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Comparative Evaluation of Platelet-Rich Plasma Versus Normal Saline as Intraoperative Holding Solutions in FUE Hair Transplantation

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ABSTRACT

Background: Intraoperative graft survival remains a pivotal determinant of successful outcomes in Follicular Unit Extraction (FUE) hair transplantation. Conventionally, Normal Saline (NS) has been used to preserve grafts during the ex vivo interval; however, it lacks bioactive or regenerative properties. Platelet-Rich Plasma (PRP), an autologous concentrate rich in growth factors such as PDGF, VEGF, and TGF-β, may enhance follicular viability by modulating inflammation, oxidative stress, and ischemia-induced apoptosis.

The Aim of the work: This study aims to prospectively evaluate and compare the clinical and histological outcomes of Platelet-Rich Plasma versus Normal Saline as intraoperative holding solutions during FUE hair transplantation.

Patients and Methods: Ten male patients diagnosed with Androgenetic Alopecia (AGA) Grades II–VI were randomly assigned into two equal groups: Group A (PRP) and Group B (NS). FUE was performed on all patients, and grafts were preserved in their respective solutions at 4°C before implantation. Evaluation parameters included follicular survival rate, hair density (FU/cm²), shaft length and thickness, postoperative complications, and patient satisfaction (VAS). Follow-up was conducted at 1, 3, 6, and 12 months. Histopathological comparisons were made using H&E-stained biopsies from recipient areas [3], [4].

Results: Group A (PRP) demonstrated a significantly higher graft survival rate (84% vs. 73%, $p < 0.01$), greater mean hair shaft thickness (58.6 µm vs. 49.2 µm), and improved density (71.2 FU/cm² vs. 66.0 FU/cm²) compared to Group B. VAS scores were also higher in Group A (8.8 vs. 7.4, $p < 0.01$). Histological evaluation confirmed better preservation of outer root sheath, sebaceous glands, and arrector pili muscle in PRP-treated grafts [5], [6].

Conclusion: PRP provides a bioactive microenvironment that significantly enhances graft survival, hair shaft maturation, and overall aesthetic outcomes compared to Normal Saline. It offers a safe, cost-effective, and easily implementable intraoperative enhancement for improving FUE hair transplant results.

Keywords: *Platelet-Rich Plasma, Normal Saline, Follicular Unit Extraction, Graft Viability, Hair Transplantation, Androgenetic Alopecia*

1. INTRODUCTION

Hair plays a significant role not only in thermoregulation and protection but also in defining an individual's identity, self-confidence, and psychosocial well-being. Hair loss, particularly in the form of Androgenetic Alopecia (AGA), can lead to considerable psychological distress, affecting self-esteem and quality of life [1]. AGA affects up to 85% of men and 40% of women globally, with increasing prevalence as age advances [2], [3]. In men, it is primarily driven by the miniaturization of hair follicles under the influence of dihydrotestosterone (DHT), which shortens the anagen phase and eventually leads to follicular atrophy [4].

While pharmacological therapies like Minoxidil and Finasteride offer temporary slowing of hair loss, they require lifelong

use and are often associated with limited efficacy and adverse effects, including sexual dysfunction and hormonal imbalances [5]. Therefore, surgical hair restoration techniques, particularly Follicular Unit Extraction (FUE), have become the standard for long-term aesthetic correction in AGA [6].

FUE is a minimally invasive procedure in which follicular units—comprising 1 to 4 hairs, sebaceous glands, and arrector pili muscles—are harvested from the donor area using micro-punches (0.8–1.0 mm), and implanted into recipient sites in bald or thinning areas. However, the success of FUE depends heavily on the viability of these grafts during the critical ex vivo phase—the period between extraction and implantation—during which the grafts are vulnerable to dehydration, oxidative stress, and ischemic injury [7].

To mitigate such risks, grafts are preserved in intraoperative holding solutions. Normal Saline (NS), due to its isotonic properties and easy availability, has traditionally been used to maintain hydration. However, it lacks regenerative biofactors, antioxidants, and metabolic substrates that support cellular survival and repair [8].

