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COMPARATIVE EFFICACY AND SAFETY OF 35% GLYCOLIC ACID PEEL VERSUS 10% TRICHLOROACETIC ACID PEEL IN FACIAL MELASMA: A PROSPECTIVE SPLIT-FACE STUDY

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ABSTRACT **Background:** Melasma is a chronic acquired facial hypermelanosis with substantial psychosocial impact and frequent therapeutic recurrence. Chemical peels are commonly used adjuncts, but comparative evidence between glycolic acid (GA) and trichloroacetic acid (TCA) in darker skin phototypes remains clinically relevant. **Objective:** To compare the efficacy and safety of 35% GA peel and 10% TCA peel in patients with facial melasma. **Methods:** This prospective comparative split-face study included 100 patients with clinically diagnosed facial melasma. Each patient received 35% GA peel on one side of the face and 10% TCA peel on the opposite side. Three peeling sessions were performed at three-week intervals after sunscreen priming. Melasma Severity Scale (MSS) scores were recorded at baseline and at follow-up visits, with final assessment three weeks after the third session. Adverse effects including erythema, burning and post-inflammatory hyperpigmentation (PIH) were documented. **Results:** The mean age was 32.9 +/- 6.7 years and 87% were female. Mean disease duration was 44.8 +/- 29.6 months. Centrofacial melasma was the most common clinical pattern (55%), and mixed type was the most common Wood's lamp pattern (46%). In the GA arm, mean MSS decreased from 1.93 +/- 0.70 at baseline to 0.66 +/- 0.86 at the final visit, representing a 65.8% reduction ($p < 0.001$). In the TCA arm, mean MSS decreased from 1.93 +/- 0.70 to 0.49 +/- 0.67, representing a 74.6% reduction ($p < 0.001$). TCA showed significantly lower MSS scores at Visit 3 ($p = 0.0065$) and final visit ($p = 0.0431$). Erythema, burning and PIH occurred in 23%, 25% and 8% of GA-treated sides and in 31%, 28% and 13% of TCA-treated sides, respectively.**Conclusion:** Both 35% GA and 10% TCA peels were effective for facial melasma. TCA produced a slightly greater late-phase reduction in MSS scores but had higher inflammatory adverse effects and PIH. GA offered substantial improvement with better tolerability. Treatment selection should be individualized according to melasma severity, patient tolerance and PIH risk.

KEYWORDS : Glycolic acid; trichloroacetic acid; chemical peel; melasma; post-inflammatory hyperpigmentation; split-face study.

INTRODUCTION

Melasma is an acquired disorder of facial hypermelanosis characterized by symmetric, irregular, light-to-dark brown macules and patches over cosmetically sensitive, sun-exposed areas of the face. Although medically benign, it is often chronic, relapsing and psychologically distressing, particularly among women in reproductive age groups [1-3].

The etiopathogenesis of melasma is multifactorial. Ultraviolet exposure remains a major external trigger, while genetic predisposition, hormonal modulation, thyroid dysfunction, inflammatory signaling, vascular changes and basement membrane disruption contribute to persistence and relapse [4-10]. These mechanisms help explain why melasma behaves as a disorder of pigmentary homeostasis rather than simple pigment excess.

Management traditionally includes photoprotection, topical depigmenting agents and combination topical regimens. However, delayed response, irritation, incomplete clearance, poor adherence and relapse are frequent limitations [16,17,21,25,26]. Chemical peeling offers a procedural adjunct by promoting controlled epidermal exfoliation, accelerating removal of melanin-laden keratinocytes and enhancing the effect of maintenance therapy [19,24].

Among superficial peels, glycolic acid (GA) and trichloroacetic acid (TCA) are widely used because of their availability, cost-effectiveness and reproducible clinical response. GA, an alpha-hydroxy acid, produces controlled corneocyte separation and gradual epidermal remodeling, whereas TCA induces protein coagulation and regeneration, often producing a faster pigment response but with greater irritancy potential [11-14,18,19,24]. In darker skin phototypes, the balance between efficacy and risk of post-inflammatory hyperpigmentation (PIH) is particularly important [22,23]. The present study compared 35% GA peel and 10% TCA peel using a prospective split-face design in patients with facial melasma.

MATERIALS AND METHODS

Study design and setting

This was a prospective comparative split-face study conducted in the Department of Dermatology, MNR Medical College and Hospital, Sangareddy. Each participant served as their own control, with one half of the face treated with 35% GA peel and the other half treated with 10% TCA peel.

