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EFFECTS OF DERMATOFUNCTIONAL RADIOFREQUENCY THERAPY ON FIBROEDEMA GELOID: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Cellulite, present in 90% of women, affects areas such as the thighs and buttocks, negatively impacting self-esteem. Although it poses no risk to health, current treatments have limited efficacy. Radiofrequency (RF) is a promising alternative, but there is a lack of studies proving its effectiveness in advanced cases.

Objectives: To evaluate the effectiveness of radiofrequency treatments in reducing cellulite, considering improvements in the skin, reduction of adipose tissue, patient satisfaction and methodological limitations of scientific studies. **Methods:** This

systematic review analyzed the effects of RF on gelatoid fibroedema (GEF) considering skin appearance, patient satisfaction and changes in subcutaneous adipose tissue. The search followed the PRISMA⁵ and used PubMed, PEDro and the Cochrane Library. Six studies were included with 163 patients, a mean age of 38.97 years (19-74) and a mean follow-up of 3 months (1-6). **Results:** The six studies analyzed showed mean reductions in cellulite severity ranging from 1.12 ± 0.83 to 4.9 ± 1.9 and a decrease in the thickness of the adipose panicle of up to 2.31 cm. In addition, improvements were seen in skin elasticity with an increase in the R5 index from 0.45 to 0.55, reductions in abdominal circumference ranging from 83.88 cm to 81.96 cm in 12 weeks, while patient satisfaction was high, ranging from 60% to 97% between the studies. **Conclusion:** Radiofrequency treatments are effective in reducing cellulite, improving skin elasticity, texture and rippling, with high patient satisfaction. However, limitations such as small samples (average of 27 participants) and short follow-up (1 to 6 months) highlight the need for more robust, diverse and long-term studies to validate these findings in a generalizable way.

Keywords: Cellulite; Radiofrequency Therapy; Adipose Tissue.

1. INTRODUCTION

Cellulite, or geloid fibroedema (GFE), is a widely prevalent aesthetic condition, affecting approximately 90% of women at some point in their lives, especially after puberty. It causes changes in skin topography, resulting in a dimpled or irregular appearance, often described as an orange peel. This condition is most commonly observed in areas such as the thighs, buttocks, and abdomen and can significantly impact patients' self-esteem and quality of life. The etiology of cellulite is multifactorial, involving hormonal, genetic, and ethnic influences, as well as factors related to body type and adipose tissue distribution.¹

Furthermore, the pathophysiology of GFE involves the hypertrophy of adipose cells and the degeneration of collagen and elastin fibers, which results in the weakening of the skin's supporting structures and, consequently, the appearance of cutaneous depressions. Although this condition does not pose a risk to physical health, it is a major aesthetic concern among women, encouraging the search for increasingly effective treatments. In response to this demand, several therapeutic approaches have

been proposed, from non-invasive methods, such as creams and radiofrequency devices, to invasive procedures, such as liposuction.²

The literature shows that existing cellulite treatments often offer temporary and limited results. Liposuction, for example, while effective in removing localized fat, may not provide lasting improvement in the appearance of cellulite, and in some cases, the condition may return after about a year. Non-invasive treatments, such as topical creams and massages, often demonstrate little long-term effectiveness, reinforcing the need for new therapeutic interventions.³

Among the new therapeutic approaches gaining prominence, radiofrequency (RF) appears to be a promising technique for treating cellulite. RF works by heating the deeper layers of the skin, stimulating collagen production and improving the structure of subcutaneous tissue. The application of radiofrequency, especially minimally invasive bipolar technology combined with microneedling, has shown good results in collagen remodeling and reducing skin depressions, as suggested by preliminary studies.⁴

