Lasers in Surgery and Medicine

CLINICAL REPORT

Clinical Efficacy and Histologic Correlation of a High-Powered 675-nm Non-Ablative Diode Laser for Facial Rejuvenation

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Received: 30 June 2026 | **Revised:** 4 August 2026 | **Accepted:** 26 August 2026

Keywords: 3D imaging | 675-nm diode laser | collagen | facial rejuvenation | non-ablative laser | skin texture

ABSTRACT

Objectives: The 675-nm diode laser has emerged as a novel wavelength for non-ablative skin rejuvenation, with potential advantages in selective dermal targeting and minimal epidermal injury. However, integrated clinical and biologic evidence across multiple esthetic domains remains limited. This study aimed to evaluate the efficacy and safety of high-powered 675-nm laser treatment for facial rejuvenation in a real-world clinical setting.

Materials and Methods: In this prospective single-center study, 22 adults with facial erythema, fine wrinkles, enlarged pores, and textural irregularities underwent 3 monthly sessions of 675-nm non-ablative diode laser treatment. Objective outcomes were assessed using three-dimensional imaging at baseline and the 3-month follow-up (T3). Blinded Global Esthetic Improvement Scale (GAIS) evaluations were performed for pigmentation and erythema. An exploratory histologic analysis was conducted in a subset of participants.

Results: Eighteen participants completed the paired imaging analysis. Significant improvements were observed in wrinkle ($+0.73 \pm 0.86$, $p = 0.002$), pore ($+1.54 \pm 2.24$, $p = 0.010$), and smoothness scores ($+2.18 \pm 2.35$, $p = 0.001$), with large effect sizes (Cohen's d_z 0.69–0.93). Blinded GAIS assessments demonstrated $\geq 50\%$ improvement in 61.1% of participants for both pigmentation and erythema. Treatment-related pain was mild (median visual analog scale score: 2.0), and no serious adverse events or post-inflammatory hyperpigmentation were observed. Histologic findings suggested increased dermal collagen components.

Conclusion: High-powered 675-nm non-ablative diode laser treatment significantly improved objective skin texture parameters and provided clinically perceptible improvements in pigmentation and erythema, with favorable tolerability. These findings support its role as a versatile and effective modality for comprehensive facial rejuvenation.

1 | Introduction

Facial aging is a multifactorial process characterized by the progressive deterioration of dermal collagen, elastin, and extracellular matrix components [1–3]. Clinically, these changes manifest as fine wrinkles, textural irregularities, enlarged pores, and variable degrees of erythema and pigmentation [4, 5]. In parallel with these biological changes, patient demand for low-downtime rejuvenation modalities has increased substantially, driving the development of non-ablative laser technologies designed to stimulate dermal remodeling while minimizing epidermal injury [6, 7].

Ye Ji Jang and Woo Jin Choi contributed equally to this work.

Among the emerging wavelengths, the 675-nm diode laser has recently attracted considerable attention as a versatile, non-ablative technology to achieve skin rejuvenation and treat pigmentary disorders. Recent reviews have summarized its unique optical properties, biologic mechanisms, and expanding clinical applications across multiple dermatologic indications [8–10]. Accordingly, the 675-nm wavelength has emerged as a promising platform for regenerative laser therapy owing to its selective affinity for collagen and melanin. Owing to its location within the tissue optical window, this wavelength enables effective dermal penetration and demonstrates affinity for collagen and melanin, with relatively low hemoglobin absorption [11, 12]. Unlike conventional non-ablative systems that primarily target water, the 675-nm laser induces a more selective photothermal effect on collagen fibers, allowing targeted energy delivery to the mid-dermis with limited superficial thermal damage [13]. Histological studies suggest that this controlled thermal stimulation promotes collagen denaturation followed by neocollagenesis, resulting in improvements in skin texture and elasticity [13].

Early clinical studies support these mechanistic observations. Improvements in atrophic acne scars and overall skin quality have been reported following treatment with the 675-nm laser [14]. In addition, recent evidence indicates that this wavelength can be safely applied to pigmentary disorders, such as melasma, particularly in darker skin phototypes, where the risk of post-inflammatory hyperpigmentation is typically higher [15, 16]. These findings suggest that the 675-nm laser may address multiple components of facial aging, including both textural and pigmentary changes.

