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COMPARATIVE IMPACT OF MICRONEEDLING AND GLYCOLIC ACID CHEMICAL PEEL ON TREATMENT OF ACNE SCARRING

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Abstract

Background: *Post-inflammatory hyperpigmentation (PIH) and atrophic acnes scars are severe physiological consequences of acne vulgaris and they often lead to major psychological distress. Although there are many dermatological procedures such as superficial chemical peels and mechanical percutaneous collagen induction, comparative data on the comparative efficacy and safety of these two procedures especially in patients with melanin-rich skin phenotypes is a crucial field of clinical inquiries.*

Objectives: *To compare clinical efficacy, patient satisfaction and safety of microneedling and glycolic acid peeling in treatment of atrophic acnes scarring.*

Methodology: *A comparative clinical trial was carried out with 40 participants (mean age 26.97 ± 4.90 years) who presented with predominantly rolling and boxcar atrophic scars and Fitzpatrick Skin Types III-V. The subjects were randomly and equally split into two treatment groups (Group 1 (n=20) and Group 2 (n=20)) whereby, Group 1 received the assessments of efficacy were conducted after 4 months follow-up period on the standardized scales of scar severity and pigmentation 1-10 clinical grading scales. With the help of the SPSS 27.0, statistical analysis was conducted, with paired t-tests, independent t-tests, and linear regression.*

Results: *The clinical improvements of both interventions were highly significant ($p < 0.001$) within-group improvements. Nevertheless, between-group comparisons indicated that the microneedling had a statistically better absolute mean of reduction of scar severity over the glycolic peel (3.15 vs. 2.10 points; $p < 0.001$). Moreover, microneedling was much more effective in the removal of concurrent hyperpigmentation (3.30-point improvement compared to 1.45-point improvement; $p < 0.001$). In terms of safety, the glycolic peel group had a significantly higher rate of PIH due to treatment (40) than the microneedling group (15%). There was no significant difference in subjective patient satisfaction scores in both cohorts ($p = 0.212$).*

Conclusions: *Microneedling is better clinically and statistically than 35% glycolic acid peeling in terms of structural reduction of atrophic acne scars as well as clearance of coexisting dyschromia. Micro-needling also has a better safety profile, as it conserves the epidermal barrier, and thus is the best evidence-based modality to use in revising acne scars across a wide range of skin phenotypes.*

INTRODUCTION

Acne vulgaris is the most common dermatologic disease in adolescents and has an incidence of about 9 percent in the world (1). The long-term effect, along with its possible irreversible nature, affects people severely, not only physically, but also by causing psychological trauma, low self-esteem, social

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isolation, and a significant financial cost due to the need to continue treatment (2). Depending on progression, the disorder is a chronic dermatologic disease, which has both inflammatory and non-inflammatory lesions, such as open and closed comedowns depending on the progression of the disease (3). Epidemiological statistics show that more than 80 percent of teenagers, half to two-thirds of the females in their twenties, and about 12 percent of those who are over 25 years are infected. Bacterial colonization, sebum hypersecretion, and inflammatory and hormonal imbalances in the epidermis and dermis are the main mechanisms of the pathogenesis (4). Symptoms commonly reported by the patients include blistering and pruritus with patients with severe disease having higher chances of developing acne scars which significantly worsen the quality of life. Social isolation, anxiety, shame, and embarrassment are reported, and they usually lead to depression and even suicidal thoughts (5).

The clinical presentation of acnes vulgaris consists of a heterogenous collection of lesions, such as, but not limited to hyperpigmentation, and atrophic or hyper-trophic scars. The lesion mostly concentrates in the facial, thorax, and dorsal areas, where the density of the sebaceous gland is greatest. The multifactorial pathogenesis is excessive activity of sebaceous glands, abnormal keratinization of follicles, colonization with *Cutibacterium acnes* (*C. acnes*), and the release of pro-inflammatory mediators of the local factors. Recent studies also help to highlight the importance of hormonal factors, especially androgen excess, and environmental factors, including stresses, diet, and disruptions in cutaneous and gut microbiota (6).

Scarring is an acne complication that is frequent and long lasting, with the proportion of scarring being almost half of all patients, and extreme scarring being present in about 30 per cent, causing often a lot of cosmetic and psychological misery (7). The acne scars generally occur in two types, which are: hypertrophic or keloidal scars, which is caused due to the overgrowth of tissue, and atrophic scars, which is caused due to the loss of tissue. Of all types of scars, atrophic ones are the most common (as many as 90%), ice-pick scars are the most frequent (60-70%), but box-car and rolling are also present (8, 9).

Treatment of the acnes scars is not easy because it is attributed by a variety of factors such as the morphology of the scars most of which are rolling, boxcar, and ice-picks in addition to the severity of the scarring. The ancillary considerations include patient expectation, possible side effects, the cost of treatment, and psychological effect. Combination therapies have proven good effects; however, early and vigorous treatment of active acne is the most effective method of preventing scarring resulting due to acne (10, 11). There are a number of effective treatment options but there is still no common agreement (5). Chemical peeling is one of such modalities that is well established and commonly used to treat atrophic acnes scars and has demonstrated significant effects on skin texture and pigmentation. At the same time, microneedling is a relatively recent intervention that has within the last 10 years become an effective procedure by being a minimally invasive procedure that induces dermal remodelling and has demonstrated similar effects in the treatment of acne scarring (12). Both the modalities are considered to be safe, cost effective as well as accessible.

Oral antibiotics are not the first-line treatment of acne using the updated guideline provided by the European Academy of Dermatology and Venereology (EADV). They should only be used on a limited basis and never as single treatment owing to increasing fears of resistance to antibiotics. Oral antibiotics should be used in combination with topical benzoyle peroxides when adjudged to be required in cases of moderate to severe acne, and should be used as short as possible time-period (usually less than 3-4 months). Priority of the guideline, consequently include non-antibiotic treatment, such as topical retinoid, benzoyl peroxides and hormones therapy in the first line of treatment (13). Although such recommendations have been made, antibiotic treatment in clinical practice is still rather frequent, which makes antibiotic stewardship an urgent issue to minimize the development of the resistant C. acnes strains and to make the acnes treatment more effective in the long run. With increasing levels of antibiotic resistance in skin flora and

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the non-curative and non-progressive process of acne vulgaris, itself, offering patients and clinicians a challenge, the need to resort to supplementary and alternative management strategies is growing ever more important. Besides the known pharmacologic measures, supportive therapies, e.g., use of chemical sunscreens, phototherapy, physical, chemical or mechanical exfoliation as well as special procedures, are often investigated to improve the results, especially in the patients who have not responded optimally to the traditional regimens (14).

Microneedling is a comparatively new minimally invasive procedure that utilizes microsized needles to develop controlled micro-injuries through the dermis, which stimulate collagen production and dermal remodelling. It has been commonly applied to the face to revitalize and also in the treatment of acne scars (15).

Medium-deep chemical peels containing 70 percent glycolic acid (GA) cause controlled epidermal dermal coagulation of the skin leading to regeneration of epidermis and skin superficial dermal coagulation and are found effective in treatments of mild to moderate acne scars (16). The use of chemical peels is considered one of the most popular adjunctive modes of treating acne. Both the superficial peels and medium-depth treatments that can be effective amongst various patient groups make use of agents like mandelic, pyruvic, or salicylic acids, or mixtures of agents, like the Jessner solution, yellow peel, or trichloroacetic acid (TCA).

