REVIEW ARTICLE

Comparative efficacy and safety of chemical peels for acne vulgaris: a systematic review and network meta-analysis of randomized controlled trials

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ABSTRACT

Background: Chemical peels are widely used for mild-to-moderate acne vulgaris, but comparative evidence is dispersed across small trials and multiple active formulations. This review synthesized randomized trial evidence and compared efficacy and tolerability across peel types using network meta-analysis.

Methods: PubMed, the Cochrane Library, Scopus, and Web of Science were searched for randomized active-comparator trials of chemical peels for acne vulgaris up to June 2026. Random-effects network meta-analyses used standardized mean differences (SMDs) for continuous outcomes and risk ratios (RRs) for categorical and safety outcomes, each with 95% confidence intervals (CIs). Salicylic acid was the reference treatment, and treatments were ranked using surface under the cumulative ranking curve (SUCRA) values.

Results: Twenty-three randomized trials with reported enrollment totaling 1,164 participants were included. Most continuous efficacy comparisons were not statistically significant. Relative to salicylic acid, Jessner's solution was associated with a smaller reduction in papule count (SMD 2.49, 95% CI 1.28 to 3.70) and a smaller reduction in Michaelsson acne score (SMD 1.78, 95% CI 0.41 to 3.16). Salicylic plus mandelic acid ranked highest for good improvement (SUCRA 91.9%), but its RR versus salicylic acid was imprecise (RR 1.96, 95% CI 0.75 to 5.13). Trichloroacetic acid was associated with more erythema than salicylic acid (RR 2.74, 95% CI 1.10 to 6.78). Heterogeneity was substantial for non-inflammatory lesion count, papule count, pustule count, and Michaelsson acne score. Treatment-label fragmentation and undocumented handling of split-face correlations limited confidence in rankings.

Conclusion: Our analysis does not establish broad superiority of one chemical peel for acne vulgaris. Salicylic acid performed favorably against Jessner's solution for selected efficacy outcomes and had a lower erythema risk than trichloroacetic acid, but most estimates were imprecise, and several networks were heterogeneous. Treatment choice should remain individualized, and the findings require confirmation in rigorously reported head-to-head trials with standardized outcomes.

Keywords: Acne vulgaris, chemical peel, salicylic acid, glycolic acid, trichloroacetic acid, network meta-analysis, randomized controlled trial.

Introduction

Acne vulgaris is a chronic inflammatory disorder of the pilosebaceous unit characterized by non-inflammatory comedones and inflammatory papules, pustules, nodules, or cysts. It is especially common in adolescents and young adults and may lead to post-inflammatory hyperpigmentation, scarring, psychosocial distress, and impaired quality of life [1]. Its pathogenesis involves follicular hyperkeratinization, increased sebum production, Cutibacterium acnes colonization, and inflammation [2].

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Superficial chemical peeling creates controlled epidermal injury and promotes exfoliation and regeneration. Common agents include alpha-hydroxy acids such as glycolic and mandelic acid; beta-hydroxy acids such as salicylic and lipohydroxy acid; trichloroacetic acid; pyruvic acid; azelaic acid; amino fruit acid; Jessner's solution; and combined formulations. Their keratolytic, comedolytic, anti-inflammatory, and antimicrobial properties make them plausible adjuncts for active acne, but concentration, vehicle, treatment interval, number of sessions, and penetration depth vary considerably [3]. Selection also requires attention to skin phototype and the risk of post-inflammatory dyspigmentation [4].

A 2018 systematic review included 12 randomized controlled trials and concluded that commonly used peels appeared similarly effective and generally well tolerated, while emphasizing small samples, clinical heterogeneity, and the absence of standardized outcomes [5]. Randomized studies have evaluated additional formulations and comparisons, including mandelic acid, combined glycolic-salicylic acid, azelaic acid, and updated salicylic versus trichloroacetic or glycolic acid comparisons [6-8]. The expanded evidence base creates a connected set of active comparisons that can be evaluated using network meta-analysis.

This systematic review and network meta-analysis aimed to compare the efficacy and safety of active chemical peels for acne vulgaris. Outcomes included changes in inflammatory and non-inflammatory lesion counts, papule and pustule counts, Michaelsson acne score, categorical improvement, burning or stinging, erythema, desquamation or exfoliation, and post-inflammatory hyperpigmentation.

Methods

Protocol and reporting

The review was prepared using the PRISMA 2020 statement and the PRISMA extension for network meta-analysis as reporting frameworks [9,10], as well as the Cochrane Handbook for Systematic Reviews and Meta-Analysis [11]. This systematic review and network meta-analysis was not registered in PROSPERO.

Data sources and search strategy

The documented search covered PubMed, the Cochrane Library, Scopus, and Web of Science. Search concepts combined acne vulgaris with terms for chemical peeling and specific agents, including hydroxy acids, glycolic acid, salicylic acid, trichloroacetic acid, pyruvic acid, lipohydroxy acid, mandelic acid, salicylic-mandelic acid, amino fruit acid, azelaic acid, Jessner's solution, resorcinol, and phenol. Reference lists of eligible studies were also used to identify reports. The final literature search was conducted in December 2025. The exact database-specific strings and final search date were retained in Supplementary Table 1.

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Eligibility criteria

Eligible studies were randomized controlled trials, including parallel-group and split-face designs, enrolling participants with active acne vulgaris and directly comparing two or more active chemical peel regimens. The primary network excluded non-randomized and quasi-randomized studies, reviews, studies with a different population or intervention framework, duplicate or overlapping populations, and a placebo-controlled trial that did not contribute to the active-comparator network. Studies focused only on acne scars or post-inflammatory dyschromia, combined peels with non-peel acceleration or device therapies, or lacked usable comparative data were not eligible for the primary network.

Study selection and data extraction

We imported search results from all databases into Rayyan and manually removed duplicates. Four authors independently screened the remaining articles, with disagreements resolved by a fifth reviewer. The review was conducted in two steps: titles and abstracts were first scanned to flag potentially relevant records, after which the complete articles were examined against the inclusion criteria to determine their suitability for the qualitative synthesis and subsequent meta-analysis. Studies with treatment comparisons disconnected from the main network were excluded from the corresponding outcome-specific network meta-analysis.

Four reviewers independently extracted data into structured workbooks containing the study identifier, country, design, sample size, population, treatment arms, schedule, follow-up, efficacy outcomes, safety outcomes, baseline characteristics, and outcome-level means, standard deviations, event counts, and totals. For change outcomes, negative values represented reductions from baseline.

Outcomes

Continuous efficacy outcomes were changed in inflammatory lesion count, non-inflammatory lesion count, papule count, pustule count, and Michaelsson acne score. Categorical outcomes were good, fair, and poor improvement based on the definitions reported by individual trials. Safety outcomes were burning or stinging, erythema or redness, desquamation or exfoliation, and post-inflammatory hyperpigmentation. Because definitions and follow-up times differed across studies, each network should be interpreted as a synthesis of the reported trial endpoints rather than a single uniform time point.

