

# Integrating Microneedling with Surgical Techniques for Improved Postoperative Scar Aesthetics

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## ABSTRACT

**Background:** Postoperative scar formation remains an important determinant of cosmetic and patient-centered surgical outcomes. **Objective:** To evaluate the effectiveness of integrating microneedling with surgical scar management for improving postoperative scar aesthetics compared with conventional scar management alone. **Methods:** This comparative cross-sectional analytical study was conducted at Khyber Girls Medical College from January 2025 to January 2026 including 196 patients with postoperative linear surgical scars. Patients were allocated into conventional scar management and surgery plus microneedling groups. **Results:** Baseline characteristics were comparable between groups. The microneedling group demonstrated significantly better scar outcomes, with lower Vancouver Scar Scale scores ( $4.9 \pm 1.7$  vs.  $8.4 \pm 2.1$ ;  $p < 0.001$ ), improved POSAS observer scores ( $18.3 \pm 5.2$  vs.  $29.6 \pm 6.8$ ;  $p < 0.001$ ), and better patient-reported POSAS scores ( $19.7 \pm 5.9$  vs.  $31.4 \pm 7.3$ ;  $p < 0.001$ ). Scar thickness was significantly lower ( $2.1 \pm 0.8$  vs.  $3.8 \pm 1.1$  mm), while pigmentation irregularity and poor pliability were less frequent. High patient satisfaction was significantly greater in the microneedling group (84.7% vs. 50.0%). Conventional scar management alone was the strongest predictor of poor scar outcome (aOR 4.28;  $p < 0.001$ ). **Conclusion:** Integration of microneedling with surgical scar management significantly improves postoperative scar aesthetics, symptom burden, and patient satisfaction compared with conventional scar care alone.

**Keywords:** Microneedling; postoperative scar; scar aesthetics; wound healing; Vancouver Scar Scale; cosmetic outcomes.

**How to cite this article:** Khan I, Abbas M, Shakir A, Turakhanov SV, Ayub M, Awan A, Tariq ZH. Integrating Microneedling with Surgical Techniques for Improved Postoperative Scar Aesthetics. *Int J Drug Deliv Technol.* 2026;16(61s): 103-108. DOI: 10.25258/ijddt.16.61s.15

**Source of support:** Nil.

**Conflict of interest:** Nil.

## INTRODUCTION

Scar formation is a great concern after surgery and plays an important role in functional recovery and cosmesis. While scars form as part of wound healing, excessive fibrosis, hypertrophic scarring, pigmentation changes and textural irregularities can have a negative impact on patient satisfaction, quality of life and psychological well-being especially if the scars are found in cosmetically sensitive areas [1]. With the continuous progress of modern surgery, the focus is more and more shifting to the patient's results and aesthetic recovery, making the evaluation and optimization of scar appearance more and more important in clinical practice [2]. There are several factors that affect

scar formation such as the surgical technique, wound tension, contamination and/or inflammation, patient age, skin type, anatomical location, genetic predisposition, and post-operative wound care [3]. Despite careful surgical healing, scar appearance may be sub-optimal due to abnormal collagen remodeling and to chronic inflammatory reactions [4]. Adjunctive therapies that can modulate wound remodeling have thus emerged as an important research focus in reconstructive and aesthetic surgery [5]. Percutaneous collagen induction therapy, or microneedling, is a relatively new minimally invasive method for the remodeling of scars and rejuvenation of the skin [6]. This is a method of inducing controlled micro-injury to the dermis, which triggers a production of collagen, remodeling of

elastin, angiogenesis and release of growth factors and maintains the integrity of the epidermis [7]. Microneedling has been found to be effective in acne scars, atrophic scars, pigmentation disorders and skin texture improvement [8]. In recent years, microneedling has also been considered as an additional treatment in postoperative scar management, either as an initial treatment in the process of scar maturation, or as a treatment combined with other surgical scar revision procedures [9]. Microneedling facilitates better organized collagen deposition and remodeling, which can lead to increased pliability of scars, decreased thickness, improved texture and uniformity of pigmentation [10]. This has sparked interest in combining these with surgical techniques to get the best aesthetic outcome. A variety of scales have been validated for assessing the outcome of surgical scars, including those related to pigmentation, vascularity, thickness, pliability, pain, itching and cosmetic appearance [11]. Better scar quality contributes to the patient's appearance, as well as helping to alleviate symptoms and boost patient confidence [12]. Combining procedural scar remodeling techniques may thus provide cosmetic and functional benefits. Previous research testing microneedling for the treatment of scars has shown positive results, especially in cases of hypertrophic and post-acne scars, but there have been relatively few studies specifically on postoperative scars [13]. There is uncertainty about optimal timing of intervention, treatment protocols, scar types and combination strategies, and this is a major variability across available studies [14]. This idea of microneedling in combination with traditional surgical procedures could be a synergistic treatment, thus, by careful surgical closure the primary scar burden is reduced and the secondary remodeling is boosted by the microneedling [15]. This integration may have beneficial effects on scar maturation, need for revision procedures and long-term patient satisfaction [16].

