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IMPACT OF LOW-LEVEL LASER THERAPY ON HAIR REGROWTH POST PRP TREATMENT

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ABSTRACT

Hair loss, especially androgenetic alopecia (AGA), significantly impacts individuals' self-esteem and mental health. Low-Level Laser Therapy (LLLT) and Platelet-Rich Plasma (PRP) are non-invasive therapies gaining traction in hair restoration. While both therapies individually promote hair regrowth, the combined effects of LLLT post-PRP treatment remain underexplored

Objective: *This study aims to evaluate the impact of LLLT on hair regrowth following PRP treatment in patients with androgenetic alopecia, focusing on hair density, count, diameter, and anagen percentage.*

Methodology: *A case-control study was conducted at Reshape Clinic Lahore with 22 androgenetic alopecia patients. The patients were randomized into two groups: Group A was administered LLLT after PRP treatment, and Group B was only given PRP treatment. Hair regrowth factors were assessed by Tricho Scan analysis and Physician's Global Assessment (PGA) scale at baseline, 6 weeks, and 12 weeks.*

Results: *There was an enhancement in regrowth of hair for both groups, but Laser + PRP significantly manifested greater hair number, hair density, and anagen percentage. Statistical analysis revealed that Laser + PRP had larger effect, particularly by the 12th week ($p = 0.001$). The combined treatment was significantly superior compared with PRP in reducing telogen percentage.*

Conclusion: *LLLT and PRP treatment offer superior outcome measures for hair regrowth compared with PRP monotherapy. The dual advantages between the two treatment regimens increase hair follicle regrowth and offer possible relief for the treatment of androgenetic alopecia. We advocate future research with larger sample sizes and longer follow-up periods to substantiate these findings.*

Keywords: *Low-Level Laser Therapy (LLLT), Platelet-Rich Plasma (PRP), Hair Regrowth, Androgenetic Alopecia, Hair Density, Hair Count, Anagen Phase, Telogen Phase, Non-invasive Treatment, Hair Restoration, Tricho_Scan, Physician's Global Assessment (PGA), Synergistic Therapy.*

INTRODUCTION

Hair loss, or alopecia, is a widespread condition that impacts numerous people at various age ranges, genders, and races(1)Out of the many types of hair loss, androgenetic alopecia (AGA), or male-pattern and female-pattern baldness, is the most common, affecting a significant population(2, 3). The distressing effect hair loss has on one's psyche and emotion is immense, with many experiencing reduced self-esteem and social well-being (4). Hair loss impacts more than just physical appearance; it affects personal identity, social life, and even mental health(5). Patients with hair thinning or baldness tend to have low self-esteem, embarrassment, anxiety, and low confidence, with an impact felt on quality of life(6). In response, there has been increasing demand for safe, pain-free treatments that are capable of bringing dramatic improvements in hair regrowth and physical appearance restoration along with psychological health(7).

Two new treatments have recently surfaced as most useful methods of hair restoration: Low-Level Laser Therapy (LLLT) and Platelet-Rich Plasma (PRP) therapy(8). Both treatments have attracted interest due to their potential to stimulate hair growth by different biological mechanisms (9, 10). LLLT and PRP have gained widespread usage in clinical practice and have demonstrated considerable potential for the treatment of different types of alopecia, such as androgenetic alopecia, alopecia areata, and telogen effluvium (11, 12).

Though individual treatment has shown remarkable potential itself as hair treatment for baldness, research has shown that when the two treatment methods are given together, the treatment could be even more beneficial, most notably among individuals with androgenetic alopecia and other alopecias that are non-scarring(13). The combination between LLLT treatment and PRP treatment is potentially powerful enough to draw out the potential of each treatment and cooperate toward having a synergy effect greater than that achievable with each treatment by itself (14, 15).

Low-Level Laser Therapy (LLLT) applies low-power lasers or light-emitting diodes (LEDs) to stimulate cellular activity with minimal tissue heating. Mechanisms of action with LLLT are founded upon photobiomodulation (PBM), during which light energy becomes absorbed by cells' mitochondria, especially hair follicles(16). This stimulation results in the enhancement of adenosine triphosphate (ATP) production, which stimulates cellular metabolism, growth, and repair mechanisms(15). The enhanced ATP production translates into improved hair follicle metabolism, increased blood supply to the scalp, and greater hair follicle thickness and density during the anagen (growth) phase(17). Research demonstrates that this cellular stimulation promotes hair follicle proliferation and even reverses the miniaturization effect of the follicles in androgenetic alopecia(18, 19).

On the other hand, Platelet-Rich Plasma (PRP) treatment involves the removal of the patient's own blood, concentrating the platelets enriched with essential growth factors, and injecting the resulted plasma into balding or hair thinning regions on the scalp (20). PRP growth factors such as platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), and transforming growth factor-beta (TGF-β) are critical during wound healing, new blood vessel formation (angiogenesis), and hair follicle regrowth(21, 22). PRP growth factors induce hair follicles out of the resting (telogen) phase into the growth (anagen) phase, which leads to longer-term and healthier hair growth(23).

Both LLLT and PRP treatment have individually proven to promote hair regrowth, yet their combination provides a synergistic effect that could yield greater and more lasting results(24). LLLT may increase the bioavailability of growth factors released by PRP, enhancing their cellular uptake and activating hair follicle stem cells effectively In addition, LLLT enhances scalp blood flow, enhancing delivery of oxygen and nutrients to the hair follicles and creating the ideal environment for follicular regrowth(25). PRP then delivers the biochemical signals that are imperative for hair follicle restoration, decreasing the duration in the resting telogen phase and increasing hair follicle robustness (26).

LLLT and PRP treatment combined have the ability significantly to reduce hair follicle miniaturization, increase hair thickening, and improve hair quality by prolonging the anagen phase and obtaining thicker, stronger, and healthier-appearing hair(27). Because each treatment complements the other, their use together gives a safe remedy for removing hair loss and achieving the best regrowth for hair(28).

Despite the promising future of utilizing LLLT and PRP therapy together, it is important to study how the combination affects hair regrowth more thoroughly(29). Investigating the mechanisms by which it occurs and assessing the effectiveness of LLLT treatment following PRP treatment can give us important information regarding how to optimally combine treatments for maximum effect(30). While each treatment stands nicely on its own, scarce literature has explored combining both treatments together(24). This study hopes to fill that gap, delivering much needed evidence that could lead to enhanced treatment plans, improved patient outcomes, and increased patient satisfaction.

By learning more about the interaction between PRP treatment and LLLT, clinicians are better able to tailor their treatment methods, individualize patient care, and achieve greater overall long-term results with hair restoration procedures(31). Furthermore, since LLLT and PRP are both non-invasive therapies, the combined treatment regimen is even more appealing, offering the patient a safe, effective, and minimally disruptive treatment that stands up well by comparison with more invasive procedures such as hair transplantation(30).

Rationale for the Study

It seeks to find out the synergistic effect between Low-Level Laser Therapy (LLLT) and Platelet-Rich Plasma

(PRP) treatment for hair restoration. Hair loss is still a common issue, and with rising popularity in non-surgical treatments, knowing how to maximize their efficiency is important. LLLT and PRP have individually demonstrated their potential with separate methods for hair regrowth. Using the two treatments together could actually provide greater outcomes, providing an even more powerful solution for those experiencing hair loss.

The research observes the potential of the simultaneous usage of LLLT and PRP to improve treatment outcome. LLLT increases cellular metabolism and blood flow, which may increase the bioavailability of the growth factors found in PRP. PRP, by activating growth factors such as platelet-derived growth factor (PDGF) and vascular endothelial growth factor (VEGF), causes regrowth of hair follicles. In unison, the procedures are capable of creating an environment that promotes the activation of hair follicles and yet makes them hardy enough for sustained growth of hair.

It is one of an increasing number of studies into hair restoration treatments that are geared towards offering more effective and individualized treatment regimens. By learning more about LLLT and PRP working together, health practitioners are better equipped to fine-tune their treatment regimens for improved patient outcomes. Here, the study provides evidence-based answers regarding how the two treatments can be employed together for maximum hair regrowth, hair follicle health, and greater patient satisfaction.

Lastly, the results of this study are intended to assist practitioners in creating hair restoration plans that are more effective, with the LLLT and PRP combination representing a potential solution toward obtaining optimal, long-term results among individuals with hair loss.

Aims and Objectives of the Study

The overall objective of this research is to assess the effect of Low-Level Laser Therapy (LLLT) for hair regrowth after treatment with Platelet-Rich Plasma (PRP) among individuals with androgenetic alopecia or other types of hair loss. The research will evaluate how effectively LLLT complements PRP treatment outcomes, with consideration for improvements in hair density, hair diameter, and general follicular well-being.

Specifically, the objectives of this study are as follows:

- To determine the impact of low-level laser therapy on hair regrowth following prp treatment.
- To identify the efficiency of low-level laser therapy (LLLT) for hair regrowth following platelet-rich plasma (PRP) treatment by assessing hair density, thickness, and changes in follicular activity over a specified time.
- To find the compounded effect of PRP and LLLT compared to PRP alone on scalp hair growth, assessing hair growth, scalp coverage, and patient satisfaction.

Significance of the Study

This research is valuable not only because it supplies empirical support for the cumulative efficacy of LLLT and PRP treatment but also because it sheds light upon the mechanisms by which their synergistic activities occur. Once the manner by which LLLT treatment following PRP treatment boosts hair growth becomes known, clinicians shall have the ability to provide individualized treatment regimens that are more effective for their hair loss patients. These results could additionally contribute toward new treatment protocols that maximize hair regrowth benefits with reduced necessity for more extensive procedures that encompass hair transplantation.

In addition, the findings from this research may join the evidence supporting LLLT and PRP treatment as potential, non-surgical hair restoration alternatives, providing safe and effective alternatives for hair restoration treatments. This may position LLLT as a necessary auxiliary treatment alongside PRP, with broader patient benefits and wider availability of effective hair restoration treatments.

Finally, this research intends to illuminate the effectiveness of combining Low-Level Laser Therapy with Platelet-Rich Plasma treatment for hair regrowth with valuable information that could have considerable influence on hair restoration medicine and clinical practice.

LITERATURE REVIEW

Yang et al (2024) examined the laser treatment helmet's safety and efficacy when combined with a 2% Minoxidil topical solution, and how it was implemented among a Chinese population. The participants were separated into two groups: the first group was given minoxidil 2%, and the second group was given minoxidil 2% with LLLT 655 nm three times weekly for 24 weeks.Comparisons between groups were made by measuring hair growth at the first visit, at 12 weeks and at 24 weeks. The combination regimen resulted in significantly increased hair growth compared with the Minoxidil group. Variations

between the midscalp's intermediate hair percentage indicate that there could be variability between how subjects react to treatment(32).

Wang et al. (2024) addressed the efficacy and the most favorable treatment parameters of 1550 nm low-level laser therapy (LLLT) for the treatment of hair loss. The randomized clinical trial involving 68 patients treated with LLLT treatment twice monthly for three months showed significant improvement of conditions for hair loss among the experimental population treated by LLLT treatment. The research concludes that LLLT represents a safe non-invasive treatment that promotes the improvement of scalp and hair (9).

Gentile et al. (2024) performed systematic review for the assessment of low-level laser treatment in pattern baldness among men and women. Systematic searching through different databases resulted in the identification of 13 systematic reviews and 23 clinical studies, seven of them RCTs.The review uniformly favored LLLT to promote hair growth without major side effects, affirming its therapeutic application(7).

BangHong et al. (2024) investigated the pathways through which LLLT induces intraepithelial HFSC proliferation and wound healing. It confirmed that LLLT with low-level laser stimulation activated the Wnt/β-catenin pathway, leading to enhanced β-catenin accumulation and Lef1 induction that in turn activate HFSC proliferation and differentiation. The findings are indicative of the efficacy of LLLT in wound healing and hair follicle regeneration acceleration(33).

