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COMPARATIVE STUDY TO EVALUATE THE EFFICACY OF FRACTIONAL CO_2 LASER + PRP VERSUS FRACTIONAL CO_2 LASER ALONE IN PATIENTS WITH VITILIGO

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ABSTRACT

Background: Vitiligo is a chronic depigmenting disorder characterized by the loss of functional melanocytes, leading to significant cosmetic and psychological impact. Fractional CO_2 laser therapy has emerged as an effective modality for inducing repigmentation through stimulation of melanocyte migration. Platelet-rich plasma (PRP), rich in growth factors, has been shown to enhance tissue regeneration and melanocyte activity. Combining these modalities may provide synergistic therapeutic benefits. **Aim:** To compare the efficacy of fractional CO_2 laser combined with platelet-rich plasma (PRP) versus fractional CO_2 laser alone in the treatment of patients with vitiligo.
Methods: This comparative study was conducted over 12 months in a tertiary care dermatology center and included 120 patients with stable vitiligo. Participants were randomly divided into two groups: Group A received fractional CO_2 laser combined with PRP, while Group B received fractional CO_2 laser alone. Clinical evaluation was performed using repigmentation percentage, onset of repigmentation, physician global assessment, and documentation of adverse effects.
Results: Combination therapy demonstrated superior outcomes compared to laser alone. A higher proportion of patients in Group A achieved greater than 50% and greater than 75% repigmentation. Earlier onset of repigmentation was also observed in the combination group. Site-wise analysis showed better response in facial and truncal lesions, while acral areas exhibited comparatively lower response in both groups. Both treatments were well tolerated with only mild and transient adverse effects.
Conclusion: Fractional CO_2 laser combined with PRP is more effective than fractional CO_2 laser alone in achieving repigmentation in patients with stable vitiligo. The combination therapy provides enhanced clinical response with an acceptable safety profile, making it a promising therapeutic option.
Keywords: Vitiligo, fractional CO_2 laser, platelet-rich plasma, repigmentation, dermatological therapy.

INTRODUCTION

Vitiligo is a long-lasting disorder that is known to cause a loss of skin colour (depigmentation) over time due to the loss of a type of cell called melanocytes in the outer layer of skin (epidermis). It causes people to develop light-coloured spots, patches or stains on their skin (depigmented) that can occur anywhere on their body[1]. It is estimated that Vitiligo affects approximately 0.5%-2% of the world population regardless of age, gender or race. While it is not fatal, the psychological and social effects caused by the visible signs of this condition, such as cosmetic disfigurement, can be very serious for those who are living with the condition[2].
The reason vitiligo happens is still being researched and is likely to be due to many different things. Researchers have proposed multiple theories regarding the cause of vitiligo which include autoimmune destruction of melanocytes, oxidative stress, genetic predisposition and neural factors[3]. The most commonly accepted theory is the autoimmune theory of vitiligo since cytotoxic T cells attack and kill melanocytes, thereby causing the depigmentation of the skin. In addition, other mechanisms such as oxidative stress and the separation of melanocytes from the base layer of the skin (basal layer) have also been proposed to contribute to disease progression[4].
Finding effective ways to treat vitiligo is not easy due to the unreliable course of the disease and the variability in how well a patient will respond to various treatment options. Current treatment options for vitiligo include topical corticosteroids, topical calcineurin inhibitors, light therapy (phototherapy) such as narrow-band ultraviolet B (NB-UVB), and excimer laser therapy. All of these treatment methods have been shown to stimulate repigmentation in some patients; however, in most cases responses to these treatments are slow and incomplete, or are limited to a specific area of the body[5].

Additionally, acral regions (hands and feet) tend to be particularly resistant to treatments.As the field of dermatology continues to grow through development of various surgical & non-surgical techniques for treating patients with vitiligo & promoting the movement of melanocytes within the body, fractional laser (CO_2) has recently attracted a lot of interest as a complementary option to the treatment of vitiligo[6]. The fractional laser creates small areas of injury (microthermal zones) within the epidermis and dermis through which the melanocyte can migrate from normal areas of skin or hair follicles to the areas of hypopigmented skin. The fractional laser also helps facilitate the delivery of topical medications to those areas as well as stimulate the growth of new tissue, which may also contribute to the repigmentation process[7].