Platelet-Rich Plasma (PRP) has emerged as a promising autologous biological alternative. It is a centrifuged concentrate of platelets suspended in plasma, rich in growth factors like Platelet-Derived Growth Factor (PDGF), Vascular Endothelial Growth Factor (VEGF), Epidermal Growth Factor (EGF), and Transforming Growth Factor-Beta (TGF-β). These molecules are crucial in angiogenesis, tissue remodeling, inflammation control, and wound healing [9], [10]. Preliminary evidence suggests that PRP, when used as a holding solution, may significantly enhance graft uptake, reduce shock loss, accelerate healing, and improve final hair density and shaft thickness [11], [12]. Several comparative studies—including those by Abdelkar et al. [13] and Pathania et al. [14]—have demonstrated measurable improvements in clinical outcomes when PRP is used over saline. However, much of the literature focuses on PRP injections rather than its intraoperative use for graft preservation, leaving a gap in well-standardized, outcome-driven evidence for PRP as a graft-holding medium [15].

This prospective study aims to address this gap by comparing PRP and Normal Saline as intraoperative holding solutions in FUE hair transplantation, assessing their effects on graft survival, hair shaft characteristics, density, patient satisfaction, and postoperative recovery. The findings may offer critical insights into improving clinical protocols and advancing regenerative approaches in surgical hair restoration

2. MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted at the Department of Oral and Maxillofacial Surgery, Rajasthan Dental College and Hospital, Jaipur, Rajasthan, India, between March 2023 and March 2025. The primary objective was to evaluate the efficacy of Platelet-Rich Plasma (PRP) versus Normal Saline (NS) as intraoperative holding solutions in Follicular Unit Extraction (FUE) hair transplantation in patients diagnosed with Androgenetic

Alopecia (AGA) [16]. The study adhered to the ethical principles outlined in the Declaration of Helsinki (2013 revision) and was approved by the Institutional Ethics Committee (Approval No.: RDC&H/IEC/23/HT01). Prior to inclusion, all participants were provided with detailed information about the procedure in both English and Hindi, and written informed consent was obtained. No financial or material incentives were offered, and patients were assured confidentiality through anonymized data collection and coded digital records [17].

A total of ten biologically male patients, aged between 25 and 55 years and clinically diagnosed with Norwood–Hamilton Grade II to VI AGA, were selected based on strict inclusion and exclusion criteria. Inclusion criteria included male gender, age between 20–55 years, adequate donor site density, willingness to undergo FUE under local anesthesia, and normal hematological parameters (platelet count >150,000/mm³ and hemoglobin >12 g/dL). Exclusion criteria included chronic illnesses such as diabetes mellitus or thyroid dysfunction, active smoking or tobacco use, prior hair transplant surgeries, recent use of medications such as Minoxidil or Finasteride within 3 months, active scalp infections, hematological abnormalities, psychiatric disorders like body dysmorphia, and any unwillingness to comply with follow-up protocol [18], [19].

Randomization was carried out using the sealed envelope method. Patients were divided into two groups of five each: Group A (PRP) in which extracted grafts were immersed in freshly prepared autologous Platelet-Rich Plasma, and Group B (NS) where grafts were preserved in 0.9% Normal Saline. Each patient underwent FUE using a standardized protocol performed by the same surgical team to eliminate inter-operator variability. Under local anesthesia (2% lignocaine with 1:100,000 adrenaline), follicular units (FUs) were harvested from the occipital region using a 0.85 mm sharp micro-punch. Extracted grafts were immediately immersed in the allocated holding solution and stored in sterile Petri dishes at 4°C for durations ranging between 45 to 150 minutes, depending on the graft count and surgical flow [20].