Despite advances in the use of radiofrequency in the treatment of cellulite, there is still a lack of systematic studies evaluating its efficacy and safety in different stages of the condition, especially in more advanced cases, such as FEG grades II and III.¹⁻⁴ A deeper understanding of how this technology can be applied in different populations and clinical settings remains limited, justifying the need for further research exploring the mechanisms and long-term effects of this therapeutic modality. This review aims to evaluate the effectiveness of radiofrequency-based treatments and associated technologies in reducing cellulite, with an emphasis on improving skin characteristics such as elasticity, texture, and dimpling, as well as reducing adipose tissue thickness in areas such as the thighs and buttocks. To this end, we seek to identify the most relevant results of the interventions described in the scientific literature, considering the feasibility and impact of these treatments on cellulite management. Among the secondary objectives, we highlight the analysis of patient satisfaction with the treatments, seeking to understand their perception of the aesthetic and functional results. Furthermore, we will highlight the limitations of the studies evaluated, such as small sample sizes, short follow-ups, limited number of articles, and possible methodological biases, which may influence the generalizability of the findings. These

aspects are crucial for guiding future research and improving the practical application of these technologies in cellulite treatment. The primary outcome will be to assess whether there is an improvement in the appearance of cellulite, while secondary outcomes include the maintenance of results, as well as improvements in self-esteem and quality of life.

2. METHODS

Search strategies

This systematic review analyzed the effects of functional radiofrequency therapy on geloid fibroedema, taking into account skin appearance, patient satisfaction, and the degree of subcutaneous adipose tissue changes associated with cellulite. A systematic search was conducted following the PRISMA⁵ guidelines using PubMed, PEDro, and the Cochrane Library for studies demonstrating the use of RF for changes in the EGF. A narrative synthesis was performed to assess differences between the factors analyzed in the clinical studies. Six studies with 163 patients, a mean age of 38.97 years, and a mean follow-up of three months were included in the review.

The protocol for this systematic review was prepared using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020⁵ guidelines, the Physiotherapy Evidence Database (PEDro)⁶ scale, and the Grading of Evidence and Strength of Recommendation for Healthcare Decision Making (GRADE)⁷. Eligibility Criteria

The review used the Patient, Intervention, Comparison, and Outcome (PICO) methodology. The PICO criteria in this study included patients of all ages undergoing RF therapy protocols that evaluated changes in EGF. The following inclusion criteria determined whether studies were included for analysis: (1) clinical and/or comparative studies, such as randomized controlled trials (RCTs), clinical trials, cohort studies, or case-control studies that investigated the effect of radiofrequency therapy relative to a control or baseline group; (2) studies that included post-intervention outcomes, such as, but not limited to, assessment of skin appearance, patient satisfaction, degree of subcutaneous adipose tissue change, and other patient-reported outcomes; and (3) patients in whom the procedure was performed for the first time. Exclusion criteria included studies that did not meet all three inclusion criteria and study designs, such

as non-comparative, non-clinical articles, case reports, review articles, animal studies, cadaver studies, expert opinions, abstracts, and commentaries. Studies were also excluded if the articles were not in English and/or Portuguese, and if the full text was not available.

Information Sources and Search Strategy

An electronic search for published, peer-reviewed articles was performed on PubMed, PEDro, and the Cochrane Library, including studies published in the last 10 years.

Data Management

Identified studies were imported into the Rayyan systematic review software (<https://www.rayyan.ai/>). Covidence systematic review software (Covidence, Melbourne, Australia) was used for full-text review, data extraction, and risk of bias assessment.

Data Collection and Analysis

Two independent reviewers screened the titles and abstracts of articles. The selected studies were independently reviewed in full to confirm eligibility. Subsequently, the reviewers evaluated the full texts to independently verify the inclusion and exclusion criteria. In cases of disagreement, a third reviewer was consulted.