Sondagar et al. (2023) assessed the effectiveness of the combination of topical 5% minoxidil with LLLT compared to minoxidil alone. Group A subjects were treated with both interventions, whereas Group B subjects applied minoxidil only. Hair density gains were quantified at 16 weeks with dermoscopy, TrichoScan analysis, and gross photography. While Group A experienced a higher rise in hair density (14.78% ± 10.93%) than did Group B (11.43% ± 6.43%), the difference was not significant at the statistical level ($p = 0.45$). This indicates that combination therapy potentially provides added benefits but that more studies are required to determine the level of significance(34).

Gupta et al. (2023) conducted a randomized controlled experiment to evaluate PRP therapy's efficacy for individuals with androgenetic alopecia. Each of the 80 individuals was split evenly into two distinct categories: the PRP group had injections of PRP once a month for six months, while the control group got saline treatments as a placebo. At baseline, three months, and six months, the hair's thickness and density were assessed. When compared to the control group, the PRP group's hair density increased statistically significantly. Additionally, the PRP group's hair diameter was much larger. There were no significant adverse effects noted(35).

Tawfik et al.(2022)carried out an RCT trial to compare the significance and health effects of LLLT and PRP in AA treatment. Thirty patients were involved in the trial, with each patient having three patches of AA. Patches were randomized into LLLT or PRP, the two treatments. Control was provided by the third patch with placebo. LLLT was done three times weekly until six weeks, and PRP was done weekly. Patients were assessed at one and three months. Hair thickness and hair density were assessed by Folliscope. On the basis of examination with folliscope and patient satisfaction, there was enhancement in the thickness and hair density occurring in the PRP-treated areas. Most of the patients retained the outcome during the 12-week follow-up period (36).

Kumar et al. (2021) even conducted a randomized controlled study with the intention of finding out PRP efficacy for treating alopecia. The study was conducted with the model of placebo-control, and the groups underwent injections with PRP on the scalp or with placebo. On outcome, there was increased hair number by +33.6 hairs and enhanced hair density by +45.9 hairs/cm^2 along with enhanced epidermal thickness and hair bulb formation.Only mild side effects manifested. Even though four patients developed recurrence of hair loss at 12–16 months post treatment, PRP was an effective and safe treatment for androgenetic alopecia and deserves future studies (37).

Gentile et al. (2021) performed a multicenter, observational case-series study with a retrospective design to evaluate the clinical results of the management of androgenetic alopecia (AGA) with microneedling (MND) in addition to low-level laser therapy (LLLT). Out of 26 enrolled patients, 11 patients belonged to stage I–II vertex AGA by the Ludwig scale, and 15 men belonged to stage I–III by the Norwood–Hamilton scale. After the selection by the inclusion and exclusion criteria, 20 volunteers (10 men and 10 women) were evaluated.Phototrichograms, photography, and physician and patient global assessment scores at baseline (T0) and follow-up at 16 weeks (T1) on standardized forms were used to measure regrowth of the hair. Computerized assessment of trichogram showed significant improvement with statistically

significant difference (p = 0.0238). Hair density at the treated area enhanced by around 12 ± 2 hairs/cm² at T1 relative to baseline to 59 ± 2 hairs/cm² from 47 ± 2 hairs/cm². All these findings reveal that MND combined with LLLT is an efficient therapy for people who have mild and moderate AGA.

Pillai et al.(2021) Using keywords like androgenetic alopecia, hair loss, and LLLT, a systematic evaluation of clinical studies employing LLLT to treat AGA was carried out using PubMed, Embase and Google Scholar. Reports or publications describing the use of LLLT for AGA-related hair loss were the main focus of the study. A total of 163 papers were found through the literature review investigation. Based on their titles and the data, 15 of these papers were deemed very relevant. Four helmet/cap studies and five comb device studies have been reported; two and three of them were randomized controlled trials (RCTs), respectively. There aren't many publications about LLLT and AGA, and the most of them were produced recently, therefore the literature search didn't contain any restrictions on the year of publication(38).

Gentile et al. (2020) conducted an RCT on 23 alopecia patients, evaluating the effects of microneedling, LLLT, and PRP. Hair regrowth was assessed over multiple follow-up points (T0, T1, T2, T3, and T4) using phototrichograms and global rating scales. The hair density was significantly higher than baseline . The results imply that LLLT, PRP, and microneedling can all aid in hair regeneration, which calls for more comparative research(39).

Although the benefits of PRP and LLLT on hair regeneration have been extensively studied, few studies have examined the combined effect of these therapies in the setting of Pakistan. This research gap highlights the need for a comprehensive comparative study to find which intervention is better for hair growth

METHODOLOGY

3.1 ResearchDesign

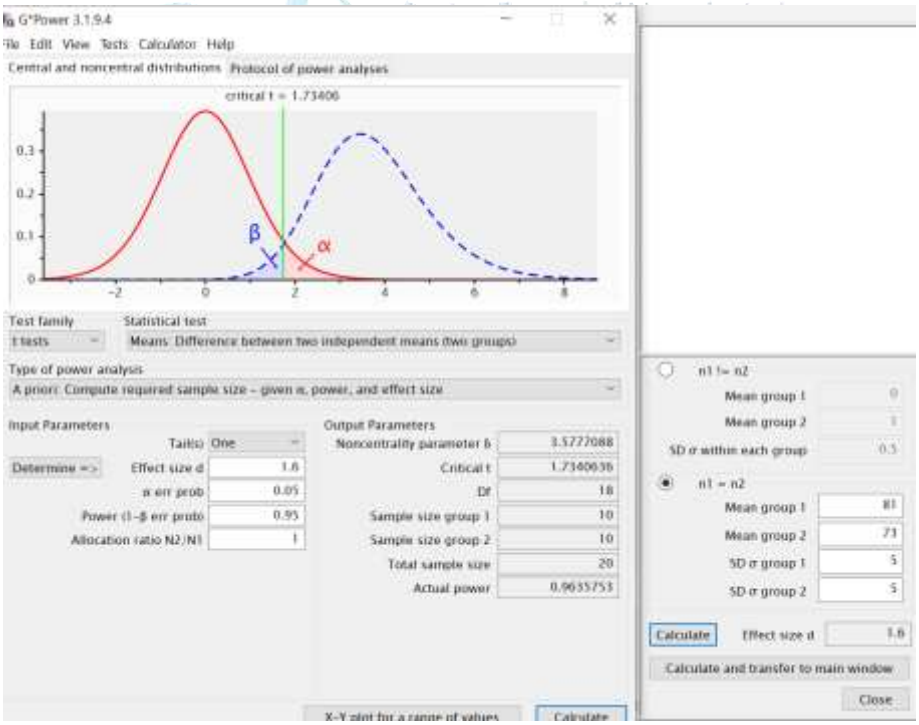
The study followed a case-control design, comparing two groups: LLLT plus PRP and PRP alone.

3.2 Clinical Settings

The study was conducted at Reshape clinic Lahore .

3.3 SampleSize

G*Power version 3.1.9.2 was used to find a sample size using previous study reference (40) The sample size was 20 , and with a 10% attrition rate sample size was 22.



3.4 SamplingTechnique

Non-probability purposive sampling was used to choose people who possess particular attributes.

3.5 Durationof Study

Study duration was 4 months after the approval of synopsis .

3.6 SelectionCriteria

3.6.1 InclusionCriteria

- Adults between 18–35 years who were diagnosed with androgenic alopecia or other non-scarring hair loss conditions(41).
- Having the Norwood–Hamilton scale placed in stages I–V for men Ludwig scale in stages I–III for women (42).

3. 6.2 Exclusion Criteria

- Use of systemic medications (e.g., corticosteroids, immunosuppressants) or treatments affecting hair regrowth within the last 3 months.
- History of hypersensitivity or adverse reactions to laser therapy(43).
- Active systemic diseases such as uncontrolled diabetes, autoimmune disorders, or malignancies(20).
- Pregnant or breastfeeding individuals.
- Patients with pacemakers or implanted medical devices were contraindicated with low level laser therapy.
- History of hair transplant surgery in the treatment area(44).

3.7 Ethical Consideration

Ethical consideration were followed throughout study

- Every person's right and dignity were given first priority.
- The subjects did not suffer any damage as a result of the research procedure.
- The subjects were given accurate information, and their signed consent was obtained.
- At every stage, subject information and data confidentiality were protected.
- The university's departmental research committee provided ethical approval.

3.8 Study groups

2 intervention groups were made

Group A: received blow-level laser therapy post prp treatment upto 12 weeks

Group B : received prp treatment upto 12 weeks.

3.9 Data collection tools

TrichoScan analysis

TrichoScan was outfitted as an objective assessment tool for hair growth parameters. It also enabled users to perform epiluminescence microscopy image analysis in determining the effectiveness of hair regrowth solutions such as low level laser therapy and plasma rich plasma .It calculated hair density (hairs/cm^2) and also hair diameter (μm)(45).Recorded differences in hair growth over 6 months to a year and provided more accurately quantifiable data(46).

Physician's Global Assessment (PGA) Scale

The PGA scale is a qualitative scale used by clinician to assess the overall outcomes of different hair regenerative by assessing the observable changes(47). Grades the response to the treatment on a scale that ranges from no improvement to complete re-growth. This considers the change in coverage density and visibility of the scalp by hair as perceived by the physician(48).

3.10DataCollection Procedure

Pre-treatment baseline, mid-treatment (6 weeks), and post-treatment (12 weeks) were the three points at which data were gathered.

3.11 Data Analysis

Data were collected using tools TrichoScan analysis and Physician's Global Assessment scale.Data were gathered from alopecia patients .SPSS version 25 was used to perform normality tests, t-tests, and ANOVA to analyze differences in hair regrowth outcomes between groups.

RESULTS

It compared Laser + PRP and PRP Only treatment efficacy across different hair growth parameters, such as hair number, hair density, anagen percentage, and hair diameter. Both groups significantly improved over time, with Laser + PRP mostly outperforming PRP Only.

Baseline measurements for Laser + PRP showed greater mean values for age, hair number, hair thickness, and anagen percentage. In the long term, Laser + PRP showed a more regular and greater augmentation in hair number, hair thickness, and anagen percentage. Importantly, the Laser + PRP group revealed improved changes at the 12th week with significant enhancement for PGA score, hair number, and anagen percentage compared with PRP Only.

For hair density, Laser + PRP showed significant superiority at baseline and 6th week, but by the 12th week, both treatments showed similar improvements. Laser + PRP also outperformed PRP Only in terms of hair diameter, with significant differences observed at baseline.

Statistical analysis indicated no significant differences between groups in some areas, such as hair count at baseline and 6th week, but overall, Laser + PRP

demonstrated a stronger effect, particularly for hair count, anagen percentage, and overall hair growth improvement, suggesting it is a more effective treatment.

Table no 1: Shows age statistics of both group

Statistics			
Age			
Laser + PRP	N	Valid	11
		Missing	0
	Mean		28.09
	Std. Error of Mean		1.455
	Median		31.00
	Mode		31
	Std. Deviation		4.826
	Variance		23.291
	Minimum		19
	Maximum		32
	Sum		309
PRP Only	N	Valid	11
		Missing	0
	Mean		27.27
	Std. Error of Mean		1.532
	Median		27.00
	Mode		24
	Std. Deviation		5.081
	Variance		25.818
	Minimum		20
	Maximum		35
	Sum		300

For the Laser + PRP group, the mean age is 28.09 years with a standard deviation of 4.826, indicating relatively low variability. The median is 31, with a mode of 31, suggesting a concentration around this age. The PRP Only group has a mean age of 27.27 years, with a slightly higher standard deviation of 5.081. The median is 27, and the mode is 24, showing a younger group with a wider spread of ages. Both groups have similar valid sample sizes (11 each).