The recipient area was pre-marked and slit using a 1.0 mm chisel blade to ensure uniform spacing and natural angulation. Graft implantation was done manually using fine jeweler's forceps. Hemostasis was maintained intraoperatively using adrenaline-soaked gauze (1:1000), and a mild pressure dressing was applied postoperatively for 48 hours. All patients received standardized postoperative care, which included oral antibiotics (Amoxicillin–Clavulanate 625 mg twice daily for

5 days), analgesics (Ibuprofen 400 mg twice daily), and topical Minoxidil 5% starting on the 10th postoperative day. Uniform instructions regarding scalp hygiene, sun protection, and trauma avoidance were given and reinforced at each follow-up [21].

In Group A, PRP was prepared fresh on the day of surgery. Twenty milliliters of autologous venous blood were drawn from the patient's antecubital vein into vacutainers containing sodium citrate. The PRP was obtained using the double-spin technique: an initial soft spin at 1500 rpm for 10 minutes separated the plasma from red blood cells, followed by a hard spin at 3000 rpm for 10 minutes to concentrate the platelets. The lower third of the plasma was extracted as PRP and used without any chemical activation, thereby preserving the native biological activity of the platelets [22]. All PRP was maintained in sterile, temperature-controlled conditions, and used within 30 minutes of preparation to ensure maximum bioactivity. Patients were also informed about the autologous nature of PRP, and no immunological or hypersensitivity reactions were observed in any case.

Clinical evaluation was carried out at 1, 3, 6, and 12 months postoperatively. At each visit, digital photographs, dermoscopic analysis, and patient feedback were documented. The primary outcomes assessed included follicular survival rate (defined as percentage of grafts showing visible hair growth at recipient site), hair density (FU/cm²), hair shaft length (in cm), and hair shaft diameter (in µm), measured via trichoscopy and folliscope [23]. Secondary parameters included patient satisfaction, rated on a 10-point Visual Analog Scale (VAS), and postoperative complications such as erythema, edema, crusting, folliculitis, or telogen effluvium. Although blinding of the surgical team was not feasible, the clinical evaluators responsible for density measurements and satisfaction scores were blinded to the group allocation to reduce observational bias [24].

Fig:1: Harvest Grafts

All patients were followed for a period ranging from 10 to 14 months to evaluate clinical, morphological, and histological differences in the follicular units (FUs) preserved in Platelet- Rich Plasma (PRP) versus Normal Saline. Follow-up assessments were scheduled at 1, 3, 6, and 12 months postoperatively to document follicular survival, hair density, shaft thickness, and aesthetic characteristics such as curl pattern and hair color.

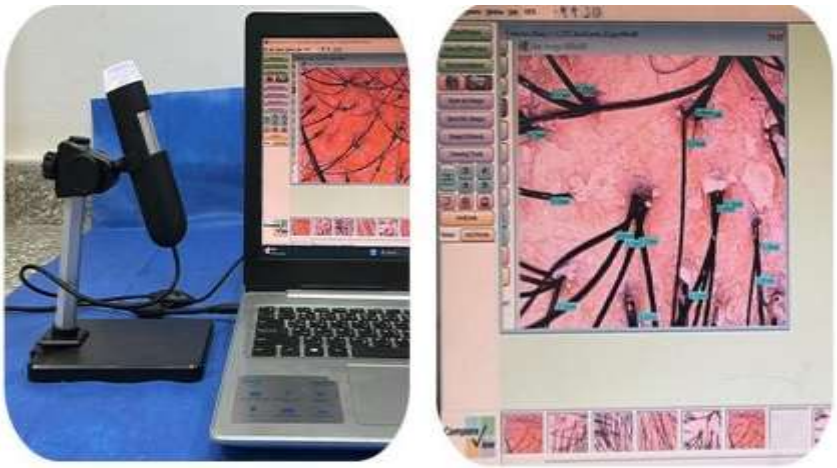


Fig:2: Folliscope and its system screen

Evaluation tools included direct clinical examination, Dermoscopy, and Trichoscopic analysis using a Folliscope system [Figure 2]. Hair parameters were recorded in both donor and