Table 1. *Characteristics of included studies.*

Study	Country	Design	*n*	Population	Comparison	Schedule	wFollow-up	Efficacy	Safety	Main finding
Abdel Meguid [7]	Egypt	Double-blind split-face RCT	20	Mild-moderate facial acne; skin III-V	25% TCA versus 30% SA	4 sessions, every 2 weeks	10 weeks	Lesion counts; improvement	Erythema; exfoliation; PIH	Both effective; TCA favored comedones, SA inflammatory lesions
Abdel Hay [8]	Egypt	Split-face RCT	34	Mild-moderate facial acne; skin III-V	20% SA + 20% azelaic versus 25% TCA	4 sessions, every 2 weeks	8 weeks	Clinical improvement; lesion counts	Burning; erythema; exfoliation; dyspigmentation	Both effective; combined peel had better tolerability
Bae [6]	South Korea	Blinded split-face RCT	13	Men with mild-moderate acne; skin III-IV	30% SA versus Jessner's solution	3 sessions, every 2 weeks	6 weeks	Inflammatory and non-inflammatory lesions	Erythema; dryness; peeling; burning; pigment	SA more effective for non-inflammatory lesions
Chilicka [13]	Poland	Parallel RCT	120	Women aged 18-25 with papulopustular acne	Azelaic versus pyruvic acid	6 sessions, every 2 weeks	12 weeks	SHVSS acne severity	No events reported in extraction	Both reduced symptoms; pyruvic favored oily skin
Dayal [14]	India	Parallel RCT	40	Grade I-II facial acne	30% SA versus Jessner's solution	6 sessions, every 2 weeks	12 weeks	MAS; comedones; papules; pustules	Burning; stinging; erythema; PIH	SA favored comedones and overall acne
Dayal [15]	India	Parallel RCT	50	Grade I-II facial acne	45% mandelic versus 30% SA	6 sessions, every 2 weeks	12 weeks	MAS; lesion counts	Burning; stinging; erythema; PIH	Similar efficacy; mandelic better tolerated
Dayal [16]	India	Parallel RCT	50	Grade I-II facial acne	25% TCA versus 30% SA	6 sessions, every 2 weeks	12 weeks	Lesion counts; MAS	Burning; stinging; erythema	Comparable efficacy; SA had better safety
El Refaei [18]	Egypt	Parallel RCT	40	Mild-moderate acne with pigmentation/scars	20% SA + 10% mandelic versus 35% glycolic	7 sessions, every 2 weeks	20 weeks	MAS; pigmentation; scars	Burning; dryness; desquamation; flare	Combination favored acne and hyperpigmentation
Gul [19]	Pakistan	Parallel RCT	60	Age 13-22; Grade I-II facial acne	25% TCA versus 30% SA	4 sessions, every 4 weeks	12 weeks	MAS; lesion counts	Not reported	SA more efficacious than TCA
How [20]	Malaysia	Double-blind split-face RCT	36	Skin IV-V; mild-moderate acne	Jessner's solution versus 30% SA	3 sessions, every 2 weeks	8 weeks	Lesion counts; MAS; PAHPI	Burning; stinging; exfoliation; PIH	Similar efficacy in skin of color
Ilknur [17]	Turkey	Single-blind split-face RCT	24	Age 13-30; mild-moderate acne	Glycolic versus amino fruit acid	12 sessions, every 2 weeks	24 weeks	Inflammatory/non-inflammatory lesions	Cutaneous tolerability; preference	Similar comedonal efficacy; AFA better tolerated
Jae [22]	South Korea	Evaluator-blind split-face RCT	20	Mild-moderate acne; skin III-IV	50% glycolic + 0.5% SA versus Jessner's	2 sessions, every 2 weeks	4 weeks	Lesion counts; GEA/PGA	Erythema; peeling; stinging; dryness; pigment	Similar efficacy; combination had fewer events
Jaffary [23]	Iran	Single-blind parallel RCT	86	Age 15-40; mild-moderate acne	50% pyruvic versus 30% SA	5 sessions over 8 weeks	8 weeks	Acne severity index; lesion counts	Burning; erythema; scaling; itching; PIH	Both effective
Jartarkar [24]	India	Single-blind parallel RCT	50	Age 15-40; mild-moderate facial acne	20% SA versus 30% mandelic	6 sessions, every 15 days	13 weeks	Inflammatory/non-inflammatory improvement	Erythema; burning; irritation; peeling; PIH	SA favored efficacy; mandelic favored safety
Jeyaraman [21]	India	Parallel RCT	50	Age 18-40; mild-moderate facial acne	30% SA versus 50% glycolic	5 sessions, every 2 weeks	8 weeks	Acne severity; lesion counts	Burning; itching; redness; scaling	Both effective; SA favored inflammatory lesions
Karim [25]	India	Prospective randomized study	40	Mild-moderate acne by GAGS	70% glycolic versus 30% SA	6 sessions, every 2 weeks	12 weeks	GAGS; photography	Minor adverse events	Both improved acne; SA showed greater reduction
Kessler [27]	USA	Double-blind split-face RCT	20	Age 13-38; mild-moderately severe acne	30% glycolic versus 30% SA	6 sessions, every 2 weeks	18 weeks	Papule and pustule counts	Redness; scaling; peeling; crusting; PIH	Similar efficacy; SA sustained effect and fewer events
Khan [26]	Pakistan	Parallel RCT	120	Age 15-40; mild-moderate acne; skin IV-V	35% glycolic versus 30% SA	Every 2 weeks over 8 weeks	12 weeks	Acne severity index reduction	Not reported	SA more effective than glycolic
Kim 1999 [28]	South Korea	Evaluator-blind split-face RCT	26	Age 16-27; mild-moderate acne; skin III-IV	70% glycolic versus Jessner's solution	3 sessions, every 2 weeks	6 weeks	Cunliffe acne grade	Erythema; exfoliation	Similar efficacy; glycolic caused less exfoliation
Levesque [30]	USA	Evaluator-blind split-face RCT	20	Adults with comedonal acne	Lipohydroxy acid versus SA	6 sessions, every 2 weeks	12 weeks	Non-inflammatory lesion count	Global tolerance; erythema; scaling; dryness	Similar comedonal efficacy
Sankeerthana [31]	India	Open-label single-blind RCT	100	Adults with Grade I-II acne	40% mandelic versus 30% SA	4 sessions, every 2 weeks	8 weeks	Michaelsson severity; lesions	Erythema; dryness; burning	SA favored efficacy; mandelic favored tolerability
Sarkar [32]	India	Three-arm parallel RCT	45	Mild-moderate active acne with pigmentation	35% glycolic versus SA-mandelic versus phytic	6 sessions, every 2 weeks	12 weeks	Lesions; MAS; pigmentation	Burning; postprocedure erythema	All three effective
Takharya [29]	India	Parallel RCT	100	Age 15-45; Grade I-II facial acne	40% mandelic versus 30% SA	6 sessions, every 2 weeks	12 weeks	MAS; total lesion reduction	Burning; dryness; erythema; pruritus	Similar efficacy; mandelic better tolerated

Risk of bias

Four investigators independently appraised the risk of bias in each eligible trial using the Cochrane Risk-of-Bias 2 (RoB 2) framework [12]. The evaluation addressed the five standard domains: (i) bias arising from the randomization process, (ii) bias due to deviations from the intended intervention, (iii) bias owing to missing outcome data, (iv) bias in the measurement of outcomes, and (v) bias in the selection of the reported result. Judgments were made separately for every prespecified outcome, with every decision explicitly justified and logged in a shared template. Disagreements were discussed until consensus was reached; if consensus could not be achieved, a senior reviewer adjudicated.