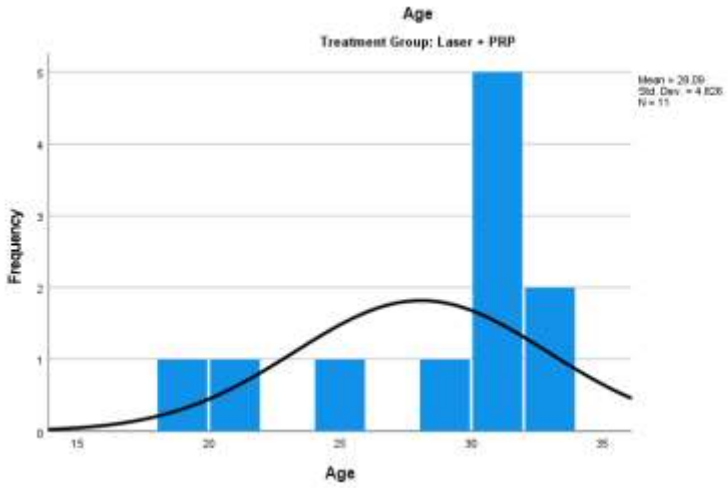


Figure no 1: Shows Laser + PRP group, the mean age is 28.09 years with a standard deviation of 4.826, indicating relatively low variability

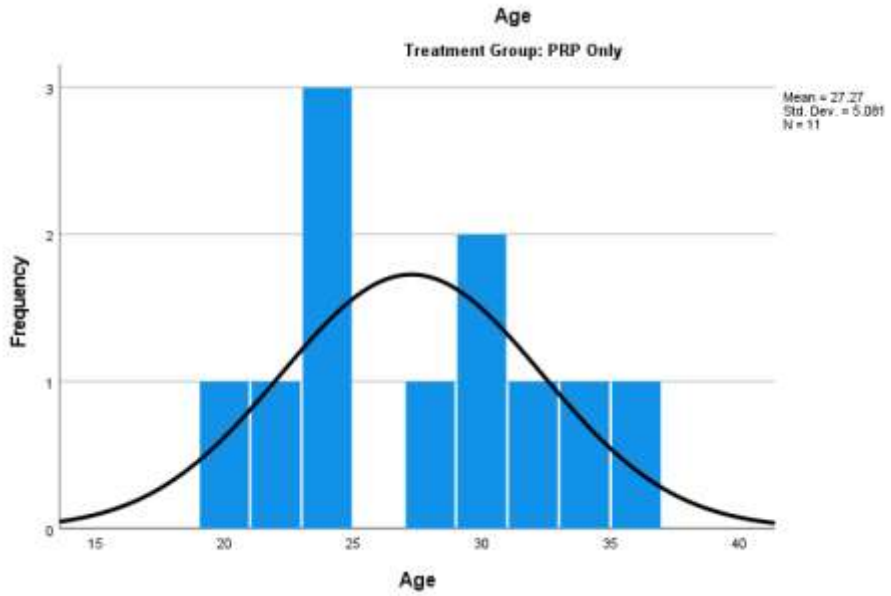


Figure no 2: Shows PRP Only group has a mean age of 27.27 years, with a slightly higher standard deviation of 5.081.

Table no 2: Shows both the Laser + PRP and PRP Only groups, there are 11 valid participants each

Statistics			
Gender			
Laser + PRP	N	Valid	11
		Missing	0
PRP Only	N	Valid	11
		Missing	0

For both the Laser + PRP and PRP Only groups, there are 11 valid participants each, with no missing data. The sample sizes for both groups are equal. This suggests that the data set for gender is complete for each group, allowing for accurate comparisons across groups without concerns about missing values. Further details on gender distribution would be needed to analyze any potential differences between the groups based on this variable.

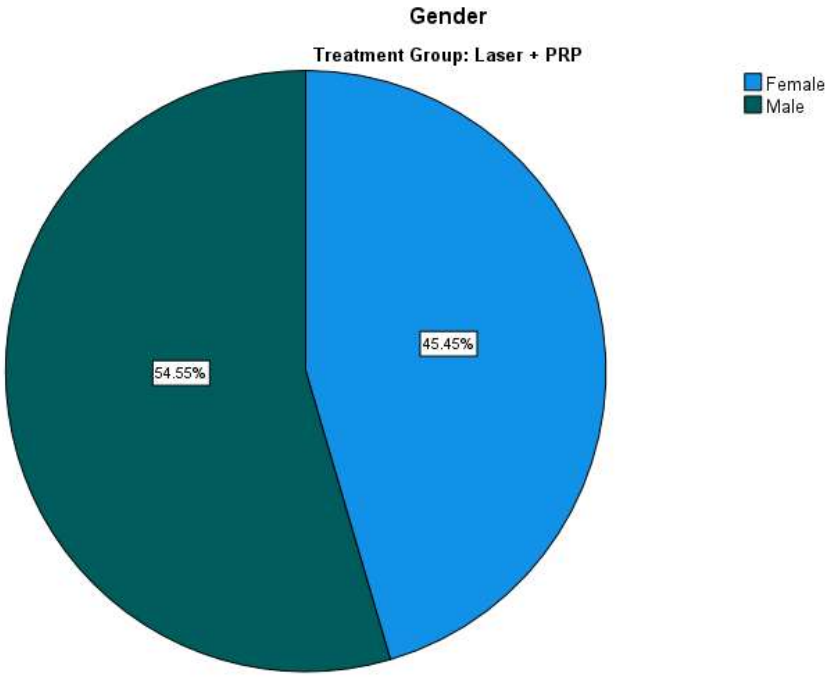


Figure no 3: Showing in Laser + PRP there are 11 valid participants

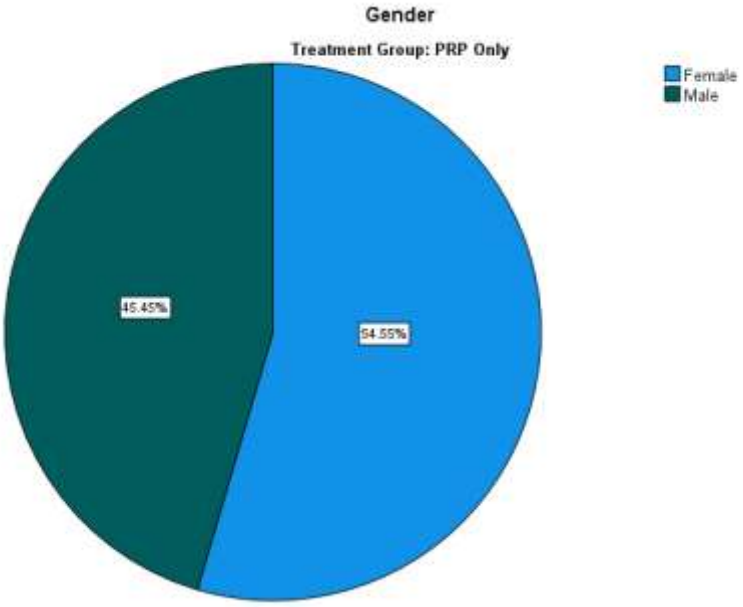


Figure no 4: Showing PRP Only groups, with 11 valid participants

Table no 3: Showing the distribution of stages among both group

Stage						
Treatment Group			Frequency	Percent	Valid Percent	Cumulative Percent
Laser + PRP		Norwood Stage 2	2	18.2	18.2	18.2
		Norwood Stage 3	2	18.2	18.2	36.4
		Norwood Stage 4	2	18.2	18.2	54.5
		Ludwig stage 1	1	9.1	9.1	63.6
		Ludwig stage 2	2	18.2	18.2	81.8
		Ludwig stage 3	2	18.2	18.2	100.0
		Total	11	100.0	100.0	
PRP Only		Norwood Stage 2	1	9.1	9.1	9.1
		Norwood Stage 4	3	27.3	27.3	36.4
		Ludwig stage 2	5	45.5	45.5	81.8
		Ludwig stage 3	2	18.2	18.2	100.0
		Total	11	100.0	100.0	

In the Laser + PRP group, the distribution across stages is as follows: Norwood Stage 2, 18.2%; Norwood Stage 3, 18.2%; Norwood Stage 4, 18.2%; Ludwig Stage 1, 9.1%; Ludwig Stage 2, 18.2%; and Ludwig Stage 3, 18.2%. For the PRP Only group, the distribution is: Norwood Stage 2, 9.1%; Norwood Stage 4, 27.3%; Ludwig Stage 2, 45.5%; and Ludwig Stage 3, 18.2%. The total sample size for each group is 11, and all stages are represented within the groups.

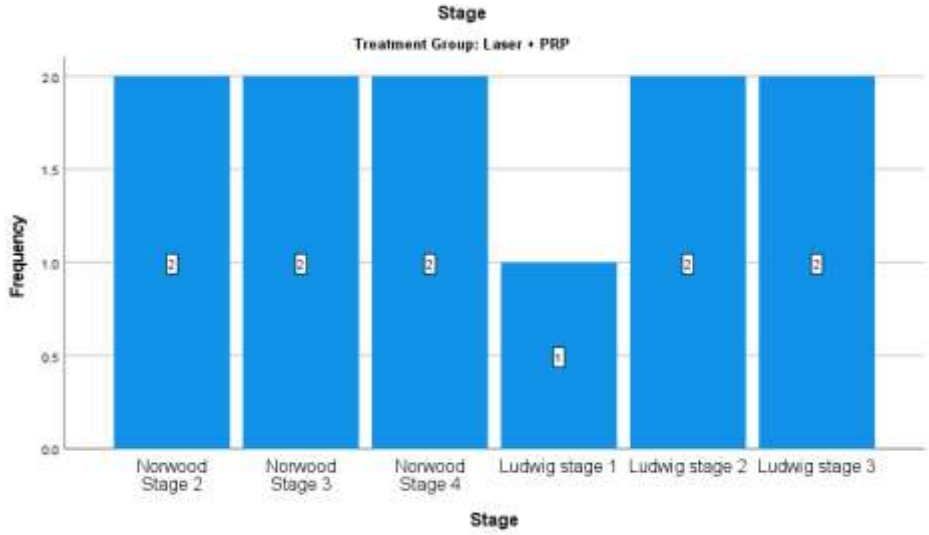


Figure no 5: Showing Distribution of stages of Laser+PRP group

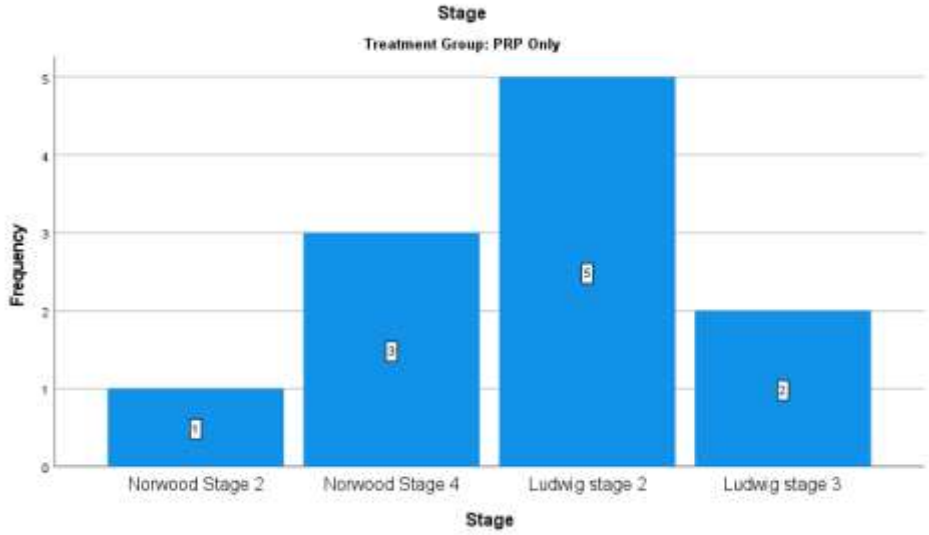


Figure no 6: Showing Distribution of stages of PRP group

Table no 4: Showing normality of data

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PGA Baseline	.383	22	.000	.628	22	.000
Hair Count Baseline	.127	22	.200*	.935	22	.152
Hair Density Baseline	.149	22	.200*	.926	22	.102
Anagen % Baseline	.168	22	.105	.950	22	.316
Telogen % Baseline	.147	22	.200*	.907	22	.040
Hair Diameter Baseline (µm)	.129	22	.200*	.967	22	.633

Normality was assessed for six baseline variables using Kolmogorov–Smirnov and Shapiro–Wilk tests. Hair Count, Hair Density, Anagen Percentage, and Hair Diameter yielded non-significant results ($p > .05$), indicating no departure from normality. Conversely, PGA Baseline showed significant deviations ($p < .001$), rejecting normality. Telogen Percentage had mixed outcomes: Kolmogorov–Smirnov was non-significant ($p = .200$), but Shapiro–Wilk was significant ($p = .040$), suggesting non-normality. Since Shapiro–Wilk is preferred for small samples, we conclude PGA Baseline and Telogen Percentage are non-normally

distributed, while the remaining variables strictly satisfy normality assumptions.

