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Clinical Evaluation Of Automated Microneedling In Facial Scar Management: A Prospective Observational Study

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Abstract:

Background*: Facial scars can result in significant aesthetic, psychological, and social concerns, thereby affecting an individual's quality of life. Automated microneedling therapy has emerged as a minimally invasive modality that promotes percutaneous collagen induction and dermal remodelling with minimal epidermal damage. This study aims to evaluate the efficacy and complications of automated microneedling therapy in the management of facial scars.*

Materials and Methods*: A descriptive longitudinal observational study was conducted with eighteen patients with facial scars of various etiologies, including traumatic, post-surgical, acne, burn, and post-herpetic scars, who were treated using an automated microneedling device (Dr. Pen Ultima A1W). Four treatment sessions were performed at one-month intervals using needle depths of 2.5–3.0 mm. Clinical evaluation was performed using the Vancouver Scar Scale for scar vascularity and scar size at baseline, 1 month, 2 months, 3 months, and 6 months follow-up. Patient satisfaction and postoperative complications were also assessed. Statistical analysis was performed using paired t-test and Wilcoxon signed-rank test, with $p < 0.05$ considered statistically significant.*

Results*: The mean age of participants was 34.61 ± 10.80 years, with male predominance (72%). Traumatic scars were the most common aetiology (44%). Significant improvement was observed in both scar size and vascularity following treatment ($p < 0.0001$). The most substantial improvement was noted between the second and third treatment sessions. At 6-month follow-up, the mean scar size score improved from 2.44 ± 0.49 preoperatively to 1.00 ± 0.57, while vascularity improved from 2.55 ± 0.49 to 1.05 ± 0.70. Patient satisfaction outcomes revealed good to excellent improvement in 66.66% of patients. Postoperative complications were minimal and transient, with erythema being the most common finding.*

Conclusion: *Automated microneedling therapy is a safe, effective, and minimally invasive modality for the management of facial scars, producing significant improvement in scar characteristics with minimal complications. Early intervention and multiple treatment sessions appear to enhance clinical outcomes.*

Key Word: *Acne Vulgaris, Cicatrix, Collagen, Dermis, Facial Injuries, Microneedling, Minimally Invasive Surgical Procedures, Skin Diseases, Wound Healing*

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I. Introduction

Facial appearance plays a significant role in self-perception, interpersonal communication, and social interaction. Facial scars resulting from acne, trauma, burns, surgery, or infectious diseases may therefore have a considerable psychological and aesthetic impact on affected individuals. In addition to cosmetic concerns, visible facial scars are frequently associated with diminished self-esteem, impaired social confidence, and reduced quality of life.[1-3] Scar formation represents an abnormal response to tissue injury in which normal skin architecture is replaced by fibrous connective tissue during wound healing, often resulting in alterations in vascularity, pigmentation, texture, and thickness.[1,2]

Various treatment modalities have been introduced for scar management, including surgical revision, dermabrasion, chemical peels, ablative and non-ablative laser therapies, injectable fillers, and topical pharmacological agents.[4-6] Although many of these techniques demonstrate clinical efficacy, they are often associated with prolonged recovery time, post-inflammatory pigmentation, thermal tissue injury, variable outcomes, and risk of recurrence.[4,5] These limitations have encouraged the development of minimally invasive procedures that promote dermal remodelling while preserving epidermal integrity.

Microneedling, also known as percutaneous collagen induction therapy, has emerged as a promising minimally invasive technique for the treatment of scars and skin rejuvenation.[5,6] The procedure involves the

creation of multiple controlled microchannels within the skin using fine needles, resulting in a localized wound-healing cascade that stimulates collagen and elastin synthesis.[7,8] Unlike ablative procedures, microneedling preserves the epidermis and minimizes thermal damage, thereby reducing downtime and the risk of pigmentary complications.[5,6]