Platelet-Rich Plasma (PRP) is a concentrated amount of platelets found in plasma, which contains many natural growth factors including platelet-derived growth factor, transforming growth factor-b, vascular endothelial growth factor, and epidermal growth factor. All these growth factors assist in wound healing, the proliferation of cells, the formation of new blood vessels (angiogenesis), and stimulating the activation of melanocytes. Recently, there have been reports that PRP may increase the production and migration of melanocytes and thus enhance the repigmentation process for patients with vitiligo[8].

Utilising both fractional CO_2 laser therapy and PRP in conjunction appears to be an encouraging approach toward treating vitiligo. By creating small channels through which PRP can be placed deeper into the dermis, fractional laser treatment allows for improved delivery of PRP and allows for greater activation of melanocytes. Conversely, the growth factors in PRP may enhance the process of tissue repair and stimulate the development of new melanocytes. Collectively, these benefits combined may result in a synergistic effect that may enhance the results of treatment[9,10].

Although there is a increasing body of research demonstrating the safety and efficacy of fractional CO_2 laser plus PRP, there remains a limited amount of available clinical data evaluating the differences between fractional CO_2 laser plus PRP and fractional CO_2 laser alone in the treatment of vitiligo. The objective of the current study was to investigate and compare the therapeutic effects of these two modalities in patients with vitiligo for the purpose of developing an improved method to obtain repigmentation and improve the overall clinical outcome for these patients.

Aim

To compare the therapeutic efficacy of Fractional CO_2 laser combined with Platelet-Rich Plasma (PRP) versus Fractional CO_2 laser alone in achieving repigmentation in patients with vitiligo.

Objectives

The present study was undertaken to evaluate the therapeutic effectiveness of fractional CO_2 laser therapy with and without Platelet-Rich Plasma (PRP) in patients with vitiligo. The study aimed to assess whether the addition of PRP enhances repigmentation outcomes when used in combination with fractional CO_2 laser treatment.

Primary Objective

To compare the efficacy of Fractional CO_2 laser combined with PRP versus Fractional CO_2 laser alone in achieving repigmentation in patients with vitiligo.

Secondary Objectives

To evaluate the degree of repigmentation achieved in vitiligo lesions following treatment with both therapeutic modalities.

To assess the onset and progression of repigmentation during the course of treatment.

To compare the clinical improvement in different anatomical sites affected by vitiligo.

To assess patient satisfaction and physician global assessment following treatment.

To evaluate the safety profile and adverse effects associated with both treatment approaches.

MATERIAL AND METHODS

Study Design

Conducted as a randomized trial, this study was intended to evaluate the therapeutic efficacy of combining Platelet-Rich Plasma (PRP) with Fractional CO_2 laser against using Fractional CO_2 laser alone for treating patients with Vitiligo.

Study Setting

The study was carried out in the Department of Dermatology of a tertiary care teaching hospital.

Study Duration

The study was conducted over a period of one year from January 2024 to December 2024.

Study Population

Patients clinically diagnosed with vitiligo who attended the dermatology outpatient department during the study period and fulfilled the eligibility criteria were included in the study.

Sample Size

A total of 120 patients with vitiligo were included in the study.

Grouping of Patients

The enrolled patients were divided into two treatment groups:

Group A: Patients treated with Fractional CO_2 laser combined with Platelet-Rich Plasma (PRP)

Group B: Patients treated with Fractional CO_2 laser therapy alone

Each group consisted of 60 patients.