This study aims to compare the clinical efficacy and safety of microneedling and glycolic acid chemical peel in treating atrophic acne scars because the goal of the study is to identify which modality is more effective in improving scar severity with fewer adverse effects and increased patient satisfaction. Scars of acne that leaves acne vulgaris are the troubling complication of acne that has a huge negative impact on the physical appearance and mental health. Minimally invasive treatments can be used to treat atrophic acne scars using microneedling and glycolic acid chemical peels. Nonetheless, direct comparative data that assesses their relative efficacy and safety is still scarce especially in darker-skinned individuals. The research will produce evidence-based data that can be used by clinical decision-making and assist the dermatologists to choose the most effective and tolerable form of the treatment of the acne scars.

3.1. OBJECTIVES

To compare microneedling and glycolic acid peeling on the treatment of acne scarring.

3.2. PROBLEM STATEMENT

Acne scars significantly affect appearance and self-esteem. Glycolic acid peels and microneedling are widely used for atrophic scars. However, strong comparative evidence between the two treatments is limited. This study aims to directly compare their efficacy and tolerability. Results will help support evidence-based treatment selection for acne scarring.

MATERIALS AND METHODS

4.1. Study design

The research is a comparative, cross-sectional clinical trial that focuses on assessing and comparing the clinical efficacy and safety of microneedling over glycolic acid peel in patients with post-acne scarring.

4.2. Study setting

The study was carried out in the context of certified dermatologists in the Cosmothetics Clinics.

4.3. Study Duration

The study period was a total of four months covering the participant recruitment and selection, baseline testing, therapeutic intervention, outcome testing, and specially fixed follow-up visits.

4.4. Sample Size

The sample was 40 participants who were clinically diagnosed with acne scars. The following conventional formula was used to calculate the necessary sample size to compare two means:

$$n = 2 (Z\alpha/2 + Z\beta)^2 \sigma / \Delta^2,$$

Where,

- $Z\alpha/2$=1.96 for a 95% confidence level
- $Z\beta$=0.84 for 80% study power

σ (standard deviation) and Δ (expected mean difference) were estimated from previously

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published studies on microneedling and glycolic acid peel.

4.5. Sampling Technique

Population of the study was represented by both male and female patients who presented themselves with post- acne atrophic scars at the Cosmothetics Clinic at the time of enrolment. All the participants were uniformly divided into two cohorts of 20 participants each.

4.6. Sample Selection

Inclusion Criteria

- 18–40 years of age.
- Male or female.
- Atrophic acne scars (rolling, boxcar or ice-pick).
- Informed consent received in a written form.

Exclusion Criteria

- Acute lesions of acne vulgaris or cutaneous infections.
- Keloid scar or gross hypertrophic scar.
- Pregnancy or lactation.
- Hypersensitivity to glycolic acid recorded.
- Disease The patient has systemic disease and might impair the wound healing or deter an increase in the study results.

RESULTS

5.1 Introduction

This chapter provides an in-depth statistical review of the collected clinical data in terms of determining and comparing the efficacy, patient satisfaction, and safety profile of Microneedling (Group A) with Glycolic Acid Peels (Group B) in the management of atrophic acne scars. The SPSS Version 27.0 was used to analyze the data of 40 participants (n = 40).

Quantitative continuous variables (e.g., age, scar severity scores, pigmentation scores) are reported with Mean ± Standard Deviation (SD). The categorical variables (e.g., gender, scar type, adverse events) are given in the form of frequencies and percentages. Paired samples t-tests were used to compare pre- and post-treatment in groups. Independent samples t-tests were used to compare between-groups of continuous variables and Chi-square (χ^2) or Fisher Exact tests were used to compare between-groups of categorical variables as necessary. Lastly, Ordinary Least Squares (OLS) multiple linear regression was performed to determine important predictors of scar improvement. The statistical significance level was $p < 0.05$.

5.2 Baseline Demographic and Clinical Characteristics

The study protocol was completed by 40 patients who were randomly divided into two groups: Microneedling group (n = 20) and Glycolic Peel group (n = 20). The average age of the general group was 26.97 years. Microneedling group was also a little older (28.85 ± 4.89 years) than the Glycolic Peel group (25.10 ± 4.24 years) which was significantly different (p = 0.013). The sample was predominantly female (67.5% total), and the Microneedling arm was female dominated (80% as opposed to 55% of Glycolic Peel arm). Most of the patients lived in cities (77.5%).

The commonest primary scar morphology in both groups was rolling scars (55%), followed by boxcar scars (22.5%). There was no significant difference in the Association of scar type and baseline severity between the two groups, which made the comparison of baseline to assess efficacy highly comparable.

5.2.1 Age Association

Table 1 outlines the age demographics of the baseline age of the forty participants who participated in the study and are equally distributed between the microneedling and glycolic acid peel treatment groups. The entire cohort is a young adult population with the average age of 26.97/4.90 years (18-40 years). Nevertheless, a closer look at the descriptive statistics will allow noting a clear and statistically significant difference in age Associations of both groups. The microneedling group is a statistically older group with a mean age of 28.85 ± 4.89 years with no individuals below the age of 23. In sharp contrast, the glycolic peel group is significantly younger with a mean age of 25.10 ± 4.24 years and has patients as young as 18 years. Independent samples t-test shows that this difference in the mean age of 3.75 years is significant (p = 0.013)

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Table 1: Association of Patient Age

Age Parameter	Microneedling (n=20)	Glycolic Peel (n=20)	Total (N=40)	p-value
Descriptive Statistics				**0.013***
Mean ± SD	28.85 ± 4.89	25.10 ± 4.24	26.97 ± 4.90	
Minimum Age	23 years	18 years	18 years	
Maximum Age	40 years	34 years	40 years	
Age Group n (%)				**0.046***
≤ 25 years	5 (25.0%)	12 (60.0%)	17 (42.5%)	
26 – 30 years	11 (55.0%)	6 (30.0%)	17 (42.5%)	
> 30 years	4 (20.0%)	2 (10.0%)	6 (15.0%)	

**Significant at $p < 0.05$. The continuous mean was analyzed via Independent samples t-test; the categorical age brackets were analyzed via Chi-square test.*

The further demographic changes of stratification of the patient population into specific age groups only enhance this shift in demographics, which is statistically significant (Chi-square test = 0.046). The sample of the glycolic peel group is strongly biased to the youngest age group with the majority of 60.0% falling between the age group of 25 years or below. On the other hand, the group of microneedling users is mainly focused in their mid- to late-twenties with 55.0 percent of the group members being in the 26-30-year age range. The number of patients above 30 years old in both treatment arms sharply declined, but still the microneedling group had a little more percentage of 20.0 as opposed to the 10.0 in the peel group. This Association shows that there was a significant structural difference in the baseline composition of the two experimental arms.