The therapeutic effects of microneedling are attributed to mechanical stimulation of the papillary and reticular dermis, which promotes neocollagenesis, neoangiogenesis, and tissue remodeling.[8-13] In addition, the transient disruption of the stratum corneum enhances transdermal delivery of topical therapeutic agents such as platelet-rich plasma, growth factors, depigmenting agents, and radiofrequency-assisted treatments, thereby improving their clinical efficacy.[7,9] Due to its favourable safety profile, low cost, minimal downtime, and applicability across different skin types, microneedling has gained widespread acceptance in aesthetic and reconstructive dermatology.[14-17]

The concept of skin needling was first introduced by Orentreich and Orentreich in 1995 through the technique of subcision for the treatment of depressed scars and wrinkles.[10] Subsequently, Camirand and Doucet demonstrated improvement in surgical scars using needle dermabrasion with tattoo gun needles.[11] Fernandes later developed percutaneous collagen induction therapy using a drum-shaped instrument embedded with fine needles, which laid the foundation for modern microneedling techniques.[12,13] Since then, multiple studies have demonstrated the efficacy of microneedling in the management of acne scars, hypertrophic scars, burn scars, post-traumatic scars, and post-surgical scars.[1,2,18-21]

Automated microneedling devices such as dermapens offer several advantages over conventional dermarollers, including adjustable needle depth, uniform needle penetration, improved precision, reduced epidermal trauma, and enhanced accessibility to anatomically difficult areas.[16,22] These devices additionally reduce the risk of cross-contamination through the use of disposable needle cartridges. Despite increasing clinical utilization of automated microneedling, limited literature exists evaluating its effectiveness in the management of heterogeneous facial scars within oral and maxillofacial surgical practice.[1,2]

Therefore, the present study was undertaken to evaluate the clinical outcomes of automated microneedling therapy in patients with facial scars by assessing changes in scar vascularity, scar height, patient satisfaction, and treatment-related complications over a 6-month follow-up period.

II. Material And Methods

A prospective observational longitudinal study was conducted in the Department of Oral and Maxillofacial Surgery, Rural Dental College and Hospital, Pravara Institute of Medical Sciences (PIMS), Loni, Maharashtra, India, from April 2023 to December 2024. The study was initiated following approval from the Institutional Ethics Committee of Rural Dental College, and written informed consent was obtained from all participants prior to enrollment (PIMS/RDC/IEC/UG-PG/02-2023)

Study Design: Prospective observational longitudinal study

Study Location: This was a tertiary care teaching hospital based study done in Department of Oral and Maxillofacial Surgery, at Rural Dental College and Hospital, Pravara Institue of Medical Sciences (PIMS), Loni, Maharashtra, India.

Study Duration: April 2023 to December 202.

Sample size: 18 patients.

Subjects & selection method: Patients presenting with facial scars to the Department of Oral and Maxillofacial Surgery during the study period were screened for eligibility. As this was an exploratory observational study, all eligible patients presenting during the study period were included. A total of 18 patients fulfilling the inclusion criteria underwent automated microneedling therapy.

Inclusion criteria:
1. Patients with post-acne scars, burn scars, or post-traumatic scars in the maxillofacial region
2. Patients with post-herpetic or post-varicella scars in the maxillofacial region
3. Patients presenting with facial scars associated with discoloration
4. Patients treated with automated microneedling therapy
5. Patients willing to participate in the study and provide written informed consent

Exclusion criteria:
1. Patients with a history of radiotherapy to the facial region

2. Patients with systemic conditions affecting wound healing, such as diabetes mellitus or immunocompromised states
3. Patients with bleeding disorders
4. Patients with active skin diseases or infections, including psoriasis, vitiligo, or local skin infections
5. Patients who had undergone previous scar treatment with botulinum toxin or dermal fillers within the preceding 6–8 months
6. Pregnant or lactating women
7. Patients with scars associated with local or systemic infection, gangrene, or non-vascularized tissue

Procedure methodology

After obtaining written informed consent, demographic and clinical details including age, sex, etiology of scar, and duration of scar were recorded preoperatively. Clinical evaluation was performed at baseline and at 1-, 2-, 3-, and 6-month follow-up visits.