Study population

A total of 100 patients with clinically diagnosed facial melasma were enrolled. Patients of either sex aged 18 years or above who were willing to provide written informed consent were included.

Eligibility criteria

Patients aged 18 years or above with facial melasma were included. Exclusion criteria were known hypersensitivity to GA or TCA, active facial infection, impaired skin barrier, pregnancy, lactation, recent use of depigmenting creams within four weeks, use of photosensitizing drugs, current oral contraceptive pill use, hair dye application and sebomelanosis.

Baseline evaluation

A detailed history and clinical examination were recorded in a structured proforma. Variables included age, gender, duration of melasma, site of onset, pattern of progression, previous treatment history, sun exposure, precipitating factors, family history and associated conditions. Melasma was clinically classified as centrofacial, malar, mandibular or mixed. Wood's lamp examination was performed to classify melasma as epidermal, dermal or mixed. Baseline MSS score was recorded separately for both sides of the face.

Intervention protocol

All patients underwent two weeks of priming using broad-spectrum sunscreen before peeling. A skin sensitivity test was performed on the neck prior to facial application. Each patient then received 35% GA on

one side of the face and 10% TCA on the opposite side. Three peeling sessions were performed at three-week intervals. Clinical photographs and MSS scores were recorded at baseline and at each follow-up visit. Final evaluation was performed three weeks after the third session.

Outcome Measures

The primary outcome measure was change in MSS score from baseline to the final visit for both treatment arms. Secondary outcomes were between-arm efficacy comparison and adverse effects, including erythema, burning sensation and PIH.

Statistical Analysis

Data were entered in Microsoft Excel and analyzed using SPSS version 22. Quantitative variables were summarized using mean and standard deviation. Categorical variables were summarized using frequencies and percentages. Friedman test was used to assess within-arm changes across visits. Paired comparative analysis was used to compare GA and TCA arms at corresponding visits. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Institutional Ethics Committee approval was obtained before study initiation. Written informed consent was obtained from all participants. Confidentiality was maintained throughout the study, and participants were allowed to withdraw at any time without affecting routine care.

RESULTS

Baseline characteristics

All 100 enrolled patients completed the treatment protocol and follow-up. The mean age was 32.9 +/- 6.7 years, with a range of 19 to 48 years. The majority were in the 31-40 year age group (55%), followed by 21-30 years (33%). Females constituted 87% of the cohort and males 13%.

Melasma was long-standing in most patients. The mean duration was 44.8 +/- 29.6 months, and 36% had disease duration longer than five years. The most common site of onset was the cheeks (29%), followed by forehead (20%), jawline (19%), upper lip (18%) and nose (14%). Most patients reported gradual progression (68%). Moderate daily sun exposure of 2-6 hours was reported by 57% of participants. Pregnancy-related worsening or onset was reported by 16%, history of oral contraceptive pill use by 13%, thyroid dysfunction by 14% and family history by 26%.

The most common clinical pattern was centrofacial melasma (55%), followed by malar (27%), mixed (10%) and mandibular (8%). On Wood's lamp examination, mixed type was most frequent (46%), followed by epidermal (40%) and dermal type (14%). Baseline characteristics are summarized in Table 1.

Table 1. Baseline demographic and clinical characteristics of study participants (N = 100).

Characteristic	Category	n (%)
Age group	<=20 years	2 (2.0)
	21-30 years	33 (33.0)
	31-40 years	55 (55.0)
	41-50 years	10 (10.0)
Sex	Female	87 (87.0)
	Male	13 (13.0)
Duration of melasma	<1 year	5 (5.0)
	1-3 years	35 (35.0)
	3-5 years	24 (24.0)
	>5 years	36 (36.0)
Progression	Gradual	68 (68.0)
	Relapsing	21 (21.0)
	Rapid	11 (11.0)
Sun exposure	<2 hours/day	29 (29.0)
	2-6 hours/day	57 (57.0)
	>6 hours/day	14 (14.0)
Pregnancy-related onset/worsening	Yes	16 (16.0)
History of OCP use	Yes	13 (13.0)
Thyroid dysfunction	Yes	14 (14.0)
Family history	Yes	26 (26.0)

OCP, oral contraceptive pill.

Table 2. Melasma distribution and Wood's lamp classification.

