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COMPARATIVE STUDY OF TRICHLOROACETIC ACID (TCA) PEEL VERSUS GLYCOLIC ACID PEEL FOR THE TREATMENT OF HYPERPIGMENTATION

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Abstract

Background:
Hyperpigmentation is defined as darkened areas of the skin created by excess pigment, where the opposite would apply, too little pigment leads to a lighter-colored skin.

Objectives:
The objective of the study was to compare Trichloroacetic Acid (TCA) peel versus glycolic acid Peel for the treatment of hyperpigmentation.

Methodology:
Data was be collected from dermatology/aesthetic clinic patients after informed consent using a pre-tested structured questionnaire covering demographics, clinical history, treatment details, and outcomes. Baseline assessment included MASI scoring and standardized facial photography, followed by 1–4 month follow-up evaluations. Outcomes include change in MASI score, clinical improvement, patient satisfaction, and adverse effects of glycolic acid vs TCA peels.

Results:
TCA peel and glycolic acid peels were all highly effective with significant hyperpigmentation reduction. Mean overall MASI score decreased from 14.07 to 7.68 ($p<0.001$). TCA peel was significantly better with lower post-treatment MASI score of 6.37 versus 9.00 with glycolic acid peel ($p<0.01$). Both peels were effective and patients were 95% very satisfied.

Conclusion:
Both trichloroacetic acid (TCA) and glycolic acid peels were effective in reducing hyperpigmentation, with a significant improvement in MASI scores. TCA peel demonstrated superior efficacy compared to glycolic acid but was associated with more moderate to severe side effects.

INTRODUCTION

Hyperpigmentation is defined as darkened areas of the skin created by excess pigment, where the opposite would apply, too little pigment leads to a lighter-colored skin. Hyperpigmentation results from overstimulated or misregulated melanocytes, which can create either localized or general regions of skin darkness. Hyperpigmentation can affect all people, although it is much more pronounced and distributed among individuals with darker skin types which will typically reflect their overall greater average melanin levels in the skin (1).

Hyperpigmentation can be classified into different types based on the clinical features. Some of the

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most common include Melasma, an acquired skin condition of irregular symmetrical brown to grey brown macules and patches typically seen on the cheeks, forehead and upper lip. It occurs commonly with hormonal factors including pregnancy or use of oral contraceptives, aggravated by U V exposure. Solar lentigines, more commonly referred to as age or liver spots, consist of round or oval defined brownmacules. They occur due to solar radiation exposure on the skin, especially on the sun-exposed regions, and are more frequently seen in the older populations (2). Post-inflammatory hyperpigmentation is acquired hyperpigmentation that occurs in response to cutaneous trauma, insult, or inflammation. At the time of wound healing or inflammatory response in the skin, melanocyte activation is noticed following local deposition of hyperpigmentation at the original inflammatory site. Dark skinned individuals are more prone to developing PIH. This form of hyperpigmentation can also last for a prolonged period if not effectively managed. Other less common forms are drug-induced and systemic related hyperpigmentation (3).

Hyperpigmentation can occur for many reasons, which are generally categorized into intrinsically and extrinsically induced causes. Perhaps one of the most common causes of hyperpigmentation is UV radiation which prompts melanosytes to function and produce melanin in an effort to protect the cell from damage to DNA. The role that hormones can play in hyperpigmentation is very important. Melasma is thought to occur due to the fact that pregnancy hormones as well as the use of oral contraceptives cause stimulation of pigment producing cells with the female hormones estrogen and progesterone (4).

Inflammation is another main culprit. This is called post-inflammatory hyperpigmentation and can be caused by burns, acne, trauma and other skin disorders. Other factors include drug induced hyperpigmentation (examples of drugs which cause pigment changes include antibiotics, chemotherapeutic agents and anti-malarials). It also appears that there are genetic factors, aging factors, endocrine factors and environmental pollutants that have a role in the pathogenesis and progression of hyperpigmentation (5).

The different types of Hyperpigmentation clinical presentations of hyperpigmentation (for example: type, background, and depth) will vary, as someone may notice the emergence of dark patches or spots on their skin. Dark patches may vary in size and color from light brown to black. Hyperpigmentation patches are usually asymptomatic (but can vary based on the individual); however, the cosmetic impact can be significant. The appearance of melasma is usually a result of exposure to the sun and is often seen on the cheeks, forehead, and upper lip as it occurs symmetrically in the exposed areas (6).

Post-inflammatory hyperpigmentation is irregular in shape and occurs following an inflammatory process (usually left behind after healing from the inflammation), typically seen most frequently where acne has occurred. Solar lentigines will vary based on an individual's age and are generally round or oval in shape and develop as a result of unprotected prolonged sun exposure. Hyperpigmentation can also occur with or without changes related to roughness or photoaging (7).

The diagnosis for hyperpigmentation is primarily made by review of the patient's history and a physical examination. Dermatologists examine the pattern of the pigmentation, as well as any possible triggers or underlying medical conditions. The Wood's lamp can be used to identify anatomical locations of pigment as it enhances the pigmentation contrast under ultraviolet light, hence assisting in the determining of whether it is epidermal vs dermal by ultraviolet light (8).

The dermatoscope may also be used for the same purpose, but helps better define pigment patterns and excludes other pigmented lesions, including malignant conditions (ex: melanoma). Only if necessary skin biopsy will also confirm diagnosis and depth of pigment; further laboratory testing may also be done, if there is a potential there may be an underlying cause (systemic/hormonal) (9).

Managing hyperpigmentation typically involves multiple approaches; prevention, topical therapy, procedures, and education. The first step in treating hyperpigmentation is protecting the skin from the sun since prolonged sunlight exposure causes additional damage to the pigment and limits the benefits of treatment. All treatment

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plans should consist of a combination of broad-spectrum sunscreen, use of protective clothing, and modifications to lifestyle as well as possible (10).

Hydroquinone, retinoids, corticosteroids, azelaic acid, and kojic acid are topical drugs usually utilized to inhibit melanin production and/or assist with skin turnover. Frequently, using these products in combination produces superior results compared to using them alone. Chemical peels, laser therapy, and microdermabrasion are used in the treatment of more resistant cases of hyperpigmentation (11).