Despite its increasing clinical use, several limitations persist in the current literature. Many studies focus on single endpoints, rather than integrated esthetic outcomes, and the combination of objective imaging with blinded clinical evaluation has not been consistently implemented. Histologic confirmation of dermal remodeling remains limited, and correlations between tissue-level changes and clinical outcomes have not been adequately explored.

In this study, we conducted a prospective clinical evaluation of high-powered 675-nm laser treatment in adults presenting with facial erythema, fine wrinkles, enlarged pores, and textural irregularities. Objective assessment was performed using three-dimensional imaging to quantify wrinkle, pore, and smoothness parameters, supplemented by blinded Global Esthetic Improvement Scale (GAIS) evaluation of pigmentation and erythema [17–19]. In a subset of participants, paired skin biopsies were obtained to investigate histological changes in collagen and extracellular matrix components. By integrating objective quantitative imaging, blinded clinical assessment, and exploratory tissue-level analysis, this study aims to provide comprehensive evidence of the clinical efficacy and biological effects of high-powered 675-nm laser treatment in a real-world setting.

2 | Materials and Methods

2.1 | Study Design and Participants

This prospective, single-center study enrolled 22 consecutive adults seeking treatment for facial erythema, fine wrinkles, enlarged pores, and skin texture irregularities. Treatments were performed at monthly intervals: baseline/first treatment (T0), second treatment (T1), third treatment (T2), and follow-up 1 month after the third session (T3). All participants completed clinical follow-up and safety assessments.

2.2 | Laser Device and Treatment Protocol

Treatments were delivered using a 675-nm non-ablative diode laser system (RedTouch Pro; DEKA, Italy). Procedures were performed on cleansed skin with the application of a conductive gel to optimize optical coupling, along with continuous integrated epidermal cooling throughout irradiation. The power setting was fixed at 15 W. Pulse duration ranged from 50 to 100 ms, and spot spacing ranged from 1000 to 1500 μm; these parameters were selected within predefined therapeutic ranges based on skin characteristics, treatment area, and patient tolerability. Routine topical anesthesia was not used.

2.3 | Clinical Photography and Blinded Assessment

Standardized facial photographs were obtained under consistent lighting conditions and positioning. Pigmentation and erythema were evaluated at T3 using the 5-point GAIS (score: 0–4) by two independent dermatologists blinded to treatment timing and patient identity. The mean score of both evaluators was used for analysis. Responder status was defined as a score ≥ 3 (at least 50% improvement). Inter-rater reliability was assessed using the quadratic weighted kappa (κ) statistic.

2.4 | Pain and Safety Assessment

Treatment-related pain was recorded immediately after each session using a 0–10 visual analog scale (VAS) [20]. Adverse events were recorded at each visit.

2.5 | Three-Dimensional Imaging

Objective assessments were conducted using the LifeViz® three-dimensional imaging system (Quantificare S.A., Valbonne, France) at T0 and T3 [21]. The manufacturer's automated software generated wrinkle, pore, and smoothness scores by comparing the patient's skin topography with an age- and sex-matched normative database. These scores were recorded on a scale from −10 to +10, where higher values indicate greater improvement relative to the reference data set, thereby providing a standardized quantitative measure of skin changes.

2.6 | Histologic Assessment

Two participants provided additional consent for paired punch biopsies at T0 and T3 from anatomically matched sites. All specimens were stained with hematoxylin and eosin, as well as antibodies against collagen I, collagen III, collagen IV, and elastin (TmBio Inc. Gyeonggi-do, Korea). Digital images were analyzed using ImageJ software (https://ij.imjoy.io/). The stained area fraction (%Area) was quantified within standardized regions of interest confined to the dermis, excluding the

epidermis. Given the limited sample size, histologic findings were analyzed descriptively.