Statistical analysis

The analyses used random-effects network meta-analysis. Continuous outcomes were expressed as SMDs with 95% CIs, and categorical and safety outcomes as RRs with 95% CIs. Salicylic acid was used as the reference treatment in the forest plots. For lesion-count and score reductions, an SMD below zero favored the listed treatment over salicylic acid; an SMD above zero favored salicylic acid. For good improvement, an RR above 1 favored the listed treatment. For poor improvement and adverse events, an RR below 1 favored the listed treatment.

Treatment rankings were summarized using SUCRA values. Heterogeneity was reported using I^2, τ^2, and Cochran's Q. The analysis software and version was R 4.3.3. An audit of treatment names identified inconsistent capitalization, spacing, and naming for some clinically equivalent regimens, resulting in fragmented network nodes in the supplied analysis. Such duplicates must be harmonized, and the affected networks re-estimated before SUCRA ranks are treated as definitive. For dichotomous outcomes, a continuity correction of 0.5 was applied when a zero-event occurred in one treatment arm. When the standard deviation of a change score was unavailable, it was calculated from the reported mean change, sample size, and two-sided p value when the p value was derived from a paired t-test. When this calculation was not possible, the standard deviation was imputed from a clinically comparable study using the same assessment scale and follow-up duration, and the robustness of this assumption was evaluated in sensitivity analyses.

Results

Study selection

The searches identified 1,857 records: 365 from PubMed, 146 from the Cochrane Library, 967 from Scopus, and 379 from Web of Science. After 639 duplicates were removed, 1,218 records were screened, and 1,167 were excluded. Fifty-one full-text reports were sought, and all were retrieved. Twenty-eight reports were excluded: four reviews, 22 reports with a different PICO, and two duplicate or overlapping populations. Twenty-three randomized studies were included in the systematic review and meta-analysis (Figure 1) [6-8,13-32].

Characteristics of included studies

The 23 trials were published from 1999 to 2025 and reported enrollment totaling 1,164 participants. Individual sample sizes ranged from 13 to 120. Nine studies used randomized split-face designs, and the remainder used parallel-group comparisons. Studies were conducted in India ($n = 9$), Egypt ($n = 3$), South Korea ($n = 3$), Pakistan ($n = 2$), the United States ($n = 2$), and one each in Iran, Malaysia, Poland, and Turkey. Most participants had mild-to-moderate facial acne; several studies restricted enrollment to Fitzpatrick skin types III-V or to women. Treatment courses ranged from two sessions over four weeks to 12 sessions over 24 weeks, and follow-up ranged from 4 to 24 weeks (Table 1). Additional baseline characteristics of the included studies are presented in Supplementary Table 2.

Abbreviations: AFA, amino fruit acid; GAGS, Global Acne Grading System; MAS, Michaelsson acne score; PAHPI, postacne hyperpigmentation index; PIH, post-inflammatory hyperpigmentation; RCT, randomized

Table 2. *Summary of network meta-analysis results.*

Outcome	Comparisons	Measure	Key result versus salicylic acid (95% CI)	Highest SUCRA	I^2
Inflammatory lesions	8	SMD	Pyruvic acid versus SA: −0.11 (−0.66 to 0.43); no significant contrast	Pyruvic acid, 74.8%	0.0%
Non-inflammatory lesions	11	SMD	LHA versus SA: −0.11 (−2.28 to 2.06); no significant contrast	SA, 67%	91.9%
Papule count	5	SMD	Jessner's versus SA: 2.49 (1.28 to 3.70), $p < 0.001$	Mandelic acid, 84%	72.4%
Pustule count	5	SMD	Pyruvic acid versus SA: −0.46 (−2.58 to 1.65); no significant contrast	Pyruvic acid, 70%	92.5%
Michaelsson acne score	7	SMD	Jessner's versus SA: 1.78 (0.41 to 3.16), $p = 0.011$	SA, 74%	92.0%
Good improvement	13	RR	SA + mandelic versus SA: 1.96 (0.75 to 5.13); no significant contrast	SA + mandelic, 91.9%	56.9%
Fair improvement	11	RR	Glycolic + SA versus SA: 5.06 (1.16 to 22.05); intermediate category	Glycolic + SA, 83%	0.0%
Poor improvement	13	RR	SA + mandelic versus SA: 0.43 (0.06 to 3.01); no significant contrast	SA + mandelic, 78%	0.0%
Burning or stinging	11	RR	Mandelic versus SA: 0.46 (0.15 to 1.36); no significant contrast	Mandelic acid, 84%	58.9%
Erythema or redness	16	RR	TCA versus SA: 2.74 (1.10 to 6.78), $p = 0.030$	SA + azelaic, 90%	0.0%
Desquamation/exfoliation	8	RR	No significant contrast; duplicate Jessner's nodes	Unreliable	44.0%
Post-inflammatory hyperpigmentation	10	RR	Mandelic versus SA: 0.14 (0.01 to 2.63); no significant contrast	Mandelic acid, 84%	0.0%

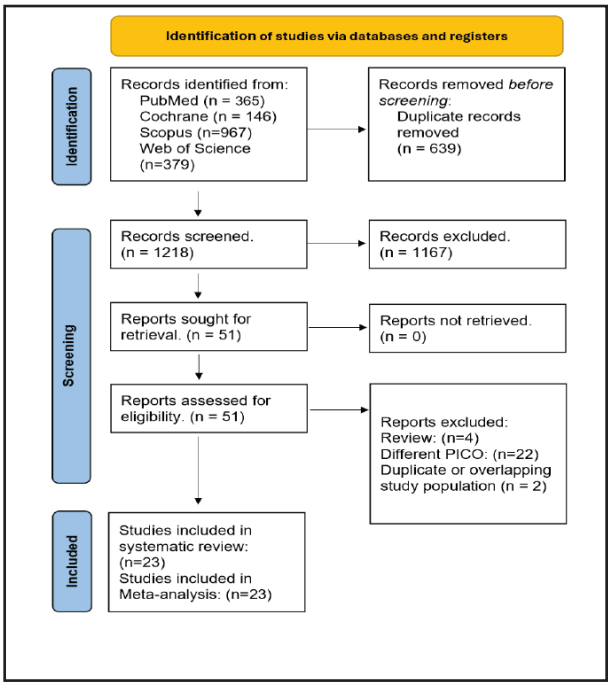


Figure 1. *PRISMA 2020 flow diagram. The searches identified 1,857 records; 23 randomized studies were included in the systematic review and network meta-analysis.*

controlled trial; SA, salicylic acid; TCA, trichloroacetic acid.