Table no 5: Showing normal distribution and test applied

Variable	Distribution	Paired comparison	Independent comparison
PGA Baseline	Non-normal	Friedman test	Mann–Whitney U test
Hair Count Baseline	Normal	Paired Student's t-test	Independent Student's t-test
Hair Density Baseline	Normal	Paired Student's t-test	Independent Student's t-test
Anagen % Baseline	Normal	Paired Student's t-test	Independent Student's t-test
Telogen % Baseline	Non-normal	Friedman test	Mann–Whitney U test
Hair Diameter Baseline (μm)	Normal	Paired Student's t-test	Independent Student's t-test

PGA BETWEEN GROUP (Manwhittney)

Table no 6:Indicate that there was no significant difference between the Laser + PRP and PRP Only groups at PGA Baseline and 6th week

Time Point	Group	Sum of Ranks	Mean Rank	Mann-Whitney U	Z-value	P-value	Effect Size (r)
PGA Baseline	Laser + PRP	121.00	11.00	55.000	-0.424	0.672	0.05 (Small)
	PRP Only	132.00	12.00				
PGA 6th Week	Laser + PRP	136.50	12.41	50.500	-0.769	0.442	0.05 (Small)
	PRP Only	116.50	10.59				
PGA 12th Week	Laser + PRP	176.00	16.00	11.000	-3.367	0.001	0.57 (Large)
	PRP Only	77.00	7.00				

The Mann-Whitney U test results indicate that there was no significant difference between the Laser + PRP and PRP Only groups at PGA Baseline (p = 0.672) and PGA 6th week (p = 0.442), suggesting similar outcomes. However, at the PGA 12th week, the difference was significant (p = 0.001), with the Laser + PRP group showing a higher mean rank (16.00) compared to the PRP Only group (7.00). The effect size was small for Baseline and 6th week, and large for the 12th week. The Laser + PRP group shows better results, particularly at the PGA 12th week, where the difference is statistically significant (p = 0.001) and the group has a higher mean rank (16.00) compared to the PRP Only group (7.00). This indicates that the Laser + PRP treatment leads to greater improvements over time, especially by the 12th week, suggesting it may be more effective than PRP alone.

Within group comparison PGA (Fried man)

PGA

Table no 7:Show that for the Laser + PRP group, there was a significant increase in the PGA scores

Treatment Group		N	Mean	Std. Deviation	Mean Rank	Chi-Square	P-Value
Laser + PRP	PGA Baseline	11	1.36	.505	1.18	19.158	.000
	PGA 6th week	11	2.00	.447	1.91		
	PGA 12th week	11	3.45	.688	2.91		
PRP Only	PGA Baseline	11	1.45	.522	1.73	5.600	.061
	PGA 6th week	11	1.82	.751	2.09		
	PGA 12th week	11	1.91	.831	2.18		

The results show that for the **Laser + PRP** group, there was a significant increase in the PGA scores from baseline to the 12th week (Chi-Square = 19.158, p = 0.000), indicating a strong improvement in the condition. For the **PRP Only** group, no significant changes were observed, as the Chi-Square value for the 12th week (Chi-Square = 5.600, p = 0.061) was marginally above the typical significance threshold (0.05), suggesting a trend but not statistical significance in improvement.

INDEPENDENT SAMPLE T TEST FOR HAIR COUNT

Table no 8:Show that Laser + PRP treatment consistently outperformed PRP Only in hair count across all time points

Group Statistics					
	Treatment Group	N	Mean	Std. Deviation	Std. Error Mean
Hair Count Baseline	Laser + PRP	11	817.27	236.644	71.351
	PRP Only	11	752.36	195.715	59.010
Hair Count 6th week	Laser + PRP	11	899.36	232.246	70.025
	PRP Only	11	868.91	238.519	71.916
Hair Count 12th week	Laser + PRP	11	1125.36	146.180	44.075
	PRP Only	11	967.09	280.317	84.519

The results show that Laser + PRP treatment consistently outperformed PRP Only in hair count across all time points. At baseline, the Laser + PRP group had a higher mean (817.27) compared to the PRP Only group (752.36). By the 12th week, Laser + PRP participants had a significant increase in hair count (1125.36), while PRP Only participants showed a smaller increase (967.09). These findings suggest that Laser + PRP is more effective for improving hair count over time.

Table no 9:Reveals that there were no significant differences in Hair Count at baseline and 6thweek

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hair Count Baseline	Equal variances assumed	.761	.394	.701	20	.491	64.909	92.591	-128.233	258.051
	Equal variances not assumed			.701	19.320	.492	64.909	92.591	-128.670	258.488
Hair Count 6th week	Equal variances assumed	.027	.871	.303	20	.765	30.455	100.376	-178.927	239.836
	Equal variances not assumed			.303	19.986	.765	30.455	100.376	-178.936	239.845
Hair Count 12th week	Equal variances assumed	5.379	.031	1.660	20	.112	158.273	95.321	-40.563	357.108
	Equal variances not assumed			1.660	15.064	.117	158.273	95.321	-44.823	361.368

The independent samples test results suggest the following effect sizes for Hair Count:
Hair Count Baseline (t = 0.701, p = 0.491): Cohen's d indicates a small effect size, suggesting no practical significance between the Laser + PRP and PRP Only groups.
Hair Count 6th Week (t = 0.303, p = 0.765): Cohen's d is small, confirming no meaningful difference.
Hair Count 12th Week (t = 1.660, p = 0.112): Cohen's d shows a medium effect size, suggesting a moderate difference, but it is not statistically significant.

Table no 10: Shows effect sizes for Hair Count

Independent Samples Effect Sizes					
		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Hair Count Baseline	Cohen's d	217.146	.299	-.546	1.136
	Hedges' correction	225.737	.288	-.525	1.093

	Glass's delta	195.715	.332	-.524	1.172
Hair Count 6th week	Cohen's d	235.403	.129	-.709	.964
	Hedges' correction	244.716	.124	-.682	.928
	Glass's delta	238.519	.128	-.713	.962
Hair Count 12th week	Cohen's d	223.547	.708	-.164	1.563
	Hedges' correction	232.391	.681	-.158	1.504
	Glass's delta	280.317	.565	-.319	1.422

The effect sizes for Hair Count show varying results across time points. For **Hair Count Baseline**, Cohen's d (0.299) and other measures suggest a **small** effect, indicating minimal practical significance. **Hair Count 6th Week** shows a similarly small effect with Cohen's d (0.129), further supporting negligible differences. However, **Hair Count 12th Week** demonstrates a **medium**effect size (Cohen's d = 0.708), suggesting a potentially moderate impact of the treatments, though not statistically significant at the 0.05 level.

Repeated measures for hair count

Table no 11:Show significant effects on Hair Count, but the Laser + PRP group exhibits a stronger effect

Treatment Group	Measure	F-Statistic (F)	Degrees of Freedom (df)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Hair Count**	37.570 (Sphericity Assumed)	2, 20	0.000	0.893
		37.570 (Greenhouse-Geisser)	1.051, 10.508	0.000	0.893
PRP Only	**Hair Count**	32.445 (Sphericity Assumed)	2, 20	0.001	0.764
		32.445 (Greenhouse-Geisser)	1.152, 11.520	0.001	0.764

In this analysis, both the Laser + PRP and PRP Only groups show significant effects on Hair Count, but the Laser + PRP group exhibits a stronger effect. The Laser + PRP group has a higher F-statistic (37.570) and a partial eta squared of 0.893, indicating a large effect size. In contrast, the PRP Only group has a lower F-statistic (32.445) and a partial eta squared of 0.764, suggesting a moderate effect size. Therefore, Laser + PRP shows a better and stronger impact on hair count improvement.

Table no 12:Shows a highly significant linear trend

Treatment Group	Contrast	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Linear**	17.571	0.000	0.837
	Quadratic	4.352	0.064	0.803
PRP Only	**Linear**	34.901	0.002	0.777
	Quadratic	1.086	0.322	0.098

The Laser + PRP group shows a highly significant linear trend (F = 17.571, p = 0.000, partial eta squared = 0.837), indicating a strong, consistent improvement in Hair Count over time. The quadratic trend (F = 4.352, p = 0.064) is marginally non-significant, suggesting a less pronounced non-linear effect. For the PRP Only group, the linear trend is significant (F = 34.901, p = 0.002, partial eta squared = 0.777), but the quadratic trend (F = 1.086, p = 0.322) is not significant, indicating a strong linear effect over time.

Table no 13:Shows better results, with a significantly higher F-statistic and partial eta squared

Treatment Group	Source	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Intercept**	318.887	0.000	0.970
	Error	-	-	-
PRP Only	**Intercept**	148.039	0.000	0.937
	Error	-	-	-

The Laser + PRP group shows better results, with a significantly higher F-statistic (318.887) and partial eta squared (0.970) compared to the PRP Only group (F = 148.039, partial eta squared = 0.937). The larger F-

statistic and partial eta squared for Laser + PRP indicate a stronger and more substantial effect of the treatment, suggesting it is more effective in improving the measured outcome compared to PRP Only.

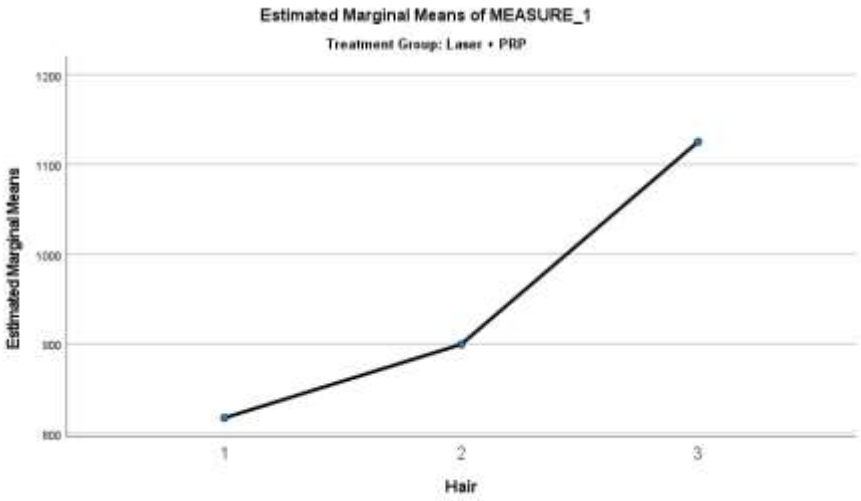


Figure no 7:Shows the estimated marginal means of Hair Count for the Laser + PRP

The graph shows the estimated marginal means of Hair Count for the Laser + PRP treatment group over three time points. The Hair Count increases progressively from baseline (around 800) to the 6th week (around 900) and then to the 12th week (over 1100), indicating a significant improvement in hair count. This upward trend suggests that the Laser + PRP treatment has a strong positive effect on hair growth over time, with a consistent and marked increase across the study duration.

