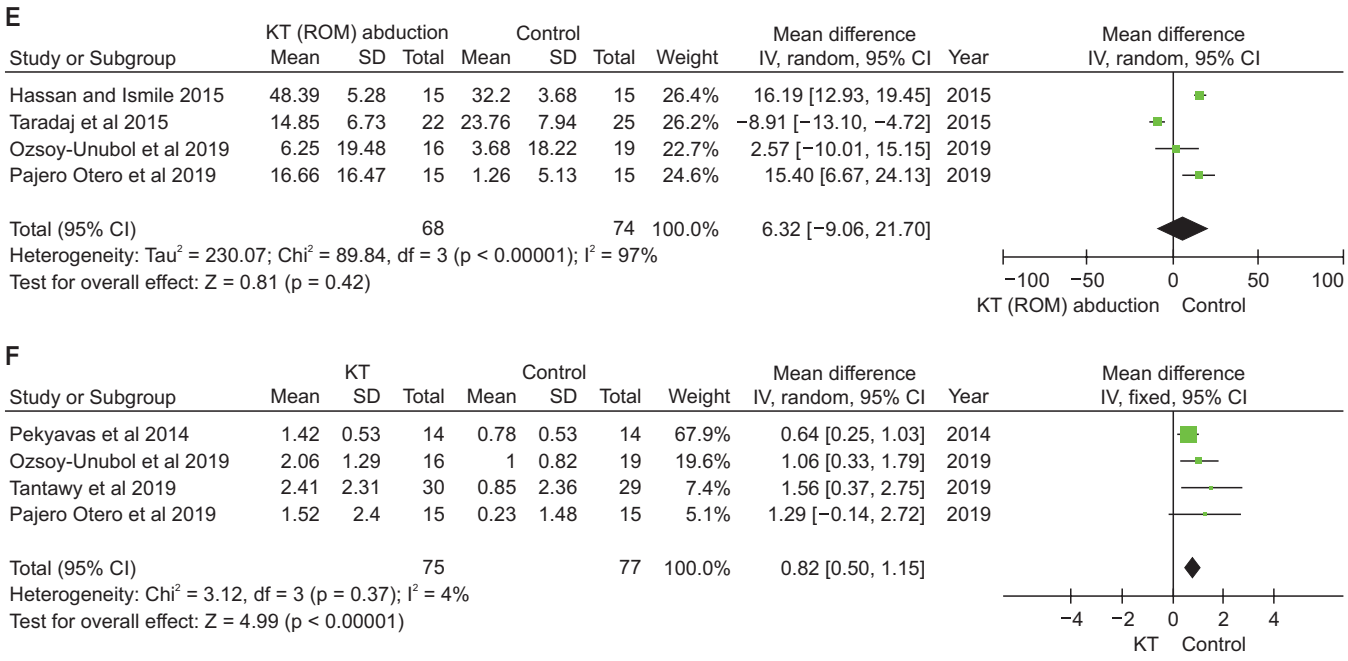

Figure 3. Continued.

(3) KT vs. control group (CG)

There was no statistically significant difference ($p > 0.05$) with an effect size mean of 0.58 (95% CI = –2.65 to 3.80) (I^2 = 90%). KT was less effective than the bandage group in reducing the volume of lymphedema and there was no significant difference from the CG group.

2) Changes in ROM

(1) KT vs control group (MLB & CG) flexion

An effect size mean 10.88 (95% CI= –16.27 to 38.03), the effect size between the two groups was not statistically significant ($p > 0.05$) (I^2 = 97%).

(2) KT vs control group (MLB & CG) abduction

The effect size was not statistically significant ($p > 0.05$) with a mean effect size of 6.32 (95% CI = –9.06 to 21.70) (I^2 = 97%).

Although the KT intervention was found to result in an increase in ROM, the effect size between the two groups was not statistically significant for both flexion and abduction.

3) Change in pain

(1) KT vs. control group (MLB & CG)

With an effect size mean of 0.82 (95% CI = 0.50 to 1.15), it was found that pain caused by the KT intervention was improved compared to the control group. The effect size between the two groups was statistically significant ($p < 0.001$), and the between-literature heterogeneity was low (I^2 = 4%).

The KT intervention was less effective than MLB in reducing the volume of edema but had better results in pain.

4. Assessment of Risk of Bias

In this study, bias risk assessment was performed on 12 selected RCTs (Figure 4). Only RCT studies could be assessed with RoB, so only 12 were analyzed for bias, excluding case studies.

