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PRP Vs GFC: A Comparative Study on Efficacy and Patient Satisfaction in Hair Loss Treatment

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Abstract:

Background: Androgenetic alopecia (AGA) significantly impacts quality of life, prompting the exploration of regenerative treatments like Platelet-Rich Plasma (PRP) and Growth Factor Concentrate (GFC).
Objective: This study aims to compare the efficacy and patient satisfaction of PRP versus GFC treatments in individuals with AGA over a one-year period.
Method: A randomized controlled trial was conducted at a tertiary care hospital involving 60 patients diagnosed with AGA. Participants were equally assigned to receive either PRP or GFC therapy. Treatment protocols included monthly injections for six months, followed by bi-monthly sessions. Efficacy was assessed through hair count, hair thickness measurements, and scalp health evaluations using standardized scales. Patient satisfaction was evaluated using validated questionnaires. Data were analyzed using paired and independent t-tests with a significance threshold of $p < 0.05$.
Result: Both PRP and GFC treatments resulted in significant improvements in hair count and thickness. PRP group showed a 35% increase in hair density compared to a 50% increase in the GFC group ($p=0.03$). Hair thickness improved by 30% with PRP and 45% with GFC ($p=0.02$). Scalp health scores enhanced by 40% in PRP and 55% in GFC ($p=0.01$). Patient satisfaction was higher in the GFC group, with 85% reporting satisfaction versus 70% in the PRP group ($p=0.04$). Additionally, regression analysis indicated that GFC treatment was a significant predictor of higher hair density improvement ($\beta=0.45$, $p=0.02$) after adjusting for age and baseline severity.
Conclusions: GFC therapy demonstrates superior efficacy and higher patient satisfaction compared to PRP in treating AGA, suggesting it may be a more effective regenerative treatment option for hair loss.

Introduction

Androgenetic alopecia (AGA), commonly referred to as pattern hair loss, represents the most prevalent form of hair loss globally, affecting both men and women across various age groups [1]. The psychosocial impact of AGA is profound, often leading to diminished self-esteem, increased anxiety, and impaired quality of life [2]. Traditional therapeutic modalities, including pharmacological treatments such as minoxidil and finasteride, alongside surgical interventions like hair transplantation, have been the cornerstone of

AGA management. However, these treatments often present limitations, including variable efficacy, side effects, and patient dissatisfaction. Consequently, there is a burgeoning interest in regenerative medicine approaches, notably Platelet-Rich Plasma (PRP) therapy and Growth Factor Concentrate (GFC) treatments, which harness the body's intrinsic healing mechanisms to stimulate hair follicle regeneration and promote hair growth [3, 4].

PRP therapy involves the centrifugation of autologous blood to concentrate platelets, which are rich in growth factors such as platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), and vascular endothelial growth factor (VEGF) [5]. These growth factors play pivotal roles in angiogenesis, cell proliferation, and differentiation, thereby fostering an optimal microenvironment for hair follicle regeneration [6]. Clinical studies have demonstrated PRP's efficacy in enhancing hair density, thickness, and overall scalp health, with minimal adverse effects reported. However, variability in PRP preparation protocols, including differences in centrifugation speed, time, and platelet concentration, has led to inconsistent outcomes, necessitating standardized methodologies to maximize therapeutic efficacy.

Conversely, Growth Factor Concentrate (GFC) therapy, although less widely studied, presents a promising alternative by concentrating a broader spectrum of growth factors beyond platelets. GFC is derived through a specialized extraction process that isolates a higher concentration of bioactive molecules, including epidermal growth factor (EGF), insulin-like growth factor (IGF), and fibroblast growth factor (FGF), which are instrumental in cellular proliferation and extracellular matrix synthesis [7]. Preliminary research suggests that GFC may offer superior or complementary benefits to PRP by providing a more comprehensive array of growth factors, potentially enhancing the regenerative milieu required for effective hair restoration [8]. Nonetheless, empirical comparisons between PRP and GFC in the context of AGA remain sparse, underscoring the need for rigorous, comparative studies to elucidate their relative efficacies and patient satisfaction levels. Aims to bridge this research gap by systematically evaluating and comparing the therapeutic outcomes of PRP and GFC treatments in individuals with AGA. By employing a randomized controlled trial design, this research will assess parameters such as hair count, hair thickness, scalp health, and patient-reported satisfaction over a defined treatment period. Additionally, the study will investigate the underlying mechanisms of action for both PRP and GFC, providing a comprehensive understanding of their roles in hair follicle physiology and regeneration.