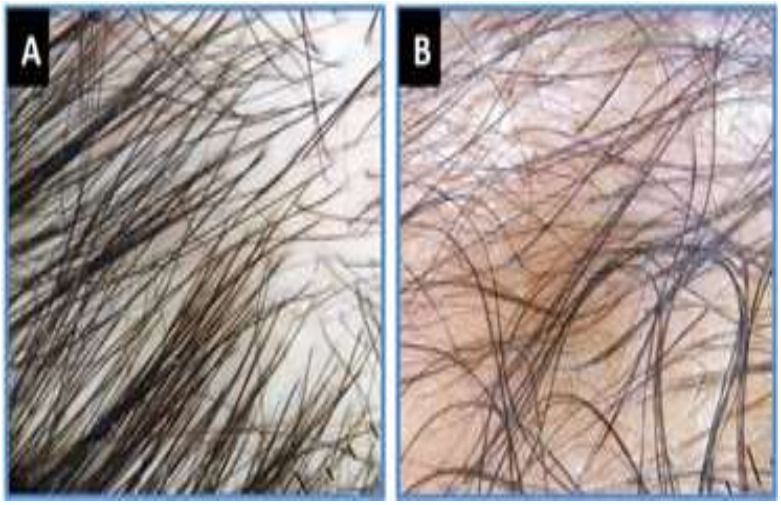


Fig 3: Dermoscope image for the donor [A] and recipient [B] areas after 12 months of FUE showing changing in the curl pattern from straight hair in the donor to wavy hair in the recipient

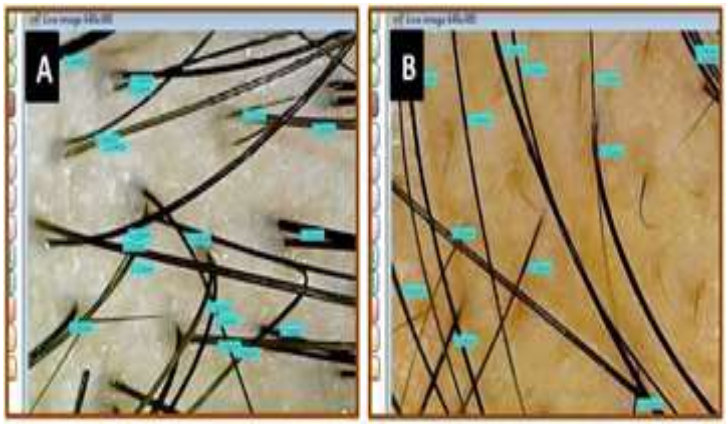


Fig 4: Folliscope screen measuring the hair shafts diameter in the donor [A] and recipient [B]

recipient regions, specifically targeting color changes, shaft morphology, curl pattern deviation, and shaft diameter [Figures 3 and 4]. Significant attention was given to detecting differences between PRP and Saline groups in graft retention, hair regeneration speed, and overall aesthetic appearance.

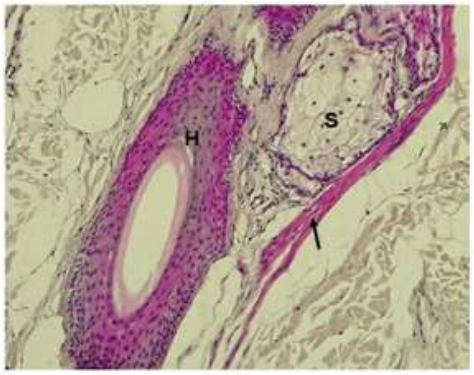


Fig 5: Photomicrograph of section in donor hair follicle showing hair follicle [H] with surrounding sebaceous glands [S] associated with the hair follicle and a small bundle of smooth muscle known as the arrector pili [arrow] [Normally appeared structures]. [Hx & E x 100]