Due to the nature of the intervention studies, participants could not be blinded to the interventions performed on them, so performance bias was assessed as high risk. All studies were well randomized, and all outcomes were numerical to match the assessment tools set out at the beginning of the study, resulting in reporting bias and selection bias as low risk. In terms of attrition bias, Taradaj et al. [11]'s study had the highest dropout rate (14.63%), six studies had a dropout rate of 10% or more, which was considered high risk, and six studies had no or negligible dropout rate. Ergin et al. [34] was the study with the highest high risk, with four dropouts but no explanation for dropouts, and no blinding of baseline examiners and post-intervention examinees.

DISCUSSION

Compression therapy, which is the standard treatment for lymphedema, is recommended to be used 24 hours a day, but

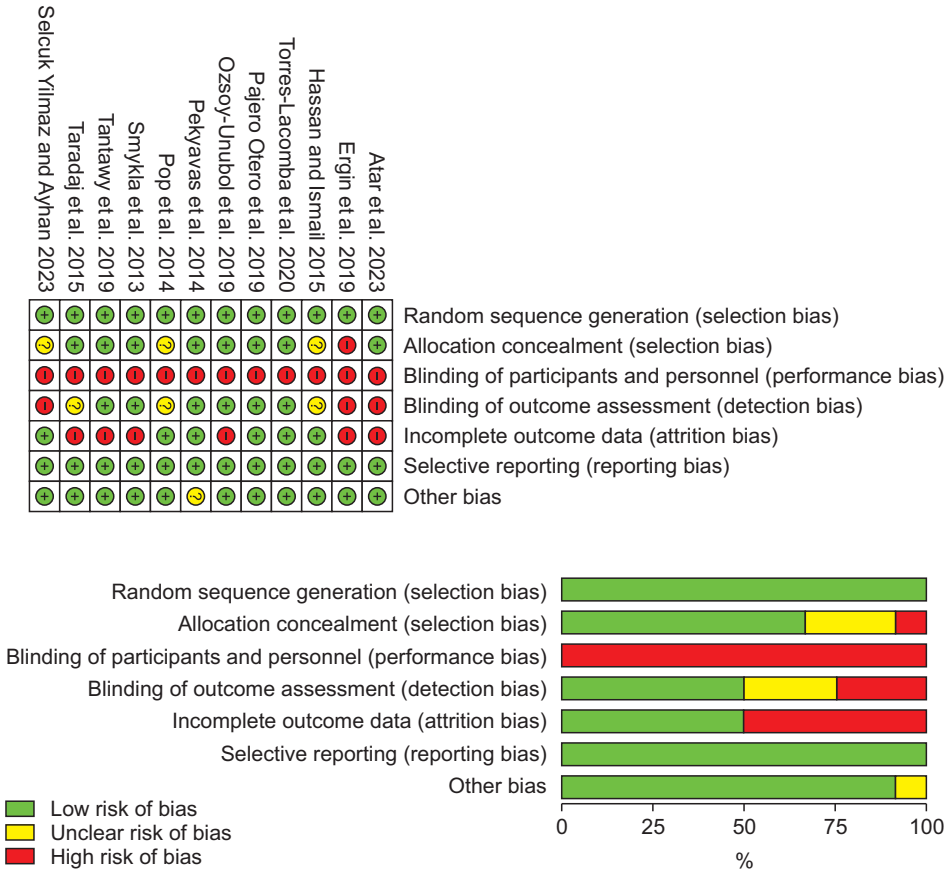

Figure 4. Risk of Bias (RoB) graph.

the quality of life is reduced due to discomfort in daily life activities, as well as failures in implementing compression due to the edema site, the patient's health condition, and hot or humid climatic conditions [4,14,15]. This study was conducted to evaluate through systematic reviews and meta-analyses whether KT therapy is effective and safe as an alternative to compression therapy when managing patients with lymphedema is difficult as described above.

As a result of the analysis, the MLB group showed an advantage over the KT group in reducing the size and volume of edema and the other hand, KT has shown benefits in pain relief and comfort through interventions [28]. Looking at previous studies, a meta-study by Kasawara et al. [43], showed that the KT intervention was effective but did not show better outcomes compared to other control groups. According to a study by Gatt et al. [44], KT was better than the compression group in controlling pain and lymphedema-related symptoms. However, the reduction in volume of edema and comfort were superior in the bandage group, so KT recommended that it should only be used cautiously where bandaging cannot be used. These two meta-analysis studies, like the results of this study, show that KT interventions are effective in managing lymphedema and are superior in pain relief.