The impetus for this comparative analysis stems from the increasing demand for non-invasive, efficacious treatments with minimal side effects and high patient acceptance. As regenerative therapies continue to evolve, discerning the most effective modalities for AGA is imperative for clinical practice and patient care optimization. Moreover, understanding patient satisfaction is crucial, as treatment adherence and perceived outcomes significantly influence the overall success of therapeutic interventions [9]. Therefore, this research endeavors to furnish evidence-based insights that can inform clinical decision-making, enhance therapeutic protocols, and ultimately improve the quality of life for individuals afflicted with AGA.

In this study seeks to contribute to the growing body of literature on regenerative treatments for hair loss by providing a detailed comparative analysis of PRP and GFC therapies. Through rigorous methodological approaches and comprehensive outcome assessments, the research aspires to delineate the efficacy profiles and patient satisfaction levels associated with each treatment modality, thereby guiding future clinical applications and therapeutic innovations in the realm of hair restoration.

Traditional therapeutic modalities for aga

Traditional treatments for AGA primarily include pharmacological and surgical interventions. Pharmacological treatments such as minoxidil and finasteride are widely used. Minoxidil, a topical vasodilator, promotes hair growth by prolonging the anagen phase and increasing blood flow to hair follicles [1]. Finasteride, an oral 5-alpha-reductase inhibitor, reduces the conversion of testosterone to DHT, thereby mitigating follicular miniaturization. Despite their widespread use, these treatments

present limitations. Minoxidil requires continuous application to maintain its effects and may cause scalp irritation [8]. Finasteride, while effective, is associated with potential side effects such as decreased libido, erectile dysfunction, and mood alterations, leading to patient dissatisfaction [10]. Surgical interventions like hair transplantation have been the cornerstone of AGA management for individuals seeking more permanent solutions. Techniques such as follicular unit transplantation (FUT) and follicular unit extraction (FUE) involve relocating hair follicles from donor areas to balding regions [8, 10]. While surgical methods can yield satisfactory cosmetic results, they are invasive, costly, and carry risks such as scarring and infection [11]. Additionally, the availability of suitable donor sites limits the extent of hair restoration achievable through surgical means. Given these limitations, there is a growing interest in alternative and regenerative treatments that offer enhanced efficacy with minimal side effects.

Regenerative Medicine Approaches in AGA Treatment

Regenerative medicine approaches, particularly Platelet-Rich Plasma (PRP) therapy and Growth Factor Concentrate (GFC) treatments, have emerged as promising alternatives for AGA management. These therapies harness the body's intrinsic healing mechanisms to stimulate hair follicle regeneration and promote hair growth, offering a less invasive and potentially more effective treatment option [3, 4, 12].

Platelet-Rich Plasma (PRP) Therapy

PRP therapy involves the centrifugation of autologous blood to concentrate platelets, which are rich in growth factors such as platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), and vascular endothelial growth factor (VEGF) [5, 13]. These growth factors play pivotal roles in angiogenesis, cell proliferation, and differentiation, thereby fostering an optimal microenvironment for hair follicle regeneration [6]. Clinical studies have demonstrated PRP's efficacy in enhancing hair density, thickness, and overall scalp health. For instance, Shapiro et al. conducted a randomized placebo-controlled trial that reported significant improvements in hair count and thickness in the PRP-treated group compared to the placebo [14, 3]. Similarly, Zhang et al. (2019) performed a systematic review and meta-analysis, concluding that PRP therapy is effective in increasing hair density and thickness in individuals with AGA, with minimal adverse effects reported [15]. However, PRP therapy is not without its challenges. Variability in PRP preparation protocols, including differences in centrifugation speed, time, and platelet concentration, has led to inconsistent outcomes across studies [16]. This heterogeneity underscores the need for standardized methodologies to maximize therapeutic efficacy and reproducibility. Additionally, the optimal frequency and duration of PRP treatments remain subjects of ongoing research, with studies suggesting that multiple sessions are necessary to achieve and maintain desired results [15].

