

Compression Therapy for Keloid Scars: A Systematic Review and Meta-analysis

Sadia M. Tahir, MD*
Diane Ihebom, MD*
Richard Simman,
MD, FACS, FACCWS†‡

Background: Keloid scars have a multitude of treatments with varying success rates. The purpose of this systematic review and meta-analysis is to study the different types of compression therapies used following surgical excision and their recurrence rates.

Methods: A literature search was conducted using the following databases: PubMed, Embase, and Cochrane Reviews. The following keywords were used in the search: “keloid” and “compression.” The following inclusion criteria were used: (1) identifying lesion must be a keloid and (2) use of any type of compression therapy for keloid scar.

Results: A total of 27 articles were included in the final analysis, grouped into three treatment modalities for comparison. The three treatment modalities are (1) surgical excision and compression earring, (2) surgical excision and silicone gel sheeting, and (3) surgical excision, compression earring, and silicone gel sheeting. Based on our analysis, combination treatment with compression earring device and silicone gel sheeting had the lowest recurrence rate when compared with compression earring device or silicone gel alone, but the difference in recurrence rates between the three treatment modalities was not statistically significant.

Conclusions: There were too few studies included in each treatment modality with even fewer sample sizes, and there is a need for a greater number of studies with increased sample size to evaluate which therapy is the most efficacious in preventing keloid recurrence following surgical excision. (*Plast Reconstr Surg Glob Open* 2024; 12:e5864; doi: 10.1097/GOX.0000000000005864; Published online 4 June 2024.)

INTRODUCTION

A keloid scar is a benign dermal growth that consists of excessive connective tissue deposition. The scar extends beyond the edges of the original wound, growing over time, and extending into the adjacent dermal tissue. Clinically, keloid scar is a firm irregular growth with a glossy pink to purple surface with occasional telangiectasia.¹ This scar can be anywhere from a few millimeters in diameter to several centimeters.² Keloid scarring commonly occurs on the ears, cheeks, shoulders, chest, upper arms, and upper back.³ They can be symptomatic with associated pruritus, tenderness, and ulceration.⁴ Keloids occur in men and

women equally but are more common in patients with darker skin types.^{5,6} They are commonly seen in patients between 10 and 30 years of age but can develop at any time.⁷ This scar can develop from any skin injury such as surgery, piercing, burns, or insect bites.⁸ Although they are benign, they can cause significant cosmetic disfigurement with associated psychosocial problems.⁹

Keloid scars have a multitude of treatments with varying success rates. These include surgical excision, radiofrequency ablation, compression, steroid injections, lasers, verapamil injections, or a combination of these treatment modalities. Surgical excision alone proved to be ineffective, with a recurrence rate between 45% and 100%, and intralesional steroid injections had recurrence rates between 9% and 50% with various side effects.¹⁰ Compression therapy has been used after removal of keloids to prevent recurrence. Initially reported in the 1960s,¹¹ the pressure from compression is thought to induce a state of hypoxia that causes fibroblast death, preventing the formation of keloids.¹² The compression pressure should be at least 24mm Hg to generate hypoxia.⁵ In addition to fibroblast death, it also increases collagenase activity to stabilize the scar.¹² Another theory is that the pressure causes the release of matrix metalloproteinase-9¹³ and prostaglandin

From the *College of Medicine and Life Sciences, University of Toledo, Toledo, Ohio; †College of Medicine and Life Sciences, Department of Surgery, University of Toledo, Toledo, Ohio; and ‡ProMedica Health Network, Wound Care Program, Jobst Vascular Institute, Toledo, Ohio.

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E2,¹⁴ which may play a role in the remodeling of the scar. The entire mechanism is not completely understood.

Our primary goal is to conduct a systematic review and meta-analysis of compression therapy used to prevent the recurrence of keloid scars following surgical excision, to determine the different types of compression used as well as their recurrence rates.

METHODS

Literature Search

A literature search for this review article was implemented according to the protocol presented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).¹⁵ We conducted a literature search on June 5, 2022 using PubMed, Embase, and Cochrane Reviews. These databases were selected as they are large citation databases, which provided optimal database combinations. We used the following keywords in our search: “keloid” and “compression.” The time frame of the search was 1974 to present. The primary outcome was to determine the compression therapy that produced the lowest keloid recurrence rates following surgical excision.

