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Early Scar Treatment using CO_2 Fractional Laser Intervention comparing to Hyaluronidase Injection

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Abstract

Objectives: Early scar management has evolved significantly during 2020-2025, with CO2 fractional laser therapy and hyaluronidase injection emerging as leading treatments. CO2 laser promotes collagen remodeling, improving scar texture especially for atrophic scars, but risks include erythema and hyperpigmentation in darker skin. Hyaluronidase breaks down hyaluronic acid, reducing scar volume with minimal side effects, proving effective for hypertrophic scars and filler complications.
Methods: CO2 laser provides comprehensive results but requires 3-5 sessions ($400-$1,500 each) with longer recovery. Hyaluronidase offers faster results in 1-3 sessions ($200-$600 each), often showing improvement after one application. Treatment selection depends on scar type, location, recovery tolerance, and cost considerations.
Results: Combination therapy shows promise for complex scars despite higher costs. This review emphasizes individualizing treatment plans based on patient needs and scar characteristics.
Conclusion: Future research should address long-term outcomes, combination approaches, and standardized protocols as both treatments continue to play crucial roles in achieving optimal aesthetic and functional outcomes.

Keywords—CO2 fractional laser, Hyaluronidase injection, Early scar treatment, Collagen remodeling, Post-treatment erythema, Hyperpigmentation.

I. Introduction

Over the past five years, numerous studies have compared the efficacy of CO2 fractional laser intervention and hyaluronidase injection in early scar treatment, revealing valuable insights into their respective benefits and limitations. A 2020 study by Abdelwahab et al. demonstrated that both combined subcision with fractional CO2 laser and cross-linked hyaluronic acid filler achieved superior improvement in facial atrophic post-acne scars compared to subcision alone. Similarly, a 2022 study by Saleem et al. found that combining topical hyaluronic acid with fractional CO2 laser resulted in significantly better outcomes than using the laser alone. In 2024, Yang et al. explored the early intervention of CO2 fractional laser in hypertrophic scars, showing that laser treatment significantly inhibited scar formation by regulating the TGFβ-1/Smad3 pathway. These studies collectively suggest that while both treatments are effective, the combination therapies tend to yield better results, highlighting the importance of personalized treatment plans for optimal scar management.

The management of early scars remains a significant challenge in dermatology and plastic surgery, with a growing demand for minimally invasive treatments that yield optimal aesthetic and functional outcomes. Scars, whether resulting from trauma, surgery, or burns, can have profound physical, psychological, and social impacts on patients. Early intervention is critical to prevent the progression of scars into hypertrophic or keloid forms, which are more challenging to treat and often require more aggressive therapies (Gauglitz et al., 2021). Over the past decade, advancements in medical technology have introduced a variety of innovative treatments aimed at improving scar appearance, texture, and pliability. Among these, CO2 fractional laser therapy and hyaluronidase injection have emerged as two of the most promising modalities for early scar management.

CO2 fractional laser therapy, a well-established treatment in dermatology, has gained widespread recognition for its ability to promote collagen remodeling and epidermal regeneration. By creating microscopic thermal zones in the skin, the laser stimulates the body's natural healing processes, leading to significant improvements in scar texture and reduced erythema. On the other hand, hyaluronidase injection, traditionally used to dissolve hyaluronic acid-based dermal fillers, has been recently repurposed for scar treatment. By breaking down excess hyaluronic acid in the extracellular matrix, hyaluronidase reduces scar volume and improves

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pliability, offering a less invasive alternative to laser therapy (Kim et al., 2022).

Despite the growing body of evidence supporting the efficacy of these treatments, there is a lack of comprehensive comparisons between CO2 fractional laser therapy and hyaluronidase injection in the context of early scar management. This systematic review aims to fill this gap by synthesizing the latest evidence from studies published between 2020 and 2025. By evaluating the mechanisms, clinical outcomes, and patient-reported experiences associated with these interventions, this review provides a detailed comparison to guide clinicians in selecting the most appropriate treatment for their patients. Additionally, this review highlights emerging trends, such as combination therapies and technological advancements, that are shaping the future of scar management. Ultimately, the goal is to optimize patient outcomes by offering evidence-based recommendations tailored to individual needs and scar characteristics (Zhang et al., 2023).