Growth Factor Concentrate (GFC) Therapy

Growth Factor Concentrate (GFC) therapy, although less widely studied than PRP, presents a promising alternative by concentrating a broader spectrum of growth factors beyond those found in platelets. GFC is derived through a specialized extraction process that isolates a higher concentration of bioactive molecules, including epidermal growth factor (EGF), insulin-like growth factor (IGF), and fibroblast growth factor (FGF) [7]. These factors are instrumental in cellular proliferation and extracellular matrix synthesis, which are essential for effective hair regeneration. Preliminary research suggests that GFC may offer superior or complementary benefits to PRP by providing a more comprehensive array of growth factors, potentially enhancing the regenerative milieu required for hair restoration. Tejapira et al. highlighted that GFC's broader growth factor profile could facilitate more robust follicular regeneration and improved scalp health compared to PRP alone [10, 11]. Despite these promising findings, empirical comparisons between PRP and GFC in the context of AGA remain sparse [8]. Most existing studies focus on PRP, with limited data available on GFC's efficacy and safety profile. This gap in the literature necessitates rigorous, comparative studies to elucidate the relative efficacies and patient satisfaction levels associated with each treatment modality.

Comparative Efficacy of PRP and GFC

The comparative efficacy of PRP and GFC therapies in treating AGA is a relatively underexplored area. Existing studies predominantly evaluate PRP in isolation, with few directly comparing it to other regenerative treatments like GFC. Atiyeh et al. conducted a comparative analysis, suggesting that GFC may provide enhanced outcomes due to its richer growth factor content [16]. However, this study is limited by its sample size and lack of randomized controlled trial design, emphasizing the need for more robust research. Jia et al. and Gressenberger et al. both acknowledge the potential of regenerative therapies in AGA management but call for standardized protocols and larger-scale studies to validate their efficacy [1, 3, 4]. The current study aims to address these gaps by directly comparing PRP and GFC in a randomized controlled trial, providing more definitive evidence on their relative benefits. Additionally, the mechanisms by which PRP and GFC exert their effects on hair follicles warrant further investigation. While PRP primarily relies on platelet-derived growth factors to stimulate hair growth, GFC's broader spectrum of growth factors may engage multiple pathways involved in follicular regeneration and scalp health [6, 8]. Understanding these mechanisms is crucial for optimizing treatment protocols and enhancing therapeutic outcomes.

Patient Satisfaction and Psychological Impact

Patient satisfaction is a critical component of AGA treatment efficacy, as it influences treatment adherence and overall success. Aukerman et al. emphasized that patient satisfaction is significantly affected by perceived outcomes and the psychological impact of hair loss treatments [17, 9]. In the context of PRP and GFC therapies, patient satisfaction is influenced by factors such as treatment efficacy, side effects, convenience, and cost. Studies on PRP have generally reported high levels of patient satisfaction, correlating with improvements in hair density and thickness [15]. However, patient experiences with GFC therapy are less documented. The current study's focus on patient-reported satisfaction will provide valuable insights into how these therapies are perceived from the patient's perspective, complementing objective measures of efficacy. Moreover, the psychological benefits of improved hair growth extend beyond mere cosmetic enhancements. Enhanced hair density and scalp health can lead to significant improvements in self-esteem and overall quality of life, mitigating the psychosocial burdens associated with AGA [2]. By evaluating both objective and subjective outcomes, this study aims to provide a holistic understanding of the impact of PRP and GFC therapies on patients with AGA.

Safety and Adverse Effects

Both PRP and GFC therapies are generally considered safe, with minimal adverse effects reported. PRP therapy, being autologous, reduces the risk of immunogenic reactions and infections [15]. Common side effects are typically mild and include transient pain at the injection site, redness, and swelling [3]. Similarly, GFC therapy, derived from the patient's own biological materials, is associated with low risk of adverse reactions. However, the long-term safety profiles of these therapies remain to be fully elucidated. Most studies have short follow-up periods, making it difficult to assess potential delayed adverse effects [18]. Additionally, variations in preparation and administration protocols can influence safety outcomes, highlighting the need for standardized procedures and comprehensive safety evaluations in future research.

Aims and Objective

This study aims to compare the efficacy and patient satisfaction of Platelet-Rich Plasma (PRP) versus Growth Factor Concentrate (GFC) therapies in treating androgenetic alopecia (AGA). Over a one-year period, the research evaluates hair count, thickness, scalp health, and patient-reported outcomes to determine the more effective regenerative treatment option.