Inclusion Criteria

Patients aged 18 years and above with clinically diagnosed vitiligo

Patients with stable vitiligo lesions for at least six months

Patients willing to undergo fractional CO_2 laser therapy and attend follow-up visits

Patients who provided written informed consent for participation in the study

Exclusion Criteria

Patients with unstable or rapidly progressive vitiligo

Patients with active skin infections at the treatment site

Patients with a history of keloid or hypertrophic scar formation

Patients receiving other concurrent vitiligo treatments during the study period

Pregnant or lactating women

Patients with systemic illnesses contraindicating laser procedures

Procedure

A thorough and comprehensive clinical assessment, including the patient's medical history, the duration of the patient's vitiligo, the areas of skin affected by the condition (lesions), and previous treatments for the patient's condition, was conducted on all patients enrolled in this study. Baseline (before the start of therapy) photographs of the vitiligo lesions were taken.

In Group A, the fractional CO_2 laser was applied, using standardized laser parameter settings, directly to the vitiligo lesions. Immediately following application of the fractional CO_2 laser, the treated areas were injected with Platelet-Rich Plasma made from the patient's own blood.

In Group B, patients received only fractional CO_2 laser treatment, using the same laser parameters but without the use of PRP.

Treatment sessions were conducted at regular intervals, and patients were periodically followed to measure their responses to treatment, as well as any potential side effects from treatment.

Preparation of Platelet-Rich Plasma

By utilizing double centrifugation, we were able to create PRP from a volume of venous blood that was taken from each patient in tubes containing anticoagulants. In order to isolate the PRP, the venous blood sample was spun in a centrifuge to isolate it from other cellular elements of the blood. After producing a concentrated form of the PRP, it was then administered intradermally into the previously treated laser-targeted areas.

Outcome Assessment

Treatment response was evaluated based on the following parameters:

Percentage of repigmentation of vitiligo lesions

Reduction in lesion size

Clinical improvement assessed through physician global assessment

Patient satisfaction with treatment outcomes

Occurrence of adverse effects such as erythema, burning sensation, edema, or infection

Clinical photographs were taken during follow-up visits to objectively document the repigmentation response.

Statistical Analysis

The data obtained from this study will be entered into a Structured Database (SDB), where it will be analyzed through the appropriate statistical tools. The determination of the summary statistics was accomplished by using descriptive statistics to obtain the characteristics of the demographic and clinical characteristics of the study population. Additionally, a comparative analysis was performed between the two groups of patients receiving treatment, which allowed for the comparison of repigmentation outcomes and treatment response. Statistical significance for this study was defined as a p-value < 0.05

RESULTS

One hundred twenty patients with clinically diagnosed vitiligo participated in this study; they were randomly allocated into two treatment groups. Patients assigned to Group A received a combination of Fractional CO_2 Laser and PRP, while patients assigned to Group B received Fractional CO_2 Laser alone. The demographic and clinical characteristics of study patients were compared, which led to a determination of whether or not the two groups were comparable at baseline. The majority of the patients were classified as belonging to the younger and middle age adult demographic. Both study groups had similar distributions for age, sex, disease duration and location of lesions indicating they had comparable baseline characteristics. Most of the patients had had vitiligo for less than five years. Lesions were most commonly located on the facial and trunk areas rather than on the acral surfaces (hands/feet). Study participants all had their baseline vitiligo area noted prior to beginning treatment. This information allowed for a comparison of these characteristics between the patient population to understand the distribution of disease characteristics within the study.

Table 1: Age-wise distribution of patients in the study

Age Group (years)	Group A (Laser + PRP) n (%)	Group B (Laser alone) n (%)	Total n (%)
18–25	12 (20.0)	10 (16.7)	22 (18.3)
26–35	18 (30.0)	20 (33.3)	38 (31.7)
36–45	16 (26.7)	15 (25.0)	31 (25.8)
46–55	9 (15.0)	10 (16.7)	19 (15.8)
>55	5 (8.3)	5 (8.3)	10 (8.3)

Table 1 shows the distribution of patients according to age group in both treatment groups.