**Objective**

To evaluate the effectiveness of integrating microneedling with surgical scar management for improving postoperative scar aesthetics compared with conventional scar management alone.

**Methodology**

This was a comparative cross-sectional analytical study conducted at Khyber Girls Medical College from January 2025 to January 2026, including 196 patients. Patients aged 18-65 years who were due for elective surgical interventions where there was likely to be a postoperative scar were included. Patients with healed postoperative linear scars amenable to scar assessment and intervention, patients willing for follow-up scar management, and patients with informed consent were included in the study.

Active wound infection, wound dehiscence, known severe pathological scarring, uncontrolled diabetes mellitus which affects wound healing, coagulation disorders, immunocompromised states, existing dermatological conditions at the treatment area, pregnancy and previous scar revision procedures were considered as exclusion criteria. The exclusion criteria included: active wound infection, wound dehiscence, keloid-prone skin with known severe pathological scarring, uncontrolled diabetes mellitus which affects wound healing, coagulation disorders, immunocompromised states, existing dermatological conditions at the treatment area, pregnancy and previous scar revision procedures.

**Data Collection**

Ethical approval was obtained and data collected using a structured proforma. Patients were divided into two groups: conventional surgical scar management group and combined surgical technique and microneedling group. Demographic data, such as age, gender, BMI, smoking history, presence of comorbidities, surgical site, surgical procedure, wound closure method, scar location, and baseline scar characteristics were considered as baseline variables. Once sufficient healing of the wounds was achieved as per the protocol, the microneedling intervention was given, following the same procedure and at a fixed interval using a set depth of needles. The scars were assessed by validated scar assessment scales including Vancouver Scar Scale and Patient and Observer Scar Assessment Scale. Scars were analyzed for pigmentation, vascularity, pliability, thickness, pain, itching, irregularity of the texture, and general cosmetic appearance. The other adverse events recorded were erythema, post-inflammatory hyper pigmentation, infection, delayed healing and treatment intolerance.

**Statistical Analysis**

Data was analyzed by SPSS 26.0. Data for continuous variables were reported as mean ± SD and for categorical variables as frequency and percentage. Comparisons of scar outcome between the study groups were made using independent t-tests and chisquare tests. To determine factors associated with suboptimal scar appearance and poor treatment outcomes, multivariable logistic regression analysis was conducted. A p-value ≤0.05 was considered statistically significant.

**Results**

Both groups were comparable at baseline. Mean age was 34.8 ± 10.6 years in the conventional group and 35.7 ± 11.2 years in the microneedling group (p=0.56). BMI, gender distribution, smoking status, diabetes, surgery type, and scar length were also similar, indicating no significant baseline difference between groups.

**Table 1: Baseline Demographic, Clinical, and Surgical Characteristics of Study Participants (n = 196)**

Variable	Conventional Scar Management (n=98)	Surgery + Microneedling (n=98)	p-value
Age (years), mean ± SD	34.8 ± 10.6	35.7 ± 11.2	0.56