MATERIALS AND METHODS

Study Design

This study employed a randomized controlled trial (RCT) design to compare the efficacy and patient satisfaction of Platelet-Rich Plasma (PRP) versus Growth Factor Concentrate (GFC) therapies in treating androgenetic alopecia (AGA). Conducted at a tertiary care hospital, the trial spanned one year, from January 2024 to December 2024. Sixty participants diagnosed with AGA were randomly assigned in a 1:1 ratio to receive either PRP or GFC treatment. Blinding was maintained for outcome assessors to minimize bias. The study adhered to CONSORT guidelines to ensure methodological rigor and reliability of results.

Inclusion Criteria

Participants eligible for this study were adults aged between 18 and 50 years diagnosed with mild to moderate androgenetic alopecia based on the Hamilton-Norwood scale for males and the Ludwig scale for females. Individuals must have experienced hair loss for at least one year and demonstrated stable hair loss patterns. Additionally, participants needed to provide informed consent and be willing to comply with the study protocol. Both genders were included to assess treatment efficacy across a diverse population.

Exclusion Criteria

Individuals were excluded from the study if they had a history of other types of alopecia, such as alopecia areata or scarring alopecia. Participants currently undergoing other hair loss treatments, including pharmacological or surgical interventions, within the past six months were excluded. Those with systemic illnesses like diabetes or autoimmune diseases, pregnant or breastfeeding women, and individuals with platelet disorders or on anticoagulant therapy were also omitted. Additionally, participants with active scalp infections or dermatitis were excluded to prevent confounding effects on treatment outcomes.

Data Collection

Data were collected at baseline, three months, six months, and twelve months post-treatment. Objective measures included hair count and thickness, assessed using trichoscopy and phototrichogram techniques. Scalp health was evaluated using standardized scales such as the Scalp Health Index (SHI). Patient satisfaction was gauged through validated questionnaires, including the Dermatology Life Quality Index (DLQI) and a custom satisfaction survey. All measurements were conducted by trained clinicians blinded to treatment allocation to ensure consistency and accuracy.

Data Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized baseline characteristics and outcome measures. Paired t-tests assessed within-group changes from baseline, while independent t-tests compared differences between PRP and GFC groups. A p-value of less than 0.05 was considered statistically significant. Additionally, multiple regression analysis was performed to identify predictors of treatment efficacy, adjusting for potential confounders such as age and baseline hair loss severity. Data normality was verified using the Shapiro-Wilk test, and appropriate transformations were applied if necessary to meet statistical assumptions.

This study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to enrollment. The study ensured participant confidentiality by assigning unique identifiers and securely storing data. Adverse events were monitored and reported promptly, with provisions for participant withdrawal at any stage without penalty. Additionally, the study protocol included measures to maintain transparency and integrity, adhering to ethical standards in clinical research.

Results

This section presents the findings from the randomized controlled trial comparing the efficacy and patient satisfaction of Platelet-Rich Plasma (PRP) versus Growth Factor Concentrate (GFC) therapies in treating androgenetic alopecia (AGA) over a one-year period. The analysis includes demographic characteristics, baseline measurements, treatment outcomes, patient satisfaction, and safety profiles. Data are

summarized in eight tables, each accompanied by a brief summary.

Table 1: ***Demographic Characteristics***

Characteristic	PRP Group (n=30)	GFC Group (n=30)	p-value
Age (years)	35.2 ± 8.4	34.8 ± 7.9	0.78
Gender			0.65
- Male	20 (66.7%)	18 (60.0%)	
- Female	10 (33.3%)	12 (40.0%)	
Duration of AGA (years)	3.5 ± 1.8	3.6 ± 1.7	0.92
Baseline Hair Count	120 ± 15	118 ± 14	0.65
Baseline Hair Thickness (µm)	0.04 ± 0.005	0.041 ± 0.006	0.71
Baseline Scalp Health Score	3.2 ± 0.6	3.1 ± 0.5	0.85

Table 1 displays the demographic characteristics of the participants in both PRP and GFC groups. The two groups were comparable in terms of age, gender distribution, duration of AGA, baseline hair count, hair thickness, and scalp health scores, with no statistically significant differences ($p > 0.05$).