Scar assessment was performed using selected parameters of the Vancouver Scar Scale (VSS), including vascularity and scar height. Vascularity was graded as normal (0), pink (1), red (2), and purple (3). Scar height was graded as flat/non-palpable (0), <2 mm (1), 2–5 mm (2), and >5 mm (3). Patient satisfaction was assessed at the 6-month follow-up using an ordinal satisfaction scale ranging from no response to excellent response to treatment. Post-treatment complications including erythema, edema, inflammation, and post-inflammatory hyperpigmentation were also recorded. Standardized clinical photographs were obtained at baseline and during each follow-up visit under consistent lighting and positioning conditions.

Microneedling Procedure

All procedures were performed under aseptic conditions using an automated microneedling device (Dr. Pen Ultima A1W, China) with disposable needle cartridges. Each patient underwent four treatment sessions at monthly intervals. Prior to the procedure, the treatment area was cleansed with soap and water followed by antiseptic preparation using alcohol swabs. A topical anesthetic cream was applied under occlusion for approximately 60 minutes and subsequently removed before treatment initiation.

Microneedling was performed using needle depths ranging from 2.5 to 3.0 mm at speed level 4, depending on scar characteristics and skin thickness. The skin was stretched manually, and the dermapen device was moved uniformly in horizontal, vertical, and diagonal directions over the scarred area until uniform pinpoint bleeding was achieved, which was considered the clinical endpoint.

The duration of each session ranged from 10 to 30 minutes depending on the size and extent of the affected area. Following the procedure, the treated area was cleansed with normal saline. Patients were advised regarding expected transient post-procedural effects including erythema, edema, and crusting.

Post-procedure care included topical fusidic acid application for 48 hours followed by moisturizer use until erythema resolved. Patients were instructed to avoid direct sun exposure and to apply sunscreen with SPF ≥30 during the follow-up period. All patients completed the study follow-up period.

Outcome Measures

The primary outcome measures included improvement in scar vascularity and scar height assessed clinically using VSS parameters. Secondary outcome measures included patient satisfaction and incidence of post-procedural complications.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 20 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. As repeated measurements were obtained over time, pairwise comparisons between follow-up visits were performed using Wilcoxon signed-rank test. A p-value <0.05 was considered statistically significant.

III. Result

A total of 18 patients with facial scars underwent automated microneedling therapy during the study period. The mean age of the study population was 34.61 ± 10.80 years, with an age range of 18–58 years.

Male patients constituted the majority of the study population, accounting for 72.2% (n = 13), while females comprised 27.8% (n = 5). With respect to scar etiology, traumatic scars were the most common type observed in 44.4% (n = 8) of patients, followed by post-surgical scars in 27.8% (n = 5). Post-acne scars accounted for 11.1% (n = 2), burn scars for 5.6% (n = 1), and other etiologies for 11.1% (n = 2). Regarding duration of scars prior to treatment, 38.9% (n = 7) of patients presented within 0–6 months of scar formation, 16.7% (n = 3) between 6–12 months, 27.8% (n = 5) between 12–24 months, and 16.7% (n = 3) had scars older than 24 months (Table 1).

Table 1: Demographic and Baseline Characteristics of Study Participants

Variable	Category	Number of Patients (%)
Gender	Male	13 (72%)
	Female	5 (28%)
Etiology of Scar	Traumatic scar	8 (44%)
	Post-surgical scar	5 (28%)
	Post-acne scar	2 (11%)
	Burn scar	1 (6%)
	Others	2 (11%)
Time Since Scar Formation	0–6 months	7 (39%)
	6–12 months	3 (16%)
	12–24 months	5 (28%)
	>24 months	3 (17%)

The mean scar height score improved significantly from 2.44 ± 0.49 at baseline to 1.00 ± 0.57 at the 6-month follow-up ($p < 0.0001$). Similarly, the mean vascularity score improved significantly from 2.55 ± 0.49 preoperatively to 1.05 ± 0.70 at the 6-month follow-up ($p < 0.0001$) (Table 2).