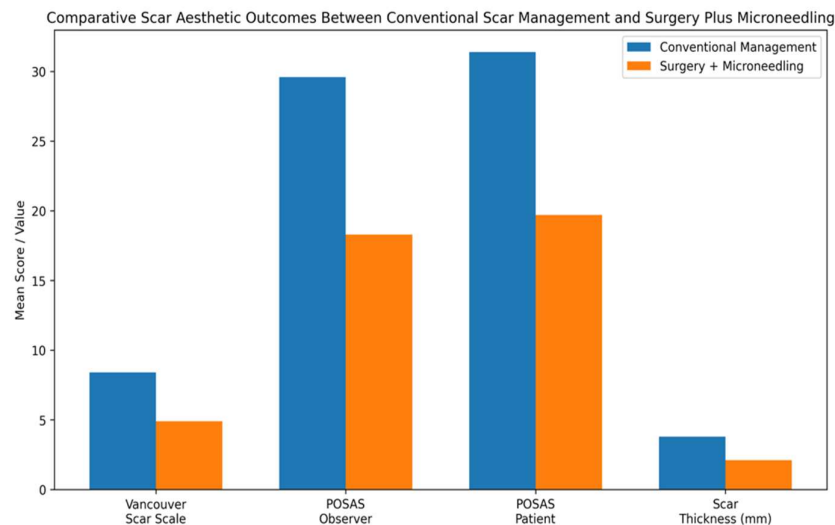
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Male Gender, n (%)	46 (46.9%)	49 (50.0%)	0.66
Female Gender, n (%)	52 (53.1%)	49 (50.0%)	
BMI (kg/m <sup>2</sup> ), mean ± SD	27.3 ± 4.4	27.8 ± 4.7	0.42
Smokers, n (%)	18 (18.4%)	16 (16.3%)	0.69
Diabetes Mellitus, n (%)	12 (12.2%)	10 (10.2%)	0.64
Abdominal Surgery, n (%)	32 (32.7%)	29 (29.6%)	0.74
Orthopedic Surgery, n (%)	25 (25.5%)	28 (28.6%)	
Plastic / Reconstructive Surgery, n (%)	21 (21.4%)	19 (19.4%)	
ENT / Head & Neck Surgery, n (%)	20 (20.4%)	22 (22.4%)	
Linear Scar Length (cm), mean ± SD	8.6 ± 2.9	8.9 ± 3.1	0.49

Scar aesthetic outcomes were significantly better in the surgery plus microneedling group. Vancouver Scar Scale score was lower with microneedling ( $4.9 \pm 1.7$  vs.  $8.4 \pm 2.1$ ;  $p < 0.001$ ), while POSAS observer and patient scores also improved markedly. Scar thickness was reduced to  $2.1 \pm 0.8$  mm compared with  $3.8 \pm 1.1$  mm, and pigmentation irregularity and poor pliability were significantly less frequent.

**Table 2: Comparative Scar Aesthetic Outcomes Between Study Groups at Final Follow-up**

Variable	Conventional Group (n=98)	Surgery + Microneedling Group (n=98)	p-value
Vancouver Scar Scale Score, mean ± SD	$8.4 \pm 2.1$	$4.9 \pm 1.7$	<0.001
POSAS Observer Score, mean ± SD	$29.6 \pm 6.8$	$18.3 \pm 5.2$	<0.001
POSAS Patient Score, mean ± SD	$31.4 \pm 7.3$	$19.7 \pm 5.9$	<0.001
Scar Thickness (mm), mean ± SD	$3.8 \pm 1.1$	$2.1 \pm 0.8$	<0.001
Scar Pigmentation Irregularity, n (%)	34 (34.7%)	14 (14.3%)	0.001
Poor Scar Pliability, n (%)	29 (29.6%)	11 (11.2%)	0.002



**Figure 1: Comparative Evaluation of Postoperative Scar Aesthetic Outcomes Between Conventional Surgical Scar Management and Combined Surgery Plus Microneedling Intervention**

Patient-reported outcomes favored microneedling. High satisfaction was reported by 83 (84.7%) patients in the microneedling group compared with 49 (50.0%) in the conventional group ( $p<0.001$ ). Persistent pruritus, pain/tenderness, and consideration for cosmetic revision were also significantly lower with microneedling, showing better comfort and scar acceptance.

**Table 3: Patient Satisfaction and Symptom-Related Scar Outcomes**

Variable	Conventional Group (n=98)	Surgery + Microneedling Group (n=98)	p-value
High Patient Satisfaction, n (%)	49 (50.0%)	83 (84.7%)	<0.001
Moderate Satisfaction, n (%)	32 (32.7%)	12 (12.2%)	
Low Satisfaction, n (%)	17 (17.3%)	3 (3.1%)	
Persistent Pruritus, n (%)	27 (27.6%)	10 (10.2%)	0.002
Persistent Pain / Tenderness, n (%)	18 (18.4%)	6 (6.1%)	0.009
Cosmetic Revision Considered, n (%)	21 (21.4%)	5 (5.1%)	<0.001

Regression analysis showed that conventional scar management alone was the strongest predictor of poor scar aesthetic outcome (aOR 4.28; 95% CI: 2.01–9.09;  $p<0.001$ ). Other significant predictors included scar length >10 cm (aOR 2.72), smoking history (aOR 2.47), and diabetes mellitus (aOR 2.16), while abdominal scar location showed increased risk but was not statistically significant.