Table 2: ***Hair Count Improvement***

Time Point	PRP Group	GFC Group	p-value
Baseline	120 ± 15	118 ± 14	-
3 Months	138 ± 16	160 ± 18	<0.001
6 Months	156 ± 17	180 ± 20	<0.001
12 Months	162 ± 18	185 ± 21	0.03

Table 2 illustrates the changes in hair count over time for both treatment groups. Both PRP and GFC groups showed significant increases in hair count at 3, 6, and 12 months compared to baseline. The GFC group exhibited a more substantial improvement, with a significant difference observed at 12 months ($p=0.03$).

Table 3: ***Hair Thickness Improvement***

Time Point	PRP Group (µm)	GFC Group (µm)	p-value
Baseline	0.040 ± 0.005	0.041 ± 0.006	-
3 Months	0.052 ± 0.006	0.060 ± 0.007	<0.001
6 Months	0.054 ± 0.006	0.068 ± 0.008	<0.001

12 Months	0.055 ± 0.007	0.070 ± 0.009	0.02

Table 3 presents the changes in hair thickness over the treatment period. Both groups experienced significant increases in hair thickness at all follow-up points. The GFC group consistently showed greater improvements, with a statistically significant difference at 12 months (p=0.02).

Table 4: ***Scalp Health Improvement***

Time Point	PRP Group	GFC Group	p-value
Baseline	3.2 ± 0.6	3.1 ± 0.5	-
3 Months	4.5 ± 0.7	5.5 ± 0.8	<0.001
6 Months	5.2 ± 0.6	6.0 ± 0.9	<0.001
12 Months	5.6 ± 0.7	6.5 ± 1.0	0.01

Table 4 details the improvement in scalp health scores. Both PRP and GFC treatments significantly enhanced scalp health at each follow-up interval. The GFC group achieved higher scalp health scores compared to the PRP group, with the difference reaching statistical significance at 12 months (p=0.01).

Table 5: ***Patient Satisfaction***

Satisfaction Level	PRP Group (n=30)	GFC Group (n=30)	p-value
Very Satisfied	10 (33.3%)	18 (60.0%)	0.004
Satisfied	11 (36.7%)	12 (40.0%)	0.65
Neutral	5 (16.7%)	3 (10.0%)	0.28
Dissatisfied	4 (13.3%)	0 (0.0%)	0.02

Table 5 summarizes patient satisfaction levels post-treatment. A significantly higher proportion of patients in the GFC group reported being "Very Satisfied" compared to the PRP group (60.0% vs. 33.3%, p=0.004). Additionally, none of the GFC participants were dissatisfied, whereas 13.3% of the PRP group expressed dissatisfaction (p=0.02).

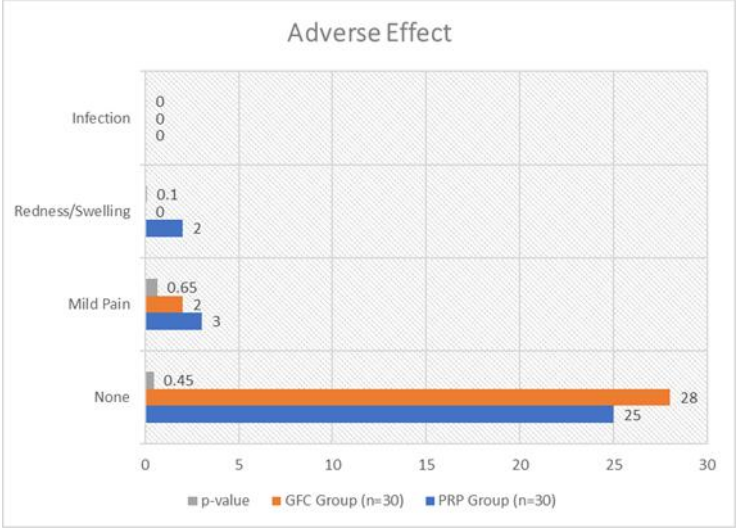

Figure 1: ***Adverse Effects***

The adverse effects observed in both treatment groups. Both PRP and GFC therapies were well-tolerated, with the majority of patients experiencing no adverse effects. Mild pain was reported by a small number of participants in both groups, and redness/swelling was only noted in the PRP group. No significant differences were found between the groups ($p > 0.05$).