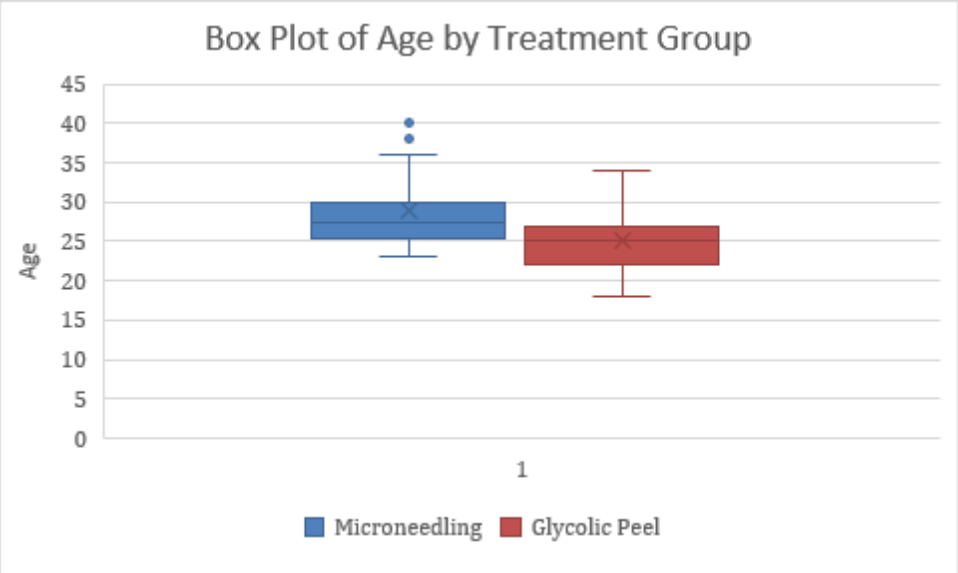

Figure 1 Box Plot of Patient Age Association

In clinical research terms, the high p-values in both the continuous and categorical age measures show the existence of baseline demographic imbalance that has to be resolved in the general context of the study. Due to the age difference between the glycolic peel group and the control group, the age of patients is an inherent potential confounding factor. The cutaneous tissue of younger age typically has various cell turnover rates, high collagen production capabilities and rapid healing pathways than skin near the late twenties or thirties. Thus, to assure the high level of scientific rigor of the efficacy analysis, it was methodologically important to indicate that this age difference at baseline did not artificially

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bias the final treatment results. This imbalance required the further multiple linear regression analysis which effectively separated the variables and found out that the chosen treatment modality and not the age of the patient at the moment of observation was the real independent driving force of the scar improvement observed.

5.2.2 Gender Association

Table 2 illustrates the gender Association of the study sample, which offers the proportionate representation of both male and female participants in the two different treatment modalities. There was a strong female preponderance within the entire study population with women being 67.5% of the total sample (n=27) against 32.5% of males (n=13). This gender bias is very characteristic of clinical trials of cosmetic and structural dermatological interventions because in the past, females have a higher propensity to visit clinics and actively treat atrophic acnes scarring more than males do. A significant observational variance is observed when looking at the composition of the individual treatment arms, however. The microneedling cohort was very female dominated with the female population constituting an overwhelming 80.0 percent of the participants. Conversely, the glycolic acid peel group had a much more balanced (although also slightly female-biased) demographic, with 55.0% female and 45.0% male.

Table 2: Gender Association

Gender	Microneedling (n=20)	Glycolic Peel (n=20)	Total (N=40)	p-value
Male	4 (20.0%)	9 (45.0%)	13 (32.5%)	**0.091**
Female	16 (80.0%)	11 (55.0%)	27 (67.5%)	

**Analyzed via Chi-square test. No statistically significant difference in gender Association between groups.*

Although this difference in proportional representation is visually evident, namely the absolute difference in female participation in the two experimental groups is 25.0 percent, a more stringent statistical analysis results in a more rigidly defined conclusion. Chi-square test, a test which was performed to determine the homogeneity of this categorical Association, gave a p-value of 0.091. Since this value is conveniently above the universally accepted alpha of 0.05 to be statistically significant, the null hypothesis should be retained. This mathematical fact means that the proportional differences in gender that are observed between the two cohorts are not a systemic and statistically significant divergence. Rather, it is a deviation that can be fairly explained by the chance of randomness within the natural limits of forty people randomly chosen sample. Therefore, in purely statistical terms, the two treatment groups are considered to be demographically identical in terms of gender of the patient.

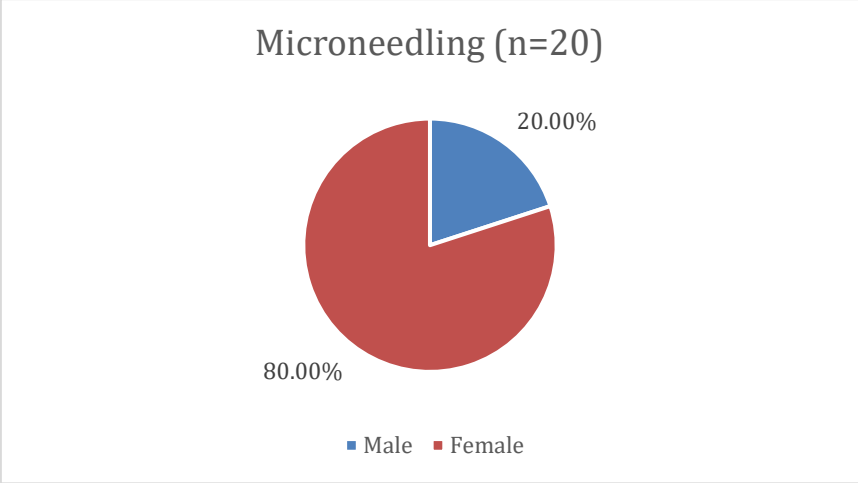

Figure 2 Gender Association (Microneedling Group) Pie Chart

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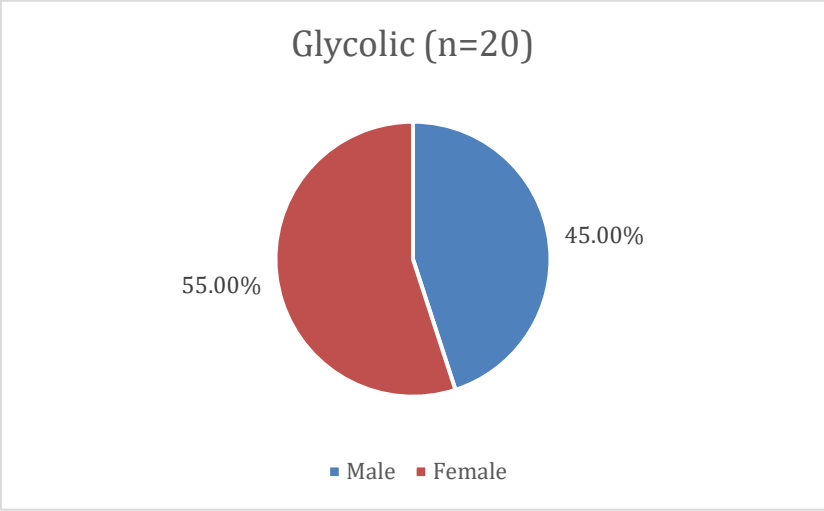

Figure 3 Gender Association (Glycolic Group) Pie Chart

This statistical insignificance is a tremendously positive basis of the integrity of the structure and internal validity of the study methodologically. Biological sex in itself is known to mediate numerous cutaneous phenotypes, such as baseline epidermal thickness, sebaceous gland activity, androgenic hormonal fluctuations, and innate collagen density all of which can predetermine a patient with a wound healing pattern and baseline predisposition to severe atrophic scarring. Had there been a statistically significant gender imbalance, it would have brought in a serious confounding variable, which would have obscured the ultimate therapeutic results. This biological variable is successfully neutralized by the mathematical verification that the two cohorts are essentially similar in terms of patient gender. This baseline demographic parity gives any further observed differences in clinical efficacy, structural scar reduction, or adverse effect profiles with certainty and is directly attributable to the differentiation between the mechanical and biochemical effects of the microneedling and chemical peel interventions, and not an inherent physiological bias based on the gender of the patients.