Trichloroacetic acid (TCA) peels are medium deep, chemical peels that are arguably one of the most widely utilized form of chemical peel therapy within the scope of dermatology in treating hyperpigmentation, among other uses for which chemical peels are performed (12). As a caustic agent TCA peels elicit chemical exfoliation through coagulating protein in both the epidermis and in the dermis. This ultimately leads to the sloughing off of pigmented keratinocytes from the skin and stimulating re-epithelialization of the skin, which regenerates evenly pigmented new skin. (13)

Glycolic acid peel is a superficial chemical peel that is a form of AHA (alpha hydroxy acids), is widely used for mild to moderate hyperpigmentation. The small molecular size of glycolic acid, smaller than any other AHA, is ideal to penetrate the epidermis and create exfoliation. The skin acts upon the acid by breaking down the cohesion of corneocytes within the stratum corneum, causing the desquamation and elimination of pigmented cells. It causes the epidermis to turn over at a faster rate, and reduces melanogenesis by inhibiting the enzyme tyrosinase. Glycolic acid has also shown to increase dermal GAG and collagen production, leading to a better tone and texture of the skin (14).

This study seeks to give an overall comparison between the TCA peel and the glycolic acid peel for the treatment of hyperpigmentation to enable practitioners make evidenced based choices for treatment choices and safe alternatives to treat patients with hyperpigmentation. This is important as the knowledge of which treatment would result in better effectiveness, better safety profile and patient satisfaction in a population with varied skin types would enable more efficient dermatological treatment and customization for patients.

OBJECTIVE

To compare Trichloroacetic Acid (TCA) peel versus glycolic acid Peel for the treatment of hyperpigmentation

MATERIAL AND METHODS

4.1: Study Design:

This was a randomized controlled trial (RCT)

4.2: Settings:

The study was conducted in Sleek skin and Cosmothetics aesthetics clinic, Lahore.

4.3: Study Duration:

The duration of the study was 4 months.

4.4: Sample Size:

A total of 60 subjects with hyperpigmentation were enrolled. The sample size was calculated using calculator.net online sample size calculator. Here, confidence level was 95%, margin of error was 5, and population proportion was 50.

4.4 Sample Size

The sample size for this study was calculated using the following formula for estimating a population proportion:

$$n = \frac{Z^{2}P(1-P)}{d^{2}}$$

Where:

(n) = required sample size

(Z) = standard normal variate at 95% confidence level (1.96)

(P) = anticipated population proportion (50% or 0.5)

(d) = margin of error (5% or 0.05)

Substituting the values in the formula:

$$n = \frac{(1.96)^{2} \times 0.5 \times (1-0.5)}{(0.05)^{2}}$$

$$n = \frac{3.84 \times 0.25}{0.0025}$$

$$n = \frac{0.96}{0.0025}$$

$$n = 384$$

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Thus, the calculated sample size was 384 participants. However, due to limitations of time, resources, and accessibility of eligible participants during the study period, a total of 60 subjects with hyperpigmentation were recruited and enrolled in the study.

4.5: Sampling Technique:

Simple random sampling technique was adopted to ensure unbiased selection of subjects.

4.6: Sample Selection:

4.6.1: Inclusion Criteria:

1. Adults aged 20 – 50 years (17)
2. Subjects clinically diagnosed with hyperpigmentation, including melasma and post inflammatory hyperpgimentation
3. Both male and female participants (23)

4.6.2: Exclusion Criteria:

1. Teenager
2. Pregnant or lactating females (24)
3. Subjects on hormonal therapy
4. Subjects with hypersensitivity to the peeling agent (24)
5. History of any topical application in the last 4 weeks (24)
6. Subjects with recurrent dermatological infections, i.e. herpes labialis infection, active dermatitis (17).

4.7: Equipment:

1. Structured data collection Performa
2. Melasma area and severity index (MASI)
3. Digital photography setup
4. Adverse event log sheet

RESULTS

Table.1 Descriptive statistics showing age of the subjects

Age of the subjects		
	Frequency	Percent
18-25	12	20.0
26-35	24	40.0
36-45	18	30.0
46+	6	10.0
Total	60	100.0

The age distribution of the participants shows that most were young to middle-aged adults: 24 patients (40%) were 26–35 years old, 18 (30%) were 36–45, 12 (20%) were 18–25, and 6 (10%) were over 46. This indicates that the majority of patients seeking chemical peel treatment for hyperpigmentation were in their mid-20s to mid-40s.

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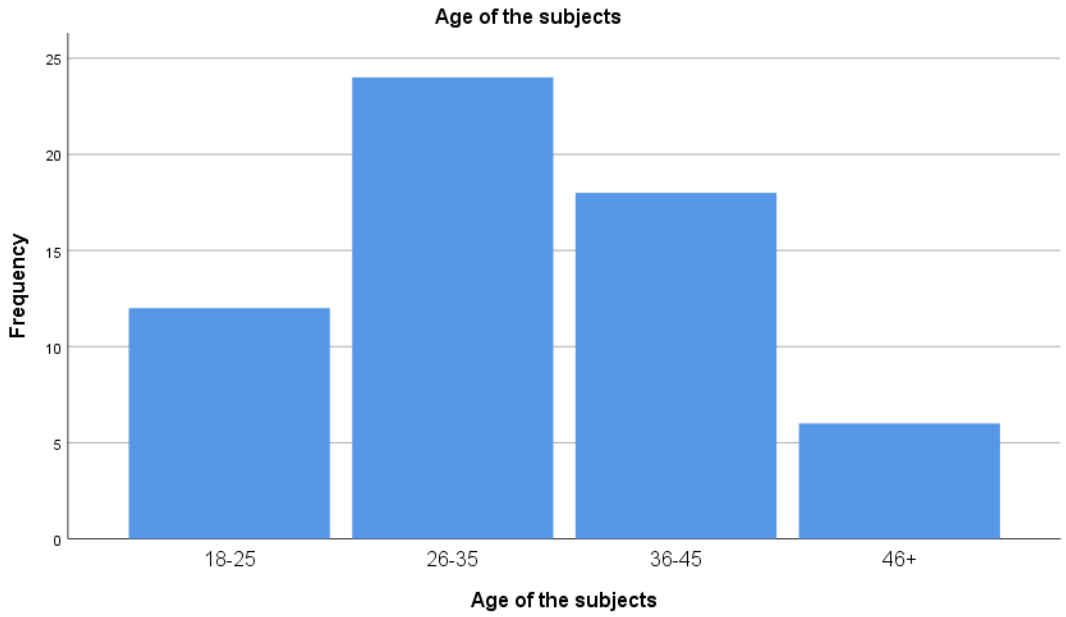

Figure.1 Bar chart showing age of the subjects

Table.2 Descriptive statistics showing gender of the subjects

Gender of subjects		
	Frequency	Percent
Female	48	80.0
Male	12	20.0
Total	60	100.0

The study population was predominantly female, with 48 participants (80%) being women and 12 participants (20%) men.