Salicylic acid was the most common comparator and connected networks involving glycolic acid, mandelic acid, pyruvic acid, trichloroacetic acid, Jessner's solution, lipohydroxy acid, amino fruit acid, azelaic acid, and combination peels. Outcome reporting was uneven as eight studies contributed inflammatory-lesion data, 11 contributed non-inflammatory-lesion data, five each contributed papule and pustule counts, seven contributed Michaelsson acne score, and between 8 and 16 comparisons contributed individual safety outcomes.

Risk of bias

The risk-of-bias assessment using the Cochrane RoB 2 framework covered all 23 included randomized trials. Five studies were judged to be at low risk of bias, 12 raised some concerns, and six were judged to be at high risk of bias. High-risk judgments were commonly associated with concerns related to the randomization process or side allocation, with additional concerns involving missing outcome data or outcome measurement in selected studies. Concerns about the selection of reported results were frequent (Supplementary Figure S1).

Continuous efficacy outcomes

The continuous-outcome networks were mostly centered around salicylic acid, which acted as the main comparator across inflammatory lesions, non-inflammatory lesions, papule count, pustule count, and Michaelsson acne score (Figure 2).

For change in inflammatory lesion count, no treatment differed significantly from salicylic acid. Pyruvic acid ranked highest (SUCRA 75%) but had an imprecise estimate versus salicylic acid (SMD −0.11, 95% CI −0.66 to 0.43; $p = 0.689$). Jessner's solution did not differ statistically significantly from salicylic acid (SMD 0.00, 95% CI −0.40 to 0.41; $p = 0.998$). Heterogeneity was negligible ($I^2 = 0.0\%$; $\tau^2 = 0$; Q $p = 0.5388$) (Figure 3a).

For non-inflammatory lesion count, no treatment differed significantly from salicylic acid. Lipohydroxyacid had SMD −0.11 (95% CI −2.28 to 2.06; $p = 0.923$), while Jessner's solution had SMD 1.13 (95% CI −0.15 to 2.41; $p = 0.084$). Salicylic acid ranked highest (SUCRA 67%), closely followed by lipohydroxyacid (SUCRA 64%). Heterogeneity was substantial ($I^2 = 91.9\%$; $\tau^2 = 1.1282$; Q $p < 0.0001$) (Figure 3b).

For papule count, mandelic acid ranked highest (SUCRA 84%) but did not differ significantly from salicylic acid (SMD −0.39, 95% CI −1.43 to 0.66; $p = 0.468$). Jessner's solution was associated with a significantly smaller papule reduction than salicylic acid (SMD 2.49, 95% CI 1.28 to 3.70; $p < 0.001$). Heterogeneity was moderate to substantial ($I^2 = 72.4\%$; $\tau^2 = 0.2026$; Q $p = 0.0570$) (Figure 3c).

For pustule count, no treatment differed significantly from salicylic acid. Pyruvic acid ranked highest (SUCRA 70%) with SMD −0.46 (95% CI −2.58 to 1.65; $p = 0.668$), whereas trichloroacetic acid ranked lowest and showed a nonsignificant trend toward less favorable outcomes (SMD 1.05, 95% CI −0.45 to 2.55; $p = 0.171$). Heterogeneity was substantial ($I^2 = 92.5\%$; $\tau^2 = 1.0856$; Q $p = 0.0003$) (Figure 3d).

For the Michaelsson acne score, salicylic acid and mandelic acid had similar favorable rankings (SUCRA 74% and 73%, respectively). Mandelic acid did not differ from salicylic acid (SMD −0.01, 95% CI −1.07 to 1.04; $p = 0.978$). Jessner's solution was associated with a significantly smaller score reduction than salicylic acid (SMD 1.78, 95% CI 0.41 to 3.16; $p = 0.011$). Heterogeneity was substantial ($I^2 = 92.0\%$; $\tau^2 = 0.8187$; Q $p < 0.0001$) (Figure 3e).

Categorical improvement

For good improvement, no treatment differed significantly from salicylic acid. Salicylic plus mandelic acid ranked highest (SUCRA 92%; RR 1.96, 95% CI 0.75 to 5.13; $p = 0.170$), followed by trichloroacetic acid (SUCRA 63%; RR 1.04, 95% CI 0.65 to 1.68; $p = 0.867$) and salicylic acid (SUCRA 62%). Heterogeneity was moderate ($I^2 = 56.9\%$; $\tau^2 = 0.0580$; Q $p = 0.0307$) (Figure 4a).

For fair improvement, the event was significantly more frequent than with salicylic acid for glycolic plus salicylic acid (RR 5.06, 95% CI 1.16 to 22.05; $p = 0.031$), glycolic acid (RR 4.63, 95% CI 1.33 to 16.11; $p = 0.016$), and Jessner's solution (RR 4.14, 95% CI 1.53 to 11.19; $p = 0.005$). These findings should be interpreted cautiously because fair improvement is an intermediate response category rather than a clearly favorable endpoint. Heterogeneity was negligible ($I^2 = 0.0\%$; $\tau^2 = 0$; Q $p = 0.4120$) (Figure 4b).

For poor improvement, no treatment differed significantly from salicylic acid. Salicylic plus mandelic acid ranked

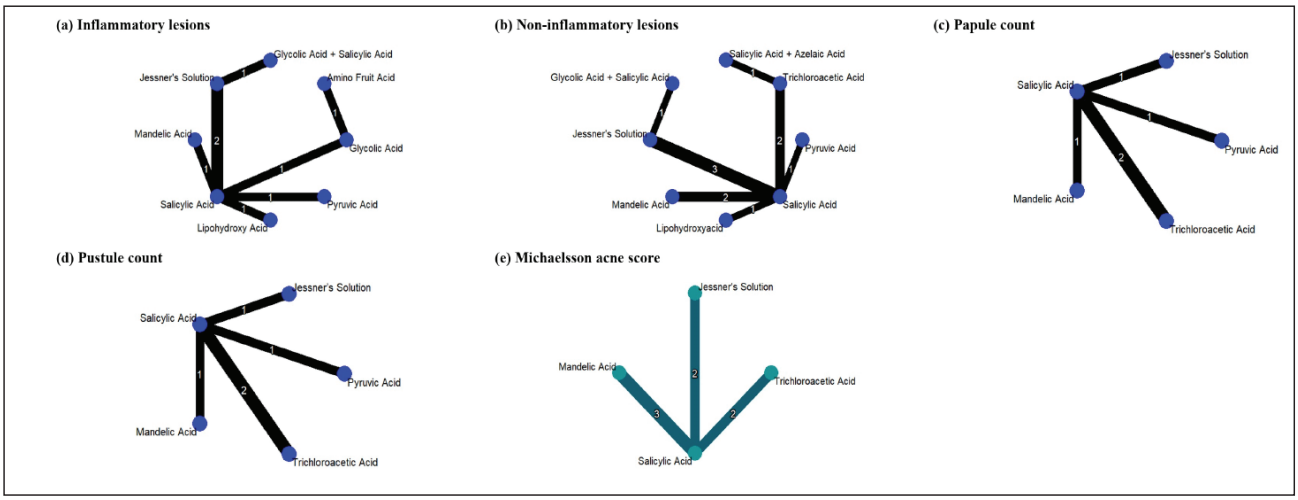


Figure 2. *Network geometry for continuous efficacy outcomes: (a) inflammatory lesion count, (b) non-inflammatory lesion count, (c) papule count, (d) pustule count, and (e) Michaelsson acne score. Node size reflects the amount of evidence and edge width reflects the number of direct comparisons.*