2.7 | Statistical Analysis

Continuous variables are presented as the means ± standard deviation or medians with interquartile ranges (IQRs), as appropriate. Paired comparisons between T0 and T3 for three-dimensional outcomes were performed using paired *t*-tests, with Wilcoxon signed-rank tests conducted as sensitivity analyses. Effect sizes were calculated as Cohen's d_z with 95% confidence intervals for mean changes. The proportions of responders were calculated with 95% confidence intervals using the Wilson method. All analyses were performed using SPSS version 30.0 for Windows (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

2.8 | Ethical Considerations

The study protocol was approved by the Institutional Review Board of Hallym University Sacred Heart Hospital (IRB No. HALLYM 2025-09-007-002). Written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

3 | Results

3.1 | Study Population

A total of 22 participants were enrolled in this study. Of these, 18 completed the 3-month follow-up (T3) with paired three-dimensional imaging and were included in the quantitative analysis (mean age: 51.4 ± 13.8 years; 83.3% female). Four participants were lost to follow-up before T3 and were therefore excluded from the quantitative analysis. Baseline characteristics, including initial three-dimensional skin scores, are summarized in Table 1.

3.2 | Objective Three-Dimensional Outcomes

As shown in Table 2, all objective 3D parameters demonstrated statistically significant improvements at T3. Wrinkle scores increased by a mean of +0.73 ± 0.86 ($p = 0.002$), while pore scores increased by +1.54 ± 2.24, showing a significant improvement ($p = 0.010$). Smoothness exhibited the greatest magnitude of improvement, increasing by +2.18 ± 2.35 ($p = 0.001$). Large effect sizes were observed across all parameters, with Cohen's d_z ranging from 0.69 to 0.93 (Table 2). Sensitivity analyses using Wilcoxon signed-rank tests confirmed the significance of these changes. Representative three-dimensional imaging outputs illustrating these clinical improvements are presented in Figure 1.

TABLE 1 | Baseline demographic and clinical characteristics of the study cohort ($N = 18$).

Characteristic	Value
Age, mean ± SD (years)	51.4 ± 13.8
Female	15 (83.3%)
Male	3 (16.7%)
Baseline 3D scores, mean ± SD	
Wrinkle score	4.97 ± 2.02
Pore score	5.87 ± 2.95
Smoothness score	4.48 ± 3.34

Abbreviations: 3D, three-dimensional; SD, standard deviation.

3.3 | Blinded GAIS Outcomes

The results of the blinded physician assessment are detailed in Table 3. At T3, the mean GAIS score was 3.03 ± 0.65 for pigmentation and 2.97 ± 0.61 for erythema. Using the predefined responder threshold (score ≥ 3), 61.1% of participants (11 of 18) were classified as responders in both the pigmentation and erythema domains. Inter-rater reliability was moderate, with quadratic weighted κ values of 0.58 and 0.53, respectively (Table 3).

3.4 | Pain and Safety

Treatment-related pain was mild and remained stable throughout the three sessions (median VAS 2.0; IQR 1.0–4.0). No serious adverse events were reported. Transient post-treatment erythema resolved within 1–2 days. Although mild crusting occurred in some participants, all cases resolved within 7 days without sequelae. No cases of scarring or post-inflammatory hyperpigmentation were observed.

3.5 | Exploratory Histology

Descriptive analysis of paired skin biopsies from two participants suggested a trend toward increased dermal matrix components. Collagen I expression increased from 47.6% to 57.1% in the first participant and from 45.1% to 50.2% in the second. Similarly, collagen III staining demonstrated an upward trend (44.2%–48.0% and 41.9%–58.8%). In contrast, collagen IV immunostaining revealed heterogeneous changes between the paired biopsy specimens, with increased expression identified in one participant and decreased expression in the other. Elastin further demonstrated heterogeneous changes across the paired biopsy specimens (Supporting Information: Table 1). Representative immunohistochemical images of collagen I and collagen III staining at baseline and follow-up are shown in Figure 2.

4 | Discussion

This prospective clinical study demonstrates that treatment with a high-powered 675-nm non-ablative diode laser results in significant and clinically meaningful improvements in objective skin texture parameters, accompanied by visible esthetic enhancement and a favorable safety profile. Quantitative three-dimensional imaging revealed statistically significant improvements in wrinkle, pore, and smoothness scores at 3 months, with large effect sizes (Cohen's d_z: 0.69–0.93). These objective findings were corroborated by blinded GAIS evaluations, in

TABLE 2 | Quantitative changes in the three-dimensional imaging parameters ($N = 18$).