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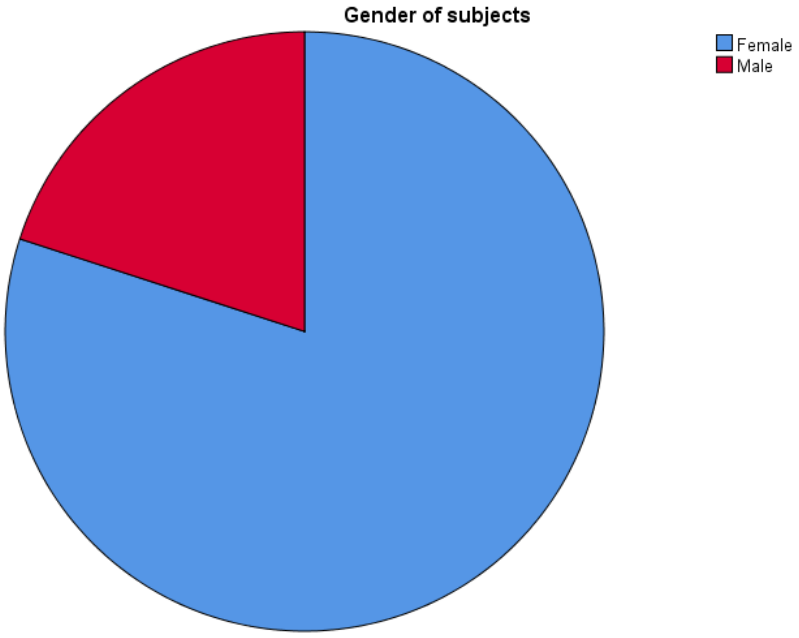

Figure.2 Pie chart showing gender of the subjects

Table.3 Descriptive statistics showing skin type of the subjects

Skin Type of subjects		
	Frequency	Percent
Brown	18	30.0
Dark	6	10.0
Fair	12	20.0
Medium	24	40.0
Total	60	100.0

The study included patients with a variety of skin types: 24 (40%) had medium skin, 18 (30%) brown skin, 12 (20%) fair skin, and 6 (10%) dark skin.

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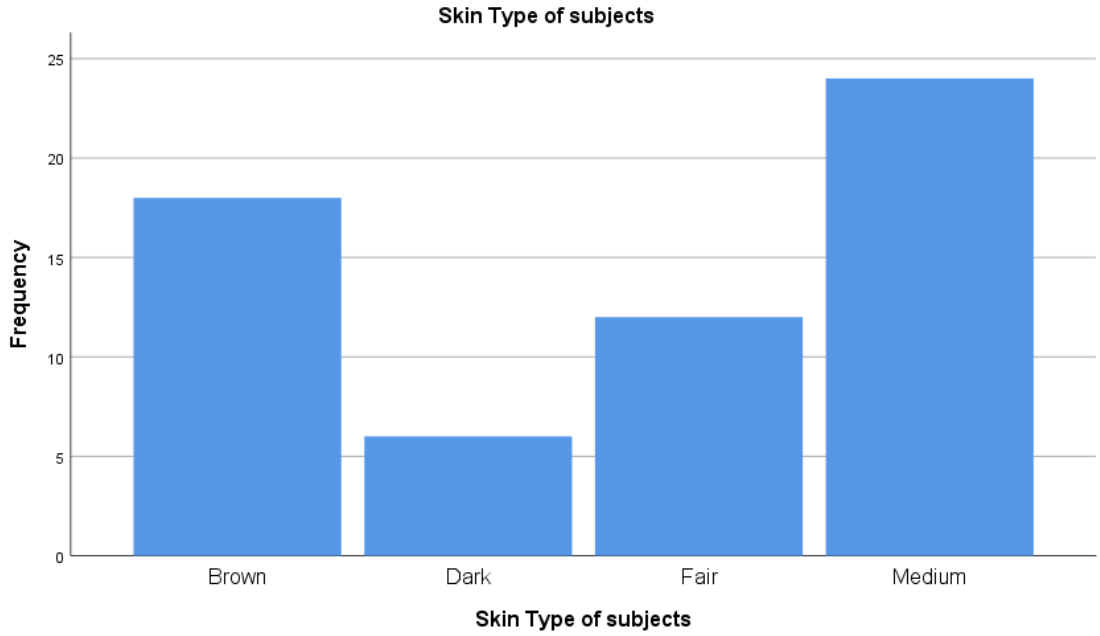

Figure.3 Bar chart showing skin type of the subjects

Table.4 Descriptive statistics showing duration of hyperpigmentation

Duration of hyperpigmentation		
	Frequency	Percent
<6m	12	20.0
>2y	24	40.0
6m-2y	24	40.0
Total	60	100.0

The duration of hyperpigmentation varied among patients: 12 patients (20%) had pigmentation for less than 6 months, 24 patients (40%) had it for 6 months to 2 years, and another 24 patients (40%) had hyperpigmentation persisting for more than 2 years.

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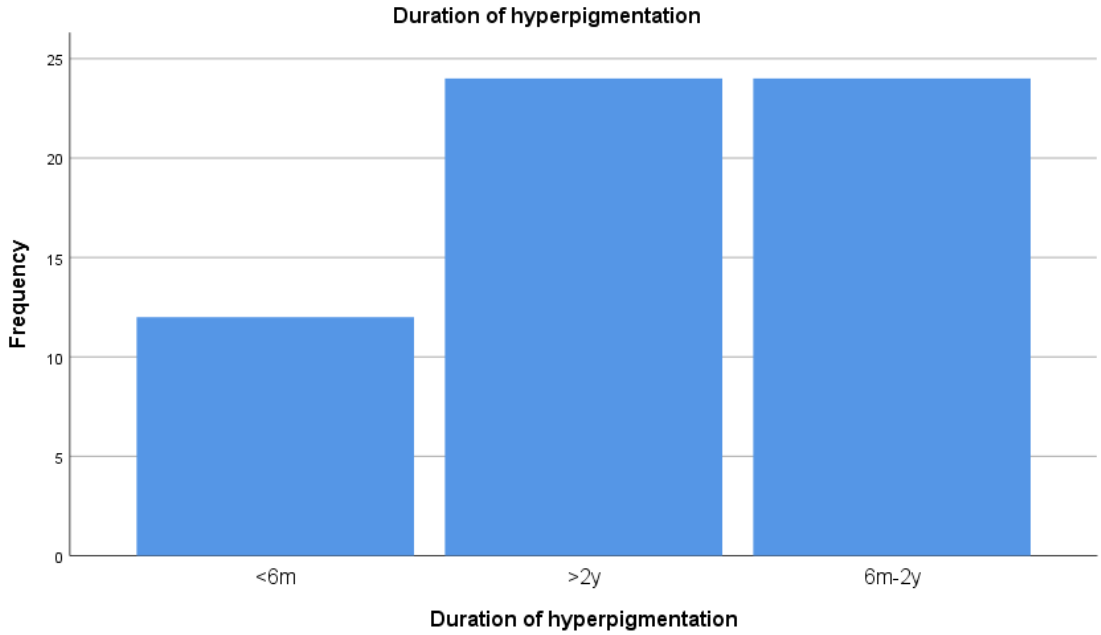