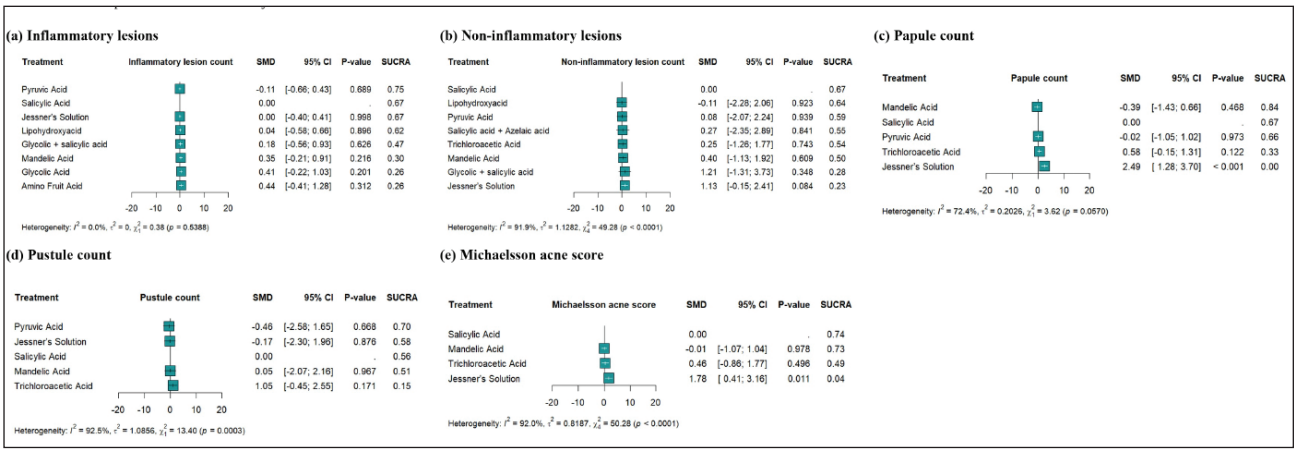


Figure 3. *Random-effects network meta-analysis for continuous efficacy outcomes: (a) inflammatory lesion countw, (b) non-inflammatory lesion count, (c) papule count, (d) pustule count, and (e) Michaelsson acne score. Standardized mean differences are presented relative to salicylic acid with 95% confidence intervals and SUCRA values.*

highest for avoiding poor improvement (SUCRA 78%; RR 0.43, 95% CI 0.06 to 3.01; $p = 0.395$), but the estimate was highly imprecise. Pyruvic acid also ranked favorably (SUCRA 74%; RR 0.52, 95% CI 0.12 to 2.19; $p = 0.370$). Heterogeneity was negligible ($I^2 = 0.0\%$; $\tau^2 = 0$; Q $p = 0.9895$) (Figure 4c).

Safety and tolerability

For burning or stinging, no treatment differed significantly from salicylic acid. Mandelic acid ranked most favorably (SUCRA 84%; RR 0.46, 95% CI 0.15 to 1.36; $p = 0.158$), while glycolic acid showed a nonsignificant trend toward more symptoms (RR 2.56, 95% CI 0.88 to 7.46; $p = 0.084$). Heterogeneity was moderate ($I^2 = 58.9\%$; $\tau^2 = 0.5283$; Q $p = 0.0451$) (Figure 5a).

For erythema or redness, trichloroacetic acid was associated with significantly more events than salicylic acid (RR 2.74, 95% CI 1.10 to 6.78; $p = 0.030$). Salicylic plus azelaic acid ranked most favorably (SUCRA 90%), although the estimate was imprecise (RR 0.13, 95% CI 0.01 to 2.47; $p = 0.174$). Heterogeneity was negligible ($I^2 = 0.0\%$; $\tau^2 = 0$; Q $p = 0.5036$) (Figure 5b).

For desquamation or exfoliation, no treatment differed significantly from salicylic acid. Jessner's solution ranked favorably in one node (SUCRA 82%; RR 0.33, 95% CI 0.01 to 12.09; $p = 0.549$), whereas another Jessner's-solution node showed an opposite nonsignificant direction (RR 11.75, 95% CI 0.94 to 146.37; $p = 0.056$), indicating unstable ranking due to sparse and inconsistent evidence. Heterogeneity was moderate ($I^2 = 44.0\%$; $\tau^2 = 0.8390$; Q $p = 0.1815$) (Figure 5c).

For post-inflammatory hyperpigmentation, no comparison reached statistical significance. Mandelic acid ranked most favorably (SUCRA 84%; RR 0.14, 95% CI 0.01 to 2.63; $p = 0.190$), while trichloroacetic acid showed a nonsignificant trend toward more events (RR 2.88, 95% CI 0.83 to 10.06; $p = 0.097$). Heterogeneity

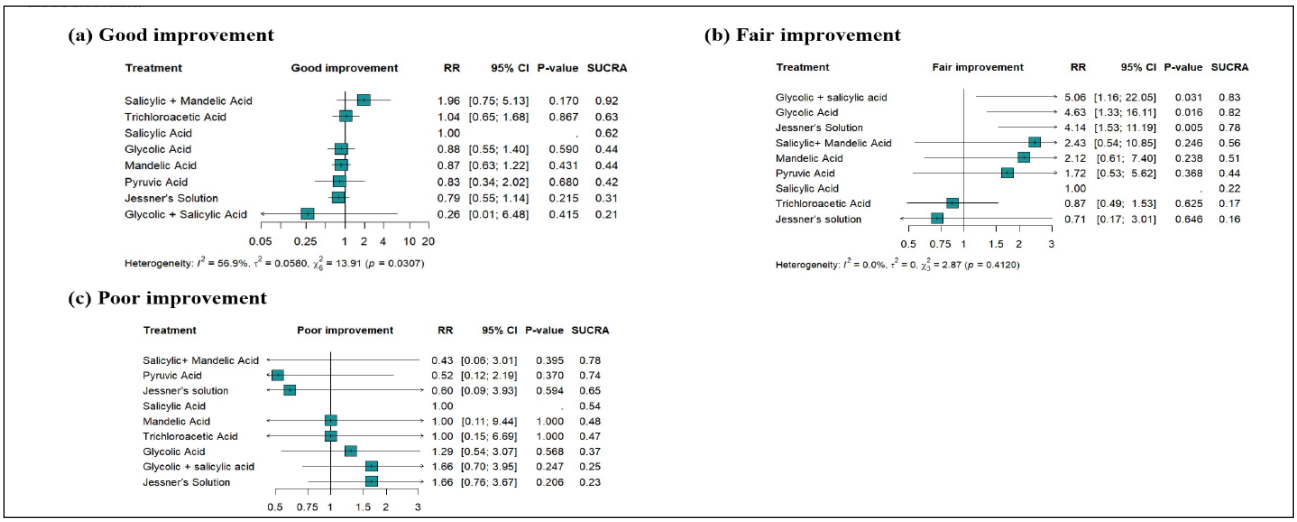


Figure 4. *Random-effects network meta-analysis for categorical improvement: (a) good improvement, (b) fair improvement, and (c) poor improvement. Risk ratios are presented relative to salicylic acid with 95% confidence intervals and SUCRA values.*