Table 2: Comparison of Scar Size and Vascularity Before and After Automated Microneedling Therapy

Variable	Time Interval	Mean ± SD	Paired t-test p-value	Wilcoxon p-value
Scar Size	Preoperative	2.44 ± 0.49	<0.0001*	<0.0001*
	Postoperative (6 months)	1.00 ± 0.57		
Scar Vascularity	Preoperative	2.55 ± 0.49	<0.0001*	<0.0001*
	Postoperative (6 months)	1.05 ± 0.70		

*Statistically significant ($p < 0.05$)

Pairwise comparison using the Wilcoxon signed-rank test demonstrated no statistically significant improvement in scar size between baseline and the 1-month follow-up ($p = 0.3173$). However, statistically significant improvement was observed between the 1st and 2nd month follow-ups ($p = 0.0455$). The greatest statistical significance was observed between the 2nd and 3rd month follow-ups ($p = 0.000108$). Further statistically significant improvement was observed between the 3rd month and 6-month follow-up assessments ($p = 0.00468$) (Figure 1).

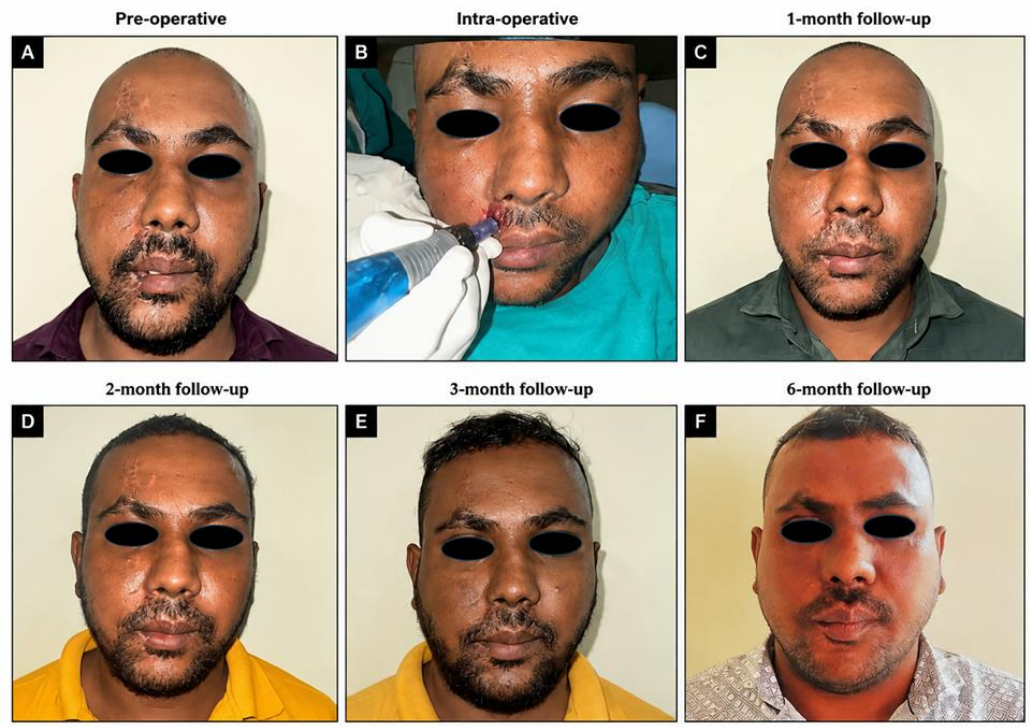

Figure 1: Representative case of post traumatic facial scar treated with automated microneedling (dermapen) therapy. (A) Pre-operative (B) Intra-operative (C) 1-month follow up (D) 2-month follow up (E) 3-month follow up (F) 6-month follow up

Similarly, vascularity assessment revealed no statistically significant difference between baseline and the 1-month follow-up (p = 0.1573). Significant improvement in vascularity scores was subsequently observed between the 1st and 2nd month follow-ups (p = 0.0455), while the greatest statistical significance was observed between the 2nd and 3rd month follow-ups (p = 0.000789). Additional statistically significant improvement was noted between the 3rd month and final follow-up assessment (p = 0.00468) (Table 3).