Figure.4 Bar chart showing duration of hyperpigmentation

Table.5 Descriptive statistics showing Previous treatments for hyperpigmentation

Previous treatments for hyperpigmentation (e.g., creams, lasers, peels)		
	Frequency	Percent
No	24	40.0
Yes	36	60.0
Total	60	100.0

Most patients (36 out of 60, or 60%) had previously tried treatments for hyperpigmentation, such as creams, lasers, or peels, while 24 patients (40%) had not received any prior therapy in life.

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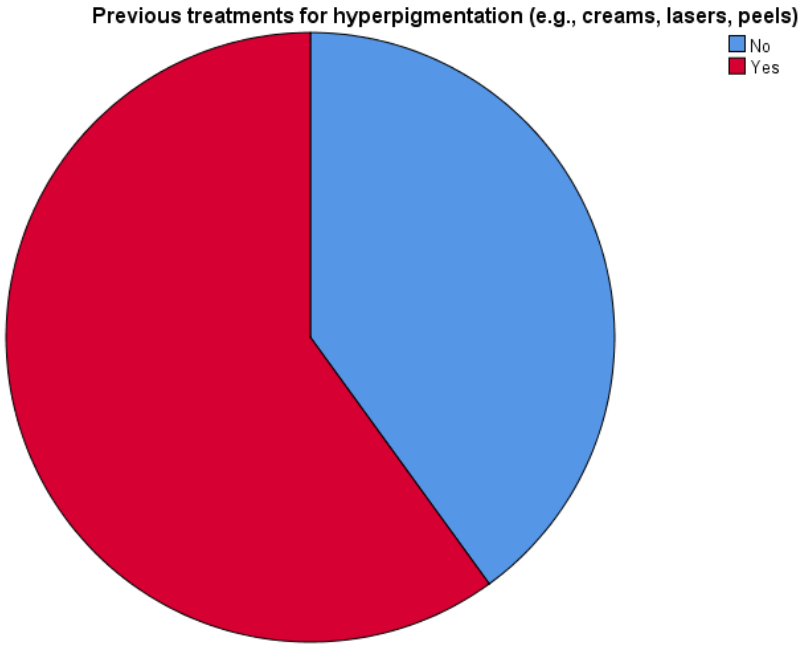

Table.5 Pie chart showing Previous treatments for hyperpigmentation

Table.6 Descriptive statistics showing interventional group

Which chemical peel did you undergo?		
	Frequency	Percent
Glycolic	30	50.0
TCA	30	50.0
Total	60	100.0

The participants were evenly divided between the two treatments: half of the patients (30, 50%) received Glycolic peel, and the other half (30, 50%) received TCA peel.

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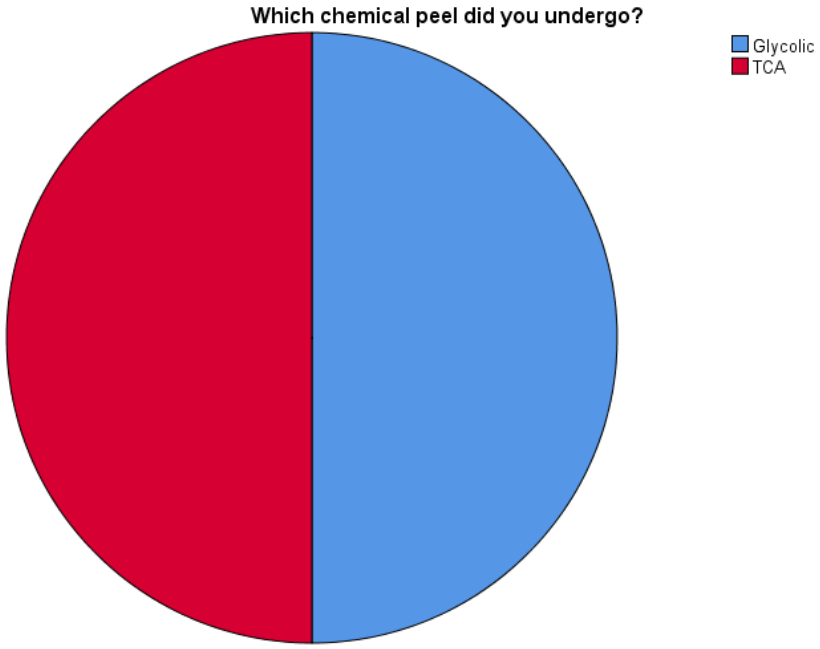

Figure.6 Pie chart showing interventional group

Table.7 Descriptive statistics showing chemical peel side effects in subjects

Side effect	Mild (%)	Moderate (%)	Severe (%)
Experienced redness	24 (40%)	23 (38.3%)	13 (21.7%)
Experienced irritation	31 (51.7%)	29 (48.3%)	6 (10%)
Experienced burning	29 (48.3%)	19 (31.7%)	12 (20%)

The side effect profile shows that most adverse reactions to chemical peels were mild to moderate. Redness affected all patients, with 40% mild, 38.3% moderate, and 21.7% severe. Irritation was mostly mild (51.7%) or moderate (48.3%), with only 10% experiencing severe irritation. Burning was reported by nearly half of the patients as mild (48.3%), moderate in 31.7%, and severe in 20%.