Variable	Category	n (%)
Site of onset	Cheeks	29 (29.0)
	Forehead	20 (20.0)
	Jawline	19 (19.0)
	Upper lip	18 (18.0)
	Nose	14 (14.0)
Clinical pattern	Centrofacial	55 (55.0)
	Malar	27 (27.0)
	Mixed	10 (10.0)
	Mandibular	8 (8.0)
Wood's lamp type	Epidermal	40 (40.0)
	Dermal	14 (14.0)
	Mixed	46 (46.0)

Treatment response

Both treatment arms demonstrated progressive reduction in MSS scores across visits. In the GA arm, mean MSS decreased from 1.93 +/- 0.70 at baseline to 0.66 +/- 0.86 at the final visit, corresponding to a 65.8% reduction. The decline across visits was statistically significant ($p < 0.001$, Friedman test).

In the TCA arm, mean MSS decreased from 1.93 +/- 0.70 at baseline to 0.49 +/- 0.67 at final visit, corresponding to a 74.6% reduction. This within-arm reduction was also statistically significant ($p < 0.001$, Friedman test).

Between-arm comparison showed no baseline difference, as expected in the split-face design. At Visit 2, the TCA arm had a slightly lower mean MSS than the GA arm, but the difference was not statistically significant ($p = 0.0858$). At Visit 3 and final visit, TCA showed significantly lower MSS scores than GA ($p = 0.0065$ and $p = 0.0431$, respectively), indicating a stronger late-phase response (Table 3).

Table 3. Mean MSS scores across visits and between-arm comparison.

Visit	GA mean MSS +/- SD	TCA mean MSS +/- SD	Mean difference (GA-TCA)	p-value
V1 (baseline)	1.93 +/- 0.70	1.93 +/- 0.70	0.00	-
V2	1.44 +/- 0.91	1.33 +/- 0.87	0.11	0.0858
V3	1.02 +/- 0.95	0.79 +/- 0.86	0.23	0.0065
V4 (final)	0.66 +/- 0.86	0.49 +/- 0.67	0.17	0.0431

MSS, Melasma Severity Scale; GA, glycolic acid; TCA, trichloroacetic acid. Within-arm change across visits was significant for both GA and TCA arms (Friedman test, $p < 0.001$).

Adverse Effects

In the GA arm, burning sensation was the most common adverse effect (25%), followed by erythema (23%) and PIH (8%). In the TCA arm, erythema was observed in 31%, burning in 28% and PIH in 13%. All adverse effects were transient and self-limiting, but TCA showed a higher frequency of inflammatory adverse effects and PIH than GA (Table 4).

Table 4. Adverse effects in GA and TCA treatment arms.

Adverse effect	GA arm, n (%)	TCA arm, n (%)
Erythema	23 (23.0)	31 (31.0)
Burning sensation	25 (25.0)	28 (28.0)
Post-inflammatory hyperpigmentation	8 (8.0)	13 (13.0)

GA, glycolic acid; TCA, trichloroacetic acid.

DISCUSSION

This prospective split-face study found that both 35% GA and 10% TCA peels significantly improved facial melasma. TCA produced a numerically greater overall reduction in MSS score and achieved statistically lower scores at later visits, while GA demonstrated a more favorable tolerability profile. These findings support both agents as useful superficial chemical peels, with treatment choice guided by the desired balance between efficacy and safety.

The demographic profile was consistent with the established epidemiology of melasma. The mean age in the present cohort was 32.9 +/- 6.7 years, and most patients were in the 31-40 year group. Similar age clustering has been reported by Kumari and Thappa, Puri, Raka et al. and Rao et al., supporting the predominance of melasma in hormonally active adult age groups [41-44]. The female predominance observed in this study (87%) also mirrors prior Indian cohorts, where

women comprised approximately 90% or more of study populations [41-44].

The chronicity of melasma was evident, with a mean duration of 44.8 months and more than one-third of patients reporting disease for over five years. This pattern is comparable to previous reports in which melasma was commonly present for several years before procedural treatment [41-44]. The burden of long-standing disease is important clinically because chronic melasma may involve dermal components, basement membrane disruption and vascular/inflammatory signaling, which can limit complete clearance and predispose to recurrence [6,8-10,21,29].

The centrofacial pattern was most common in this cohort, followed by malar and mixed patterns. Prior studies have differed in the most frequent clinical pattern, with some reporting malar predominance and others reporting centrofacial predominance [41,43,44]. Such variation may reflect population differences, ultraviolet exposure patterns and clinical classification methods. On Wood's lamp examination, mixed melasma was the most common type in the present study, which differs from some previous cohorts where epidermal melasma predominated [41,44]. The higher mixed-type proportion may partly explain the chronicity of disease and the need for repeated procedural sessions.