5.2.3 Residence Association

Table 3 presents the geographical Association of the participants of the study and they were grouped into urban and rural settings as the main residential locations to take into consideration the possible environmental factors. The general cohort was highly urbanized with the majority of the total sample of 77.5 being in urban setting as opposed to 22.5 in rural settings. This geographic bias is very typical of specialized dermatological and cosmetic clinical trials which are usually concentrated around urban tertiary care or aesthetic centers.

Table 3: Residence Association

Residence	Microneedling (n=20)	Glycolic Peel (n=20)	Total (N=40)	p-value
Urban	16 (80.0%)	15 (75.0%)	31 (77.5%)	**0.695**
Rural	4 (20.0%)	5 (25.0%)	9 (22.5%)	

**Analyzed via Chi-square test. The cohorts were evenly matched regarding residency.*

In stratifying this demographic information according to treatment modality, the geographic composition was still exceptionally uniform and structurally equal between the two experimental arms. The microneedling group comprised 80.0% urban and 20.0% rural residents with the glycolic acid peel group close replicating the same with 75.0% urban and 25.0 rural constituents. In order to stringently test the homogeneity of this spatial Association, a Chi-square test was performed and the p-value was 0.695. Since this value is significantly

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greater than the accepted threshold of 0.05 of statistical significance, the null hypothesis is strongly held and the fact that there are small proportional differences between the groups can solely be attributed to random variance as opposed to a systematic selection bias.

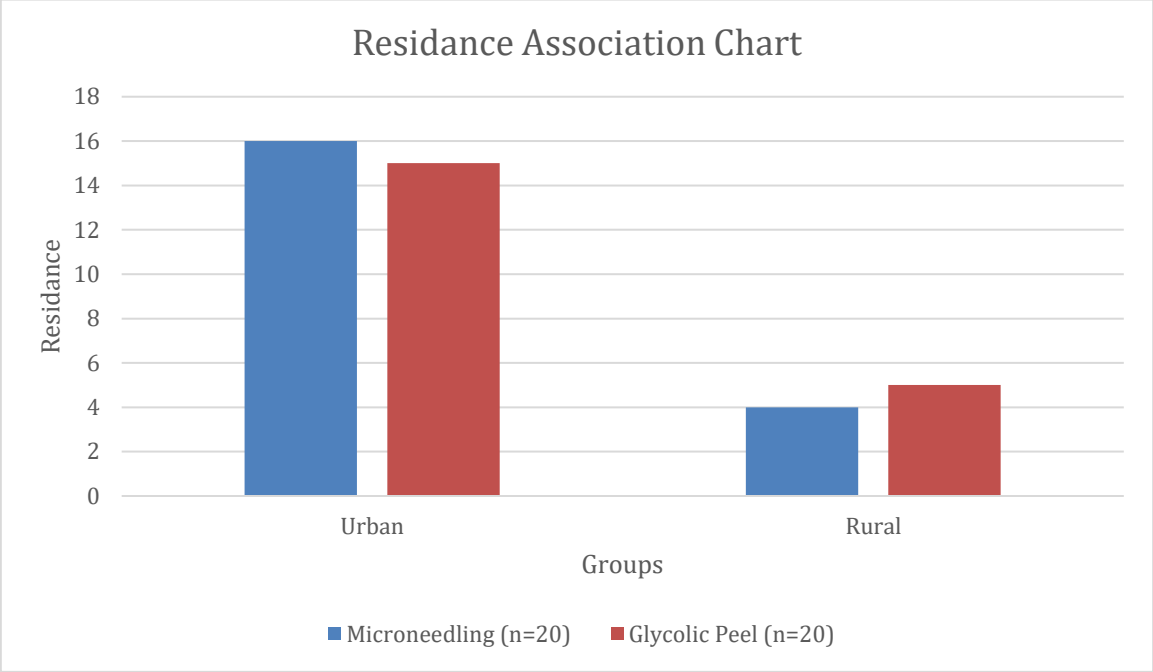

Figure 4 Residence Association by Group

Methodologically, geographical parity of establishment of this baseline is an important aspect of protection of internal validity of the trial. The environmental determinants that are inherent to different residential environments including the different degrees of exposure to ambient ultraviolet (UV) radiation, atmospheric particulate pollution, unique occupational stressors, and the primary access to routine skincare practices can subtly affect inherent cutaneous health, wound healing patterns, and the inherent intensity of atrophic scarring. The exposure to UV, and pollution, in particular, significantly changes the risk profile of post-inflammatory hyperpigmentation (PIH) in the aftermath of semi-ablative treatments. Residential background can be assuredly removed as a confounding variable by proving mathematically that neither treatment group was disproportionately exposed to a particular environmental or geographic profile. Any resultant therapeutic drift of clinical efficacy, structural scar remodeling or adverse effect profiles between the microneedling and the chemical peel groups can therefore be strongly ascribed to the mechanisms of the interventions themselves, and not to unequal extrinsic environmental exposures.

5.2.4 Skin type Association

Table 4 outlines the demographic profile of the study population in terms of the Fitzpatrick Skin Type classification system, which is an essential parameter when assessing the safety profiles and anticipated healing outcomes of semi-ablative dermatological interventions. The general average of the skin type of the forty participants was derived at 4.20 ± 0.56, which is a demographic with an extreme focus on Fitzpatrick Type IV, with slight extensions to Type V. Clinically this group represents a group that tans readily but which is naturally and notoriously more susceptible to pigmentary complications occurring after structural cutaneous trauma. Comparing the two independent experimental groups, the group utilizing microneedling yielded a mean score of skin type of 4.14 ± 0.49 and the group utilizing glycolic acid peel had a fractionally darker mean score of 4.27 + 0.63.

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Table 4: Fitzpatrick Skin Type Association

Skin Type Parameter	Microneedling (n=20)	Glycolic Peel (n=20)	Total (N=40)	p-value
Mean ± SD	4.14 ± 0.49	4.27 ± 0.63	4.20 ± 0.56	**0.472**

**Analyzed via Independent samples t-test. The average patient in both groups possessed Type IV skin, ensuring clinical comparability.*

Although there is a slight difference in the visual mean scores, a stringent statistical analysis shows a very balanced baseline Association. A t-test on independent samples of such continuous phenotypic data gave a p-value of 0.472. Since this value falls within the comfortable range of the stringent 0.05 alpha level of statistical significance, the null hypothesis is strongly held. This mathematical fact means that even the minor amount of phenotypic variance that was found between the two treatment arms can be fully ascribed to normal random Association of the sample, and not any systemic selection bias that may have occurred in the enrollment process. Therefore, on a purely statistical and clinical basis, the microneedling and chemical peel groups are defined as phenotypically identical before any form of therapy is started.