Table 2: Gender distribution among study participants

Gender	Group A (Laser + PRP) n (%)	Group B (Laser alone) n (%)	Total n (%)
Male	34 (56.7)	32 (53.3)	66 (55.0)
Female	26 (43.3)	28 (46.7)	54 (45.0)

Table 2 presents the gender-wise distribution of patients in both treatment groups.

Table 3: Duration of vitiligo among study participants

Duration of Disease	Group A n (%)	Group B n (%)	Total n (%)
<1 year	10 (16.7)	9 (15.0)	19 (15.8)
1–3 years	20 (33.3)	22 (36.7)	42 (35.0)
3–5 years	18 (30.0)	17 (28.3)	35 (29.2)
>5 years	12 (20.0)	12 (20.0)	24 (20.0)

Table 3 shows the duration of vitiligo among the patients included in the study.

Table 4: Distribution of vitiligo lesions according to anatomical site

Site of Lesion	Group A n (%)	Group B n (%)	Total n (%)
Face	14 (23.3)	13 (21.7)	27 (22.5)
Trunk	18 (30.0)	17 (28.3)	35 (29.2)
Upper limbs	12 (20.0)	14 (23.3)	26 (21.7)
Lower limbs	10 (16.7)	9 (15.0)	19 (15.8)
Acral areas	6 (10.0)	7 (11.7)	13 (10.8)

Table 4 shows the anatomical distribution of vitiligo lesions among patients in both groups.

Table 5: Baseline Vitiligo Area Severity Index (VASI) score distribution

Baseline VASI Score	Group A n (%)	Group B n (%)	Total n (%)
Mild	18 (30.0)	16 (26.7)	34 (28.3)
Moderate	26 (43.3)	28 (46.7)	54 (45.0)
Severe	16 (26.7)	16 (26.7)	32 (26.7)

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Table 5 shows the baseline disease severity among patients before treatment initiation.

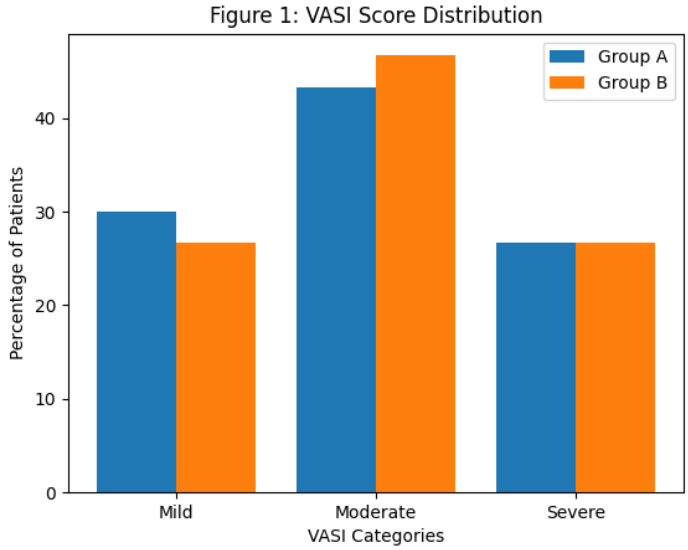

Figure 1: VASI Score Distribution (Baseline)

Figure 1: Baseline VASI score distribution among study participants. Both groups showed comparable disease severity at baseline, with the majority of patients presenting with moderate VASI scores, followed by mild and severe categories.

Table 6: Percentage of repigmentation after treatment

Repigmentation (%)	Group A n (%)	Group B n (%)	Total n (%)
<25%	6 (10.0)	15 (25.0)	21 (17.5)
25–50%	12 (20.0)	18 (30.0)	30 (25.0)
50–75%	22 (36.7)	17 (28.3)	39 (32.5)
>75%	20 (33.3)	10 (16.7)	30 (25.0)

Table 6 shows the degree of repigmentation observed in both treatment groups after completion of therapy.