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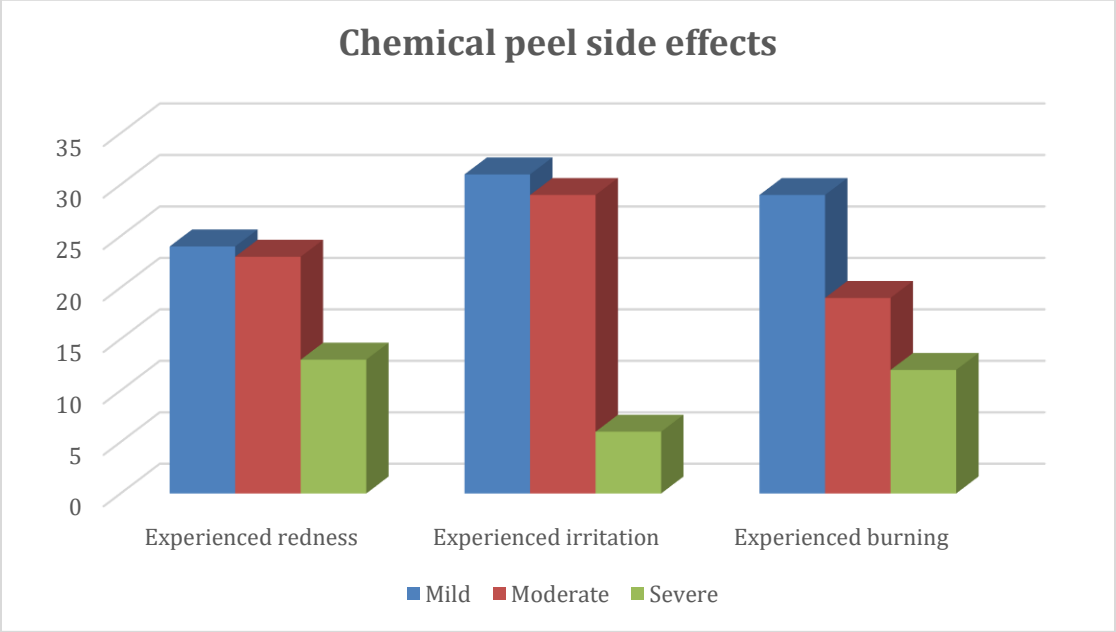

Figure.7 Bar chart showing chemical peal side effects in subjects

Table.8 Descriptive statistics showing duration of side effects

Duration of side effects		
	Frequency	Percent
<24h	13	21.7
1-3d	35	58.3
4-7d	12	20.0
Total	60	100.0

The majority of patients experienced short-lived side effects: 13 (21.7%) lasted less than 24 hours, 35 (58.3%) lasted 1–3 days, and only 12 (20%) lasted 4–7 days. This indicates that while adverse effects were common, they were generally mild and transient, resolving within a week for all patients.

Volume 4, Issue 6, 2026

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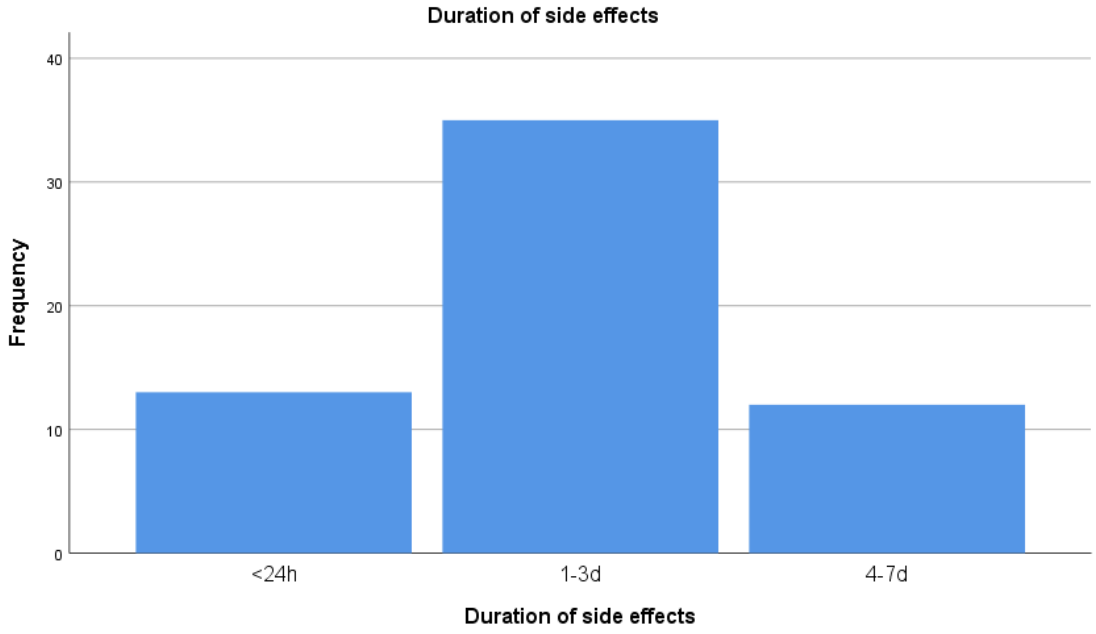

Figure.8 Bar chart showing duration of side effects

Table.9 Descriptive statistics showing post-treatment Improvement in hyperpigmentation

Improvement in hyperpigmentation after treatment		
	Frequency	Percent
Moderate	33	55.0
Significant	27	45.0
Total	60	100.0

After treatment, all patients experienced improvement in hyperpigmentation: 33 patients (55%) had moderate improvement, and 27 patients (45%) had significant improvement. This shows that the chemical peels were consistently effective in reducing pigmentation, with nearly half of the patients achieving substantial results.

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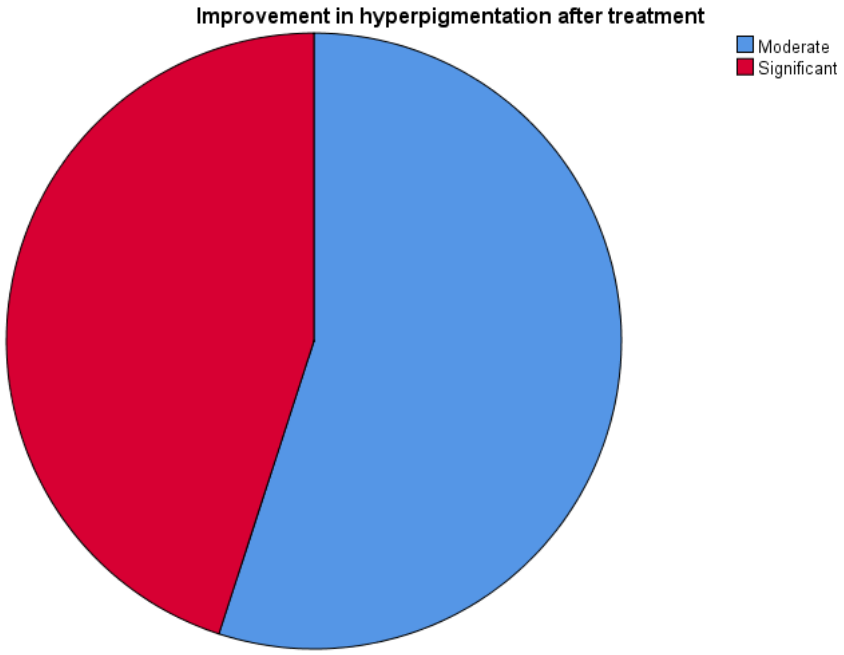

Figure.9 Pie chart showing post-treatment Improvement in hyperpigmentation

Table.10 Descriptive statistics showing post-treatment Improvement in skin texture

Improvement in skin texture		
	Frequency	Percent
No	3	5.0
Yes	57	95.0
Total	60	100.0

Improvement in skin texture was reported by 57 out of 60 patients (95%), with only 3 patients (5%) noting no improvement. This indicates that, in addition to reducing melasma severity, the chemical peels also had a consistent positive effect on overall skin texture for the vast majority of participants.