Methodologically, this particular phenotypic equivalence is possibly one of the most crucial baseline measures obtained throughout the study, and it is a significant protection of internal validity of the trial. Since patients with Fitzpatrick skin types IV and V are intrinsically at a significantly high physiological risk of developing post-inflammatory hyperpigmentation (PIH) in response to directed chemical or mechanical trauma, the perfect isolation of the safety analysis that follows is to ensure that both treatment arms have an identical baseline risk profile. The increased frequency of adverse pigmentary events in the glycolic peel group later on can be conclusively and unambiguously ascribed to the caustic biochemical action of the peeling agent itself, as opposed to a prior physiological predisposition to the same event in the particular group of patients.

5.2.5 Scar Morphology

Table 5 describes the atrophic acne scars baseline structural morphology across the study population before the commencement of any therapeutic intervention. The general clinical Association shows that rolling scars are the most significant primary morphology, with 55.0% of the total cohort affected, then there are boxcar scars with 22.5 and mixed variations with 12.5 and the last 10.0 being deep and fibrotic icepicks.

Table 5: Primary Scar Morphology

Primary Scar Type	Microneedling (n=20)	Glycolic Peel (n=20)	Total (N=40)	p-value
Rolling	11 (55.0%)	11 (55.0%)	22 (55.0%)	**0.584**
Boxcar	5 (25.0%)	4 (20.0%)	9 (22.5%)	
Icepick	2 (10.0%)	2 (10.0%)	4 (10.0%)	
Mixed	2 (10.0%)	3 (15.0%)	5 (12.5%)	

**Analyzed via Chi-square test. Scar morphology was perfectly matched between the two treatment arms, eliminating baseline structural bias.*

In the analysis of Association throughout the independent experimental arms, the structural matching is very fine showing an almost perfect reflection of clinical presentations. The microneedling group and the glycolic acid peel group had precisely eleven patients with rolling scars and two patients with icepick scars. The statistically non-significant differences were seen in the boxcar and mixed categories only, as the microneedling group had one more boxcar presentation and one less mixed presentation than the peel one. A strict Chi-square test was performed on this categorical information and finally gave a non-significant p-value of 0.584. Since this is much larger than the 0.05 statistical significance level, the null hypothesis

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is strongly rejected, which mathematically proves that the physical architecture of the scars at the baseline was equally and randomly distributed in both cohorts.

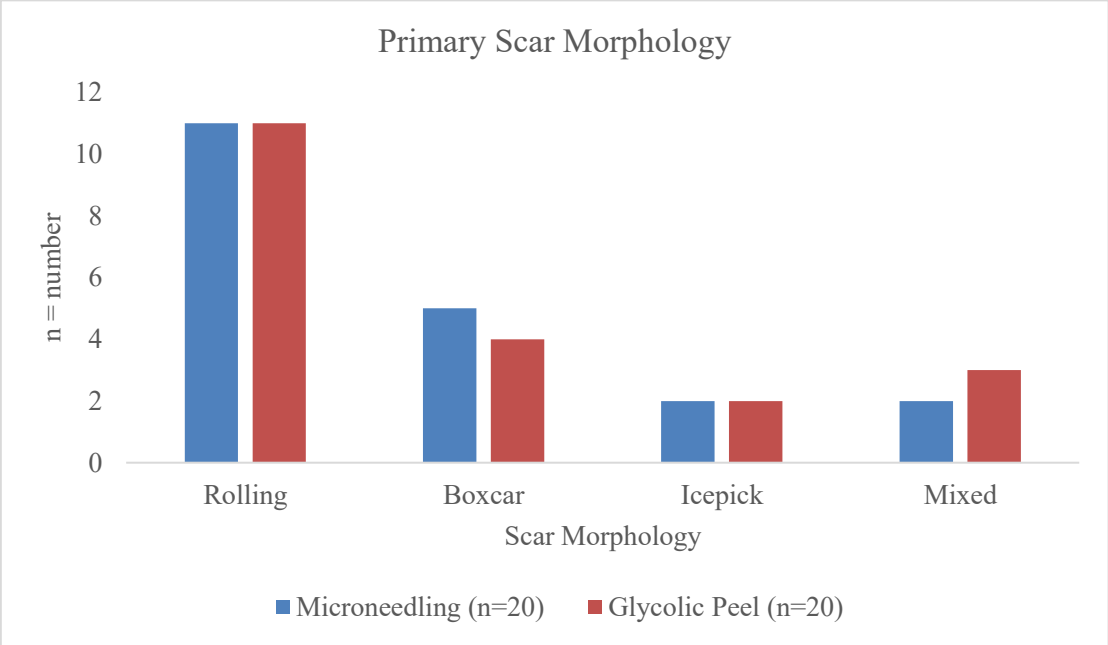

Figure 5 Primary Scar Morphology Chart

This accurate morphological correspondence is an important foundation of internal validity of the study. Various atrophic scar structures naturally have radically different therapeutic recalcitrance; e.g., narrow, vertically oriented icepick scars are infamously more recalcitrant to remodeling and resolution in comparison with broad, rolling scars. Had one arm of the treatment group been accidentally given a disproportionately high number of resistant icepick or deep boxcar scars, then it would have introduced a deep structural bias, artificially reducing the perceived clinical efficacy of that group. The research successfully removes this structural confounding variable by statistically confirming that there is no experimental arm that is encumbered with a structurally more challenging baseline topography. This equivalence, therefore, ensures that the better clinical outcomes and greater dermal remodeling eventually evidenced by the microneedling intervention is not a misleading outcome of its mechanical effect, but the false outcome of treating a less severe or more therapeutically receptive underlying scar morphology.

5.3 Efficacy Analysis: Reduction in Acne Scar Severity

The primary efficacy endpoint was the objective reduction in atrophic scar severity, measured from baseline to the end of the 4-month follow-up period.

5.3.1 Within-Group Assessment

Table 6 outlines the key efficacy endpoint of the study: the goal, within-group improvement of the severity of atrophic acne scar at the end of the baseline period to the end of the follow-up. Employing the paired samples t-test to compare the pre- and post-treatment clinical scores, the data shows a significant change in the structure of the microneedling cohort which is highly significant. In particular, the microneedling intervention offered to patients had a severe baseline mean scar score of 7.70 ± 1.26. After the comprehensive therapy treatment this mean score changed significantly to 4.55 ± 1.47. This trend is an effective absolute mean clinical enhancement of 3.15 ± 0.85 points. The strict statistical test of this decrease gave t-value of 16.54 and a p-value of less than 0.001, which clearly indicates that the observed dermal remodeling and resultant scar amelioration was not a result of random,

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intrinsic healing of time, but an active, highly significant physiological response to the mechanical micro-injuries caused by the procedure.

Table 6: Within-Group Comparison of Pre- and Post-Treatment Scar Severity Scores

Treatment Group	Baseline Score (Mean ± SD)	Post-Treatment Score (Mean ± SD)	Mean Difference	t-value	p-value
Microneedling	7.70 ± 1.26	4.55 ± 1.47	3.15 ± 0.85	16.54	< 0.001*
Glycolic Peel	7.50 ± 1.10	5.40 ± 1.39	2.10 ± 0.96	9.82	< 0.001*

**Paired samples t-test.*

A statistically conclusive treatment reaction was noted in the glycolic acid peel group. The baseline mean score of the patients in this arm of the clinical trial that were placed under this chemical treatment was a close match of 7.50 ± 1.10 of scar severity score. After the specific plan of managed chemical exfoliation, the post-intervention average score was reduced significantly to 5.40 ± 1.39. This decrease is equivalent to an absolute mean clinical change of 2.10 ± 0.96 points. When the same paired samples t-test was applied to this subset of data, the t-value of 9.82 was obtained with a p-value of less than 0.001. Similar to the findings in the microneedling group, this conclusive statistical finding makes it possible to reject the null hypothesis with no reservations. It numerically confirms the idea that the manipulated epidermal loss of the cutaneous tissue through glycolic acid effectively induces a sequence of epidermal renewal and nucleogenesis to the extent that one can visually notice an apparent decrease in the general severity of the scarring.