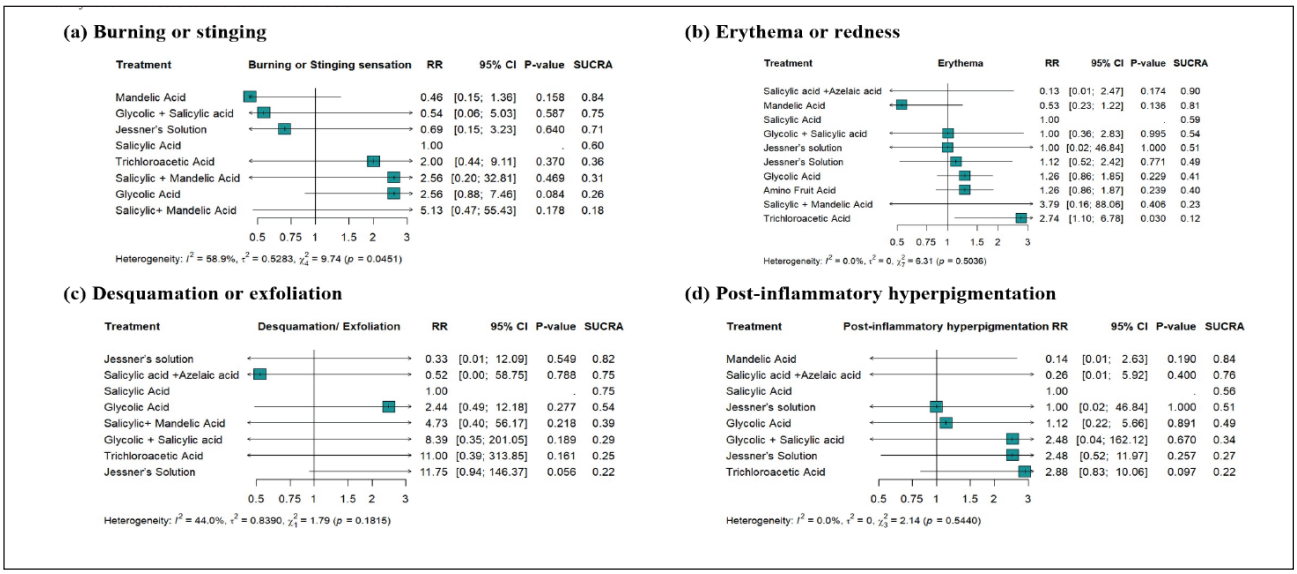


Figure 5. *Random-effects network meta-analysis for safety outcomes: (a) burning or stinging, (b) erythema or redness, (c) desquamation or exfoliation, and (d) post-inflammatory hyperpigmentation. Risk ratios are presented relative to salicylic acid with 95% confidence intervals and SUCRA values.*

was negligible (I^2 = 0.0%; τ^2 = 0; Q p = 0.5440) (Figure 5d).

A comparative summary of outcome-specific network results is provided in Table 2.

For continuous reductions, negative SMDs favor the listed treatment over salicylic acid. For good improvement, RR > 1 favors the listed treatment. For poor improvement and adverse events, RR < 1 favors the listed treatment. Rankings from networks with treatment-label fragmentation should be interpreted cautiously.

Discussion

This network meta-analysis synthesized 23 randomized trials comparing active chemical peels for acne vulgaris. Three findings merit attention. First, the evidence did not identify a peel that was consistently superior across efficacy and safety outcomes. Second, salicylic acid was favored over Jessner's solution for papule reduction and Michaelsson acne score and was associated with less erythema than trichloroacetic acid. Third, most remaining estimates were imprecise, and several apparently favorable rankings were not accompanied by statistically convincing treatment effects. The results therefore support selective, outcome-specific interpretation rather than a single treatment hierarchy.

The findings extend the 2018 systematic review, which judged commonly used peels to be broadly similar but could not pool the trials because of clinical heterogeneity [5]. The larger network now permits indirect comparison,

yet it does not overturn that cautious conclusion. The advantage of salicylic acid over Jessner's solution for selected outcomes is directionally consistent with individual trials in which salicylic acid performed well for comedonal or inflammatory lesions [6,14,20]. By contrast, the network did not show a reproducible advantage for glycolic acid, mandelic acid, pyruvic acid, or combination peels across outcome domains. This pattern suggests that any comparative benefit may depend on the lesion type and regimen rather than on a universal superiority of one agent.

The agent-specific results should not be overstated. Salicylic acid is lipophilic, keratolytic, and comedolytic and can penetrate the pilosebaceous unit, properties that support its performance in papular and comedonal acne [33]. Glycolic acid acts primarily through epidermal exfoliation and altered corneocyte cohesion [34]. Jessner's solution combines several keratolytic constituents, whereas trichloroacetic acid produces concentration-dependent protein coagulation and a more intense controlled injury [35]. These differences explain greater erythema with trichloroacetic acid, but mechanism alone cannot establish comparative clinical efficacy [36].

The distinction between absence of evidence and evidence of equivalence is central to this review. Most CIs crossed the null, but many were wide enough to include clinically important benefit and harm. No significance in these small networks therefore does not demonstrate that treatments are equivalent. SUCRA values must be interpreted similarly, as they estimate rank probabilities under the fitted model but do not measure effect magnitude, clinical importance, or certainty. Salicylic plus mandelic acid illustrates the problem, ranking first for good improvement despite a wide confidence interval. The fair-improvement endpoint is additionally ambiguous because more patients in an intermediate category can coexist with fewer patients achieving a good response.

In particular, a higher SUCRA value does not establish the clinical superiority of a peel when the corresponding relative effect is imprecisely estimated, or its confidence interval overlaps the null. Treatment ordering should therefore remain exploratory rather than a basis for definitive comparative claims.

Clinical and statistical heterogeneity further constrain interpretation. Concentrations, vehicles, neutralization procedures, session intervals, treatment duration, follow-up, baseline severity, and outcome definitions varied across trials. High I^2 values for non-inflammatory lesions, papules, pustules, and Michaelsson acne score indicate that the connected evidence network was not clinically homogeneous. Network meta-analysis also assumes that effect modifiers are sufficiently comparable across treatment comparisons. Combining split-face and parallel-group trials without documented within-person correlations may have produced CIs that are too narrow or too wide [11].

In split-face trials, outcomes measured on opposite facial halves are paired within participants. Because the within-person correlations were not consistently available in the trial reports and could not be verified in the supplied analysis specifications, the precision of pooled estimates from those studies may be misstated. A reanalysis incorporating appropriate paired estimates or a prespecified correlation sensitivity analysis would strengthen confidence in the network findings.