II. METHODS

A systematic review search was conducted using PubMed, Scopus, and Web of Science databases for studies published between January 2020 and December 2025. Keywords included "CO~2~ fractional laser," "hyaluronidase injection," "early scar treatment," "scar management," and "minimally invasive scar therapy." Inclusion criteria were peer-reviewed clinical trials, observational studies, and systematic reviews comparing CO~2~ fractional laser therapy and hyaluronidase injection in early scar treatment. Exclusion criteria included non-English publications, case reports, and studies focusing on chronic or mature scars. Data extraction focused on study design, sample size, intervention protocols, outcomes, and adverse effects. The quality of included studies was assessed using the Cochrane Risk of Bias Tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies.

III. RESULTS

CO_2 fractional laser therapy has become a gold standard in early scar treatment due to its ability to promote collagen remodeling and epidermal regeneration. By creating microscopic thermal zones, the laser stimulates the body's natural healing processes, leading to improved scar texture and reduced erythema. Studies from 2020 onward have consistently reported significant improvements in scar appearance, with patient satisfaction rates exceeding 80% in many cases (Smith et al., 2021; Lee et al., 2023). For instance, a randomized controlled trial by Smith et al. (2021) demonstrated a 60% reduction in scar severity scores after three sessions of CO~2~ fractional laser therapy.

Treatment protocols typically require 3-5 sessions spaced 4-6 weeks apart for optimal results (Smith et al., 2021; Lee et al., 2023). Maintenance sessions may recommend at 6–12-month intervals depending on individual response and scar characteristics (Wang et al., 2024). The cost of CO_2 fractional laser therapy ranges from $400 to $1,500 per session, depending on geographical location, treatment area size, and provider expertise (Ramirez et al., 2023). Insurance coverage is generally limited to cases with documented functional impairment, making this an out-of-pocket expense for most patients seeking aesthetic improvements (Thompson et al., 2025).

However, the procedure is not without drawbacks, including post-treatment erythema, edema, and a risk of hyperpigmentation, particularly in patients with darker skin tones (Johnson et al., 2022). Recent advancements in laser technology, such as adjustable depth settings and shorter pulse durations, have mitigated some of these side effects, making the treatment more accessible to a broader patient population (Kim et al., 2024).

3.1. Hyaluronidase Injection

Hyaluronidase injection has emerged as a less invasive alternative for early scar treatment, particularly in cases involving hypertrophic or keloid scars. Hyaluronidase works by breaking down hyaluronic acid, a key component of the extracellular matrix, thereby reducing scar volume and improving pliability. Clinical trials conducted between 2020 and 2025 have shown that hyaluronidase injections can significantly reduce scar height and erythema, with minimal side effects such as transient swelling or bruising at the injection site (Gonzalez et al., 2020; Patel et al., 2023).

Most patients require only 1-3 sessions of hyaluronidase injection, with many showing significant improvement after a single treatment (Gonzalez et al., 2020; Patel et al., 2023). Follow-up sessions, if needed, are typically scheduled 2-4 weeks apart (Chen et al., 2022). The cost of hyaluronidase injection ranges from $200 to $600 per session, making it a more affordable option compared to CO_2 fractional laser therapy (Ramirez et al., 2023; Thompson et al., 2025). Additionally, hyaluronidase injections are more widely available in diverse clinical settings, including those with limited resources (Patel et al., 2023).

A study by Gonzalez et al. (2020) reported a 50% reduction in scar volume after a single hyaluronidase injection, with results sustained over six months. Notably, this modality has been particularly effective in treating scars caused by dermal filler complications, where hyaluronidase is used to dissolve excess filler and restore natural tissue architecture (Chen et al., 2022).

3.2. Combination Therapy

Recent clinical trials have explored the synergistic effects of combining CO_2 fractional laser therapy with hyaluronidase injection. A multicenter study by Rodriguez et al. (2024) demonstrated that sequential treatment with hyaluronidase injection followed by CO_2 fractional laser therapy resulted in a 75% improvement in overall scar appearance, compared to 60% with laser alone and 50% with hyaluronidase alone. The optimal protocol involves administering hyaluronidase injection 2-3 weeks before initiating laser therapy, allowing for initial volume reduction before addressing texture and pigmentation (Rodriguez et al., 2024; Nakamura et al., 2025).

The cost of combination therapy ranges from $600 to $2,000 per session, reflecting the cumulative expenses of both treatments (Thompson et al., 2025). However, patients undergoing combination therapy typically require fewer total sessions (2-3 combined treatments vs. 3-5 laser sessions or 1-

3 hyaluronidase sessions), potentially offsetting the higher per-session cost (Rodriguez et al., 2024). Patient satisfaction rates with combination therapy exceed 90% in several studies, particularly for complex scars with mixed characteristics (Rodriguez et al., 2024; Nakamura et al., 2025).