Eligibility Criteria

The following inclusion criteria were used: (1) identifying lesion must be a keloid and (2) use of any type of compression therapy for keloid scar. The following exclusion criteria were used: (1) articles that stated both hypertrophic and keloid scars, (2) single case reports, (3) not in the English language, (4) letters, (5) and animal or in vitro studies.

Study Selection

The search results of each database were exported into a software program for systematic reviews. Duplicate articles were manually removed. Two blinded independent reviewers applied the inclusion and exclusion criteria to the studies. The first screening included title and abstract screening followed by screening of the full text for eligible studies. Conflicts were resolved by a third reviewer.

RESULTS

Study Selection

A total of 312 articles were retrieved from our database searches. The removal of duplicates yielded 247 articles. Title and abstract screening excluded 199 articles. The full text of the remaining 48 articles was evaluated using the inclusion and exclusion criteria. Another 21 articles were excluded during the full text screening. A total of 27 articles were included in the final analysis, grouped into three treatment modalities for comparison (Fig. 1).

Study Characteristics

The extracted data from the 27 studies included in the final analysis are listed in Table 1. A total of 2281 keloids were identified across all included studies. A total of 2161 keloids were auricular keloids, and 120 were in the head,

Takeaways

Question: This systematic review and meta-analysis is the first of its kind to investigate the data for compression therapy to prevent keloid recurrence following surgical excision.

Findings: Using the PRISMA method for study selection, the combination treatment with compression earring device and silicone gel sheeting had the lowest recurrence rate when compared with compression earring device or silicone gel alone.

Meaning: This combination treatment should be used to prevent keloid recurrence; however, further high-quality studies are needed to evaluate keloid recurrence with a larger sample size.

neck, chest wall, or trunk regions. Three treatment options met our inclusion criteria: (1) surgical excision and compression earring; (2) surgical excision and silicone gel sheeting; and (3) surgical excision, compression earring, and silicone gel sheeting. Only studies whose treatment exclusively involved compression following surgical excision were included. All included studies had a follow-up period of at least 6 months. The data for each treatment modality are listed in Table 2.

Efficacy of Treatment Modalities

Recurrence rates of keloid scars were calculated for each treatment modality using forest plots. A random effects model was used for compression earring treatment, and a fixed effects model was used for silicone gel sheeting treatment as well as combination treatment. Also, 95% confidence intervals (CIs) were calculated and the I^2 statistic was used to assess heterogeneity. The recurrence rate for excision plus compression earring was 10.66% (95% CI, 6.75%–15.33%), $I^2 = 74%$ (Fig. 2). The recurrence rate for excision plus silicone gel sheeting was 12.86% (95% CI, 8.38%–18.59%), $I^2 = 0%$ (Fig. 3). The recurrence rate for excision plus combination treatment with compression earring and silicone gel sheeting was 9.09% (95% CI, 3.79%–17.69%), $I^2 = 0%$ (Fig. 4). Based on our analysis, combination treatment with compression earring device and silicone gel sheeting had the lowest recurrence rate when compared with compression earring device or silicone gel alone, but the difference in recurrence rates between the three treatment modalities was not statistically significant.

DISCUSSION

Wound healing traditionally consists of four stages: hemostasis, inflammation, fibroblast proliferation, and maturation.⁴² The inflammatory phase is characterized by the development of a clot composed of collagen, platelets, and thrombin, which produces hemostasis.⁴² These factors release cytokines that are chemotactic and initiate the inflammatory stage.⁴² Neutrophils and macrophages migrate to the area of injury. Neutrophils aid in the clearing of bacteria and cellular debris.⁴² Macrophages secrete key enzymes and cytokines essential for the transition