Burning, stinging, erythema, desquamation, and pigmentary change were the most frequently reported events. Only erythema showed a statistically significant treatment difference, with greater risk for trichloroacetic acid than salicylic acid. This limitation is particularly important in darker skin phototypes, for which post-inflammatory hyperpigmentation may be more clinically consequential [37,38]. Rare or delayed events cannot be excluded because follow-up was short and adverse-event definitions were inconsistent. Under-detection of harms is a recognized problem in randomized trials [39].

For practice, peel selection should be individualized by lesion pattern, skin phototype, previous tolerability, desired recovery time, concentration, and clinician experience rather than chosen from the rank order alone. Salicylic acid is a defensible active comparator and may be preferred when papular acne or concern about trichloroacetic acid-associated erythema is prominent. Mandelic acid and combination peels remain reasonable alternatives when tolerability is prioritized, but their high rankings do not yet establish superior efficacy. All agents require appropriate patient selection, pre-peel assessment, photoprotection, and monitoring for irritation and dyspigmentation [36].

This review has several strengths. It evaluates both efficacy and tolerability and uses network methods to integrate a set of active comparisons that cannot be summarized by conventional pairwise meta-analysis alone. Study characteristics, outcome estimates, treatment rankings, and heterogeneity statistics are reported together, allowing the reader to distinguish statistically significant effects from rank probabilities.

The manuscript also has some limitations. Follow-up times and outcome definitions differed, several networks were highly heterogeneous, and publication bias could not be assessed reliably in small networks. Incomplete reporting of randomization and blinding in the trial reports further weakens causal confidence [40]. These findings should therefore be regarded as an exploratory synthesis of the supplied analysis rather than definitive comparative-effectiveness evidence.

Additional uncertainty arises from treatment-label fragmentation: different text labels for potentially identical peeling regimens may have been treated as separate network nodes. The affected treatment rankings must be interpreted cautiously until the labels are harmonized, and the network estimates are recomputed.

Future trials should use concealed randomization, blinded outcome assessment where feasible, prespecified adverse-event definitions, and reporting consistent with nonpharmacologic-trial standards [40]. Core outcomes should include standardized inflammatory and non-inflammatory lesion counts, a validated global severity measure, patient-reported benefit, post-inflammatory

hyperpigmentation, and follow-up beyond the treatment course. Split-face studies should report paired analyses and within-person correlations. Comparative trials should also prespecify peel concentration, vehicle, neutralization, session interval, concomitant skin care, and skin-phototype strata.

Conclusion

Across 23 randomized trials, chemical peels generally improved mild-to-moderate acne. Salicylic acid was favored over Jessner's solution for papule reduction and Michaelsson acne score and was associated with less erythema than trichloroacetic acid. Most other comparisons were inconclusive, and rankings were limited by heterogeneity, imprecision, and data-quality concerns. Treatment should be individualized, and definitive ranking requires prospectively registered trials with standardized outcomes, harmonized treatment definitions, and longer follow-up across diverse skin phototypes.

List of Abbreviations

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Supplementary content (If any) is available online.

References

1. Guguluș DL, Vâță D, Popescu IA, Pătrașcu AI, Halip IA, Mocanu M, et al. The epidemiology of acne in the current era: trends and clinical implications. Cosmetics. 2025;12(3):106. https://doi.org/10.3390/cosmetics12030106
2. Reynolds RV, Yeung H, Cheng CE, Cook-Bolden F, Desai SR, Druby KM, et al. Guidelines of care for the management of acne vulgaris. J Am Acad Dermatol. 2024;90(5):1006.e1–1006.e30. https://doi.org/10.1016/j.jaad.2023.12.017
3. Dréno B, Fischer T, Perosino E, Poli F, Viera M, Rendon M, et al. Expert opinion: efficacy of superficial chemical peels in active acne management - what can we learn from the literature today? evidence-based recommendations. J Eur Acad Dermatol Venereol. 2011;25(6):695–704. https://doi.org/10.1111/j.1468-3083.2010.03852.x
4. Salam A, Dadzie OE, Galadari H. Chemical peeling in ethnic skin: an update. Br J Dermatol. 2013;169 Suppl 3:82–90. https://doi.org/10.1111/bjd.12535
5. Chen X, Wang S, Yang M, Li L. Chemical peels for acne vulgaris: a systematic review of randomised controlled trials. BMJ Open. 2018;8(4):e019607. https://doi.org/10.1136/bmjopen-2017-019607
6. Bae BG, Park CO, Shin H, Lee SH, Lee YS, Lee SJ, et al. Salicylic acid peels versus jessner's solution for acne vulgaris: a comparative study. Dermatol Surg. 2013;39(2):248–253. https://doi.org/10.1111/dsu.12018
7. Abdel Meguid AM, Elaziz Ahmed Attallah DA, Omar H. Trichloroacetic acid versus salicylic acid in the treatment of acne vulgaris in dark-skinned patients. Dermatol Surg. 2015;41(12):1398–1404. https://doi.org/10.1097/dss.0000000000000522
8. Abdel Hay R, Hegazy R, Abdel Hady M, Saleh N. Clinical and dermoscopic evaluation of combined (salicylic acid 20% and azelaic acid 20%) versus trichloroacetic acid 25% chemical peel in acne: an RCT. J Dermatolog Treat. 2019;30(6):572–7. https://doi.org/10.1080/09546634.2018.1484876
9. Hutton B, Salanti G, Caldwell DM, Chaimani A, Schmid CH, Cameron C, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. Ann Intern Med. 2015;162(11):777–84. https://doi.org/10.7326/m14-2385

10. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71

11. Monash University. Cochrane handbook for systematic reviews of interventions [Internet]. 2019 [cited 2026 Feb 23]. Available from: https://research.monash.edu/en/publications/cochrane-handbook-for-systematic-reviews-of-interventions/

12. Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898. https://doi.org/10.1136/bmj.l4898

13. Chilicka K, Rogowska AM, Szyguła R, Dzieńdziora-Urbińska I, Taradaj J. A comparison of the effectiveness of azelaic and pyruvic acid peels in the treatment of female adult acne: a randomized controlled trial. Sci Rep. 2020;10(1):12612. https://doi.org/10.1038/s41598-020-69530-w

14. Dayal S, Amrani A, Sahu P, Jain VK. Jessner's solution vs. 30% salicylic acid peels: a comparative study of the efficacy and safety in mild-to-moderate acne vulgaris. J Cosmet Dermatol. 2017;16(1):43–51. https://doi.org/10.1111/jocd.12266

15. Dayal S, Kalra KD, Sahu P. Comparative study of efficacy and safety of 45% mandelic acid versus 30% salicylic acid peels in mild-to-moderate acne vulgaris. J Cosmet Dermatol. 2020;19(2):393–399. https://doi.org/10.1111/jocd.13168

16. Dayal S, Singh S, Sahu P. Efficacy and safety of 25% trichloroacetic acid peel versus 30% salicylic acid peel in mild-to-moderate acne vulgaris: a comparative study. Dermatol Pract Concept. 2021;11(3):e2021063. https://doi.org/10.5826/dpc.1103a63