Parameter	Baseline (T0)	Follow-up (T3)	Change (T3–T0), mean ± SD	*p* value*	Effect size (d_z)
Wrinkle score	4.97 ± 2.02	5.70 ± 1.84	+0.73 ± 0.86	0.002**	0.85
Pore score	5.87 ± 2.95	7.41 ± 2.34	+1.54 ± 2.24	0.010*	0.69
Smoothness score	4.48 ± 3.34	6.66 ± 3.07	+2.18 ± 2.35	0.001**	0.93

Note: Values are presented as means ± standard deviation (SD). The paired t-test was used for the analysis.
*$p < 0.05$; **$p < 0.01$.

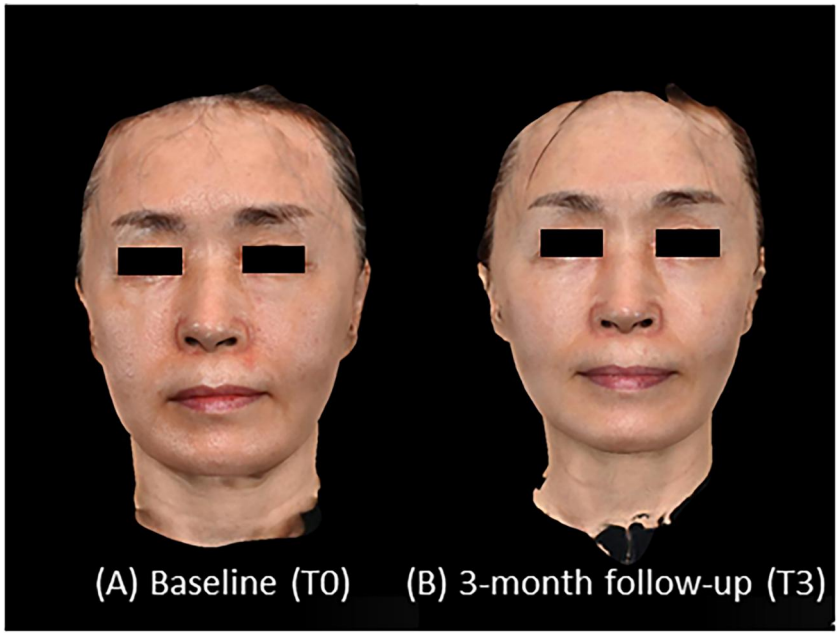

FIGURE 1 | Representative three-dimensional imaging outputs at baseline (A) and at the 3-month follow-up (B) demonstrating improvement in wrinkle, pore, and smoothness parameters.

TABLE 3 | Blinded Global Esthetic Improvement Scale (GAIS) outcomes ($N = 18$).

Domain	GAIS score (mean ± SD)	Responders, *n* (%)[a]	Inter-rater reliability (κ)[b]
Pigmentation	3.03 ± 0.65	11 (61.1%)	0.58
Erythema	2.97 ± 0.61	11 (61.1%)	0.53

Abbreviation: SD, standard deviation.
[a]Responders are defined as those with a GAIS score ≥ 3 (≥ 50% improvement).
[b]Quadratic weighted κ for inter-rater agreement.

which more than 60% of participants achieved ≥ 50% improvement in both pigmentation and erythema.

The clinical efficacy observed in the present study is attributed to the unique biophysical properties of the 675-nm wavelength. Strategically positioned within the tissue optical window, this wavelength exhibits a high affinity for melanin and collagen, while maintaining relatively low absorption by hemoglobin compared with shorter wavelengths such as 532 nm or 595 nm [1, 11]. Unlike traditional non-ablative systems (e.g., 1320–1540 nm), which primarily target water to indirectly heat the dermis, the 675-nm laser acts directly on collagen fibers through a selective photothermal effect. Furthermore, the low absorption coefficient for water at 675 nm enables deeper dermal penetration than mid-infrared lasers, which are often limited by high water absorption. Recent in vitro and clinical data confirm that this wavelength can effectively reach the mid-to-deep dermis at depths exceeding 1 mm, facilitating direct interaction with target collagen fibers without significant energy attenuation. This supports the use of a high-powered (15 W) configuration in the present study, which generates localized micro-thermal zones of collagen denaturation while preserving the stratum corneum, thereby accounting for the minimal downtime and low pain scores (median VAS score: 2.0).