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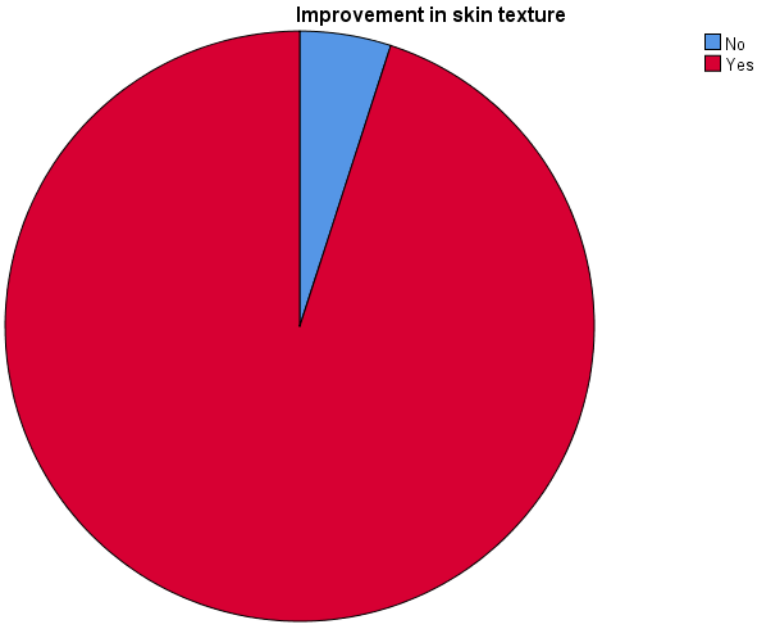

Pie chart.10 Pie chart showing post-treatment Improvement in skin

Table.11 Descriptive statistics showing post-treatment satisfaction with results

Satisfaction with results		
	Frequency	Percent
Dissatisfied	3	5.0
Satisfied	57	95.0
Total	60	100.0

Patient satisfaction with the results was very high: 57 out of 60 patients (95%) reported being satisfied, while only 3 patients (5%) were dissatisfied. This aligns closely with the willingness to recommend the peel, reinforcing that the treatment was both effective and well-tolerated by most participants.

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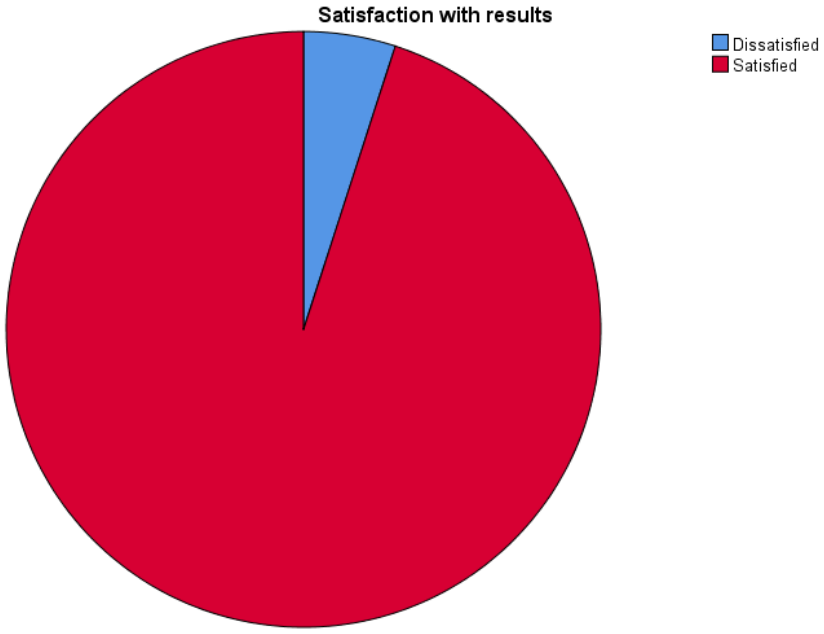

Figure.11 Pie chart showing post-treatment satisfaction with results

Table.12 Descriptive statistics showing peel recommendation

Would you recommend this peel to others?		
	Frequency	Percent
No	2	3.3
Yes	58	96.7
Total	60	100.0

Nearly all patients (58 out of 60, or 96.7%) would recommend the chemical peel to others, while only a small fraction (3.3%) would not. This indicates a high level of overall patient satisfaction with the treatment, despite the reported mild to moderate adverse effects.

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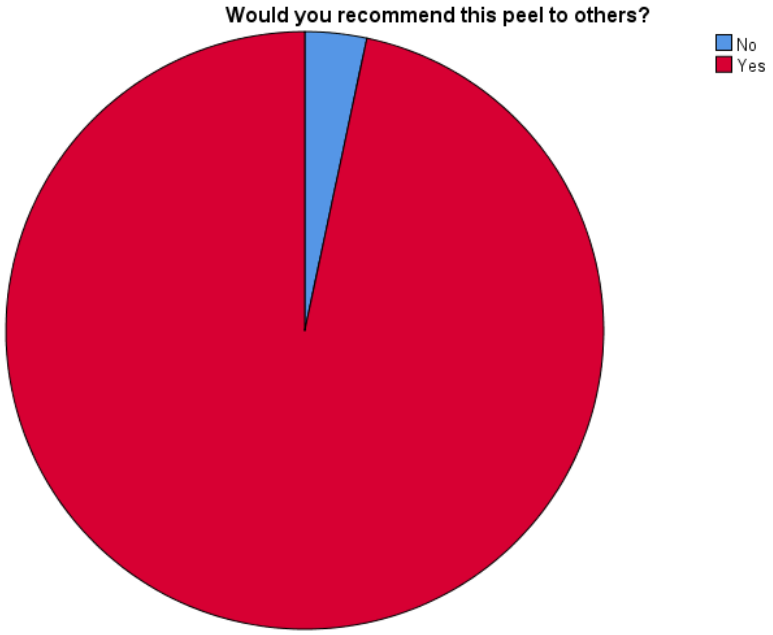

Figure.12 Pie chart showing peel recommendation

Table.13 Descriptive statistics showing MASI value at baseline

Statistics		
Score of MASI at baseline		
N	Valid	60
	Missing	0
Mean		14.07
Std. Deviation		1.990

This shows the baseline MASI scores for all 60 patients before any chemical peel treatment. The mean score was 14.07 with a standard deviation of 1.990.