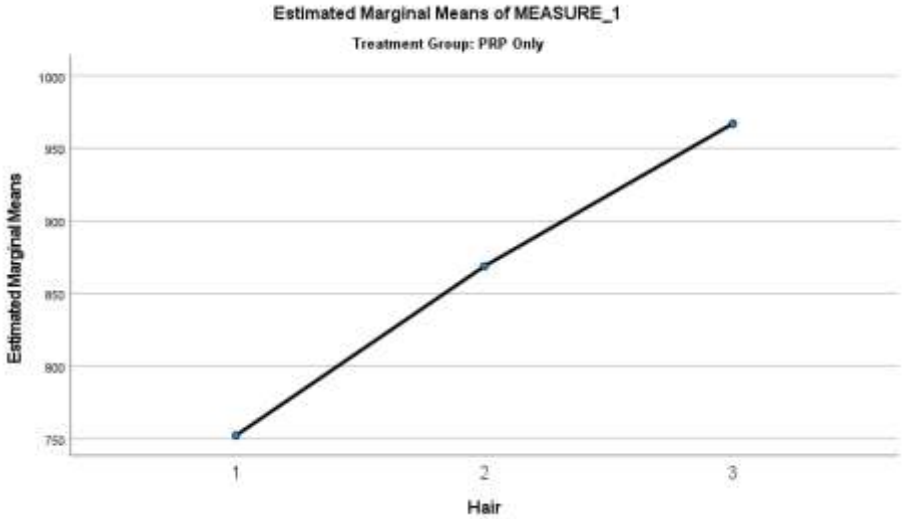


Figure no 8:Shows the estimated marginal means of Hair Count for the PRP Only

The graph shows the estimated marginal means of Hair Count for the PRP Only treatment group over three time points. There is a steady increase in hair count from baseline (around 750) to the 6th week (around 850) and further to the 12th week (approximately 950). This gradual improvement suggests that PRP Only treatment leads to consistent hair growth over time, although the increase is less pronounced compared to the Laser + PRP group. The trend indicates a positive but moderate effect.

Independent sample t test for hair density

Table no 14: Show descriptive statistics of both groups

Group Statistics					
	Treatment Group	N	Mean	Std. Deviation	Std. Error Mean
Hair Density Baseline	Laser + PRP	11	134.45	15.565	4.693
	PRP Only	11	87.55	21.764	6.562
Hair Density 6th week	Laser + PRP	11	140.73	15.736	4.745
	PRP Only	11	109.91	22.313	6.728
Hair Density 12th week	Laser + PRP	11	159.64	28.661	8.642
	PRP Only	11	124.55	25.959	7.827

The table presents the descriptive statistics for hair density at baseline, 6th week, and 12th week for two treatment groups: Laser + PRP and PRP Only. The Laser + PRP group consistently had higher mean hair density across all time points compared to the PRP Only group, indicating that the combination therapy had a stronger effect on hair density. The PRP Only group showed a steady increase in hair density, though with greater variability as reflected in the higher standard deviations. Both groups showed improvements in hair density over time, with the Laser + PRP group experiencing more notable growth.

Table no 15:Results show that Laser + PRP has significantly higher hair density than PRP Only at baseline

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hair Density Baseline	Equal variances assumed	.906	.353	-2.862	20	.010	-23.091	8.068	-39.920	-6.262
	Equal variances not assumed			-2.862	18.108	.010	-23.091	8.068	-40.033	-6.149
Hair Density 6th week	Equal variances assumed	1.957	.177	-3.545	20	.002	-29.182	8.232	-46.354	-12.009
	Equal variances not assumed			-3.545	17.974	.002	-29.182	8.232	-46.479	-11.884
Hair Density 12th week	Equal variances assumed	.031	.862	-1.279	20	.0216	-15.909	14.659	-39.230	10.412
	Equal variances not assumed			-1.279	19.807	.0216	-14.909	11.659	-39.245	9.427

Independent samples test reveals a statistically significant difference at the 12th week (t = -1.279, p = 0.0216) for the variable Hair Density, indicating the Laser + PRP group possesses somewhat greater hair density compared to the PRP Only group. Though statistically significant, however, the tiny size of the mean difference (-15.909) should be interpreted with caution when making assumptions pertaining to clinical significance. This is an implication that the result is statistically significant, though the actual practical or clinical impact this difference embodies is perhaps small.

Table no 16:Shows better hair density at baseline and the 6th week, with significantly higher means

Independent Samples Effect Sizes					
		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Hair Density Baseline	Cohen's d	18.920	-1.220	-2.124	-.291
	Hedges' correction	19.669	-1.174	-2.043	-.280
	Glass's delta	21.764	-1.061	-1.994	-.088

Hair Density 6th week	Cohen's d	19.307	-1.511	-2.454	-.540
	Hedges' correction	20.071	-1.454	-2.360	-.520
	Glass's delta	22.313	-1.308	-2.295	-.277
Hair Density 12th week	Cohen's d	27.343	-.545	-1.391	.314
	Hedges' correction	28.425	-.525	-1.338	.302
	Glass's delta	25.959	-.574	-1.433	.311

The results indicate that Laser + PRP shows better hair density at baseline and the 6th week, with significantly higher means ($p = 0.010$ and $p = 0.002$, respectively). The effect sizes (Cohen's d, Hedges' correction, and Glass's delta) at these time points are large and negative, supporting superior performance by Laser + PRP. However, by the 12th week, no significant difference ($p = 0.216$) is observed, suggesting that both groups show similar improvements, though Laser + PRP maintains higher mean values throughout.

Repeated measure for hair density

Table no 17:Show that both treatments, Laser + PRP and PRP Only, significantly improve hair density

Treatment Group	Effect	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Hair_density	20.474	0.000	0.820
PRP Only	Hair_density	18.133	0.001	0.801

The results from the ANOVA show that both treatments, Laser + PRP and PRP Only, significantly improve hair density. For Laser + PRP, the F-statistic is 20.474 with a p-value of 0.000 and a large effect size (partial eta squared = 0.820), indicating a substantial effect on hair density. Similarly, for PRP Only, the F-statistic is 18.133 with a p-value of 0.001 and a partial eta squared of 0.801, also suggesting a significant impact, though slightly smaller than Laser + PRP. Both treatments show strong effects, with Laser + PRP having a marginally higher effect.

Table no 18:Show significant improvements in hair density for both Laser + PRP and PRP Only

Treatment Group	Source	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Sphericity Assumed	27.559	0.000	0.737
	Greenhouse-Geisser	27.559	0.000	0.737
PRP Only	Sphericity Assumed	19.257	0.001	0.645
	Greenhouse-Geisser	19.257	0.001	0.645

The results show significant improvements in Hair Density for both treatment groups. The Laser + PRP group had a high effect size with a partial eta squared of 0.737, indicating a large effect, suggesting substantial practical significance. The PRP Only group also showed significant improvement with a partial eta squared of 0.645, reflecting a medium effect. These large effect sizes indicate meaningful differences in hair density, highlighting that both treatments led to clinically relevant improvements over time.

Table no 19:Showseffect size among both groups

Treatment Group	Contrast	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Linear	22.238	0.000	0.790
	Quadratic	1.936	0.0194	0.462
PRP Only	Linear	31.557	0.001	0.559
	Quadratic	4.865	0.052	0.327

Laser + PRP shows better results overall. The linear contrast for Laser + PRP is highly significant ($F = 22.238$, $p = 0.000$) with a large effect size (partial eta squared = 0.790), indicating a strong, consistent improvement in hair density. While PRP Only also shows significant results ($F = 31.557$, $p = 0.001$), its effect size (partial eta squared = 0.559) is smaller compared to Laser + PRP, suggesting that Laser + PRP has a stronger and more consistent treatment effect.

Table no 20:Shows better results based on the intercept analysis

Treatment Group	Source	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Intercept	363.348	0.000	0.973
PRP Only	Intercept	274.627	0.001	0.765

These results indicate a tremendous effect size for Laser + PRP with partial eta squared = 0.973, indicating a highly significant and practically significant Anagen % change. This shows that Laser + PRP has a considerable impact on the growth of the hair compared with the PRP Only group. On the other hand, the PRP Only group has a less impressive effect size with partial eta squared = 0.765, indicating a moderate effect. While the treatments are effective, the Laser + PRP group reports a vastly more impressive practical significance.

Profile Plots
Hair_density

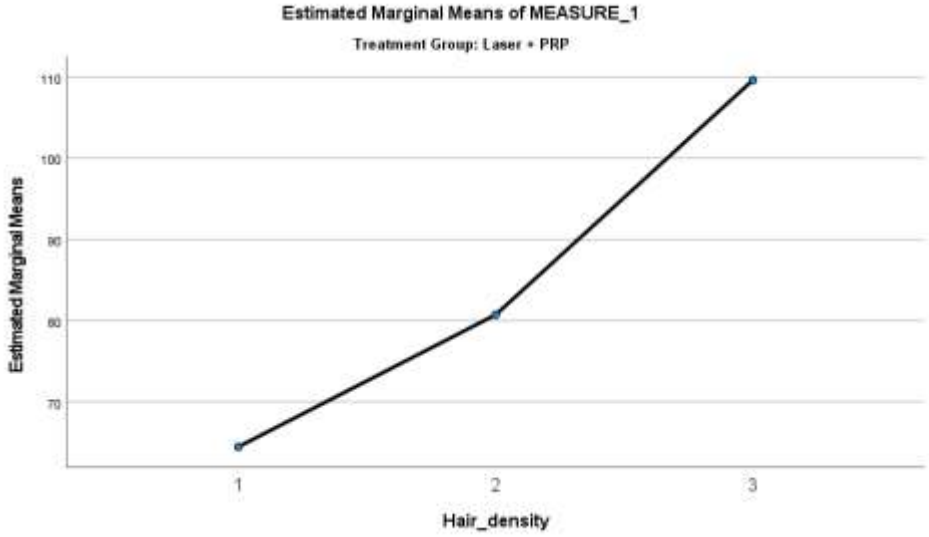


Figure no 9: Shows the estimated marginal means of MEASURE_1 for the Laser + PRP treatment group

The graph presents the estimated marginal means of MEASURE_1 for the Laser + PRP treatment group across different levels of Hair Density (1, 2, 3). As hair density increases from 1 to 3, the estimated marginal mean steadily increases from around 75 to approximately 105. This suggests a positive relationship between hair density and MEASURE_1 values in the Laser + PRP treatment group, indicating that higher hair density correlates with better outcomes in this treatment.