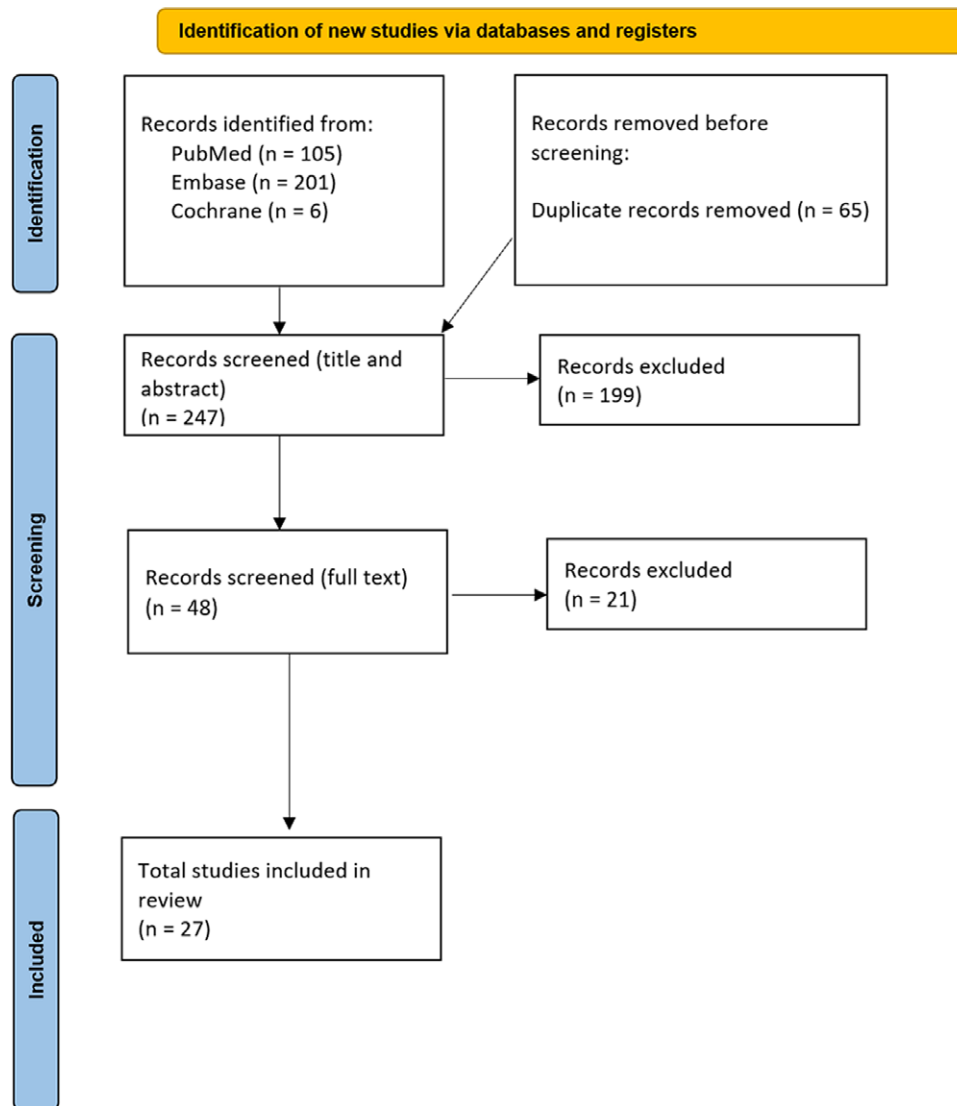


Fig. 1. PRISMA flow diagram of study selection.

of wound healing into the proliferative phase.⁴² These include cytokines such as interleukins and tumor necrosis factor, which stimulate fibroblasts.⁴² In the proliferative stage, fibroblasts migrate to the area of injury, are activated, and begin synthesizing a structural matrix composed of type III collagen, glycosaminoglycans, and fibronectin.⁴² As the wound transitions into the maturation and remodeling stage, there is an increased rate of collagen synthesis as well as degradation, which results in organization and flattening of the scar. When there is an imbalance of collagen synthesis and degradation, a hypertrophic or keloid scar can form.