These mechanistic considerations are supported by our exploratory histologic findings. The increased collagen I and III area fractions provide evidence suggestive of neocollagenesis, consistent with previous histological reports demonstrating the proliferation of new collagen fibers 45 days after treatment [13]. Specifically, the densification of the dermal framework, driven

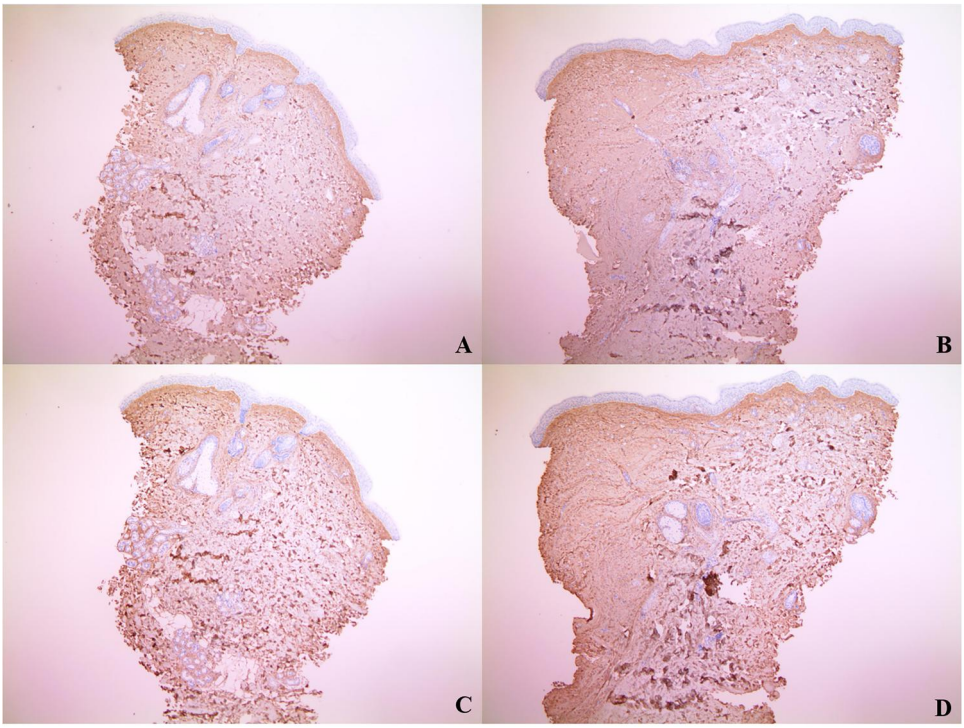

FIGURE 2 | Representative histologic findings demonstrating increased dermal collagen following 675-nm laser treatment. Immunohistochemical staining shows collagen I (A, B) and collagen III (C, D) at baseline (T0) and at the 3-month follow-up (T3). Compared with T0, increased collagen staining intensity is observed at T3 (original magnification ×40).

by the selective stimulation of perifollicular collagen fibers, provides better structural support to follicular openings and the skin surface [14]. This process directly correlates with the statistically significant improvements in pore size and smoothness scores observed in our three-dimensional quantitative analysis, supporting the role of the 675-nm laser in reversing follicular laxity through targeted dermal remodeling.

This restoration of the dermal matrix is essential for "prejuvenation," a proactive clinical strategy aimed at delaying the onset of visible signs of aging in younger populations. By selectively stimulating the synthesis of type III collagen—which is abundant in youthful skin but progressively declines with age—the 675-nm laser helps to maintain an optimal collagen I/III ratio [22–24]. Furthermore, such early intervention may effectively disrupt the "aging cascade" by reinforcing the reticular structure of the skin before structural deterioration becomes clinically irreversible. Our findings indicate that, rather than merely repairing the established damage, 675-nm irradiation may function as an interventional therapy that preserves the biological integrity of the dermis, potentially contributing to the prevention of structural deterioration.