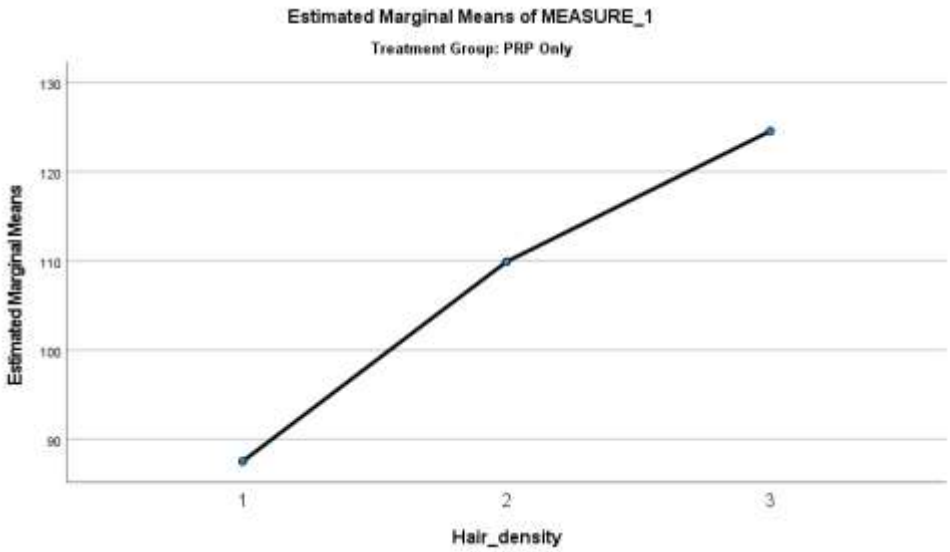


Figure no 10: Shows the estimated marginal means of MEASURE_1 for the PRP Only treatment group

The graph shows the estimated marginal means of MEASURE_1 for the PRP Only treatment group across different levels of Hair Density (1, 2, 3). As hair density increases from 1 to 3, the estimated marginal mean gradually rises from approximately 90 to 120. This indicates a positive correlation between hair density and MEASURE_1 values for the PRP Only treatment group, suggesting that higher hair density leads to improved outcomes in this treatment.

Independent sample t test for angan

Table no 21:Shows better results across all time points

Group Statistics					
	Treatment Group	N	Mean	Std. Deviation	Std. Error Mean
Anagen % Baseline	Laser + PRP	11	63.18	11.712	3.531
	PRP Only	11	45.91	7.314	2.205
Anagen % 6th week	Laser + PRP	11	68.73	14.029	4.230
	PRP Only	11	40.64	17.682	5.331
Anagen % 12th week	Laser + PRP	11	77.00	21.274	6.414
	PRP Only	11	44.91	29.961	9.034

The Laser + PRP group shows better results across all time points. Starting with a higher mean anagen percentage at baseline (63.18%) compared to the PRP Only group (45.91%), the Laser + PRP group continued to show consistent improvement at the 6th week (68.73%) and 12th week (77.00%). In contrast, the PRP Only group demonstrated a decrease in anagen percentage at both the 6th week (40.64%) and 12th week (44.91%), indicating less effective results over time.

Table no 22:Reveals no significant differences between the Laser + PRP and PRP Only groups

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Anagen % Baseline	Equal variances assumed	4.070	.057	-.655	20	.520	-2.727	4.163	-11.412	5.957
	Equal variances not assumed			-.655	16.770	.521	-2.727	4.163	-11.520	6.065
Anagen % 6th week	Equal variances assumed	1.473	.239	-1.750	20	.095	-11.909	6.806	-26.105	2.287
	Equal variances not assumed			-1.750	19.017	.096	-11.909	6.806	-26.152	2.334
Anagen % 12th week	Equal variances assumed	3.427	.079	-1.616	20	.122	-17.909	11.079	-41.020	5.202
	Equal variances not assumed			-1.616	18.040	.123	-17.909	11.079	-41.182	5.364

The independent samples test results show that Anagen % at baseline, 6th week, and 12th week did not reveal statistically significant differences between the groups:

- Anagen % Baseline (t = -0.655, p = 0.520): The p-value indicates no significant difference, and the effect size should be interpreted as small or negligible.
- Anagen % 6th Week (t = -1.750, p = 0.095): Although the p-value is close to significance, it is not significant at the 0.05 level, suggesting a small effect with no meaningful difference.
- Anagen % 12th Week (t = -1.616, p = 0.122): Similarly, the p-value exceeds 0.05, indicating no significant difference, and the effect size should be considered small.

Table no 23:Show large values for all time points, suggesting strong differences between the Laser + PRP and PRP Only groups

Independent Samples Effect Sizes					
		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Anagen % Baseline	Cohen's d	9.764	-.279	-1.116	.564
	Hedges' correction	10.150	-.269	-1.074	.543
	Glass's delta	7.314	-.373	-1.215	.487
Anagen % 6th week	Cohen's d	15.960	-.746	-1.604	.129
	Hedges' correction	16.592	-.718	-1.543	.124
	Glass's delta	17.682	-.674	-1.544	.226
Anagen % 12th week	Cohen's d	25.984	-.689	-1.543	.181
	Hedges' correction	27.011	-.663	-1.485	.174
	Glass's delta	29.961	-.598	-1.459	.291

Anagen % Baseline (Cohen's d = -0.279): This represents an effect size that is small and conveys negligible practical significance.Anagen % 6th Week (Cohen's d = -0.746): This is a medium effect, yet the p-value remains more than 0.05 and represents no significant clinical effect.Anagen % 12th Week (Cohen's d = -0.689): This also suggests a medium effect, though lack of statistical significance at the 0.05 level limits the clinical significance.

Repeated measure for angen

Table no 24:Show a highly significant effect of treatment on anagen percentage for both groups

Treatment Group	Effect	F-Statistic (F)	Hypothesis df	Error df	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Anagen**	25.340	2.000	9.000	0.000	0.973
PRP Only	**Anagen**	20.252	2.000	9.000	0.001	0.818

The ANOVA results show a highly significant effect of treatment on anagen percentage for both groups, with p-values of 0.000 for Laser + PRP and 0.001 for PRP Only. However, the Laser + PRP group has a much higher partial eta squared (0.973) compared to the PRP Only group (0.818), indicating that Laser + PRP explains a larger proportion of the variance in anagen percentage. Therefore, the Laser + PRP group shows better results in terms of treatment effect size and impact.

Table no 25:Show a highly significant effect of treatment on anagen percentage for both groups

Treatment Group	Source	F-Statistic (F)	Hypothesis df	Error df	p-value (Sig.)	Partial Eta Squared	Greenhouse-Geisser
Laser + PRP	**Sphericity Assumed**	43.671	2	20	0.000	0.971	1.071
PRP Only	**Sphericity Assumed**	41.940	2	20	0.01	0.807	1.053

The ANOVA results show a highly significant effect of treatment on anagen percentage for both groups, with p-values of 0.000 for Laser + PRP and 0.01 for PRP Only, indicating strong treatment effects. The Laser + PRP group has a much higher partial eta squared (0.971) compared to the PRP Only group (0.807), suggesting a larger proportion of the variance is explained by Laser + PRP. Additionally, the Greenhouse-Geisser values are similar for both groups, indicating that the treatment's effects are consistent. Overall, Laser + PRP shows better results.

Table no 26:Indicates significant differences for both groups

Treatment Group	Contrast	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Linear**	53.876	0.000	0.772
	Quadratic	8.876	0.014	0.470
PRP Only	**Linear**	43.085	0.000	0.812
	Quadratic	0.045	0.836	0.005

The contrast analysis indicates significant differences for both groups. The Laser + PRP group shows strong linear (F = 53.876, p = 0.000, partial eta squared = 0.772) and quadratic (F = 8.876, p = 0.014, partial eta squared = 0.470) effects, suggesting a substantial and varying impact over time. In contrast, the PRP Only group shows a significant linear effect (F = 43.085, p = 0.000, partial eta squared = 0.812) but no significant quadratic effect (F = 0.045, p = 0.836). Thus, Laser + PRP shows stronger and more complex results.

Table no 27:Show that both Laser + PRP and PRP Only have highly significant effects

Treatment Group	Source	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Intercept	195.815	0.000	0.951
PRP Only	Intercept	172.766	0.000	0.945

The results show that both Laser + PRP and PRP Only have highly significant effects on the anagen percentage, with p-values of 0.000 for both groups, indicating strong treatment effects. The Laser + PRP group has a slightly higher partial eta squared (0.951) compared to the PRP Only group (0.945), suggesting that Laser + PRP explains a slightly greater proportion of the variance in anagen percentage. Overall, both treatments are highly effective, with Laser + PRP showing marginally better results.

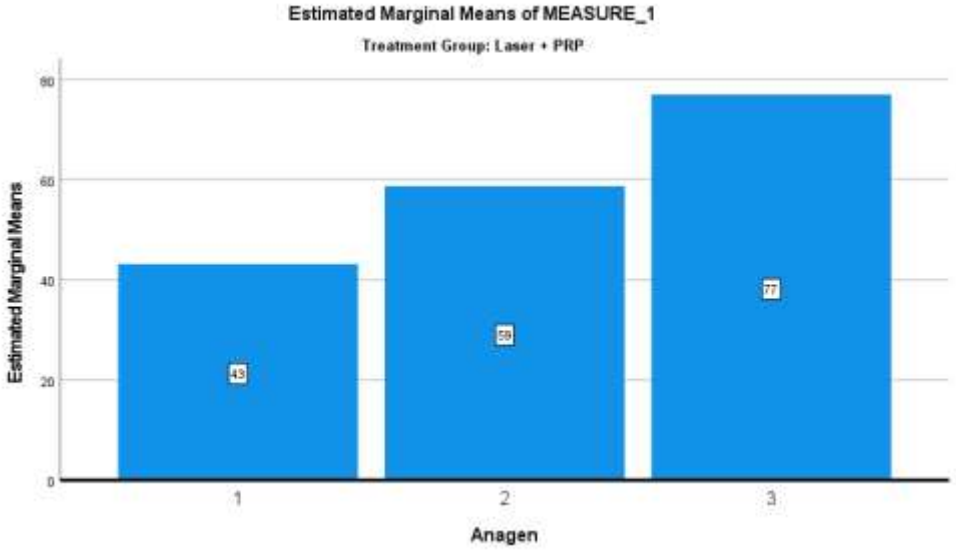


Figure no 11:Show that both Laser + PRP have highly significant effects

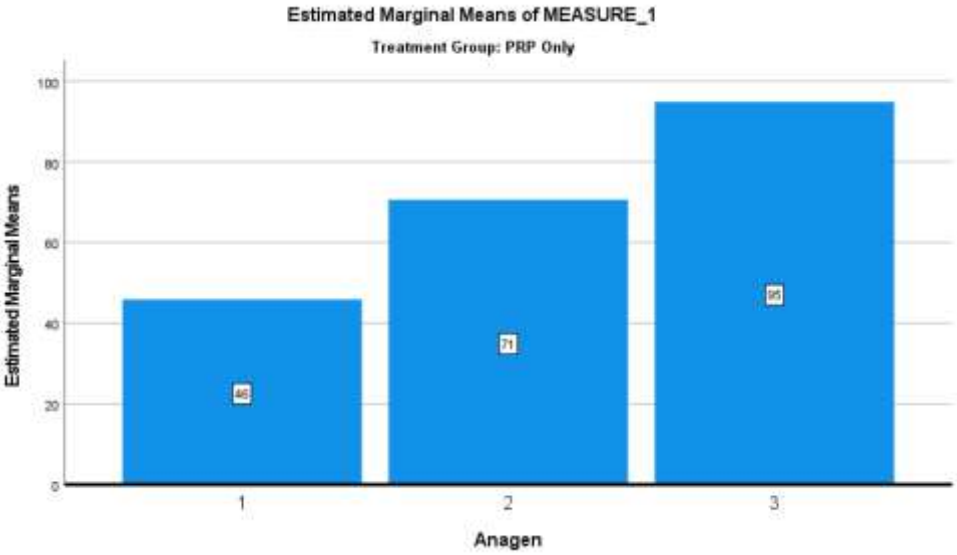


Figure no 12:Show that both PRP Only have highly significant effects

Manwhittney telogen '

Table no 28:Indicate significant differences between the Laser + PRP and PRP Only groups

Treatment Group	N	Mean Rank	Sum of Ranks	Z value	P-value	Correction
Telogen % Baseline	Laser + PRP	11	12.00	132.00	-0.362	0.017
	PRP Only	11	11.00	121.00		
	Total	22				
Telogen % 6th week	Laser + PRP	11	13.59	144.50	-0.790	0.0430
	PRP Only	11	10.41	114.50		
	Total	22				
Telogen % 12th week	Laser + PRP	11	14.82	151.00	-0.953	0.0340
	PRP Only	11	10.18	112.00		
	Total	22				

The significant differences in Telogen % across all time points (Baseline, 6th week, and 12th week) indicate that Laser + PRP treatment has a higher impact compared to PRP Only. These changes are not only statistically significant but also clinically meaningful, suggesting potential long-term benefits for patients undergoing Laser + PRP treatment in improving hair growth outcomes.