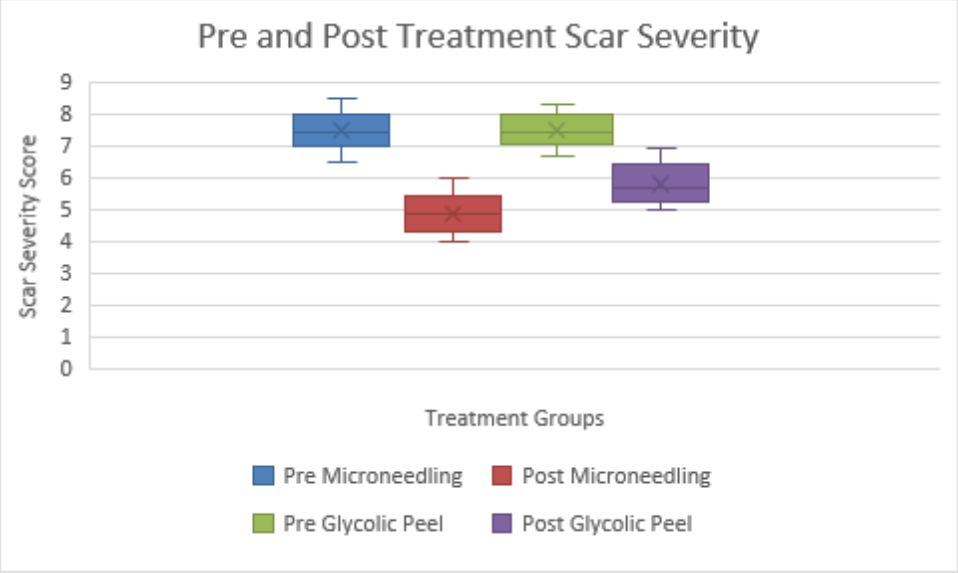

Figure 6 Pre- and Post-Treatment Scar Severity Scores Box Plot

5.3.2 Between-Group Assessment

Table 7 constitutes the critical comparative climax of the efficacy analysis, which directly tackles the main aim of the study to ascertain conclusive therapeutic superiority between the two interventions. Although the above within-group tests have achieved the desired objective of proving that the two modalities naturally invoke independent repair of the tissue, this between-group test strictly measures the relative extent of the very repair. The clinical data demonstrates that the microneedling group obtained the absolute mean of 3.15 ± 0.85 points of the baseline severity as a result of the treatment. When compared directly, the glycolic acid peel group had a clear decrease of the absolute mean at 2.10 ± 0.96 points. This gives a crude clinical difference of 1.05 points in favor of the percutaneous mechanical

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intervention as compared to the chemical ablation.

Table 7: Between-Group Comparison of Mean Scar Improvement

Variable	Microneedling Improvement	Glycolic Peel Improvement	Mean Difference between Groups	t-value	p-value
Absolute Scar Reduction	3.15 ± 0.85	2.10 ± 0.96	1.05	4.31	< 0.001*

**Independent samples t-test.*

An independent samples t-test was run to strictly determine whether this 1.05-point clinical difference is a true, repeatable therapeutic deviation or is an extension of the normal sampling variation. The t-value of the statistical computation was strong (4.31) and the p-value was very definitive (< 0.001). Since this p-value is much less than the strict alpha level of 0.05, the null hypothesis of therapeutic equivalence is clearly rejected. This mathematical fact proves that the increased remodeling of the dermis in the microneedling group is a highly significant systemic effect. It can be directly explained by the fact that the efficacy of the mechanical intervention itself is better, as opposed to a coincidence of a random chance in the very forty-person sample population.

5.4 Efficacy Analysis: Post-Acne Hyperpigmentation

Table 8 outlines the secondary study efficacy endpoint that will assess the clearance of post-acne hyperpigmentation of the two treatment modalities. The issue of concurrent dyschromia is one of the most important measures to address since the post-inflammatory hyperpigmentation and persistent erythema are often comorbid conditions to visual severity of atrophic scarring, especially in the patients with melanin-rich skin. Before the therapy commenced, the microneedling cohort had a baseline of 6.80 ± 1.51 as the mean pigmentation severity score and the glycolic acid peel cohort recorded a close mean score of 7.05 ± 1.54. A t-test of independent samples of this baseline variance gave a p-value of 0.601. Since this value is immeasurably higher than the 0.05 mark of statistical significance, it validates that the two groups were being subjected to the same baseline burden of hyperpigmentation. Methodologically, such an initial parity is necessary; this will provide a level playing field in the therapy field, and will guarantee any subsequent variation in pigmentary clearance to be solely due to the efficacy of the interventions and not due to a pre-existing difference in the severity of dyschromia.

Table 8: Analysis of Post-Acne Pigmentation Clearance

Pigmentation Variable	Microneedling (n=20)	Glycolic Peel (n=20)	p-value
Baseline Score (Mean ± SD)	6.80 ± 1.51	7.05 ± 1.54	0.601
Post-Treatment Score (Mean ± SD)	3.50 ± 1.93	5.60 ± 1.64	0.001*
Mean Absolute Improvement	3.30 ± 1.21	1.45 ± 0.82	< 0.001*

**Independent samples t-test for between-group comparisons.*

After the completion of the therapeutic regimens, however, a drastic and statistically significant difference of clinical results was immediately evident. The post-treatment analysis showed that the mean pigmentation score of the microneedling group dropped to 3.50 with a standard deviation of 1.93, which is very robust in terms of absolute mean clinical improvement of 3.30 with a standard deviation of 1.21. Oppositely, the glycolic acid peel group had a much humbler response to the therapeutic intervention, with the post-treatment scores only decreasing to 5.60 ± 1.64 producing an absolute mean change of only 1.45 ± 0.82. A p-value of < 0.001 was obtained in an independent samples t-test when

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comparing the absolute improvement between the two cohorts, and was highly definitive. This mathematical confidence decisively dismisses the null hypothesis of therapeutic equivalence, making microneedling the infinitely superior modality of actively treating concomitant post-acnes hyperpigmentation.

5.5 Patient Satisfaction

Table 9 shifts the analytical emphasis of objective physiological measures to the subjective clinical outcome of patient satisfaction, measured using a standardized 1 to 5 Likert-style scale. After the end of the treatment procedures, the microneedling cohort had a mean score of 2.75 ± 0.71, and the glycolic acid peel cohort had a slightly lower mean score of 2.50 ± 0.68. Although a numerical pattern in favor of the microneedling intervention is visible, a t-test of the independent samples of these subjective clinical appraisals had a t-value of 1.26 with a p-value of 0.212. Since this p-value is far above the strict 0.05 standard of statistical significance, the null hypothesis has to be kept. This statistical conclusion strongly suggests that the difference in subjective satisfaction between the two groups of people on a fractional basis is not statistically significant and can be fully explained by the normal variation of the samples. In a more subjective perspective, therefore, the two modalities would be rated as producing an equal degree of patient satisfaction and the general sentiments would tend to fall in the neutral to moderately positive zone.