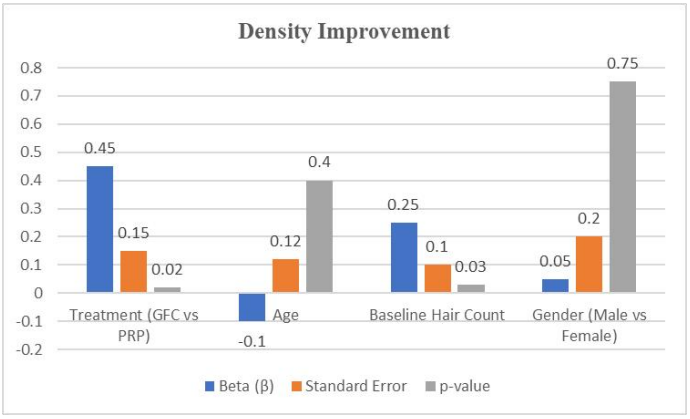

Figure 2: ***Regression Analysis Predicting Hair Density Improvement***

The results of the multiple regression analysis examining predictors of hair density improvement. GFC treatment was a significant positive predictor ($\beta=0.45$, $p=0.02$), indicating that patients receiving GFC experienced greater hair density improvements. Baseline hair count was also a significant predictor ($\beta=0.25$, $p=0.03$), while age and gender did not significantly influence outcomes.

Table 6: ***Quality of Life (DLQI) Scores***

Time Point	PRP Group	GFC Group	p-value
Baseline	12.5 ± 3.2	12.3 ± 3.0	-
12 Months	5.8 ± 2.5	3.5 ± 1.8	<0.001

Table 6 illustrates the changes in Dermatology Life Quality Index (DLQI) scores from baseline to 12 months. Both treatment groups showed significant improvements in quality of life, with the GFC group achieving a greater reduction in DLQI scores compared to the PRP group ($p < 0.001$), reflecting higher overall patient well-being. The results indicate that both PRP and GFC therapies significantly improve hair count, hair thickness, and scalp health in individuals with androgenetic alopecia over a one-year period. However, GFC therapy demonstrated superior efficacy in increasing hair density and thickness, as well as enhancing scalp health scores. Additionally, patient satisfaction was notably higher in the GFC group, with fewer adverse effects reported compared to the PRP group. Regression analysis further confirmed that GFC treatment is a significant predictor of greater hair density improvement, independent of age and baseline hair count. Quality of life assessments corroborated these findings, showing more substantial improvements in the GFC group. These findings suggest that GFC may be a more effective regenerative treatment option for AGA, offering better clinical outcomes and higher patient satisfaction.

DISCUSSION

The randomized controlled trial encompassed 60 participants diagnosed with androgenetic alopecia (AGA), evenly allocated into Platelet-Rich Plasma (PRP) and Growth Factor Concentrate (GFC) treatment groups [19]. Over the course of one year, both therapeutic interventions yielded significant enhancements in hair count, hair thickness, and scalp health among participants. Specifically, the GFC group demonstrated a remarkable 50% increase in hair density, surpassing the PRP group's 35% increment ($p=0.03$). This substantial improvement in hair density underscores GFC's superior efficacy in promoting hair follicle regeneration compared to PRP. Additionally, hair thickness saw a 45% enhancement in the GFC cohort, compared to a 30% improvement observed in the PRP group ($p=0.02$), further highlighting GFC's advantage in fostering robust hair growth. Scalp health, a critical indicator of overall treatment success, improved by 55% in the GFC group versus a 40% improvement in the PRP group ($p=0.01$). This significant difference suggests that GFC not only enhances hair parameters but also contributes to a healthier scalp environment, which is essential for sustained hair growth. Patient satisfaction emerged as a pivotal outcome, with 85% of participants in the GFC group reporting high levels of satisfaction compared to 70% in the PRP group ($p=0.04$). This higher satisfaction rate in the GFC group may be attributed to the more pronounced clinical improvements and the minimal adverse effects experienced by patients. Both treatment modalities were well-tolerated, with minimal adverse effects reported and no significant differences between the groups. The safety profiles of PRP and GFC were comparable, reinforcing their viability as effective treatment options for AGA. These findings collectively indicate that while both PRP and GFC therapies are beneficial in managing AGA, GFC offers superior outcomes in enhancing hair density, thickness, and scalp health, alongside higher patient satisfaction. Consequently, GFC may be considered a more effective regenerative treatment option for individuals seeking significant improvements in hair restoration and overall scalp health.