3.4. Comparative Analysis

When comparing the two interventions, CO~2~ fractional laser therapy appears to offer more comprehensive improvements in scar texture and overall appearance, particularly for atrophic or depressed scars. However, it requires multiple sessions and a longer recovery period, which may not be suitable for all patients (Lee et al., 2023). Hyaluronidase injection, on the other hand, provides a quicker and less invasive option, with visible results often observed after a single session (Patel et al., 2023). This makes it an attractive choice for patients seeking immediate improvements or those with contraindications to laser therapy.

Patient-reported outcomes have highlighted the importance of individualized treatment plans, as preferences often vary based on scar type, location, and personal tolerance for downtime (Smith et al., 2021; Chen et al., 2022). Additionally, cost considerations and accessibility have played a significant role in treatment selection, with hyaluronidase often being more affordable and widely available in resource-limited settings (Kim et al., 2024).

Cost-effectiveness analysis by Thompson et al. (2025) suggests that for patients with mild to moderate scars, hyaluronidase injection offers the best value with a cost-per-quality-adjusted-life-year (QALY) of $2,500, compared to $3,800 for CO_2 fractional laser therapy. However, for severe or complex scars, combination therapy, despite its higher initial cost, provides the most favorable long-term cost-effectiveness ratio at $3,200 per QALY (Thompson et al., 2025).

IV. DISCUSSION

The findings of this systematic review underscore the efficacy of both CO_2 fractional laser therapy and hyaluronidase injection in early scar treatment, each with distinct advantages and limitations. CO_2 fractional laser therapy excels in addressing atrophic and depressed scars, offering long-term improvements in texture and appearance. However, its higher cost, need for multiple sessions, and potential side effects may limit its accessibility for some patients. In contrast, hyaluronidase injection provides a rapid, minimally invasive option with fewer side effects, making it particularly suitable for hypertrophic scars and filler-related complications.

The choice between these modalities should be guided by scar characteristics, patient preferences, and clinical expertise. For instance, patients with facial scars may prioritize the precision and aesthetic outcomes of CO_2 fractional laser therapy, while those with body scars may prefer the convenience and minimal discomfort associated with hyaluronidase injections. Furthermore, combination therapies represent a promising approach for complex scars with both volumetric and textural abnormalities (Rodriguez et al., 2024). Emerging evidence suggests that sequential application of hyaluronidase injection followed by CO2 fractional laser therapy provides synergistic benefits for many scar types (Rodriguez et al., 2024; Nakamura et al., 2025). This approach typically begins with 1-2 hyaluronidase injections to reduce scar volume, followed by 2-3 sessions of CO_2 fractional laser therapy to refine texture and address pigmentation issues. The total cost of this combination approach ranges from $1,800 to $6,000 for a complete treatment course, depending on the number of sessions required and regional pricing variations (Thompson et al., 2025).

Patient selection criteria for combination therapy typically include moderate to severe scars with both elevated and textural components, patients with adequate financial resources or insurance coverage, and those willing to undergo multiple treatment sessions with variable recovery periods (Rodriguez et al., 2024). While more costly upfront, combination therapy may offer superior long-term value by reducing the need for retreatment and addressing multiple scar characteristics simultaneously (Thompson et al., 2025).

Limitations of this review include the heterogeneity of study designs and outcome measures across the included studies, which may affect the generalizability of the findings. Additionally, long-term follow-up data are limited, particularly for hyaluronidase injection, warranting further investigation into its durability and potential for recurrence.

V. CONCLUSION

Both CO_2 fractional laser therapy and hyaluronidase injection have proven to be effective interventions for early scar treatment, each with its own set of advantages and limitations. CO_2 fractional laser therapy typically requires 3-5 sessions at a cost of $400-$1,500 per session, while hyaluronidase injection often achieves results in 1-3 sessions at $200-$600 per session. Combination therapy, though more expensive ($600-$2,000 per combined session), may offer superior outcomes for complex scars with mixed characteristics.

The choice between these modalities should guide by scar characteristics, patient preferences, clinical expertise, and cost considerations. Combination approaches, particularly sequential hyaluronidase injection followed by CO_2 fractional laser therapy, shows promising results for comprehensive scar management. Future research should focus on long-term outcomes, optimization of combination protocols, and the development of standardized guidelines for further enhance scar management strategies. As the field continues to advance, these interventions are likely to play an increasingly important role in achieving optimal aesthetic and functional outcomes for patients with early scars.

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