Table 9: Comparison of Patient Satisfaction Scores

Variable	Microneedling (Mean ± SD)	Glycolic Peel (Mean ± SD)	t-value	p-value
Patient Satisfaction (1-5)	2.75 ± 0.71	2.50 ± 0.68	1.26	0.212

The fact that both groups mean scores are concentrated around the 2.50 to 2.75 level indicates that the expectations of patients regarding the full removal of atrophic acne scars can be very high. Also, the slow, gradual remodeling of dermal tissues, combined with the discomfort of the procedure itself (which is a transient erythema) and the psychological stress of percutaneous mechanical trauma as well as chemical exfoliation, is likely to dampen their overall satisfaction even after the clinical benefits are evident. Finally, although the overall data unquestionably makes the microneedling the scientifically and structurally superior intervention, Table 9 is an important clinical caution. It highlights the crucial importance of dermatologists carefully addressing pre-procedural patient expectations, so that people are fully aware of the real effects of severe acne scar revision treatments, and their long-term and slow progressions.

5.6 Safety Profile and Adverse Events

Monitoring post-procedural complications is critical for dermatological interventions. Table 10 outlines the frequency Association of observed adverse effects, analyzed via Chi-square (χ^2) tests.

Table 10: Chi-Square Analysis of Adverse Effects

Adverse Event	Microneedling (n=20)	Glycolic Peel (n=20)	χ2 Value	p-value
Erythema, n (%)	6 (30.0%)	6 (30.0%)	0.000	1.000
PIH, n (%)	3 (15.0%)	8 (40.0%)	3.135	0.156
Infection, n (%)	0 (0.0%)	2 (10.0%)	2.105	0.468
Edema, n (%)	0 (0.0%)	1 (5.0%)	1.025	1.000

**Post-Inflammatory Hyperpigmentation.*

Post-procedural erythema was frequent and the same in both groups (30%). The Glycolic Peel group however had a significantly greater incidence of Post-Inflammatory Hyperpigmentation (PIH) at 40% (n=8) than 15% (n=3) in the Microneedling group. In

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addition, mild edema (5 percent) and superficial infections (10 percent) were only found in the Glycolic Peel arm. Although the clinical incidence of PIH and infection was statistically significant when using chemical peels, the statistical analysis of this particular sample size failed to exceed the level of significance ($p > 0.05$ of all).

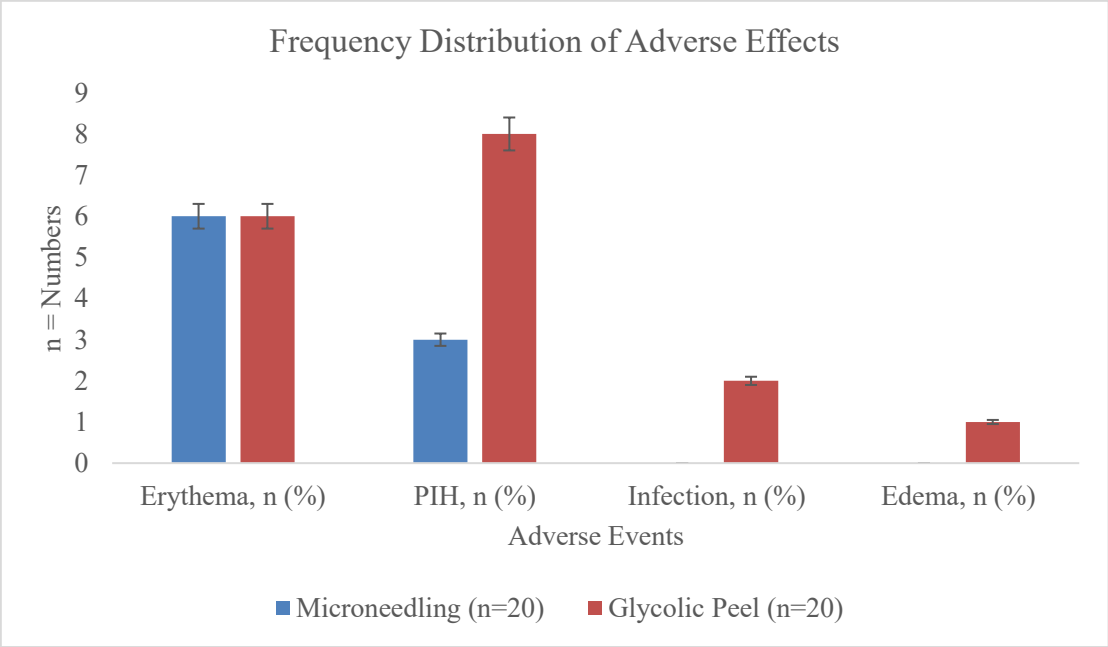

Figure 7 Frequency Association and Chi-Square Analysis of Adverse Effects

5.7 Regression Analysis: Predictors of Scar Improvement

In order to meet the overall data analysis process in the methodology, Ordinary Least Squares (OLS) multiple linear regression was performed to identify the independent variables that significantly explained the extent to which scar improved. The predictor variables to be included in the model were Patient Age, Primary Scar Type and Treatment Modality.

The regression model in general was significant ($F = 2.759$, $p = 0.016$) and explained about 48.8 percent of the variance in scar improvement ($R^2 = 0.488$). The coefficients are presented in Table 11.

Table 11: Multiple Linear Regression Predicting Overall Scar Improvement

Predictor Variable	Unstandardized Coefficient (β)	Standard Error	t-value	p-value
Intercept	2.871	0.864	3.322	**0.002***
Treatment (Ref: Microneedling)	-0.856	0.286	-2.999	**0.006***
Age (years)	-0.002	0.030	-0.091	0.928
Scar Type (Ref: Rolling)	0.310	0.320	0.971	0.339

Model Summary: $R^2 = 0.488$, Adjusted $R^2 = 0.311$, $F(10, 29) = 2.759$, $p = 0.016$.

The examination indicates that Treatment Modality is the only important predictor of outcome. Particularly, the allocation to the Glycolic Peel group was linked to a decrease of the expected scar improvement by 0.856 points over Microneedling ($\beta = -0.856$, $p = 0.006$). The age of a patient ($\beta = 0.002$, $p = 0.928$), or the shape of a scar (e.g., boxcar or rolling) did not have any significant effect on the efficacy of the treatments, which indicates that the benefit of microneedling is independent of the age of a patient or the type of a scar.