Keloid scars pose a therapeutic challenge, and though many treatment modalities exist, there is no therapy that is the evidence-based gold standard for the treatment of keloids. Two systematic reviews with meta-analyses have been conducted regarding surgical excision of keloid scars following adjuvant therapy. Shin and colleagues studied a comparison of surgical excision with adjuvant

triamcinolone injections versus surgical excision with adjuvant radiotherapy.⁴³ Recurrence rates were 15.4% (CI, 9.4%–24.1%) and 14% (95% CI, 9.6%–19.9%) respectively, and the authors did not find a significant difference in recurrence rates between these two treatment modalities.⁴³ This review and meta-analysis did not differentiate between primary and recalcitrant keloids or between external beam radiation or brachytherapy. Zawadiuk and colleagues conducted a systematic review and meta-analysis studying recalcitrant auricular keloids specifically.⁴⁴ They collated data from studies that used four treatment modalities: surgical excision with brachytherapy, surgical excision with compression therapy, surgical excision with external beam radiation, and surgical excision with steroid injections.⁴⁴ Recurrence rates were 9% (95% CI, 3%–25%), 14% (95% CI, 12%–17%), 17% (95% CI, 3%–56%), and 18% (95% CI, 4%–53%) respectively.⁴⁴ Zawadiuk and colleagues only studied recalcitrant auricular keloids, and they did not find a

Table 1. Outcome Data Extracted from Included Studies

Study	No. Keloids	Recurrence Rate (%)	Follow-up (Mo)
Surgical excision + compression earring			
Bran et al ¹⁶	8	0 (0%)	24*
Carvalhoes et al ¹⁷	81	3 (5%)	24
Chamaria et al ¹⁸	2	0 (0%)	12
Chavez-Alvarez et al ¹⁹	19	10 (54%)	10*
Christostomidis et al ²⁰	8	0 (0%)	20*
Hassel et al ⁹	10	2 (20%)	18.2*
Hao et al ²¹	98	8 (12.8%)	12
Ho-Asjoe et al ²²	46	0 (0%)	24
Jun et al ²³	22	2 (9.1%)	6
Li et al ²⁴	10	0 (0%)	12*
Mercer et al ²⁵	9	1 (11%)	1–24 months
Park et al ²⁶	1436	152 (10.6%)	18
Park et al ²⁷	80	9 (11.2%)	18
Park et al ²⁸	15	1 (6.7%)	18
Sun et al ²⁹	20	0 (0%)	18
Snyder ³⁰	3	0 (0%)	8
Tanaydin et al ³¹	28	8 (29%)	102*
Tanaydin et al ³²	88	26 (29.5%)	78*
Walliczek et al ³³	37	3 (8.1%)	30*
Yencha et al ³⁴	6	0 (0%)	60*
Surgical excision + silicone gel sheeting			
Agbenorku 2000 ³⁵	120	15 (12.5%)	13
De Sousa et al ³⁶	22	2 (9.1%)	16*
Ramesh et al ³⁷	26	2 (9%)	18
Valdatta et al ³⁸	11	3 (27%)	2-36
Surgical excision + compression earring + silicone gel sheeting			
Akoz et al ³⁹	12	1 (8%)	28*
Masoodi et al ⁴⁰	24	3 (12.5%)	17*
Park et al ⁴¹	40	2 (5%)	18

*Mean no. months.

Table 2. Treatment Collated Data

Treatment	No. Articles	No. Keloids
Compression earring	20	2026
Silicone gel sheeting	4	179
Compression earring + silicone gel sheeting	3	76

significant difference in recurrence rates between these four treatment modalities.⁴⁴ Our systematic review and meta-analysis examined compression therapies of keloids following surgical excision. The three treatment modalities were compression earring device, silicone gel sheeting, and combination treatment with compression earring device and silicone gel sheeting. Similar to Shin and colleagues, our systematic review and meta-analysis did not differentiate between primary and recalcitrant keloids. Unlike both prior systematic reviews which focused on auricular keloids, we included keloids anywhere on the body.