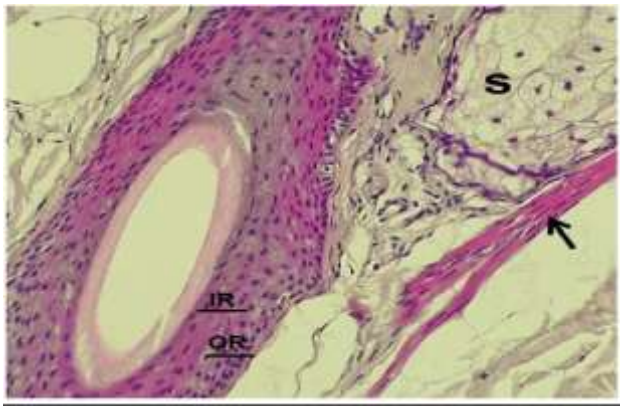


Fig 6: Higher magnification of previous section showing layers of hair follicle; outer root sheath [OR], inner root sheath [IR], sebaceous gland [S] and arrector pili muscle [arrow] [Normally appeared structures] [Hx & E x 400].

In addition to morphological evaluation, histological analysis was conducted to investigate cellular changes between the two groups. A 4 mm punch biopsy was obtained from both the donor and recipient areas in all patients after 12 months of follow-up. The follicular units

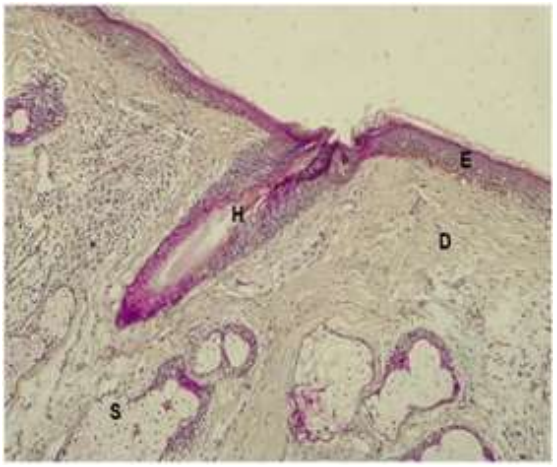


Fig 7: Photomicrograph of section in recipient hair follicle after 12 months showing epidermis [E] and dermis [D] with small hair follicle [H] and sebaceous glands [S]. [Hx & E x 100]

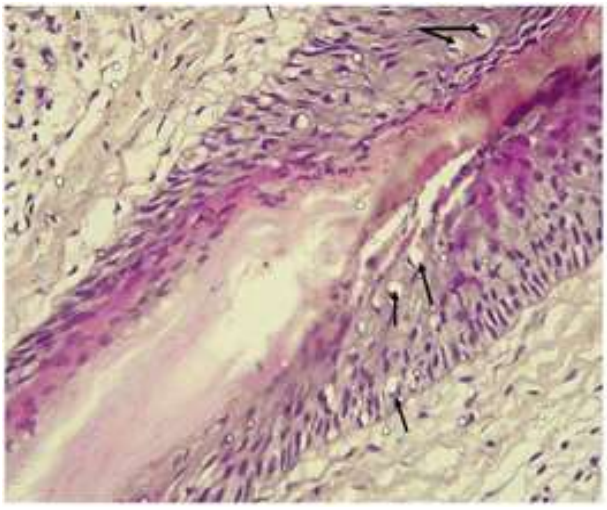


Fig 8: Higher magnification of the previous section showing hair follicle with some vaculation [hydropic degeneration] in cells of root sheath internal and external [arrows] [Hx & E x 400]