**Table 4: Multivariable Logistic Regression Analysis for Predictors of Poor Scar Aesthetic Outcome**

Variable	Adjusted OR	95% CI	p-value
Conventional Scar Management Only	4.28	2.01–9.09	<0.001
Smoking History	2.47	1.12–5.42	0.02
Diabetes Mellitus	2.16	1.01–4.63	0.04
Scar Length >10 cm	2.72	1.29–5.71	0.008
Abdominal Surgical Scar Location	1.94	0.93–4.03	0.07

**Discussion**

In this study, the combination of microneedling and surgical scar management yielded enhanced postoperative outcomes both cosmetically and patient-reportedly, compared to traditional scar management. These results indicate that microneedling is a highly beneficial adjunctive procedure for postoperative scar remodeling and improvement of the appearance outcomes. Baseline characteristics were comparable between both groups, with similar age ( $34.8 \pm 10.6$  vs.  $35.7 \pm 11.2$  years), BMI ( $27.3 \pm 4.4$  vs.  $27.8 \pm 4.7$  kg/m<sup>2</sup>), smoking status, diabetes prevalence, surgery types, and scar length ( $8.6 \pm 2.9$  vs.  $8.9 \pm 3.1$  cm), allowing a balanced comparison. This comparability helps to increase the trustworthiness of the observed treatment effects. Other studies have investigated the results of scar interventions with similar baseline cohorts [17]. One of the most significant results was the significant improvement in objective scar aesthetic scores with microneedling integration. The combined treatment group ( $4.9 \pm 1.7$ ) had significantly lower Vancouver Scar Scale scores, suggesting improved vascularity, pigmentation, pliability and thickness of the scars ( $p<0.001$ ). There were also significant improvements in patient-reported scores of POSAS ( $19.7 \pm 5.9$  vs.  $31.4 \pm 7.3$ ) and observer scores of POSAS ( $18.3 \pm 5.2$  vs.  $29.6 \pm 6.8$ ) which represented a better cosmetic outcome. Another study showed marked improvements in scar assessment scores that were validated after scar

remodeling using microneedling [18]. The thickness of scars and quality of their structure also increased considerably. The thickness of the scars was reduced in the microneedling group to  $2.1 \pm 0.8$  mm from  $3.8 \pm 1.1$  mm in the conventional group ( $p<0.001$ ). The percentage of irregular pigmentation decreased from 34.7% to 14.3% and the percentage of poor pliability of scars dropped from 29.6% to 11.2%, respectively. The results presented here confirm the biological process of microneedling which involves controlled remodeling of collagen, neovascularization, and better organization of the extracellular matrix. One previous study also noted that there was an improvement in the pliability, pigmentation, and thickness of the scar after collagen induction therapy [19].

Patient-centred outcomes were also highly beneficial. In the microneedling group, 84.7% of patients had high satisfaction, whereas only 50.0% of patients in the conventional group had high satisfaction ( $p<0.001$ ). Among patients with low satisfaction, the number dropped from 17.3% to 3.1% ( $p<0.001$ ) in the microneedling group. Persistent pruritus was significantly decreased (10.2% vs. 27.6%) and persistent pain or tenderness was down from 18.4% to 6.1%. The proportion of considerations for cosmetic revision dropped significantly from 21.4% to 5.1%. The improvements in objective appearance and the significant patient comfort and patient acceptance, suggest

that microneedling is a valuable improvement to the patient's comfort level and acceptance. Another study was conducted that likewise showed an enhancement in satisfaction and symptom decrease after scar remodeling post surgery [20]. This was confirmed by the results of regression analysis. Poor aesthetic outcome was the most likely to be associated with conventional scar management alone, with an increased risk more than fourfold (aOR 4.28; 95% CI: 2.01–9.09;  $p < 0.001$ ). Other factors were also significant, such as smoking history (aOR 2.47), scar length  $> 10$  cm (aOR 2.72), and diabetes mellitus (aOR 2.16), and these factors are known to have adverse effects on healing, chronic inflammation and poor collagen remodeling. Smoking, diabetes and scar burden were also found to be important factors influencing scar outcome in a previous study [21].

#### Limitations

This study has several limitations. Being a single-center comparative cross-sectional study, causal conclusions regarding the superiority of microneedling cannot be established with complete certainty. Patients were not strictly randomized, which may introduce selection bias. Scar assessment includes some subjective components despite validated scoring tools. Differences in individual wound healing response, skin type, compliance with postoperative scar care, and surgical technique variation may have influenced outcomes. Long-term scar maturation beyond the study follow-up period was not assessed, and histological scar remodeling analysis was not performed.

#### Conclusion

It is concluded that integrating microneedling with conventional surgical scar management significantly improves postoperative scar aesthetics compared with conventional management alone. Patients receiving microneedling demonstrated better scar appearance, lower scar thickness, improved pigmentation and pliability, reduced pain and pruritus, higher patient satisfaction, and lower likelihood of considering cosmetic revision.

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