Excision with Compression Earring

The recurrence rate for surgical excision plus compression earring was 10.66% (95% CI, 6.75%–15.33%). These were all auricular keloids. A recent

systematic review found a recurrence rate of 14% (95% CI, 12%–17%).⁴⁴

Compression earring devices were not standardized across studies. The device used, pressure exerted, and treatment duration varied. Most studies recommended patients wear the device for 8–12 hours per day.^{16,23,24,26–29,31–33} The duration of therapy ranged from 1 week to 18 months. Nearly half of the studies required at least 6 months of compression therapy.^{9,18,20,21,23,24,26–29,31–33} Adequate pressures are required to produce the hypoxia necessary to prevent keloid scar recurrence while also avoiding ischemia. The compression pressure should be at least 24mm Hg to generate hypoxia,⁵ and one study provided a range of 24–30 mm Hg.²⁰ Five studies reported the pressure applied by the compression earring.^{17,20,21,23,26} One study decreased the period of application from 1 year to 6 months with pressure maintained between 24 and 30 mm Hg and found it was still effective.²⁰ Another study reports pressures between 10 and 25 mm Hg for more than 8 hours per day for 1 year.²¹ Another study’s device exerted 30 mm Hg pressure 18 hours per day for 4 months.¹⁷ Park and colleagues used a device that exerted 35 mm Hg pressure 12 hours per day for 6 months.²⁶ Jun and colleagues used various magnet sizes, which exerted varying pressures; the bigger the magnet, the greater the pressure.²³ The authors used magnets that exerted 24, 42, and 60 kPa.²³ Park and colleagues’ study had the greatest number of keloids in the sample numbering 1436;²⁶ the other studies ranged between 2 and 120 keloids in the sample size.

All compression therapies require patient agency, and noncompliance with therapy can lead to keloid recurrence. Possible side effects of compression earring devices include pruritus, pain, or dysesthesia as well as skin reactions and pressure lesions with device usage. Patients in one study reported itching.¹⁷ Li and colleagues adjusted the pressure based on the patient’s discomfort and recommended a gradual buildup of therapeutic pressure to allow patients to get accustomed to the device and to minimize discomfort.²⁴ Another study used hydrocolloid dressing between the magnet device and the wound to provide padding and support.²⁸ Four studies measured patient comfort and satisfaction objectively.^{9,31–33} Patients rated the comfort of the ear clip 6.7 of 10 and rated the appearance as 4.7 of 10.³² Walliczek and colleagues measured pruritus, pain, and satisfaction with the compression earring.³³

Compression earrings designed to generate variable pressure can be especially therapeutic.^{22,24,29,31–33} These devices allow for pressure adjustment to strike a balance between hypoxia and ischemia. We can confidently recommend compression earrings as a treatment modality following surgical excision of keloid scars to prevent recurrence. We would recommend usage of compression earring for 8–12 hours a day for at least 12 months. Many of the studies also used intralesional steroids along with the compression earring following surgical excision of keloids. We would recommend supplementing intralesional steroids while monitoring for side effects such as thinning of the skin.