Table 3: Comparison of Scar Size and Vascularity Outcomes at Different Follow-up Intervals

Comparison	Scar Size t-value	Scar Size p-value	Scar Size Wilcoxon p-value	Scar Vascularity t-value	Scar Vascularity p-value	Scar Vascularity Wilcoxon p-value
Preoperative vs 1st month follow-up	1.00	0.3306	0.3173	1.447	0.1631	0.1573
1st month vs 2nd month follow-up	2.19	0.0419*	0.0455*	2.220	0.0416*	0.0455*
2nd month vs 3rd month follow-up	8.22	<0.0001*	0.000108*	5.433	0.000055*	0.000789*
3rd month vs Postoperative follow-up	3.62	0.00197*	0.00468*	3.671	0.0018*	0.00468*

*Statistically significant (p < 0.05)

Patient Satisfaction

Patient-reported satisfaction at the 6-month follow-up was favorable overall. Excellent response to treatment was reported by 22.2% (n = 4) of patients, while 44.4% (n = 8) reported good improvement. Fair improvement was noted in 27.8% (n = 5) of patients, and only one patient (5.6%) reported poor response to treatment. No patient reported absence of clinical improvement.

Post-Procedural Complications

The most commonly observed post-procedural complication was transient erythema, occurring in 50.0% (n = 9) of patients. Edema and inflammation were each observed in 11.1% (n = 2) of patients. Post-inflammatory hyperpigmentation occurred in 5.6% (n = 1) of patients. No complications were observed in 27.8% (n = 5) of patients. All complications were mild and self-limiting, resolving with conservative management (Table 4).

Table 4: Patient Satisfaction and Postoperative Complications

Variable	Category	Number of Patients (%)
Patient Satisfaction Score	Excellent response	4 (22.22%)
	Good response	8 (44.44%)
	Fair response	5 (27.77%)
	Poor response	1 (5.57%)
	No response	0 (0%)
Postoperative Complications	Erythema	9 (50%)
	Edema	2 (11%)
	Inflammation	2 (11%)
	Post-inflammatory hyperpigmentation	1 (5%)
	None	5 (28%)

IV. Discussion

Scar formation is an inevitable consequence of wound healing following injury involving the reticular dermis and may result in considerable aesthetic, functional, and psychosocial impairment.[3] The management of facial scars, therefore, remains an important component of reconstructive and aesthetic practice.

Microneedling has emerged as a minimally invasive therapeutic modality that promotes dermal remodelling through controlled mechanical microinjury, stimulating the release of growth factors such as platelet-derived growth factor, fibroblast growth factor, and transforming growth factors α and β, thereby enhancing fibroblast proliferation and collagen synthesis, collagen remodelling and neocollagenesis.[5,8] The controlled disruption of old collagen bundles initiates a wound-healing cascade that ultimately improves scar vascularity, scar height, and overall scar appearance.[23] Unlike ablative resurfacing procedures, microneedling preserves much of the epidermal barrier, thereby minimizing thermal injury, reducing downtime, and lowering the risk of post-inflammatory pigmentation and secondary scarring.[17]

In the present study, 18 patients with facial scars underwent automated microneedling therapy using the Dr. Pen Ultima A1W dermapen device. The mean age of the study population was 35 years, with patients ranging from 18 to 58 years of age. Male participants constituted the majority of the sample (72%). Similar demographic findings were reported by Shokeir et al., who also observed a predominance of male participants in patients undergoing automated microneedling for scar management.[24] However, Lakshmi et al. reported a younger study population with a higher proportion of female participants.[2]

The results of the present study demonstrated statistically significant improvement in scar vascularity and scar height over the follow-up period ($p < 0.0001$). Progressive clinical improvement was observed after successive treatment sessions, with the most pronounced changes occurring between the second and third months of therapy. In addition to objective improvement, patient satisfaction scores and photographic outcomes also demonstrated favorable treatment responses. These findings are consistent with the study conducted by K TS and Li MK, who reported significant clinical improvement in facial and non-facial scars of varying etiologies treated with microneedling therapy.[25]