Data were independently extracted onto a predefined electronic data collection form, including: study characteristics (author, year of publication, country of origin, study design, start/end date, sample size), patient characteristics (including age, sex, ethnicity), number of participants, number of events, outcomes (definitions, measurement, timing of measurement, duration of follow-up), model development (predictor selection method, model type, model variables), and model performance (calibration, discrimination measures). When measures were not reported, we followed previously described methods to calculate missing performance measures whenever possible. Summary Measures and Data Synthesis

Baseline characteristics are summarized using means with standard deviations, medians with interquartile ranges, and frequencies with percentages, as appropriate. Included studies and overall conclusions were reported through narrative synthesis.

Whenever possible, data are presented in summary tables and graphical representations.

Inclusion and Exclusion Criteria

INCLUSION CRITERIA	
Design	Randomized controlled clinical trials; Clinical trials; Cohort studies or case-control studies; Studies that included desired outcomes after the intervention; Patients in whom the procedure was performed for the first time.
Patients	Humans; Presence of geloid fibroedema
Period	2013-2023
Language	English and Portuguese
Intervention	Radiofrequency Dermatophysiotherapy

EXCLUSION CRITERIA	
Design	Unclear or poorly described methods; Duplicate studies; Incomplete studies; Studies of a different typology than that designed
Patients	Animal studies; Absence of geloid fibroedema

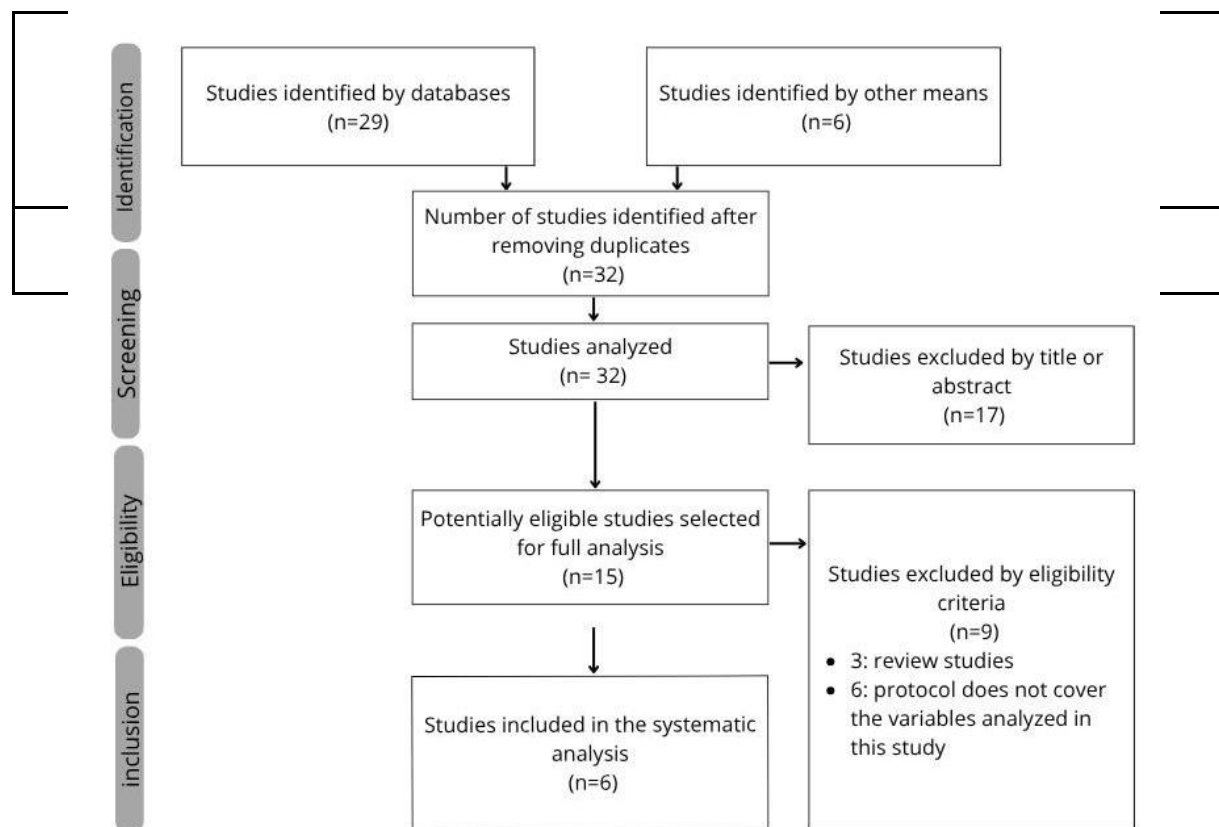


Table 1 - Inclusion and exclusion criteria and main outcomes.