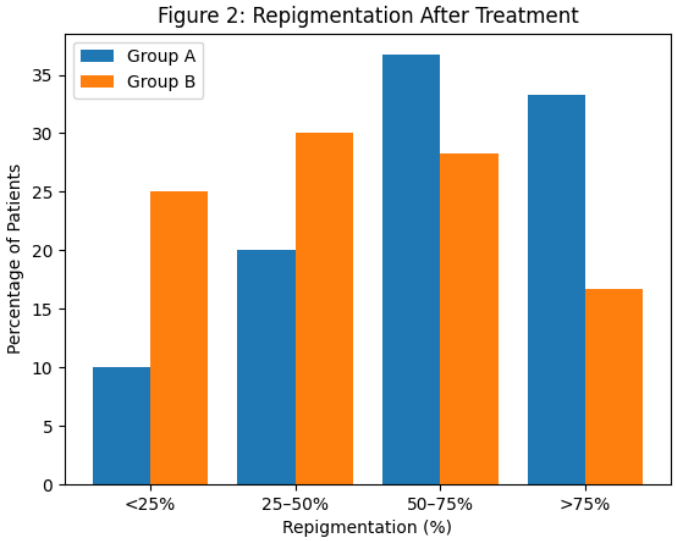

Figure 2: Repigmentation After Treatment

Figure 2: Comparison of repigmentation outcomes following treatment, demonstrating higher proportions of patients achieving greater than 50% and greater than 75% repigmentation in the combination therapy group.

Table 7: Onset of repigmentation following treatment

Onset of Repigmentation	Group A n (%)	Group B n (%)	Total n (%)
≤4 weeks	24 (40.0)	15 (25.0)	39 (32.5)
5–8 weeks	22 (36.7)	25 (41.7)	47 (39.2)
>8 weeks	14 (23.3)	20 (33.3)	34 (28.3)

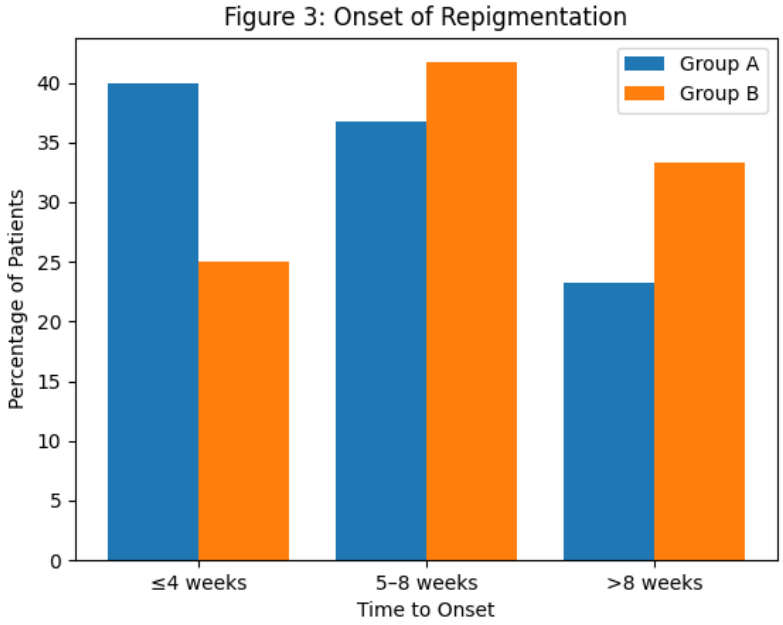

Figure 3: Onset of Repigmentation

Figure 3: Onset of repigmentation following treatment, showing earlier response in the combination therapy group with a higher proportion of patients demonstrating repigmentation within 4 weeks.

Table 8: Site-wise response to treatment

Site	Good Response (>50%) Group A n (%)	Good Response (>50%) Group B n (%)
Face	12 (85.7)	8 (61.5)
Trunk	14 (77.8)	10 (58.8)
Upper limbs	7 (58.3)	6 (42.9)
Lower limbs	5 (50.0)	4 (44.4)
Acral areas	2 (33.3)	1 (14.3)

Table 8 shows variation in treatment response based on anatomical site.