In a systematic review and meta-analysis of the effects of KT on myofascial pain syndrome, it was stated that KT is a recommended treatment because it has superior results over other non-invasive treatments in reducing pain intensity and improving ROM [45]. According to Banerjee et al. [18], KT can play an auxiliary role in pain management in cancer treatment, and in a study of 1,083 medical professionals in the United States, 67% reported that pain control was the main reason for employing KT [46]. Other systematic reviews of the effects of KT interventions have also reported that KT is more effective in short-term pain relief compared to controls who received other types of physiotherapy [47-49].

According to the systematic review of this study, when KT was used in combination with other treatments such as MLB, MLD, LLLT, IPC, etc., the results were better than when used alone, furthermore, the combination of bandages and KT had noticeable results. In the only case study in Korea in which KT was applied to lymphedema patients, the combination of additional pad and KT before MLB reduced excess volume by

608 ml (79.5%) during a 2-week inpatient intensive treatment period [24].

In the comparative study of KT and CG group included in this review, the KT intervention was superior or similar. Patients who received KT experienced relief of edema as well as related symptoms and pain, increased ROM, hand grip strength, and quality of life compared to the CG group. In the treatment of the maintenance phase, it has been shown that KT has the potential to effectively replace CG. KT can be a viable alternative for patients who have difficulty wearing CG every day.

Appropriate time of the KT application depending on the stage of edema, can also be an important matter. A suitable time to apply KT to lymphedema treatment is in the early stages when the skin is soft and prone to fluid movement from tissue to lymphatic vessels (until the beginning of stage 2), before the skin tissue becomes fibrotic and hardens into hard adipose tissue [17]. In a study of early BCRL, the control group without any treatment reported an increase in excess volume of 11.5 ml, while the KT intervention group reported a decrease in excess volume of 235.57 ml [50]. Pop et al. [33] reduced the volume by 55% with KT intervention alone in BCRL patients who were in the initial soft edema state. Many patients who have clinical lymphedema but do not have visible swelling are excluded from compression therapy [51]. Considering that the incidence of lymphedema in breast cancer within 1 year after surgery is 71%, KT can be implemented as a preventive treatment if there are subjective symptoms in patients such as edema, heaviness, numbness, and pressure, among others [52].

KT may be applicable in a wide range of circumstances and various cases of patient conditions. In the case studies included in this review, KT was used in arm with A-V fistula patients with kidney dialysis [39,40] or with permanent nerve damage due to diabetes [37], and satisfactory results were achieved with KT intervention alone in palliative care for patients with terminal cancer [38]. KT can be applied in a wide range from early preclinical edema to palliative care. Wee et al. [14] suggested that KT on the toes of women with lower limb lymphedema who have fibrotic skin changes in the feet and toes could effectively reduce fibrotic edema, as it was convenient for patients who had difficulty performing toe bandages due to low back pain. In this review, there were no studies that applied KT to hands, fingers, feet, and toes, but KT therapy, which can be maintained in the shower for 3–5 days once applied, may be a much more comfortable and better alternative than the cotton bandage method that needs to be applied to the fingers or toes every day. Additionally, Tsai et al. [13], noted that KT is effective for BCRL patients in Taiwan's hot and humid summer climate. Wee et al. [14] also revealed that KT was climate-friendly on Singapore's hot weather. Given South Korea's climate environment, where increasingly hot and humid summers persist for a long time, the previous two studies are noteworthy.

In this review, we also reviewed the method of KT intervention likely the direction of KT adhesion and use of anastomosis. There have been several review studies and meta-analyses related to KT, but no studies have examined in detail about the effect of differences in KT intervention methods. González Blanco and Soto González [53] mentioned the region and direction of taping, but this did not lead to a full analysis and was limited to BCRL. Kase et al. [20] and Bosman [17] recommended to apply KT from proximal to distal, with Kase et al. [20] using 10%–15% tension and Sijmonsma [21] and Bosman [17] applying 0% tension [26]. In 20 literatures, both the study using the reverse lymphatic direction and the various KT methods using 0%–25% tension was effective. According to Malicka et al. [50], KT further compared anastomosis with and non-anastomosis groups in a subgroup of the KT intervention group, and anastomosis lengthening showed no additional effect, as in Ergin et al. [34]'s study. A comparison of taping methods in the literature included in this review showed that all of the different taping methods were effective, and it was not clear which method was superior.