3. RESULTS

The search identified 32 studies, but only six randomized controlled trials were included in this systematic review, involving 129 participants in the sample, as shown in Figure 1. The studies inferred RF treatment using different protocols, and the outcomes are included in Table 1.

Figure 1: Flowchart of the selection of studies included in the systematic review

Descriptive characteristics, such as protocols and main results, were included in Table 1.

Table 1. Study characteristics and outcomes.

study	Database	Country of Origin	Sample Characteristics				Key Findings
			Sex			age	
			N	Men	Female	Average only	
							Variables (there may be more than one)
Alexiades M, et al. (2018)	PubMed	EUA	50	4	46	44 ± 9	Fifty individuals with grade II or III cellulite were treated with subcutaneous radiofrequency with microneedles (67 °C for 4 seconds) at 4 centers. Efficacy was assessed at 1, 3, and 6 months by three blinded dermatologists using standardized photographs. According to the FDA, success was defined as an improvement of at least 1 point on the cellulite scales in evaluations by two of the three experts. Self-assessments, satisfaction questionnaires, pain levels, and adverse events were also recorded. Blinded medical evaluations revealed a 93% success rate for the procedure at the 6-month follow-up. The pain level for the procedure was 3.74 ± 1.96 on a 10-point scale. There were no adverse events. Seventy-five percent of individuals were satisfied with the results at the 6-month follow-up.
Vanitphakdeedecha R, et al. (2018)	PubMed	Thailand	25	0	25	37,56	A multipolar RF device with pulsed magnetic fields was used to treat abdominal cellulite. Twenty-five healthy adult women with stage II or III abdominal cellulite underwent 8 weekly treatments. Assessments were performed at baseline and at weeks 1, 4 and 12 after the final treatment. A reduction in subcutaneous thickness in the axial and sagittal planes of the abdomen was observed 1 week after the start of treatment. The results of the self-reported questionnaires revealed a significantly high level of patient satisfaction (60%). Evaluations by a blinded investigator at one, four, and twelve weeks after the final treatment demonstrated a significant improvement in the appearance of cellulite. No adverse effects were reported, and the treatment was well tolerated.
Nicoletti G, et al. (2017)	PubMed	Italy	19	5	14	31	Twenty Caucasian patients (15 women and 5 men) with 26 mature scars participated in the study. The treatments, performed twice a week for 3 months, used a radiofrequency, electric pulse, and vacuum device. Objective assessments included corneometry, transepidermal water loss, elastometry, colorimetry, and three-dimensional analysis of the skin surface with the MPA and PRIMOS pico systems. Subjective assessments used the VAS and PSAS scales. Scars were compared before and after treatment and with the corresponding contralateral healthy skin. A reduction in scar surface wrinkling and overall scar flattening were demonstrated after treatment. The scar also tended to slightly approach the color and elasticity of healthy skin.