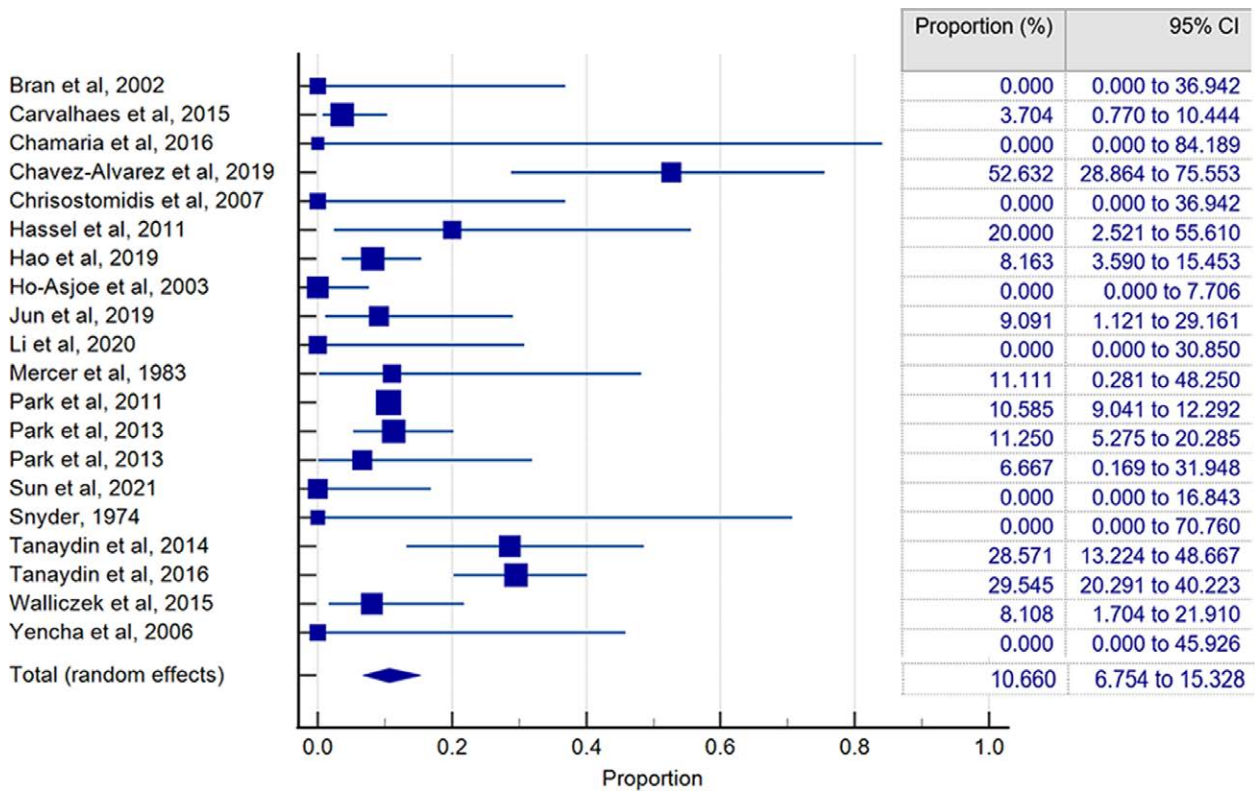


Fig. 2. Forest plot showing the estimated recurrence rate for surgical excision and compression earring.

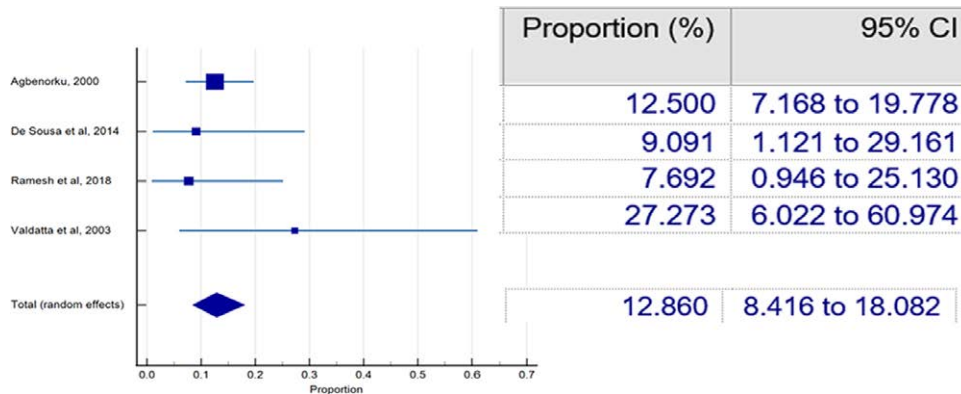


Fig. 3. Forest plot showing the estimated recurrence rate for surgical excision and silicone gel sheeting.

Excision with Silicone Gel Sheetting

The recurrence rate for surgical excision and silicone gel sheetting was 12.86% (95% CI, 8.38%–18.59%). The application of silicone ranged from silicone gel sheetting to liquid silicone gel. Valdatta and colleagues also supplemented with radiotherapy.³⁸ There was only one study in this entire review that did not involve auricular keloids, but they found success with long pressure applications of silicone gel strips and sheets across various body surfaces including the head and neck, chest wall, trunk, and suprapubic area.³⁵ There were a total of four studies included in this category, and more research is needed to determine whether silicone gel sheetting is effective for prevention of keloid recurrence.