17. İlknur T, Demirtaşoğlu M, Biçak MÜ, Özkan Ş. Glycolic acid peels versus amino fruit acid peels for acne. J Cosmet Laser Ther. 2010;12(5):242-245. https://doi.org/10.3109/14764172.2010.514919

18. El Refaei AM, Abdel Salam HA, Sorour NE. Salicylic-mandelic acid versus glycolic acid peels in egyptian patients with acne vulgaris: journal of the egyptian women's dermatologic society. Journal of the Egyptian Women's Dermatologic Society. 2015;12(3):196–202. https://doi.org/10.1097/01.ewx.0000464740.18592.42

19. Gul K, Muzaffar B, Siddiqui MA, Hussain M, Ilyas S, Farid H. Comparative efficacy of 25% trichloroacetic acid peel versus 30% salicylic acid peel in mild to moderate acne vulgaris. Pak Armed Forces Med J. 2025;75(5):850–4. https://doi.org/10.51253/pafmj.v75i5.9910

20. How KN, Lim PY, Wan Ahmad Kammal WSL, Shamsudin N. Efficacy and safety of jessner's solution peel in comparison with salicylic acid 30% peel in the management of patients with acne vulgaris and postacne hyperpigmentation with skin of color: a randomized, double-blinded, split-face, controlled trial. Int J Dermatol. 2020;59(7):804–812. https://doi.org/10.1111/ijd.14948

21. Jeyaraman B, Kunjaram G, Thomas J, A M AJ. A comparative study of 30% salicylic acid peel and 50% glycolic acid peel in mild to moderate acne vulgaris. IJCED. 2025;11(1):121–5. https://doi.org/10.18231/j.ijced.2025.018

22. In Jae J, Dong Ju H, Dong Hyun K, Yoon MS, Lee HJ. Comparative study of buffered 50% glycolic acid (PH 3.0) + 0.5% salicylic acid solution vs jessner's solution in patients with acne vulgaris. In: Jae J, Dong Ju H, Dong Hyun K, Yoon MS, Lee HJ. 2018. pp. 797–801

23. Jaffary F, Faghihi G, Saraeian S, Hosseini SM. Comparison the effectiveness of pyruvic acid 50% and salicylic acid 30% in the treatment of acne. J Res Med Sci. 2016;21(1):31. https://doi.org/10.4103/1735-1995.181991

24. Jartarkar S, Gangadhar B, Mallikarjun M, Manjunath P. A randomized, single-blind, active controlled study to compare the efficacy of salicylic acid and mandelic acid chemical peel in the treatment of mild to moderately severe acne vulgaris. Clin Dermatol Rev. 2017;1(1):15.

25. Karim MF, Agarwal R, Ali S, Sahu VK, Yadav R, Jhad MK. Comparative study on the efficacy of 70% glycolic acid versus 30% salicylic acid peel in the management of mild to moderate acne vulgaris. J Neonatal Surg. 2025;14(31S):667–72. Available from: https://www.jneonatalsurg.com/index.php/jns/article/view/7244/6283

26. Khan FN, Saeed W, Ain QU, Mansoor M, Niazi N, Imtiaz A. Comparison of the outcome of 35% glycolic acid and 30% salicylic acid peels in treatment of patients with acne vulgaris. PJMHS. 2022;16(4):150–2. https://doi.org/10.53350/pjmhs22164150

27. Kessler E, Flanagan K, Chia C, Rogers C, Anna Glaser D. Comparison of alpha- and beta-hydroxy acid chemical peels in the treatment of mild to moderately severe facial acne vulgaris. Dermatol Surg. 2008;34(1):45–50; discussion 51. https://doi.org/10.1111/j.1524-4725.2007.34007.x

28. Kim SW, Moon SE, Kim JA, Eun HC. Glycolic acid versus Jessner's solution: which is better for facial acne patients?: a randomized prospective clinical trial of split-face model therapy. Dermatol Surg. 1999;25(4):270–273. https://doi.org/10.1046/j.1524-4725.1999.08251.x

29. Dileep J, Takharya R, Oudeacoumar P, Kaliyaperumal D, Sadasivam I, Dsouza L. Comparison of efficacy of 40% mandelic acid with 30% salicylic acid peels in mild-to-moderate acne vulgaris: a randomized study. Turk J Dermatol. 2023;17(2):44. https://doi.org/10.4103/tjd.tjd_106_22

30. Levesque A, Hamzavi I, Seite S, Rougier A, Bissonnette R. Randomized trial comparing a chemical peel containing a lipophilic hydroxy acid derivative of salicylic acid with a salicylic acid peel in subjects with comedonal acne: comparison of chemical peels in comedonal acne. J Cosmet Dermatol. 2011;10(3):174–178. https://doi.org/10.1111/j.1473-2165.2011.00566.x

31. P Sankeerthana Shea M. A randomized control trial to compare the efficacy and safety of 40% mandelic acid peel with 30% salicylic acid peel in acne vulgaris. IJSR. 2024;13(3):1624–31. https://doi.org/10.21275/sr24211200829

32. Ghunawat S, Sarkar R, Garg V. Comparative study of 35% glycolic acid, 20% salicylic-10% mandelic acid, and phytic acid combination peels in the treatment of active acne and postacne pigmentation. J Cutan Aesthet Surg. 2019;12(3):158–163. https://doi.org/10.4103/jcas.jcas_135_18

33. Arif T. Salicylic acid as a peeling agent: a comprehensive review. Clin Cosmet Investig Dermatol. 2015;8:455–61. https://doi.org/10.2147/ccid.s84765

34. Sharad J. Glycolic acid peel therapy - a current review. Clin Cosmet Investig Dermatol. 2013;6:281–8. https://doi.org/10.2147/ccid.s34029

35. Kontochristopoulos G, Platsidaki E. Chemical peels in active acne and acne scars. Clin Dermatol. 2017;35(2):179–182. https://doi.org/10.1016/j.clindermatol.2016.10.011

36. Jackson A. Chemical peels. Facial Plast Surg. 2014;30(1):26–34. https://doi.org/10.1055/s-0033-1364220

37. Al-Waiz MM, Al-Sharqi AI. Medium-depth chemical peels in the treatment of acne scars in dark-skinned individuals. Dermatol Surg. 2002;28(5):383–387. https://doi.org/10.1046/j.1524-4725.2002.01081.x

38. Handog E, Datuin MS, Singzon I. Chemical peels for acne and acne scars in asians: evidence based review. J Cutan Aesthet Surg. 2012;5(4):239–46. https://doi.org/10.4103/0974-2077.104911

39. Wahab I, Pratt N, Kalisch L, Roughead E. The detection of adverse events in randomized clinical trials: can we really say new medicines are safe? Curr Drug Saf. 2013;8(2):104–13. https://doi.org/10.2174/15748863113089990030

40. Boutron I, Altman DG, Moher D, Schulz KF, Ravaud P. CONSORT statement for randomized trials of nonpharmacologic treatments: a 2017 update and a CONSORT extension for nonpharmacologic trial abstracts. Ann Intern Med. 2017;167(1):40–7. https://doi.org/10.7326/m17-0046