Fritz K, et al. (2018)	PubMed	Germany Bulgaria, Romania	30	0	30	34	A multicenter clinical trial treated 30 women (average age 34 years, BMI 25.9 kg/m ²) with gluteofemoral cellulite using a system that combines monopolar radiofrequency and targeted pressure energy (BTL UNISON). Four weekly treatments of 24 minutes each were performed on an area of 1,000 cm ² , with temperatures of 40-45°C reached in 90 seconds. Standardized photos at baseline and 3 months after treatment were evaluated by blinded experts on a scale of 0 to 4 points. Circumferential measurements of the hip and thigh, weight, and satisfaction (5-point Likert scale) were collected. In five selected patients, ultrasound (Mindray M7, 10 MHz) and infrared thermography analyzed changes before and 3 months after treatment. Statistical analyses used Student's t-tests and Wilcoxon tests with a significance level of 5%.	The combined RF and targeted pressure energy protocol resulted in clinical improvement of 54% ± 24% after 3 months, with visible reduction of cellulite in 93% of cases, especially in moderate to severe cellulite. There was a reduction of 2.31 cm in the hips and 2.13 cm in each thigh (P < 0.001), with no change in average weight. No adverse events were observed, and 97% of patients reported satisfaction (mean 4.47 ± 0.57). Ultrasound showed significant improvement in the dermis (+0.28 mm) and reduction in subcutaneous fat (1.96 mm), while thermography indicated thermal improvement in 2 patients and reduction of irregularities in baseline images.
Albornoz-Cabello M, et al. (2017)	PubMed	Spain	9	0	9	25	This controlled clinical study evaluated radiofrequency treatment with Xculp® equipment (850 kHz, 160 Hz, 8 kV) in relation to the degree of cellulite, adipose panicle thickness, and body circumferences. Cellulite was classified by a specialist using the CSS scale (0 to 15) based on five dimensions: depressions (number and depth), skin appearance, flaccidity/undulations, and the Nürnberger and Müller classification. Adipose tissue thickness was measured by ultrasound (GE Logic-e, 12 MHz probe) in the gluteal, lateral thigh, and posterior thigh regions, with patients standing.	A descriptive analysis showed that the nine participants had a mean age of 25 ± 7.96 years, were all right-handed, with an initial BMI of 25.11 ± 5.17, which decreased to 24.57 ± 5.02 at the end of the study. The recorded temperatures increased after each session, but did not exceed 40°C and remained stable, especially in the treated limb. The Wilcoxon test revealed statistical significance in the final score of the treated limb (p = 0.023), but not in the control limb (p = 0.622).
Busso M, et al. (2023)	PubMed	EUA	30	2	28	46	A prospective clinical study followed participants with grade 2 or 3 cellulite (Nürnberger-Müller Scale), treated with four sessions of 10 to 25 minutes, over 2 to 4 consecutive weeks. The Emtone device (combined TPE and RF) was used on areas such as the hips, thighs, abdomen, and arms. Efficacy was assessed using the Cellulite Severity Scale (CSS), Global Aesthetic Improvement Scale (GAIS), Patient Satisfaction Questionnaire, and circumference measurements. Data were collected at baseline, after treatment, and at 1, 3, and 6-month follow-ups, with statistical analysis (p<0.05).	The improvement in cellulite severity was significantly improved from moderate to mild (p<0.001) in 95% of patients, aesthetic improvement in 90% of participants, reduction in circumference of treated areas (abdomen, hips, and thighs) up to six months after treatment, 86% of participants expressed satisfaction with the improved appearance of cellulite, and 82% reported firmer, less sagging skin in the treated area.

Qualitative Analysis

The methodological quality of the included studies was analyzed using the PEDro scale, whose parameters include: clear definition of eligibility criteria; presence of randomization; concealed subject allocation; initial comparability between subjects for at least the most important prognoses; blinding of participants; blinding of therapists; blinding of evaluators; Measurement of at least one key outcome in 85% of subjects; All subjects for whom outcome measurements were presented received the treatment or control condition according to allocation or, when this was not the case, data were analyzed for at least one of the key outcomes by "intention to treat"; The results of intergroup statistical comparisons were described for at least one key outcome; The study presents both precision and variability measures for at least one key outcome.