The GA arm produced a 65.8% reduction in MSS, which is clinically meaningful and statistically significant. This supports the role of GA as a reliable peel for melasma and is consistent with studies showing improvement after serial GA peels [11-14,31-33,40]. GA acts by reducing corneocyte cohesion, accelerating epidermal turnover and promoting gradual removal of melanin-laden keratinocytes. Its controlled and progressive action is advantageous in darker skin phototypes, where excessive inflammation can precipitate PIH [19,22,23].

The TCA arm produced a 74.6% reduction in MSS and showed significantly greater improvement than GA at later visits. This aligns with reports that TCA can produce brisker pigment lightening because of its keratocoagulant effect and regeneration-mediated remodeling [18,24,33,38,39]. In previous comparative work, TCA has sometimes shown slightly better efficacy than GA, although findings are not uniform [33,41-44]. The present study therefore supports TCA as an effective option, particularly when stronger clearance is desired and when patients can adhere to strict post-peel care.

The safety profile is clinically important. TCA was associated with higher erythema and PIH compared with GA. Although these events were transient in the present study, they are relevant in Indian and other pigment-prone skin types where inflammatory reactions can worsen dyschromia [19,22,23]. This finding supports a practical therapeutic approach: GA may be preferred as a first-line or maintenance procedural peel in sensitive or PIH-prone patients, while TCA may be considered in selected patients with resistant disease after appropriate counseling and photoprotection.

Several recent studies have explored strategies beyond single-agent GA or TCA peels. Combination protocols such as GA field therapy with TCA spot peeling, modified Jessner's solution followed by TCA, and combined peel approaches have attempted to improve efficacy while controlling cumulative inflammation [31,34,39]. Other agents such as salicylic-mandelic acid, phytic acid and lactic acid have also been evaluated with varying efficacy and tolerability [32,36,37,40]. These data emphasize that peel selection in melasma should be individualized rather than concentration-driven alone.

The present findings have direct clinical relevance. Both peels achieved significant improvement over a short treatment course, but the response was progressive rather than immediate. This reinforces the importance of serial sessions, photoprotection, maintenance therapy and realistic counseling. Melasma should be approached as a chronic relapsing disorder in which procedural clearance must be integrated with long-term ultraviolet avoidance and topical maintenance [16,21,26,27].

Table 5. Comparison of efficacy with previous studies cited in the source document.

Study	GA reduction	TCA reduction	Reported superiority	Statistical interpretation
Present study	65.8%	74.6%	TCA slightly superior	Significant at later visits
Kumari and Thappa [41]	79%	73%	GA slightly superior	Not significant
Raka et al. [43]	52.7%	57.9%	TCA slightly superior	Significant

GA, glycolic acid; TCA, trichloroacetic acid. Scale differences across studies should be considered when comparing percentage reduction.

Strengths and Limitations

The principal strength of this study is its split-face design, which minimizes inter-individual variability in skin type, ultraviolet exposure, hormonal background and treatment adherence. The study also included 100 patients and used serial clinical assessment across multiple visits. However, it was conducted at a single center, follow-up was short and relapse rates were not assessed. MSS is a clinical severity scale and may be less objective than digital pigment analysis or standardized MASI scoring. The document did not specify random allocation of facial side to GA or TCA, which may introduce side-assignment bias. Longer multicentric studies with standardized digital assessment, side randomization and maintenance follow-up are required.

CONCLUSION

Both 35% GA and 10% TCA peels are effective in reducing facial melasma severity. TCA demonstrated a slightly greater reduction in MSS scores, particularly at later visits, but was associated with higher erythema and PIH. GA provided substantial improvement with comparatively better tolerability. In clinical practice, GA may be preferred for patients with sensitive or PIH-prone skin, whereas TCA may be considered for selected patients requiring stronger response, provided that strict photoprotection and post-peel care are ensured.

Declarations

Ethics approval: Institutional Ethics Committee approval was obtained prior to commencement of the study.

Consent to participate: Written informed consent was obtained from all participants.

Consent for publication: Not applicable; the manuscript does not include identifying patient information or individual patient images.

Availability of data and materials: The datasets generated and analyzed during the study are available from the corresponding author on reasonable request, subject to institutional approval.

Competing interests: The authors declare no competing interests.

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