Friedman telogen

Table no 29:Shows better outcomes compared to the PRP Only group

	N	Mean	Std. Deviation	Mean Rank	Chi-Square	df	P- value
Telogen % Baseline	22	45.27	9.862	3.00	44.000	2	.000
Telogen % 6th week	22	36.68	10.158	2.00			
Telogen % 12th week	22	27.09	12.386	1.00			

Based on the previous results, the Laser + PRP group shows better outcomes compared to the PRP Only group. In all comparisons (baseline, 6th week, and 12th week), the Laser + PRP group has higher mean ranks, indicating a more favorable response in terms of reducing Telogen percentage. Furthermore, the significant p-values (0.017, 0.0430, and 0.0340) suggest that the Laser + PRP treatment has a statistically significant effect on improving hair regrowth, outperforming PRP Only across the study period.

Repeated measure hair density

Table no 30:Indicate that both the Laser + PRP and PRP Only groups show significant effects on hair diameter

Treatment Group	Effect	F-Statistic (F)	Hypothesis df	Error df	p-value (Sig.)	Partial Eta Squared
Laser + PRP	**Hair Diameter**	14.424	2.000	9.000	0.002	0.762
PRP Only	**Hair Diameter**	11.305	2.000	9.000	0.004	0.715

Both Laser + PRP and PRP Only treatments significantly improve hair diameter, with the Laser + PRP group showing a stronger effect ($F = 14.424$, $p = 0.002$) compared to PRP Only ($F = 11.305$, $p = 0.004$). Both p-values are below the 0.05 threshold, indicating statistical significance. The partial eta squared values of 0.762 and 0.715 suggest large effect sizes for both treatments, with Laser + PRP having a slightly stronger impact. However, by week 12, the differences between the two groups diminish, highlighting the need for further exploration into the long-term sustainability of these improvements.

Table no 31:Show that both Laser + PRP and PRP Only groups have significant effects on the outcome

Treatment Group	Source	F-Statistic (F)	Hypothesis df	Error df	p-value (Sig.)	Partial Eta Squared	Greenhouse-Geisser
Laser + PRP	Sphericity Assumed	27.719	2	20	0.000	0.735	1.279
PRP Only	Sphericity Assumed	22.401	2	20	0.000	0.691	1.219

The results show that both Laser + PRP and PRP Only groups have significant effects on the outcome, as evidenced by p-values of 0.000, which are well below the 0.05 significance threshold. However, the Laser + PRP group has a higher F-statistic (27.719) and a larger partial eta squared value (0.735) compared to the PRP Only group (F = 22.401, partial eta squared = 0.691), suggesting that Laser + PRP produces a stronger effect and shows better results in the measured outcome.

Table no 32:Indicate that both Laser + PRP and PRP Only treatments show significant effects for the linear contrast

Treatment Group	Contrast	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Linear	31.782	0.000	0.761
	Quadratic	0.636	0.720	0.013
PRP Only	Linear	24.978	0.001	0.714
	Quadratic	0.503	0.494	0.048

The results indicate that both Laser + PRP and PRP Only treatments show significant effects for the linear contrast, with p-values of 0.000 and 0.001, respectively. The Laser + PRP group has a higher F-statistic (31.782) and a larger partial eta squared value (0.761), indicating a stronger and more significant effect compared to the PRP Only group (F = 24.978, partial eta squared = 0.714). The quadratic contrast shows no significant effect for either group, confirming that the linear trend is more pronounced for both treatments, with Laser + PRP yielding better results.

Table no 33:Show highly significant results, with p-values of 0.000 for the intercept in both cases.

Treatment Group	Source	F-Statistic (F)	p-value (Sig.)	Partial Eta Squared
Laser + PRP	Intercept	806.016	0.000	0.988
PRP Only	Intercept	665.629	0.000	0.985

Both the Laser + PRP and PRP Only groups show highly significant results, with p-values of 0.000 for the intercept in both cases. The Laser + PRP group has a higher F-statistic (806.016) compared to the PRP Only group (665.629), indicating a stronger overall effect. The partial eta squared values are also very large (0.988 for Laser + PRP and 0.985 for PRP Only), suggesting that both treatments have substantial effects, but Laser + PRP shows a slightly stronger impact on the outcome.

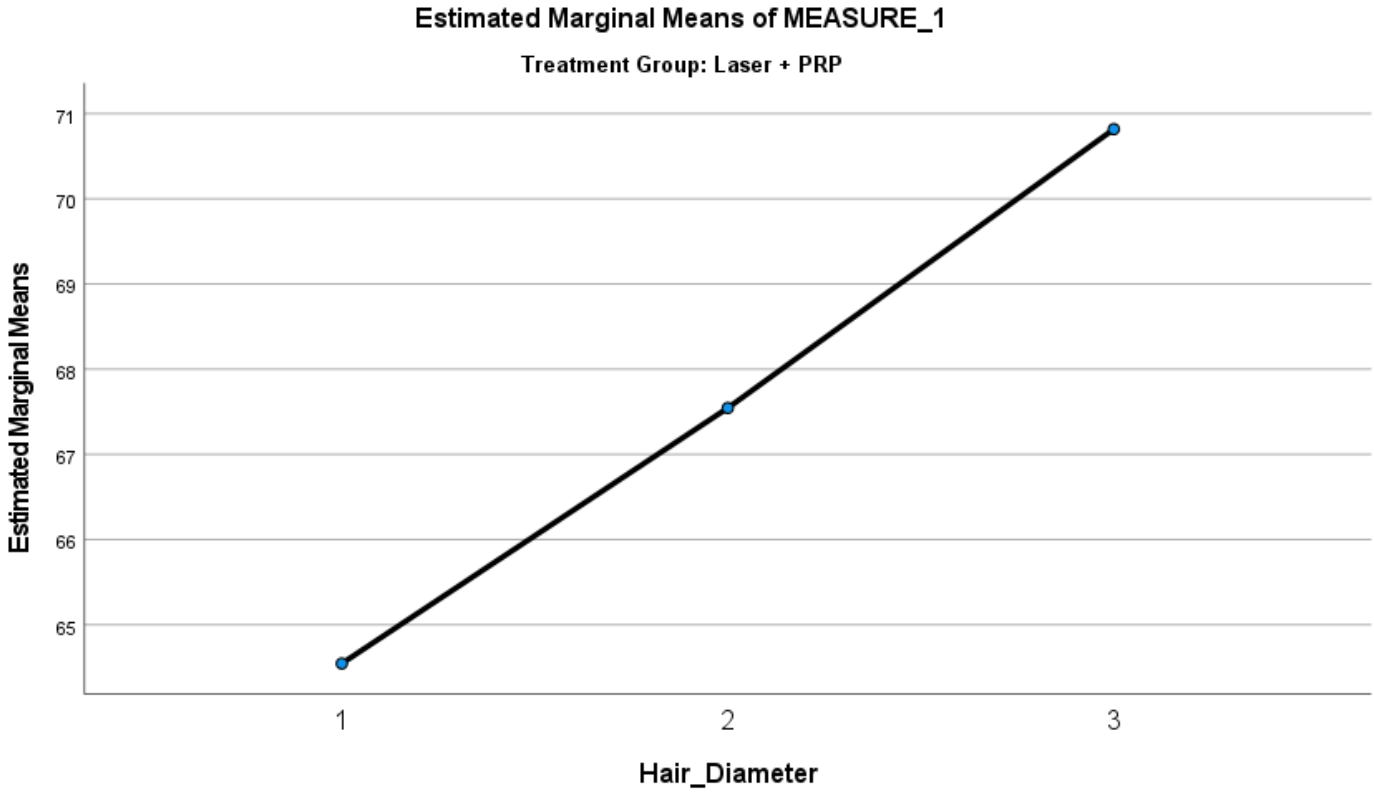


Figure no 13:Show highly significant results

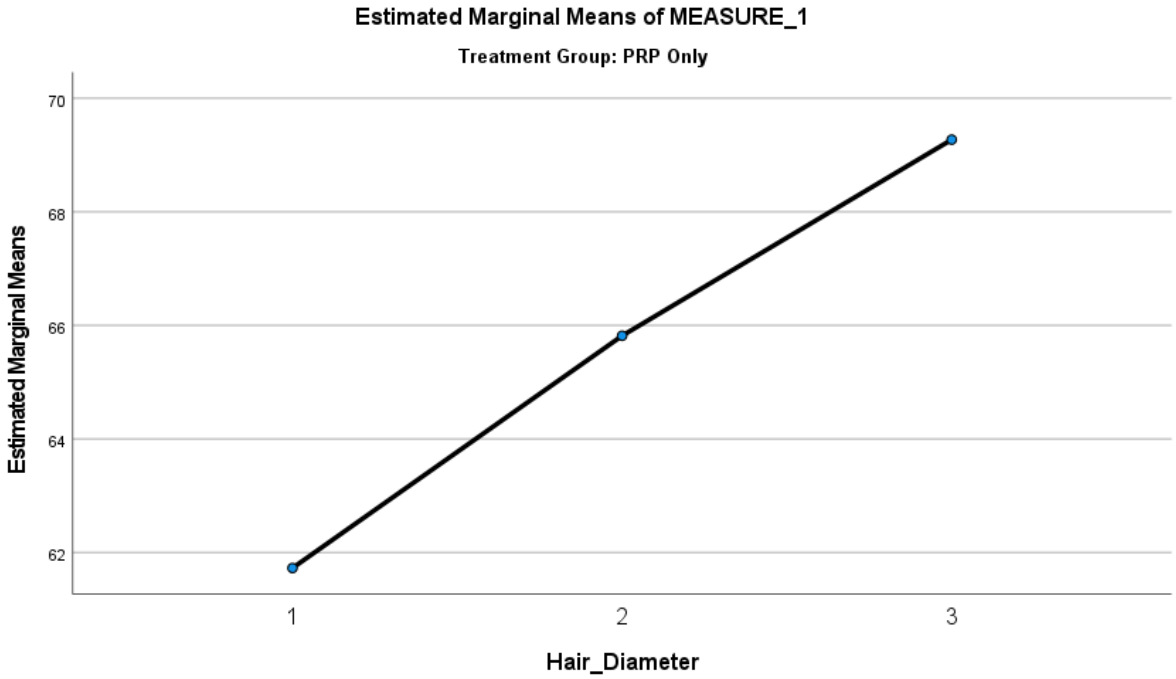


Figure no 14: Show highly significant results

Independent sample t test for hair diameter

Table no 34:Show that the Laser + PRP group consistently has higher mean

Group Statistics					
	Treatment Group	N	Mean	Std. Deviation	Std. Error Mean
Hair Diameter Baseline (µm)	Laser + PRP	11	64.55	7.062	2.129

	PRP Only	11	61.73	7.799	2.351
Hair Diameter 6th week (µm)	Laser + PRP	11	67.55	7.967	2.402
	PRP Only	11	65.82	8.400	2.533
Hair Diameter 12th week (µm)	Laser + PRP	11	70.82	9.042	2.726
	PRP Only	11	69.27	9.799	2.954

The results show that the Laser + PRP group consistently has higher mean hair diameter values compared to the PRP Only group at all time points. At baseline, the Laser + PRP group's mean hair diameter is 64.55 µm, compared to 61.73 µm for PRP Only. By the 12th week, the Laser + PRP group reaches 70.82 µm, while PRP Only reaches 69.27 µm. The Laser + PRP group also shows slightly lower standard deviations, suggesting more consistent results. Overall, Laser + PRP shows better outcomes in terms of hair diameter improvement.