The use of an automated dermapen device provided several practical advantages over conventional dermarollers, including adjustable needle depth and speed, enhanced precision, uniform penetration, and improved accessibility to anatomically difficult areas.[16,22] Disposable needle cartridges additionally reduced the risk of cross-contamination and facilitated treatment of focal lesions with greater accuracy. In the present study, approximately 22% of patients demonstrated excellent treatment response, which was comparable to the findings reported by Shokeir et al.[24]

Needle penetration depth has been shown to significantly influence clinical outcomes following microneedling therapy.[22] To maximize dermal collagen induction, the present study utilized a needle depth of 2.5–3.0 mm. Salman and Mohammed demonstrated superior clinical improvement and patient satisfaction with 2.5 mm needle penetration compared with 1.5 mm penetration in the treatment of acne scars.[22] The favorable outcomes observed in the present study may therefore be partially attributed to the greater depth of dermal stimulation achieved with automated microneedling.

A negative association was observed between scar duration and treatment response, with younger patients and relatively newer scars demonstrating better clinical improvement following therapy. Similar findings were reported by Sharad, who observed enhanced treatment outcomes in patients with recent acne scars compared with long-standing lesions.[26] Early initiation of treatment may therefore improve scar remodelling by modulating the wound-healing process before complete scar maturation occurs.

Most studies evaluating microneedling therapy have traditionally included mature scars present for at least six months.[27] In contrast, the present study initiated treatment as early as 6–8 weeks following scar formation in selected cases. Patients with relatively immature scars demonstrated greater improvement in scar vascularity and overall scar characteristics. These findings are supported by the study conducted by Claytor et al., who reported significantly superior aesthetic outcomes when microneedling was initiated during the early postoperative period compared with delayed intervention.[28] Early scar modulation may therefore represent an important therapeutic window for improving long-term scar outcomes.

The present study demonstrated progressive improvement in scar characteristics with repeated treatment sessions. Improvement in scar height and vascularity became more evident after the second and third sessions, with maximum improvement observed at the 6-month follow-up. These findings support the need for multiple treatment sessions to achieve clinically meaningful scar remodeling. Singh and Yadav, in their review of microneedling applications, similarly suggested that a minimum of four to six sessions may be necessary for significant clinical improvement.[29] Bandral et al. additionally reported superior outcomes in superficial scars compared with deeper scars, highlighting the influence of scar depth on treatment response.[1]

The duration of follow-up in previous studies evaluating microneedling therapy has varied considerably.[25,30] In the present study, patients were followed for 6 months following initiation of treatment. However, collagen remodeling following microneedling is known to continue for several months after therapy completion. Fabbrocini et al. suggested that maximal clinical improvement may become evident 8–12 months following treatment.[30] Therefore, studies with larger sample sizes and longer follow-up periods are required to better assess the long-term efficacy of automated microneedling therapy.

Postoperative complications observed in the present study were mild and self-limiting. Transient erythema was the most common adverse effect, followed by mild edema and inflammation, all of which resolved spontaneously within a few days. Only one patient developed post-inflammatory hyperpigmentation. Similar findings have been reported in previous studies evaluating microneedling therapy, supporting its favorable safety profile.[17,21]

The present study was limited by a relatively small sample size and the absence of a control group. In addition, the study included scars of varying etiologies, which may have influenced treatment response and outcome assessment. Clinical evaluation was primarily based on subjective scar assessment scales and photographic analysis. Furthermore, the follow-up duration was limited to 6 months, whereas collagen

remodelling following microneedling may continue for a longer period. Therefore, larger controlled studies with standardized treatment protocols and longer follow-up durations are recommended to validate the findings of the present study.

V. Conclusion

Automated microneedling appears to be a safe, minimally invasive, and effective modality for the management of facial scars. Significant improvement was observed in scar vascularity, scar height, and patient satisfaction following four treatment sessions. Early intervention and repeated sessions were associated with better clinical outcomes. The controlled penetration and precision offered by automated dermapen devices may enhance treatment efficacy compared to conventional manual techniques. However, further large-scale controlled studies with standardized protocols and longer follow-up are required to establish definitive clinical guidelines

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