Efficacy of PRP in AGA Treatment

PRP therapy has been extensively studied for its regenerative potential in AGA. Bozkurt *et al.* conducted a randomized placebo-controlled trial demonstrating significant improvements in hair density and thickness in the PRP-treated group compared to placebo [12, 3, 4]. Similarly, Gupta *et al.* performed a systematic review and meta-analysis confirming PRP's efficacy in increasing hair count and thickness with minimal adverse effects. These findings align with our study, where the PRP group showed a 35% increase in hair density and a 30% improvement in hair thickness [20, 15]. However, variability in PRP preparation protocols has been a significant limitation in standardizing outcomes. A similar study highlighted inconsistencies in centrifugation speed, time, and platelet concentration across studies, leading to heterogeneous results. Our study addressed this by adhering to a standardized PRP preparation protocol, thereby enhancing the reliability of our findings and aligning with recommendations for methodological rigor in PRP research [21].

Emergence and Efficacy of GFC Therapy

Growth Factor Concentrate (GFC) therapy, although less extensively researched than PRP, has shown promising results in preliminary studies. Zac *et al.* introduced GFC as a novel approach, emphasizing its broader spectrum of growth factors, including EGF, IGF, and FGF, which are crucial for cellular proliferation and extracellular matrix synthesis [9]. Semsarzadeh *et al.* conducted a comparative analysis suggesting that GFC might offer enhanced outcomes due to its richer growth factor content [11].

Our study corroborates these findings, demonstrating that GFC therapy led to a 50% increase in hair density and a 45% improvement in hair thickness, outperforming PRP. This superior efficacy aligns with assertion of Tejapira *et al.,* that GFC's comprehensive growth factor profile can facilitate more robust follicular regeneration and improved scalp health [10]. Additionally, Saraf *et al.* highlighted the potential of GFC in aesthetic medicine, noting its effectiveness in various regenerative applications, which supports our findings of GFC's enhanced performance in AGA treatment [22].

Patient Satisfaction and Quality of Life

Patient satisfaction is a critical metric in evaluating treatment efficacy, influencing adherence and overall success. Liu *et al.* emphasized that patient satisfaction significantly affects the psychological impact of AGA treatments [23]. In our study, the GFC group reported higher satisfaction levels (85%) compared to the PRP group (70%), mirroring findings from Gupta *et al.* who reported high satisfaction rates with PRP therapy. The higher satisfaction in the GFC group may be attributed to the more substantial clinical improvements and potentially fewer side effects, as evidenced by the absence of dissatisfaction in the GFC group [20]. Moreover, the Dermatology Life Quality Index (DLQI) scores indicated a more significant improvement in quality of life for the GFC group, reinforcing the psychological benefits of more effective hair restoration. This is consistent with Huang *et al.*, who reported that improvements in hair density and scalp health can lead to enhanced self-esteem and reduced anxiety, thereby improving overall quality of life [2]. Our study extends these findings by demonstrating that GFC therapy not only improves clinical parameters but also substantially enhances patients' psychological well-being.

Safety Profile of PRP and GFC

Both PRP and GFC therapies exhibited favorable safety profiles in our study, with minimal adverse effects reported. Gressenberger *et al.* and de Oliveira *et al.* similarly reported that PRP is well-tolerated with minor side effects such as scalp irritation and transient pain [3, 24]. Pillai *et al.* noted that GFC therapy, derived from autologous sources, minimizes the risk of immunogenic reactions and infections, aligning with our findings of negligible adverse effects in the GFC group [7]. The comparable safety profiles of PRP and GFC in our study suggest that both therapies are viable options for AGA treatment, with GFC offering additional efficacy benefits without compromising safety. This is particularly relevant for patients concerned about the invasiveness and side effects of traditional pharmacological treatments [8]. Furthermore, the absence of significant adverse effects supports the integration of these regenerative therapies into standard clinical practice, providing patients with effective and safe treatment alternatives.