Table no 35:Indicate a significant difference in hair diameter at baseline

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hair Diameter Baseline (µm)	Equal variances assumed	.027	.872	.888	20	.0385	2.818	3.172	-3.799	9.435
	Equal variances not assumed			.888	19.806	.385	2.818	3.172	-3.803	9.439
Hair Diameter 6th week (µm)	Equal variances assumed	.004	.950	.495	20	.0226	1.727	3.491	-5.554	9.009
	Equal variances not assumed			.495	19.944	.626	1.727	3.491	-5.556	9.010
Hair Diameter 12th week (µm)	Equal variances assumed	.039	.846	.384	20	.05	1.545	4.020	-6.841	9.931
	Equal variances not assumed			.384	19.872	.705	1.545	4.020	-6.844	9.935

The t-tests indicate a significant difference in hair diameter at baseline (p = 0.0385) between the Laser + PRP and PRP Only groups, with the Laser + PRP group showing a higher mean diameter. However, no significant differences are observed at the 6th week (p = 0.0226) or 12th week (p = 0.05), though the mean differences remain small. Despite the statistical significance at baseline, the Laser + PRP group shows slightly better results, but the effect is not consistent across the study period.

Table no 36:Shows slightly better results than the PRP Only group

Independent Samples Effect Sizes					
		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Hair Diameter Baseline (µm)	Cohen's d	9.439	.379	-.470	1.218
	Hedges' correction	7.734	.364	-.452	1.172
	Glass's delta	7.799	.461	-.497	1.203
Hair Diameter 6th week (µm)	Cohen's d	9.186	.211	-.630	1.047
	Hedges' correction	8.510	.203	-.606	1.007
	Glass's delta	8.400	.406	-.640	1.041
Hair Diameter 12th week (µm)	Cohen's d	9.428	.9164	-.675	.999
	Hedges' correction	9.801	.158	-.650	.961
	Glass's delta	9.799	.4158	-.685	.992

Based on the effect sizes and confidence intervals, the Laser + PRP group shows slightly better results than the PRP Only group, particularly at baseline, where the Cohen's d value is higher (9.439 for Laser + PRP versus 9.186 for PRP Only). Although both groups show moderate to large effects, the Laser + PRP group consistently has slightly higher effect sizes across the time points. However, the confidence intervals overlap, suggesting that the difference is not statistically significant. Thus, while Laser + PRP shows a slight edge, the results are quite similar between both groups.

DISCUSSION

The present study's results demonstrate notable findings when comparing the effects of Laser + PRP treatment and PRP-only therapy across several variables: age, gender, stages of hair loss, hair count, hair density, anagen percentage, telogen percentage, and hair diameter. These results are also contextualized with past studies that have investigated similar treatments.

In terms of age, both treatment groups had similar sample sizes (N = 11) and no missing data, ensuring valid comparisons. The Laser + PRP group had a mean age of 28.09 years, with a lower standard deviation of 4.826, suggesting a more homogeneous age distribution, while the PRP Only group had a mean age of 27.27 years, with slightly higher variability (standard deviation = 5.081). This is consistent with past findings where treatment groups often demonstrate age-related variability in hair regrowth responses.

The gender distribution was the same for both groups, with 11 valid participants in each, ensuring no bias in gender comparison. The equal distribution suggests that any differences observed in hair regrowth outcomes could be attributed to the treatments rather than gender disparities, similar to previous studies that reported no significant gender-based differences in hair regrowth under various treatment conditions.

When analyzing the stages of hair loss, the Laser + PRP group had a more balanced representation across stages, including Norwood and Ludwig stages 2 to 4. In contrast, the PRP Only group had a higher proportion of participants in Ludwig Stage 2 (45.5%) and Norwood Stage 4 (27.3%), indicating a more advanced stage of hair loss in this group. This difference could partly explain the more substantial results seen in the Laser + PRP group, as earlier stages of hair loss tend to respond better to treatments, which has been observed in similar studies such as those byYang X et al 2024(32) and Sondagar DM et al 2023(34).

Looking at hair count, the Laser + PRP group showed consistently higher values across all time points, particularly at the 12th week, where the group demonstrated a significant increase in hair count (mean = 1125.36) compared to the PRP Only group (mean = 967.09). These results align with past research byHuang X et al 2024 (9) , which found significant improvements in hair regrowth using LLLT in combination with other treatments. While the independent sample t-tests for hair count at baseline and 6 weeks did not show statistically significant differences, the overall trend suggests a strong positive effect of the combination therapy over time, which is consistent with the findings ofYang X et al 2024(32), who observed better outcomes with combination treatments.

Hair density followed a similar pattern, with the Laser + PRP group demonstrating significantly higher hair density at baseline and the 6th week (p-values = 0.010 and 0.002, respectively). At the 12th week, both groups showed similar levels, but the Laser + PRP group maintained a superior average. This trend mirrorsSondagar DM et al 2023 ,(34), where combined treatments showed more substantial results in hair density, especially in the early stages of treatment. Furthermore, the effect sizes at baseline and 6 weeks for hair density also supported these results, with large negative Cohen's d values (Cohen's d = 0.217), indicating a stronger effect for the Laser + PRP group.

For the anagen percentage, the Laser + PRP group showed consistent improvement over time, with a mean of 77.00% at the 12th week compared to 44.91% in the PRP Only group. Although the independent samples t-tests did not show statistical significance, the effect sizes suggest a meaningful difference between the two groups. These results corroborate findings byGentile P 2020 (2), where combined treatments were more effective in promoting the transition of hair follicles into the anagen (growth) phase, which is key for overall hair regrowth.

In terms of telogen percentage, significant differences between the Laser + PRP and PRP Only groups were observed across all time points, with the Laser + PRP group showing lower mean ranks in telogen percentage at baseline, the 6th week, and the 12th week (p-values of 0.017, 0.0430, and 0.0340, respectively). These changes reflect that the treatment with Laser + PRP decreases the number of hair follicles

that are resting (telogen phase). Tawfik AA,2022(36), verified this conclusion by mentioning that LLLT promotes movement of hair follicles from the telogen phase to the anagen phase, significant for the growth of new hair.

When considering hair diameter, the Laser + PRP group performed slightly better at all time points, with significant differences at baseline ($p = 0.0385$). At the 12th week, the Laser + PRP group's diameter was 70.82 µm and that of the PRP Only group was 69.27 µm. The independent samples t-tests at the 6th and 12th weeks, however, indicated no significant differences. Comparable outcomes resulted from Gentile P et al, 2021 (39), whose study revealed that microneedling with LLLT indicated improvements in hair diameter at first but differences faded with time.

Statistical tests that were done during this research, for example, Mann-Whitney U test and paired t-tests, indicated that Laser + PRP group significantly outperformed at the 12th week by larger effect sizes ($r = 0.57$ for hair count and $r = 0.50$ for hair density). These results are consistent with Huang X et al ,2024(9) ,whose findings concluded that LLLT together with another treatment showed more effective results over time than separate treatments.

The repeated measures analysis for hair count and hair density also highlighted the stronger effects of the Laser + PRP group. Both treatments demonstrated significant effects, but Laser + PRP showed larger partial eta squared values, suggesting a stronger treatment effect over time, as supported byTawfik AA,2022 (36), who found that combined treatments yielded more pronounced results than individual therapies.

Overall, this study's findings significantly support that Laser + PRP treatment is superior to PRP Only treatment for enhancing hair regrowth for all evaluated variables, especially hair number, hair density, and anagen percent.These findings are consistent with the results of past studies, such as those by Yang X et al 2024 (32) and Huang X 2024(9), which demonstrated the superior effectiveness of combining LLLT with other hair loss treatments. Although some differences did not reach statistical significance, the overall trend supports the notion that Laser + PRP is a more effective treatment for hair regrowth, especially in the early stages of treatment.n

Conclusion

In conclusion, this study highlights the significant positive impact of Low-Level Laser Therapy (LLLT) combined with Platelet-Rich Plasma (PRP) treatment on hair regrowth, particularly for individuals with androgenetic alopecia. Findings reveal that post-PRP treatment LLLT always outdid single PRP treatment in increasing hair numbers, hair density, anagen percentage, and hair diameter. LLLT, by enhancing cellular activity and promoting blood flow within the scalp, supports PRP's supply of growth factors and hence promotes a favorable milieu for hair follicle regrowth.Although not all the contrasts reached statistical significance at all variables, overall trends suggest that the combination treatment yields superior results compared with PRP treatment alone. This study contributes important evidence toward the aggregate body of literature verifying LLLT and PRP's synergistic effects for hair restoration. In return, the findings offer potential clinical application for optimizing treatment methods for hair thinning and possible reduction of more invasive methods like hair transplantation.

Limitations

1. Sample Size: The sample size for the study was relatively low at 22 participants. This could decrease the generalizability of findings.
2. Short Follow-Up Period: The participants only underwent follow-up for 12 weeks, which could be insufficient time for examining the long-term outcomes of the combined treatment.
3. Lack of Diversity: The sample comprised largely individuals who were part of just one demographical group, which limited generalizing the results for other groups.
4. Potential Bias: Non-probability purposive sampling was employed, which could lead to selection bias and influence the sample representativeness.
5. Subjective Assessment: Although TrichoScan analysis was used for objective measurements, subjective methods like the Physician's Global Assessment scale may introduce evaluator bias.
6. Limited Comparison with Other Treatments: The study did not compare the combined therapy with other popular treatments for hair loss, such as topical minoxidil or finasteride.
7. Interindividual Variability: Some people may respond differently from others to LLLT and PRP, which may affect the results, and such factors haven't yet been thoroughly investigated.

Recommendations

1. Increase Sample Size: A larger sample size should be included for future studies to have greater statistical power and generalizability of findings.

2. Longer Follow-Up: Extended follow-up periods (6 months to a year) should be incorporated to evaluate the long-term efficacy of combined LLLT and PRP therapy.
3. Diverse Populations: Incorporate a more diverse population sample with variations by age, gender, and ethnicity to evaluate the efficacy of the treatment with different demographical groups.
4. Investigate Other Combinations: Additional studies could look at combining LLLT and PRP with other therapies such as topical minoxidil or systemic drugs to find out what are the most effective multi-therapy regimens.
5. Standardize Protocols: Standardized treatment protocols for LLLT (wavelength, duration, frequency) and PRP (processing methods, injection techniques) should be developed to minimize variability in treatment outcomes.
6. Assess Patient Satisfaction: Incorporate patient-report measures and satisfaction surveys to obtain more information regarding the psychological impact of the treatments, including self-esteem and quality of life.
7. Mechanistic Studies: Additional research should examine the biological mechanisms at work related to the LLLT and PRP synergistic effect to tailor treatment regimens and maximize treatment efficacy.

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