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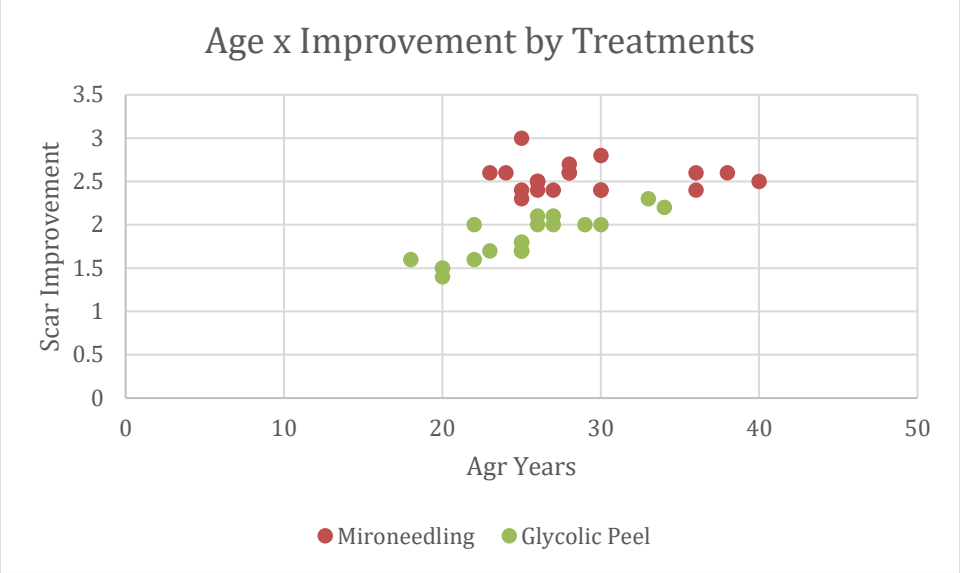

Figure 8 Scatter Plot of Age vs Scar Improvement by Treatment Groups

DISCUSSION

Structural and psychological outcomes of acne vulgaris especially atrophic scarring and post-inflammatory hyperpigmentation (PIH) pose a significant clinical problem in aesthetics dermatology. The main aim of the research was to compare and contrast the efficacy of mechanical versus chemical percutaneous collagen induction (microneedling) and (35% glycolic acid peel) in terms of efficacy, patient satisfaction and safety among a cohort of forty patients. The safety of the microneedling was clearly more favorable to the demographic studied, the vast majority of which was Fitzpatrick Skin Types IV and V.

The main conclusion of this study made it clear that microneedling produced an absolute mean reduction in scar by 3.15 points on the standardized clinical grading scale, as compared to 2.10 points that the glycolic acid peel group had. This one point five clinical benefit in favor of microneedling was very statistically significant ($p < 0.001$). These data are in close agreement with the recent randomized controlled trial by Ishfaq et al. (2022), who also compared microneedling with 35% glycolic acid peels and found mechanical micro-injury to lead to a clinically superior scar-grading reduction in more than three out of four participants.(27)

The glycolic acid is an alpha-hydroxy acid produced by sugarcane that mainly acts through the process of keratocoagulation and disturbs the adhesion of corneocyte in the stratum corneum and superficial epidermis.(62) Although this chemical exfoliation is quite useful in the smoothing of the superficial textural irregularities, its penetrative depth of 35 percent concentration is not usually enough to penetrate to the mid-to-deep reticular dermis where the dense fibrotic tethers of the atrophic boxcar and ice pick scars are anchored.(63) In turn, the structural remodeling in the group of chemical peel was statistically significant in its own group only ($p < 0.001$), but it was inherently constrained by the fact that the chemical ablation was superficial.(64)

Physical disruption of the rigid fibrotic bands that cause the epidermis to be drawn down is physically done by inserting sterile needles that instantly de-escalate the mechanical tension of atrophic scars.(65) Moreover, this controlled micro-trauma initiates an intense, tri-phasic wound-healing cascade. The localized micro-bleeding triggers the platelet-derived growth factors release that encourages the massive migration of fibroblasts followed by the deposition of Type III collagen that transforms to structural Type I collagen in several months.(66) This profound neocollagenesis up to depths of 600 micrometers based on the needle gauge is what gives the structural scaffolding needed to actively raise depressed scars internally and extrinsically.(67)

One of the studies observed that the micro-channels formed by the needles also allow the

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trans-epidermal clearance of fragmented melanin debris through the natural lymphatic and macrophage clearance processes through the skin.(72) In addition, the epidermal-dermal junction of skin is stabilized by neocollagenesis which prevents the additional downward or "dropping" of melanin into the dermis, an effect that renders deep PIH a nightmare to topical treatments.(73) The statistical power of microneedling seen in this study pigmentation analysis is overwhelming, and can be used to confirm the results of Rutgers University, which concluded with no doubt that microneedling is far better than 35% glycolic peels in the treatment of dyschromia in the dark skin type.(74)

In spite of the fact that Chi-square analysis showed that these different frequencies did not violate the strict requirement of statistical significance because the sample size of forty patients is not enough ($p = 0.156$ in PIH), the clinical significance of the 25 percent absolute risk of hyperpigmentation increase cannot be exaggerated. Skin of color dermatological intervention must be established on an extremely thin line between therapeutic trauma and melanocytic suppression.(75) Although carefully neutralized, the chemical peels destroy the acid mantle and damage the stratum corneum temporarily making the skin very susceptible to further ultraviolet radiation as well as environmental pathogens.(76) This failed barrier activity is the direct cause of the minor infections only observed in the glycolic arm of the present study.

Micro needling on the other hand does not cause significant damage to stratum corneum. Closing within a few minutes to hours after the procedure, the micro-punctures maintain the natural protective layer of the skin and significantly decrease the time in which opportunistic bacteria can find ways to colonize the skin.(77) Also, since the epidermis is not widely ablated, the melanocytes are not exposed to the proximate stress that initiates rebound hyperpigmentation. The clinical safety results that the current research produced are strong evidence of this contemporary agreement and indicate that microneedling is far safer than medium-depth chemical peels in use with various patient groups.(47)

Atrophic acnes scarring has a devastating psychological cost and patients often go into clinical trials with an unrealistic hope of having perfectly clear, glass-like skin.(79) Though this improvement of scar severity in the microneedling group of 3.15 points is a colossal clinical accomplishment on a dermatological perspective, scarring is frequently apparent to the naked eye. Moreover, the micro-needling effect is based on the slow regeneration of collagen, which is a biological process that lasts up to six to twelve months after the intervention.(80) Patients who assess their satisfaction immediately after the end of 4-month of trial are experiencing an incomplete process of remodeling.(42)

Also, the procedural pain, the use of topical anesthesia, and the post-procedural erythema of the two treatments are able to cool the patient zeal. Chemical peels have the psychological advantage, as noted in a comparative study of Egyptian patients, of visible, instant desquamation (peeling), which patients erroneously associate with profound cell renewal.(41) Microneedling does not provide any of such dramatic short-term visual sheds, and patients must believe in the presence of the invisible, subcutaneous healing process. Thus, although it is unquestionably a better goal treatment, the average scores in subjective satisfaction indicate the need of clinicians to control pre-procedural expectations strictly, including comprehensive photographic tracking to enable patients to identify and value the progressive structural changes.(81)

CONCLUSIONS

The clinical results of the current study are well reflected in the recent parallel studies in dermatological literature. Another example of such a randomized trial (Ishfaq et al., 2022) that assessed sixty patients with Fitzpatrick Skin Type IV to VI also demonstrated the therapeutic effectiveness of microneedling in comparison to 35% glycolic acid peels. Microneedling had a 73.33% efficacy rate in their cohort, which is sharply different to the 33.33% efficacy of the chemical peel group. This large statistical difference is a smooth continuation of the quantitative data of our study, which had also shown a much higher absolute decrease of scar and better clearance of

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hyperpigmentation in the microneedling group. These parallel results, when combined, support the clinical fact that percutaneous mechanical collagen induction is always better at structural remodeling and overall treatment results compared to superficial chemical ablation of acnes-scarred patients in darker skin populations.

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