Therefore, the scale consists of a checklist composed of 11 items, assessed with "yes" or "no" answers. The final score ranges from 0 to 10, since the first item, related to the eligibility criteria, is not used in the total calculation. Studies with scores lower than 4

were considered to be of low quality, those with scores between 4 and 5 were classified as of fair quality, studies with scores between 6 and 8 as of good quality, and those with scores ≥ 9 as of excellent quality, according to the methodology described by Pouwels et al., 2015 (10).

In the present study, all selected articles had a score greater than or equal to six, as shown in Table 2, indicating a predominant methodological quality classified as good quality.

Table 2. Risk of bias assessment of the included studies.

QUALITY EVALUATION OF THE PEDRO SCALE						
	Alexiades M, et al. (2018)	Wanitphakdeedecha R, et al. (2018)	Nicoletti G, et al. (2017)	Fritz K, et al. (2018)	Albornoz-Cabello M, et al. (2017)	Busso M, et al. (2023)
Eligibility criteria	✓	✓	✓	✓	✓	✓
Randomization	✓	✓	✗	✗	✓	✗
Comparable Groups	✓	✓	✗	✗	✗	✗
Blinding of participants	✗	✗	✓	✓	✓	✗
Blinding of assessors	✓	✓	✗		✓	✗
Blinding of therapists	✗	✗	✓	✗	✗	✓
Intent-to-treat analysis	✓	✗	✓	✓	✗	✓
Reporting results	✓	✓	✓	✓	✓	✓
Statistical results	✓	✓	✓	✓	✓	✓
Conclusions based on results	✓	✓	✓	✓	✓	✓
Score	8/10	7/10	7/10	7/10	7/10	6/10

The quality of the evidence and recommendations for clinical application was classified as low, moderate, or high using the GRADE assessment, as shown in Table 3.

Table 3 – GRADE assessment of included studies.

Study	Year	Study Type	Risk of Bias	Inconsistency	Imprecision	Effect Magnitude	Adverse Effects	Quality of Evidence
Alexiades M. (2018)	2018	Prospective multicenter clinical trial	Moderate	Low	Moderate	High	Few reported	Moderate

Rungsi ma Wanitp hakdee decha (2018)	2018	Randomi zed clinical trial	High	Moderate	High	High	Few reported	Mode
Giovan ni Nicolet ti (2017)	2017	Non- randomiz ed clinical trial	High	High	Moderate	High	Reports of adverse effects	Low
Alborn oz- Cabell o (2017)	2017	Non- randomiz ed clinical trial	High	Moderate	Moderate	Modera te	No adverse effects reported	Mode
Combi ned Monop olar Radiofr equenc y and Target ed Pressu re Energy (2023)	2023	Randomi zed clinical trial	Low	Low	High	High	No adverse effects reported	High

4. DISCUSSION

This systematic review aimed to evaluate the effectiveness of radiofrequency treatments in reducing cellulite, considering skin improvements, adipose tissue reduction, patient satisfaction, and methodological limitations of the scientific studies.

The results of the six studies analyzed demonstrate the effectiveness of radiofrequency-based treatments and associated technologies in reducing cellulite, focusing on improving skin characteristics such as elasticity, texture, and dimpling, in addition to reducing adipose tissue thickness. According to Alexiades et al.,⁸ evaluated the use of microneedling combined with bipolar radiofrequency, demonstrating success in reducing skin dimpling and cellulite severity. At 3- and 6-month follow-ups, the mean reductions in the number of dimples were 1.12 ± 0.83 and 1.06 ± 0.70 , respectively, while the severity of dimples decreased by 0.83 ± 0.51 and 0.60 ± 0.52 . According to Wanitphakdeedecha et al.,⁹ focused on multipolar radiofrequency associated with the pulsed magnetic field, they observed a significant reduction in the thickness of the abdominal adipose tissue ($p < 0.001$) and sustained reductions in abdominal circumference, from 83.88 cm at baseline to 81.96 cm after 12 weeks. These findings confirm the ability of the treatment to reduce adipose tissue thickness and improve the appearance of cellulite without significant changes in body weight. According to Nicolleti et al.,¹⁰ radiofrequency was combined with electrical stimulation and negative pressure, resulting in improvements in skin elasticity, evidenced by an increase in the R5 index from 0.45 to 0.55, as well as improvements in the texture and compactness of the treated areas, even in more resistant conditions, such as mature scars.