Table 9: Physician Global Assessment of treatment response

Response Category	Group A n (%)	Group B n (%)	Total n (%)
Poor	6 (10.0)	14 (23.3)	20 (16.7)
Moderate	18 (30.0)	24 (40.0)	42 (35.0)
Good	22 (36.7)	15 (25.0)	37 (30.8)
Excellent	14 (23.3)	7 (11.7)	21 (17.5)

Table 9 presents the physician global assessment of treatment outcomes.

Table 10: Adverse effects observed during treatment

Adverse Effect	Group A n (%)	Group B n (%)	Total n (%)
Erythema	16 (26.7)	14 (23.3)	30 (25.0)
Burning sensation	12 (20.0)	10 (16.7)	22 (18.3)
Edema	6 (10.0)	5 (8.3)	11 (9.2)
Infection	1 (1.7)	1 (1.7)	2 (1.7)
No adverse effects	25 (41.7)	30 (50.0)	55 (45.8)

Table 10 shows the frequency of adverse effects observed during the treatment period.

Patients aged 26 to 35 years were the largest age group represented in the study, with 30.0% of all the patients being in this age group in Group A and 33.3% of all the patients being in this age group in Group B **(Table 1).** The other major age group was 36 to 45 years, which represented 26.7% of the patients in Group A and 25.0% of the patients in Group B. This suggests that the overwhelming majority of patients with vitiligo became ill when they were within the younger and middle-aged adult age ranges.

The data presented in **Table 2** will show that the majority of patients were male, with 56.7% in Group A and 53.3% in Group B. In contrast, females were the minority, accounting for 43.3% of the patients in Group A and 46.7% of the patients in Group B. These percentages indicate that there was a male predominance among the study population.

Regarding the duration of disease in patients, **Table 3** indicates that the majority of patients (33.3% in Group A and 36.7% in Group B, respectively) had a disease duration of between 1 and 3 years, while patients with a disease duration of 3-5 years accounted for 30.0% of Group A and 28.3% of Group B.

According to **Table 4,** the trunk was the most common site of vitiligo lesions, with 30.0% of patients in Group A and 28.3% of patients in Group B having lesions in this area. The second most common location was on the face, with 23.3% of patients in Group A and 21.7% of patients in Group B having lesions.

Table 5 shows that the majority of patients had moderate disease severity at the time of evaluation, with 43.3% of patients in Group A and 46.7% of patients in Group B meeting this definition; mild and severe disease accounted for a significantly lower proportion of patients in the study.

Table 6 indicates that patients receiving combination therapy had a significantly higher rate of repigmentation than patients receiving laser therapy alone; 33.3% of patients receiving combination therapy had greater than 75% repigmentation compared to only 16.7% of patients receiving laser therapy alone.

Table 7 indicates that patients in Group A showed repigmentation more quickly, with 40.0% of patients having developed pigmentation by 4 weeks, compared to only 25.0% of patients in Group B.

Table 8 indicates that patients with facial vitiligo lesions experienced the best treatment response; 85.7% of patients from Group A achieved a good response compared with 61.5% of patients from Group B. The poorest treatment responses occurred with acral vitiligo lesions in both groups.

As shown in Table 9, 23.3% of patients receiving combination therapy had excellent responses, compared to only 11.7% of patients receiving laser therapy alone.

Erythema was the most frequently observed adverse effect in this study, occurring in 26.7% of patients in Group A and 23.3% of patients in Group B **(Table 10).** Most adverse effects were classified as mild and transient, which supports the overall safety of both treatment modalities.