Volume 4, Issue 6, 2026

Frontier in Medical & Health Research

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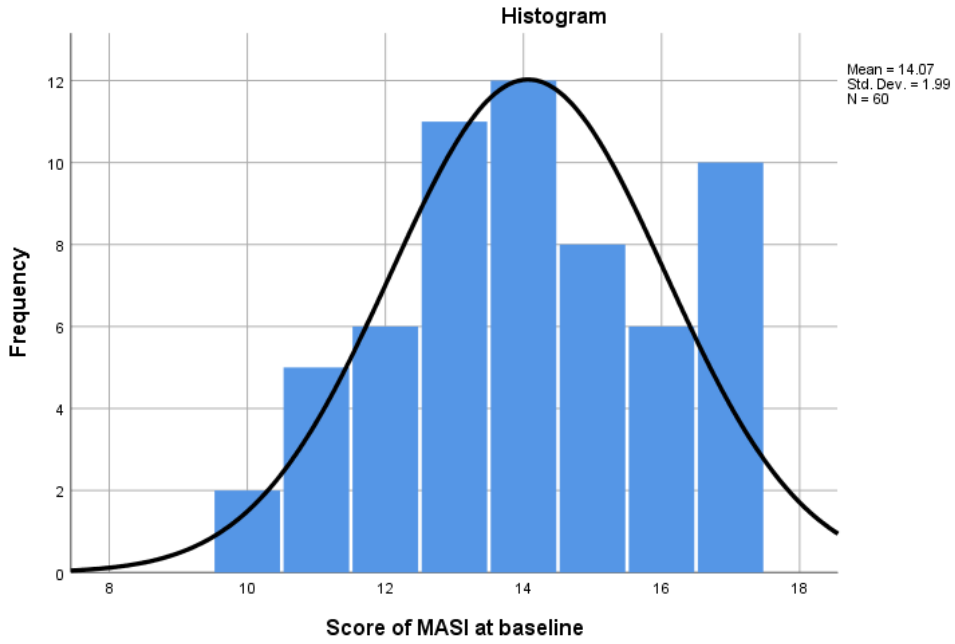

Figure.13 Histogram showing MASI value at baseline

Table.14 Descriptive statistics showing MASI value after intervention

Statistics		
Score of MASI after intervention		
N	Valid	60
	Missing	0
Mean		7.68
Std. Deviation		1.742

This simply confirms the post-treatment MASI scores for all 60 patients. After the chemical peel interventions, the average MASI score was 7.68, with a standard deviation of 1.742.

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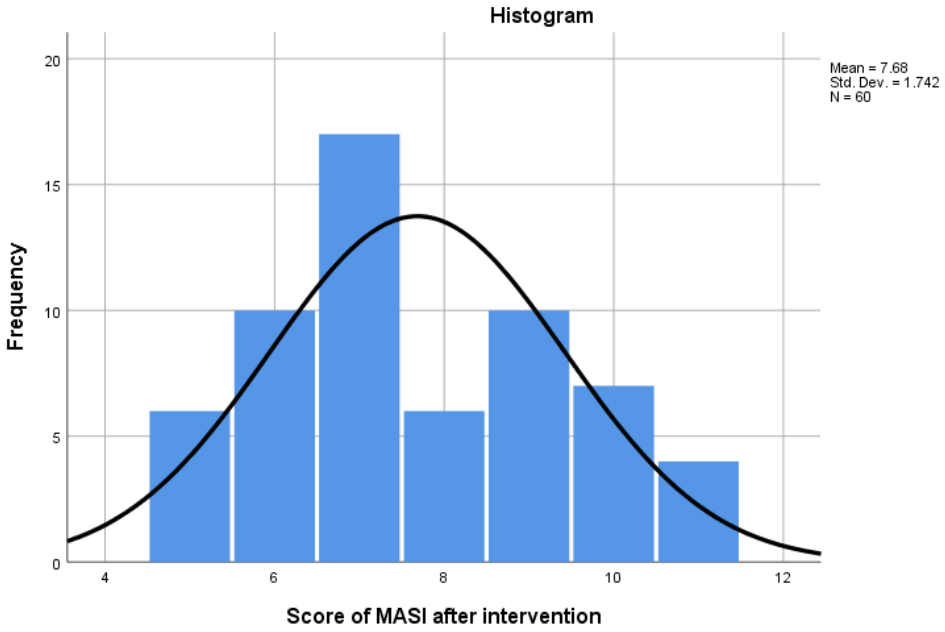

Figure.14 Histogram showing MASI value after intervention

Table.15 Paired sample T-test between pre and post values of MASI.

Paired Samples Statistics					
	Mean	N	Std. Deviation	Std. Error Mean	P value
Score of MASI at baseline	14.07	60	1.990	.257	<0.001
Score of MASI after intervention	7.68	60	1.742	.225	

This paired analysis looks at the overall effect of chemical peels (both Glycolic and TCA combined) on MASI scores in all 60 patients. The mean MASI score dropped from 14.07 at baseline to 7.68 after intervention, a highly significant reduction ($P < 0.001$). This demonstrates that chemical peeling overall leads to a substantial improvement in melasma severity.

Table.16 Independent T-test between pre and post values of MASI

Group Statistics						
	Which chemical peel did you undergo?	N	Mean	Std. Deviation	Std. Error Mean	P value
Score of MASI at baseline	Glycolic peel	30	13.90	1.971	.360	0.521
	Trichloroacetic acid (TCA) peel	30	14.23	2.029	.370	
Score of MASI after intervention	Glycolic peel	30	9.00	1.313	.240	<0.01
	Trichloroacetic acid (TCA) peel	30	6.37	.928	.169	

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This table presents the Melasma Area and Severity Index (MASI) scores for patients undergoing Glycolic and TCA peels. At baseline, both groups had similar MASI scores (Glycolic: 13.90, TCA: 14.23; P = 0.521), indicating comparable severity before treatment. After the intervention, scores decreased in both groups, but TCA peel showed a significantly greater improvement (Glycolic: 9.00 vs. TCA: 6.37; P < 0.01), suggesting that TCA peel was more effective in reducing melasma severity.