Beyond improvements in texture, 61.1% of participants showed significant improvement in pigmentation. This effect is likely attributable to both direct melanin absorption and indirect modulation of melanocytes through the restoration of dermal integrity. Recent studies have also highlighted the safety of the 675-nm wavelength in treating mixed melasma, even in darker skin phototypes (IV–VI), where its selectivity minimizes the risk of post-inflammatory hyperpigmentation commonly associated with conventional laser therapies [15, 16].

More remarkably, clinical improvement was noted in facial erythema, despite the lower absorption coefficient for hemoglobin at 675 nm. We hypothesize that this represents a secondary effect of "dermal densification," where a thickened papillary dermis increases the optical distance between the skin surface and the underlying vascular plexus, effectively reducing the visibility of surface redness. Furthermore, recent evidence suggests that 675-nm irradiation may directly interact with the collagenous components of the vascular adventitia [15]. In contrast to the consistent increases observed for collagens I and III, changes in collagen IV showed greater heterogeneity between the two biopsy specimens. This variability may reflect the distinct biological role of collagen IV as a major structural component of the vascular and epidermal basement membranes, rather than the interstitial dermal matrix. Unlike fibrillar collagens, collagen IV remodeling may occur indirectly through remodeling of the vascular basement membrane structures following dermal collagen reorganization, rather than through a uniform increase in expression. This interpretation is consistent with prior evidence suggesting that 675-nm irradiation interacts with collagenous components of the vascular wall and could contribute to improvements in vascular homeostasis [15]. Nevertheless, given the exploratory nature of the histologic analysis and the limited number of paired biopsy samples, these findings should be interpreted with caution, and further studies are warranted to clarify the biological significance of collagen IV remodeling following 675-nm laser treatment.

Importantly, the present study reflects a real-world clinical scenario in which patients present with multiple coexisting features of facial aging, including erythema, fine wrinkles,

enlarged pores, and textural irregularities. Unlike previous studies that have primarily focused on single endpoints, our findings demonstrate that 675-nm laser treatment can simultaneously improve multiple esthetic domains. This suggests that the 675-nm wavelength may serve as a practical and efficient therapeutic option for patients with complex, multifactorial skin concerns, potentially reducing the need for combination treatments in clinical practice.

The safety profile was favorable, with treatment-related pain remaining mild and stable across all sessions. The absence of any post-inflammatory hyperpigmentation or scarring confirms that 675-nm laser systems can deliver efficient energy for dermal remodeling while preserving epidermal safety. This favorable safety profile is further enhanced by the integrated cooling system, which prevents the formation of microscopic necrotic debris and ensures excellent tolerability, even in darker skin phototypes (IV–VI), where the risk of pigmentary complications is typically elevated [25].

This study has several strengths, including the use of reproducible quantitative three-dimensional imaging, blinded dual-evaluator GAIS assessment, and the inclusion of exploratory histology to provide biological context. Nevertheless, this study also has several limitations. First, the sample size was modest, and the absence of a control group limits drawing any direct causal inference regarding the observed treatment effects. Second, the exploratory histologic analysis was conducted in only two participants and should therefore be interpreted cautiously. Finally, long-term follow-up is required to determine the durability of collagen remodeling and the associated clinical improvements.

5 | Conclusion

High-powered 675-nm non-ablative diode laser treatment improved objective three-dimensional measures of facial texture and produced clinically perceptible improvements in pigmentation and erythema, with favorable tolerability. The integration of quantitative imaging, blinded clinical assessment, and supportive histologic findings suggests that this wavelength represents a versatile and safe tool for comprehensive non-ablative facial rejuvenation.

Acknowledgments

The authors would like to thank the participants who volunteered for this study.

Funding

The authors have nothing to report.

Ethics Statement

This study was approved by the Institutional Review Board of Hallym University Sacred Heart Hospital (IRB No. HALLYM 2025-09-007-002).

Consent

Written informed consent was obtained from all participants for the procedure, biopsies, and publication of clinical photographs.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.
Supporting File: lsm70204-sup-0001-Supplementary_information.docx.