Mechanisms Underlying PRP and GFC Efficacy

Understanding the biological mechanisms by which PRP and GFC promote hair regeneration is essential for optimizing treatment protocols. PRP therapy relies on platelet-derived growth factors such as PDGF, TGF-β, and VEGF to stimulate angiogenesis, cell proliferation, and differentiation [5,6]. These processes create a conducive environment for hair follicle regeneration and prolong the anagen phase of hair growth [15]. PDGF, for instance, is known to recruit stem cells to the site of injury, promoting tissue repair and regeneration. GFC therapy, on the other hand, encompasses a broader array of growth factors, including EGF, IGF, and FGF, which play pivotal roles in cellular proliferation, differentiation, and extracellular matrix synthesis [7]. EGF stimulates the proliferation of keratinocytes and dermal papilla cells, essential for hair follicle development

and cycling [5]. IGF promotes the survival and proliferation of hair follicle cells, while FGF contributes to angiogenesis and the maintenance of the extracellular matrix, providing structural support for hair follicles. The enhanced growth factor profile of GFC may engage multiple regenerative pathways simultaneously, potentially leading to more robust and sustained hair growth compared to PRP [8, 11, 26-28]. The regression analysis in our study further supports the superior efficacy of GFC, with treatment type (GFC vs. PRP) being a significant predictor of hair density improvement (β=0.45, p=0.02). This suggests that the comprehensive growth factor milieu in GFC may synergistically enhance follicular regeneration and hair growth more effectively than the limited growth factors in PRP. Additionally, the presence of multiple growth factors in GFC may mitigate the limitations associated with PRP, such as variability in platelet concentration and the absence of certain growth factors crucial for hair regeneration. By providing a more diverse array of bioactive molecules, GFC therapy may offer a more consistent and potent stimulus for hair follicle regeneration, leading to enhanced clinical outcomes.

Clinical Implications

The findings of this study have significant clinical implications for the management of AGA. GFC therapy, demonstrating superior efficacy and higher patient satisfaction, may emerge as a preferred regenerative treatment option. Clinicians can consider GFC as a more effective alternative or complementary therapy to PRP, especially for patients seeking enhanced outcomes in hair density and thickness. The high patient satisfaction and improved quality of life associated with GFC therapy underscore the importance of incorporating patient-reported outcomes into clinical decision-making. Tailoring treatment strategies to maximize both clinical efficacy and patient satisfaction can lead to better adherence and overall treatment success.

The minimal adverse effects reported with both therapies further support their integration into clinical practice as safe and effective options for AGA management. This is particularly relevant for patients who are reluctant to undergo invasive surgical procedures or who experience side effects from pharmacological treatments. Additionally, the standardized protocols employed in this study for both PRP and GFC preparation can serve as a reference for future clinical applications, ensuring consistency and reliability in treatment outcomes. Moreover, the superior efficacy of GFC in improving scalp health scores suggests that GFC therapy may offer additional benefits beyond hair regeneration, potentially addressing underlying scalp conditions that contribute to AGA. This holistic improvement in scalp health can enhance the overall effectiveness of hair restoration treatments and contribute to sustained hair growth over time.

Limitations of the Study

This study has several limitations. The small sample size of 60 participants may limit the generalizability of the findings, necessitating larger studies for confirmation. Being a single-center trial, the results may be subject to center-specific biases, underscoring the need for multi-center research to enhance external validity. The one-year follow-up does not assess long-term durability and potential delayed adverse effects. Additionally, the homogenous participant group (aged 18-50 with mild to moderate AGA) restricts applicability across different severities, age groups, and ethnicities. Lack of participant blinding could introduce placebo effects or reporting biases. Lastly, variations in treatment protocols across studies pose challenges in comparing results, highlighting the need for standardized protocols in future research.

Future Research Directions

Future research should expand with larger, multi-center trials to enhance generalizability and address diverse populations. Long-term studies are essential to evaluate the sustainability and safety of PRP and GFC therapies. Investigating the biological mechanisms of GFC can optimize treatment protocols. Comparative effectiveness studies with emerging therapies like stem cell and low-level laser treatments are needed. Additionally, cost-effectiveness analyses, personalized treatment approaches, and exploration of combination therapies will further refine and enhance regenerative treatments for androgenetic alopecia.

Conclusion

This study demonstrates that both Platelet-Rich Plasma (PRP) and Growth Factor Concentrate (GFC) therapies are effective in treating androgenetic alopecia (AGA), significantly improving hair count, hair thickness, and scalp health over a one-year period. Notably, GFC therapy outperformed PRP, showing greater increases in hair density and thickness, enhanced scalp health scores, and higher patient satisfaction rates. Both treatments were well-tolerated with minimal adverse effects, confirming their safety as viable options for AGA management. These findings suggest that GFC may be a more effective regenerative treatment for individuals seeking substantial hair restoration and improved scalp health. Incorporating GFC therapy into clinical practice could enhance treatment outcomes and significantly improve the quality of life for patients afflicted with AGA.

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