Table.16 Association between peel type and post-treatment experiences

Adverse Effect	Which Chemical Peel	Mild	Moderate	Severe	Total	P value
Redness	Glycolic peel	22	7	1	30	
	TCA peel	2	16	12	30	**<0.01**
	Total	24	23	13	60	
Irritation	Glycolic peel	24	4	2	30	
	TCA peel	4	22	4	30	**<0.01**
	Total	28	26	6	60	
Burning	Glycolic peel	26	3	1	30	
	TCA peel	3	16	11	30	**<0.01**
	Total	29	19	12	60	

The adverse reactions from Glycolic peel and TCA peel among 60 patients were tabulated into the table as being mild, moderate and severe. Reactions from Glycolic peel were mostly of mild level with redness (22/30), irritation (24/30) and burning (26/30). The severe and moderate reaction from Glycolic peel was not significant with most patients. TCA peel however showed mostly of a moderate to severe level with redness (16 of the patients moderate, 12 of the patients severe), irritation (22 patients moderate) and burning (16 patients moderate, 11 patients severe). The level of difference between the Glycolic peel and TCA peel among all three adverse reactions showed to be statistically significant (P<0.01).

DISCUSSION

The objective of this study was to compare clinical and patient reported efficacy and safety between trichloroacetic acid (TCA) peel and glycolic acid (GA) peel in hyperpigmentation treatment. This is a randomized controlled trial that attempt to fill this literature gap in comparing the efficacy and safety of two most frequently used chemical peels. Its objective was to assess changes in MASI scores, extent of clinical improvement, side effect profiles and patient's satisfaction. It provides evidence for selection of appropriate peeling agents for hyperpigmentation treatment.

This study shows that both TCA and glycolic acid peels help in treating hyperpigmentation as indicated by the significant drop in the total MASI score from the base line (14.07) to the post treatment MASI score (7.68) with highly significant p value (<0.001). On the contrary, between TCA peel and glycolic acid peel, TCA peel resulted in better and significantly lower post treatment MASI score (6.37) as against 9.00 in glycolic acid. It is apparent from these data that though both are useful modalities in treatment of hyperpigmentation, the former produces better clinical improvement in comparison to latter.

These findings also correlate with findings of some previous researchers. For example, Bharati et al. (2024) found that 15% TCA peel gave significantly better result than 35% glycolic acid peel in patients with acanthosis nigricans, showing the superiority of TCA in comparison with GA which also proved true in the present study (24). Moreover, Javed et al. (2023) claimed that though both GA and TCA peel could bring statistically significant decrease in MASI score in melasma patients, TCA gave significantly better outcome when compared with GA and that it supports the present study with some minute variation (23). Further, Vaghasia et al. (2024) found the better result of TCA peel over glycolic acid peel and even

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laser therapy in both pigmentation and in patient assessed parameters (26).

In another study by Manjhi et al. (2024), although it aimed to evaluate effectiveness of TCA peel for acne scars, the result also favored better effectiveness of TCA peel. In a split- face trial performed by the authors, they found greater reduction in the severity score on the TCA- treated side as compared to glycolic acid, which implies better penetrability and stronger exfoliative effect by TCA (25). Overall, these results highlight better efficacy of TCA peel over glycolic acid peel by targeting deeper pigmentation.

Beyond efficacy, overall clinical improvement and patient satisfaction were also assessed. We found that 100% of patients had improved, of which 55% showed moderate improvement and 45% showed significant improvement. Furthermore, we saw high satisfaction rates of 95%, with 96.7% stating that they would recommend the treatment to another individual. This is in line with Sitohang et al. (2021) who noted high patient satisfaction, as well as an effective treatment with satisfactory cosmetic results following TCA peeling (20). Sahu et al. (2021) also saw significant improvements in quality of life after treating melasma with both TCA and glycolic acid, concluding that chemical peels are effective not only in clinical improvement but psychological benefits as well (22).

While it is evident that TCA is more effective than GA, the results from the current study do raise the point of a compromise between the effectiveness of the TCA procedure and safety and tolerability. From the above results, predominantly minimal adverse effects were reported with GA peel, while moderate to severe adverse effects such as redness, burning and irritation were associated with the TCA peel. These variations were significant ($p<0.01$) and demonstrate the increased risk of adverse events with TCA over the more effective agent. It should be pointed out, however, that most of these side effects were of a temporary nature, generally subsiding within 1-3 days, and did not last for more than a week.

These results are also consistent with previous studies in the literature. Manjhi et al (2024) had similar findings in that TCA peel was accompanied by side effects of dryness and crusting, whereas glycolic acid had a more favorable profile with good tolerance (25). In parallel, Javed et al (2023) commented on the increased severity of reactions observed with TCA, such as frosting and burning, in comparison with the more subdued sensations seen with glycolic acid. The potential to achieve the greater benefits of TCA while avoiding these more uncomfortable sensations make the role of glycolic acid in sensitive skin types or patients where the downtime is limited more apparent (23).

Despite this, not all studies are completely consistent with the results of the current study. Several studies have found similar results when comparing the two peeling agents. For example Sonkusale et al (2020) concluded that glycolic acid and TCA peels had the same effect on the reduction of MASI scores in patients with epidermal melasma and showed no statistically significant difference between the two (17). Again, Sahu et al (2021) demonstrated that when both a glycolic acid and TCA peel are used there is no significant difference in MASI score reduction at 12 weeks between the two agents (22).

Skin texture showed substantial improvement in the current study also, 95% of participants noticed skin quality improvement. This finding correlated well with the mechanism of action of chemical peel peels that results in enhanced epidermal turnover, collagenesis, and epidermal peeling. Bhardwaj et al. (2021) also documented that TCA peels boost collagen synthesis, lower melanin production, hence, improving skin texture and tone (12). Such added advantages render peels useful in hyperpigmentation management and skin rejuvenation.

In conclusion, the evidence presented in this paper strongly suggests that both TCA and glycolic acid peels are beneficial for the treatment of hyperpigmentation with TCA being more efficacious but less well tolerated. The results are generally in accord with the existing literature, however a few reports show no significant differences in efficacy between both agents. Ultimately the peeling agent choice depends on the fine line between efficacy and safety, the individual patient and therefore requires

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

individual judgment and experience. The implications of this are important to provide a better rationale to make the appropriate choice in clinical practice.

CONCLUSION

Both trichloroacetic acid (TCA) and glycolic acid peels were effective in reducing hyperpigmentation, with a significant improvement in MASI scores. TCA peel demonstrated superior efficacy compared to glycolic acid but was associated with more moderate to severe side effects. Therefore, treatment selection should balance effectiveness with tolerability based on individual patient needs.

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