Fritz et al.¹¹ examined monopolar radiofrequency in the treatment of the buttocks and thighs, observing a significant reduction in subcutaneous tissue thickness and body mass index, along with an increase in tissue temperature, which reflects the thermal efficiency in adipose tissue mobilization and skin remodeling. According to Cabello et al.,¹² also regarding monopolar radiofrequency, average reductions of 2.31 cm and 2.13 cm were recorded in the hip and thigh circumferences, respectively, in addition to a visible softening of the orange peel appearance, solidifying its effectiveness in the treatment of cellulite. According to Busso et al.,¹³ using a combined protocol of targeted pressure energy and radiofrequency, results were observed that included a significant reduction in cellulite severity and a marked

improvement in skin laxity. The absence of serious adverse effects in all the studies analyzed reinforces the safety of the technologies used. These results confirm that radiofrequency-based treatments meet the main objectives of improving skin quality, including elasticity, texture, dimpling reduction, and decreasing adipose tissue thickness, positioning them as effective and promising approaches for the treatment of cellulite.

Regarding patient satisfaction with radiofrequency treatment, high acceptance was observed among patients, with consistent perceptions of improved aesthetic appearance, reduced cellulite, and improved skin quality, demonstrating its effectiveness over time. The studies included in this review demonstrated largely positive results. Busso et al.¹³ reported an 86% satisfaction rate, with patients noting improvements not only in cellulite but also in sagging and skin quality. This was corroborated by aesthetic assessments performed by independent evaluators, who identified improvements in 90% of participants. Additionally, Fritz et al.¹¹ reported an average satisfaction score of 4.47 ± 0.57 on a 5-point scale, with 97% of participants satisfied three months after treatment. In turn, despite slightly lower rates, Wanitphakdeedecha et al.⁹ demonstrated that 60% of patients reported satisfaction after 12 weeks, suggesting differences in individual perception of results. Although precise numerical data are lacking, other researchers^{10,12} have highlighted positive patient perceptions of improvements in skin quality and the characteristics of treated scars, reinforcing the observed benefits.

Analyses of the studies demonstrated that determining the efficacy of radiofrequency therapy (RFET) treatment for EGD can be hampered by moderate-quality evidence, with only a few randomized clinical trials and well-designed prospective studies addressing this issue.^{8,13} We observed that the studies evaluated had small patient samples, such as those of Cabello et al.¹², presenting a smaller sample size than other studies on the same topic. This may represent a limitation in the probabilistic analysis and the inclusion of different ethnic groups in the articles. Furthermore, the post-treatment follow-up period in each study ranged from none to up to 6 months.^{8,12,13} This short period of time can be considered short enough to confirm the absence of gradual deterioration after treatment or relative stabilization.

LIMITATIONS

Despite the promising results, important limitations were identified in the analyzed studies, including small sample sizes, short follow-up periods, and heterogeneity in methodological designs. The scarcity of randomized clinical trials and well-structured prospective studies hinders a more robust and generalizable analysis, especially in diverse populations. Therefore, the need for future research with greater methodological rigor is evident, aiming to include larger sample sizes, greater ethnic diversity, and long-term follow-ups.

5. CONCLUSION

The results of this systematic review highlight the effectiveness of radiofrequency-based treatments and associated technologies in reducing cellulite and improving key clinical parameters such as skin elasticity, texture, and dimpling, as well as reducing adipose tissue. Studies demonstrate the ability of these therapies to deliver significant results, with high patient satisfaction, and evidence points to growing acceptance of these treatments, not only for cellulite reduction but also for their positive impact on sagging and overall skin quality.

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