Excision with Compression Earring Device and Silicone Gel

The recurrence rate for surgical excision and combination treatment with compression earring device and silicone gel sheetting was 9.09% (95% CI, 3.79%–17.69%). One study used a compression earring that was coated with silicone gel sheet,³⁹ and another study used magnet compression earrings with silicone gel sheetting.⁴¹ A small group of patients complained about pruritus and pain, but the symptoms resolved in the third postoperative week.³⁹ One study included in this category studied giant auricular keloids, with a mean size of 11 cm².⁴⁰ The researchers used several treatment modalities following surgical excision: intraoperative injection of triamcinolone, split-thickness skin grafting,

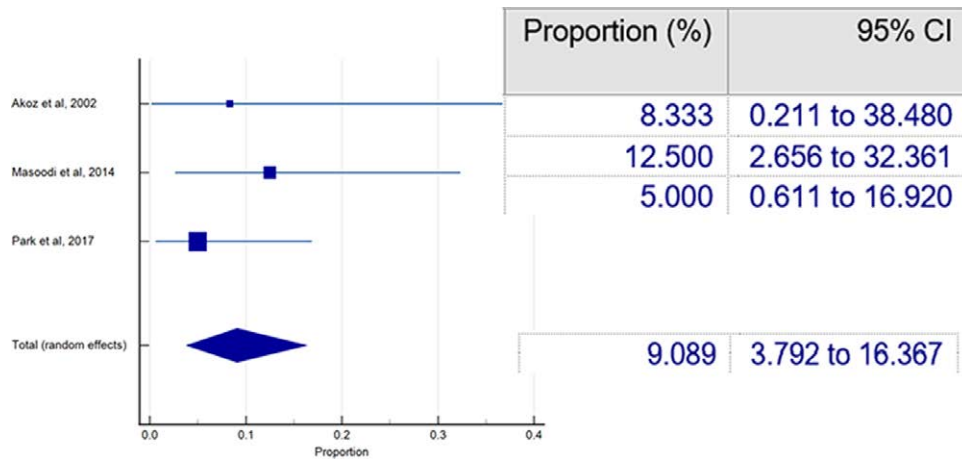


Fig. 4. Forest plot showing the estimated recurrence rate for surgical excision and compression earring plus silicone gel sheeting.

adjuvant radiotherapy, silicone sheets, and plastic clips if necessary.⁴⁰

Other Treatments

Adjunct therapies included intralesional corticosteroids and radiotherapy. We cannot conclude whether the adjunct therapies improved outcomes for patients using compression earrings, silicone gel sheeting, or both, as adjunct therapies were not controlled. Other studies outside this review have used intralesional verapamil. We would recommend supplementing compression earring therapy with intralesional steroid rather than intralesional verapamil, as several studies have shown the increased efficacy and reduced rates of recurrence with the use of intralesional steroid.^{45,46}

LIMITATIONS

This systematic review and meta-analysis is the first of its kind to investigate the data for compression therapy to prevent keloid recurrence following surgical excision. In an attempt to standardize data, we selectively included studies based on the inclusion criteria. There were 27 studies included in the final analysis and many of these studies have a small sample size.^{9,16-41} The sample size of studies in the three different groups can influence the results obtained as one group included a larger number of studies, but in our review, the difference between groups was not statistically significant, so the differences in sample size is not as relevant. The patients treated in each study had varying age, keloid size, and ethnicities, among other variables, which we could not control for. Additionally, the pressure exerted by compression earring device was not reported uniformly by each study, so recommendations cannot be made about the pressure needed to prevent keloid recurrence. More than half of the studies used adjuvant intralesional corticosteroid injection, so this supplementation should be kept in mind when attributing the success specifically to the compression device used.

CONCLUSIONS

The aim of this systematic review was to evaluate the current data on compression therapy for prevention of keloid scars following surgical excision. The variety of therapeutic approaches available for the treatment of keloid scars have not provided a clear answer to this challenge. Based on our analysis, combination treatment with compression earring device and silicone gel sheeting had the lowest recurrence rate, although this difference was not statistically significant. There were too few studies included in this group with even fewer sample sizes, and there is a need for a greater number of studies with increased sample size to evaluate this combination modality. Treatment with surgical excision following silicone gel sheeting resulted in higher recurrence rates, although this difference was not statistically significant. There is a great need for additional high-quality studies evaluating keloid recurrence with a larger sample size. All the studies in this analysis were nonrandomized observational studies, and randomized controlled trials will have greater utility in distinguishing between treatment modalities.

Richard Simman, MD, FACS, FACCS
2109 Hughes Dr., CJT Suite 400
Toledo, OH

E-mail: richard.simmanmd@promedica.org

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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