DISCUSSION

Vitiligo is an enduring condition that can create both psychological and cosmetic issues as a result of the lack of pigment in the skin. The possibility of repigmenting the skin using treatments is still a concern[11]. However, in recent years, advancements in procedural dermatology techniques using fractional CO_2 lasers and PRP (platelet-rich plasma) have allowed for enhanced clinical outcomes, as both therapeutic methods work to stimulate increased melanocyte activity and enhance repigmentation[12]. This study demonstrates that the use of fractional CO_2 lasers in conjunction with PRP provided better clinical results than using fractional CO_2 lasers alone, resulting in a greater percentage of patients exhibiting 75% or greater pigmented skin. The results also indicate a probable synergistic effect between the two treatment modalities[13]. Fractional CO_2 lasers induce microthermal injury to the skin, allowing for the migration of melanocytes from adjacent normal skin, and likely from hair follicle, to the depigmented areas of skin[14]. Meanwhile, PRP provides a natural source of

growth factors that promote the proliferation of both melanocytes and new blood vessels (angiogenesis) and new tissues. Based on the results of this study, the combination of these two therapeutic therapies contributes to the repigmentation of vitiligo. Important factors in addition to early improvement of pigmentation include that patients receiving combination treatment experienced earlier appearance of pigmented skin in comparison to patients treated exclusively with fractional CO_2 lasers[15]. This earlier visible improvement in pigmentation is crucial to maintain patient compliance and satisfaction in the management of a chronic disease, such as vitiligo. By looking at outcome data by treatment site, the face and trunk area were found to be the most responsive to treatment[16]. Published literature has published similar results and attributes it to the greater density of hair follicles and melanocytes located in the upper back and front as opposed to the acral areas of the body (hands and feet). In previously published research, the acral areas of the body have been historically resistant to treatment because of decreased density of melanocytes[17]. The results of the Global Physician's Assessment Score support the conclusion that the combination therapy of fractional CO_2 laser therapy with PRP is a superior means of treatment for patients with stable vitiligo[18]. The Global Physician's Assessment Score also confirms that there were a greater percentage of patients in the combination therapy group who received a "good" to "excellent" rating than the patients treated with fractional CO_2 lasers alone; therefore, confirming the added value of adding PRP to fractional CO_2 laser therapy[19]. Patients receiving both types of treatment experienced minimal tolerance to treatment. The most common side effects encountered were mild erythema and mild burning sensations that spontaneously resolved with no intervention required. There were no serious complications associated with either therapy. Therefore, both therapies have an excellent safety record[20].

In summary, this study supports the safe and effective use of combination of fractional CO_2 laser therapy and PRP in the treatment of stable vitiligo.

Limitations of the Study

The limitations of this research include studying in only one location, which restricts the generalizability of the results. Also, the period of the study, i.e., the length of time that subjects were followed, was not long enough to determine whether there is any long-term durability of pigmentation restoration. In addition, there has been no examination of histology to check for active melanocytes within the biopsied skin needed to fully validate effectiveness of combination therapy. Future studies should be created with larger patient populations, multiple clinics participating, and longer durations of follow-up to enable more significant evaluations on combination therapy.

CONCLUSION

Fractional CO_2 laser therapy combined with platelet-rich plasma (PRP) demonstrated superior clinical efficacy compared to fractional CO_2 laser therapy alone in the treatment of stable vitiligo. Patients receiving combination therapy showed a higher degree of repigmentation, earlier onset of pigment formation, and better overall clinical response. The enhanced therapeutic effect observed with the addition of PRP may be attributed to the synergistic action of fractional CO_2 laser-induced microthermal injury facilitating melanocyte migration, along with PRP-derived growth factors promoting melanocyte proliferation, angiogenesis, and tissue regeneration. Both treatment modalities were well tolerated, with only mild and transient adverse effects such as erythema and burning sensation, and no serious complications were observed during the study period. Based on these findings, fractional CO_2 laser combined with PRP can be considered a safe, effective, and promising therapeutic approach for the management of stable vitiligo. Further large-scale, multicentric studies with longer follow-up are recommended to validate these results and establish standardized treatment protocols.

Ethical Considerations

Research involving human participants not only conducted according to the principles established by the American Medical Association, but also complied with legal regulations governing human research (such as the Federal Food, Drug, and Cosmetic Act). Informed consent had to be obtained by the physician from each participating individual before participating in the study. All information gathered during the study remained confidential at all times and was used only for research purposes.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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