Finally, in this study, it was confirmed that KT can be safely applied to the skin of lymphedema patients. A meta-analysis by Gatt et al. [44], found that adverse effects from tape ranged from 10% to 21%. In this review, skin adverse events were reported in nine out of 20 studies between 2.5%–20.68%, whilst no adverse events were reported in 11 studies. Overall, 7.7% of the studies reported adverse skin events, including mild symptoms. Studies using interventions that maintained the tape for 3–5 days, removed it and then took a day or two off reported no adverse skin effects. However, skin damage in patients with lymphedema can be a trigger for worsening edema, so it's important to always check the skin condition while applying KT and it should not be used in patients with a history of allergy to tape adhesives.

As a limitation, this review's exclusion of studies written in

languages other than English and the fact that 80% of the studies were BCRL meant that a wide spectrum of lymphedema patients was not included. Likewise, there were no studies on the application of KT to primary lymphedema or lymphedema around the lower abdomen or genitals. The number of selected literatures and the number of study participants were small, and the risk of bias was identified in the quality assessment of the literature, making it difficult to generalize the effectiveness and safety of the intervention. To identify the various interventional effects of KT and expand its utilization, more studies are needed on lymphedema in other areas besides BCRL. The reliability and validity of the tool for evaluating the effectiveness of the intervention are also factors that can objectively evaluate the effectiveness of KT. If more studies are conducted using standardized intervention protocols, it will be possible to identify the applicable categories and efficacy of KT.

Whether differences in taping methods influence relieving lymphedema symptoms also needs to be confirmed by repeated experiments using larger sample sizes and standardized assessment tools.

CONCLUSIONS

The purpose of this study was to assess through a systematic review and meta-analysis whether KT can be safely and effectively applied to lymphedema patients, and the following points could be confirmed through qualitative and quantitative analysis. In the intensive phase of lymphedema management, which requires volume reduction, KT may not a substitute for bandages (MLB). However, a combined intervention of KT with MLB can be expected to have a greater effect and seems to be useful for pain control. KT may be an alternative method in lymphedema maintenance phase for patients who are contraindicated to use CG. KT may be helpful in the management and prevention of early stage of lymphedema. Although there was no significant difference in the application method of KT, the sample size was small, hence, further research is required in the future to identify the most effective technique.

This is the first systematic review and meta-analysis study in Korea to investigate the role and potential of KT in lymphedema management, serving as a foundation for future studies in this area.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: JY, EJL. Data curation: JY, EJL. Formal analysis: JY, EJL. Investigation: JY, EJL. Methodology: JY, EJL. Project administration: JY, EJL. Resources: JY, EJL. Software: JY, EJL. Supervision: JY, EJL. Validation: JY, EJL. Visualization: JY, EJL. Writing - original draft: JY, EJL. Writing - review & editing: JY, EJL.

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Appendix 1. Search strategy

Database	No.	Search term	Result
Ovid-Embase	1	Population = lymphedema	28,430
	2	Intervention = kinesio taping	3,658
	3	1 AND 2 (synonym select all = 22)	85
Cochrane Library	1	lymphedema	1,775
	2	kinesio* tap*	1,467
	3	elastic tape	421
	4	taping	1,920
	5	athletic tap*	630
	6	lymph tap*	149
	7	1 AND (2 OR 3 OR 4 OR 5 OR 6)	72
CINAHL	1	lymphedema	4,614
	2	kinesio tape OR kinesiotape OR kinesiology tape OR kinesio taping OR kinesiotaping	5,780
	3	taping	2,607
	4	lymphtape or lymphtaping	23
	5	2 OR 3 OR 4	7,680
	6	1 AND 5	65
PubMed	1	lymphedema	18,183
	2	kinesio tape	1,118
	3	taping	9,217
	4	athletic tape	1,003
	5	lymph tape	111
	6	2 OR 3 OR 4 OR 5	9,842
	7	6 AND 7	85
Web of Science	1	lymphedema	11,191
	2	taping	64,217
	3	kinesio* tap*	1,741
	4	athletic tap*	435
	5	lymph tap*	1
	6	2 OR 3 OR 4 OR 5	62,489
	7	1 AND 6	154
RISS	1	lymphedema taping	22
	2	림프테이핑[a]	2
	Total		24
PEDro	1	lymphedema AND kinesio* tap*	18
	(simple)	lymphedema AND taping	75
		(taping, splinting)	
	2	oedema	
	(advanced)	oncology	62
		Clinical trial	
	3	1 AND 2 (duplicated)	75
Google Scholar	Allintitle	lymphedema kinesiotape	6
		lymphedema taping	38
		lymphedema elastictape	2
		lymphedema elastictaping	2
		lymphedema kinesiology tape or lymphedema kinesiology taping	8
	Total		56

[a]This key word is searched in Korean as RISS is a Korean database.