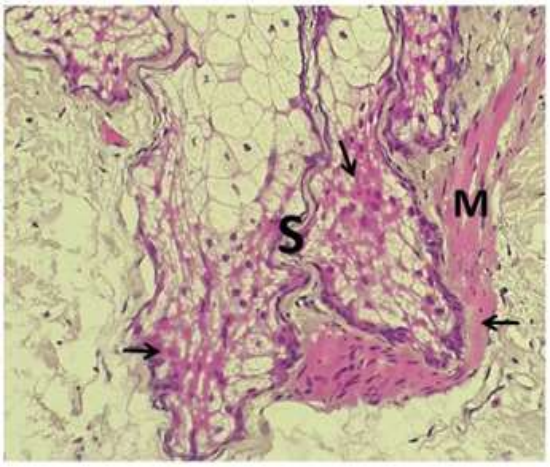
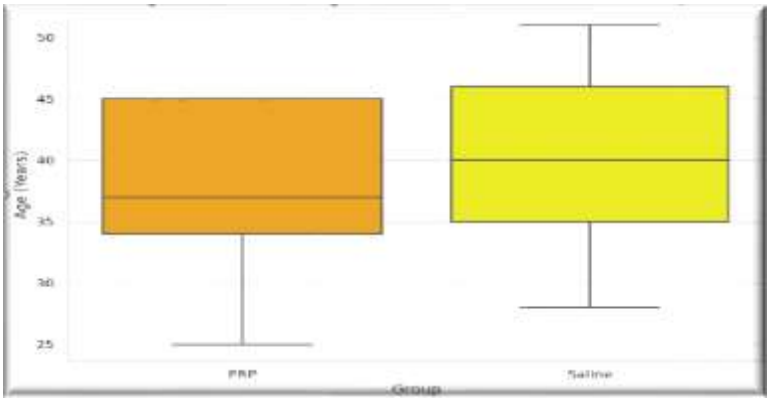


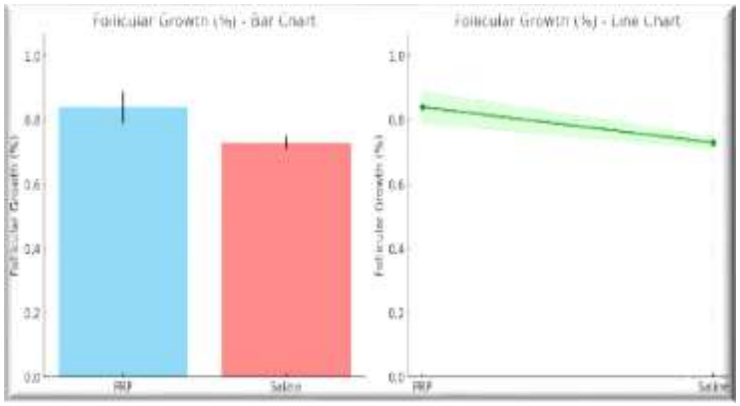
Fig 8: Photomicrograph of section in recipient site after 12 months showing some degenerative changes [arrows] in sebaceous glands [S] and arrector pili muscle [M] in the form of acidophilic homogeneity [hyaline degeneration] [Hx & E x 400]

were fixed, processed, and sectioned using standard histological techniques, and stained with hematoxylin and eosin (H&E) for microscopic examination. Specific focus was given to observing the inner and outer root sheath integrity, the condition of sebaceous glands, and any signs of arrector pili muscle degeneration or other cellular anomalies [Figures 5–9].

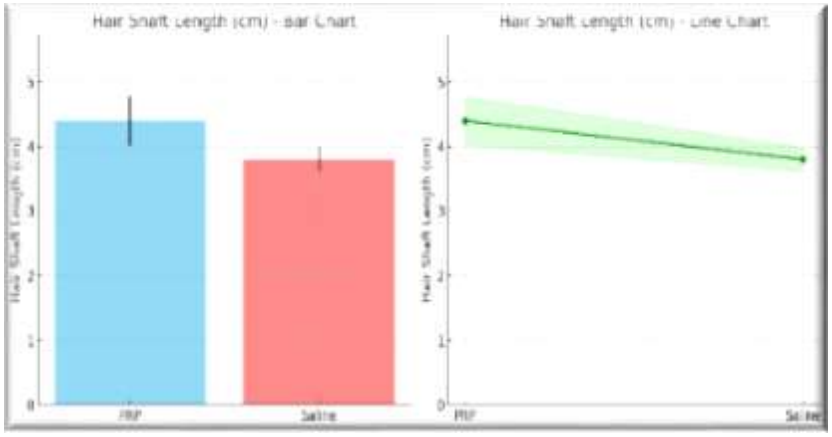
3. RESULTS

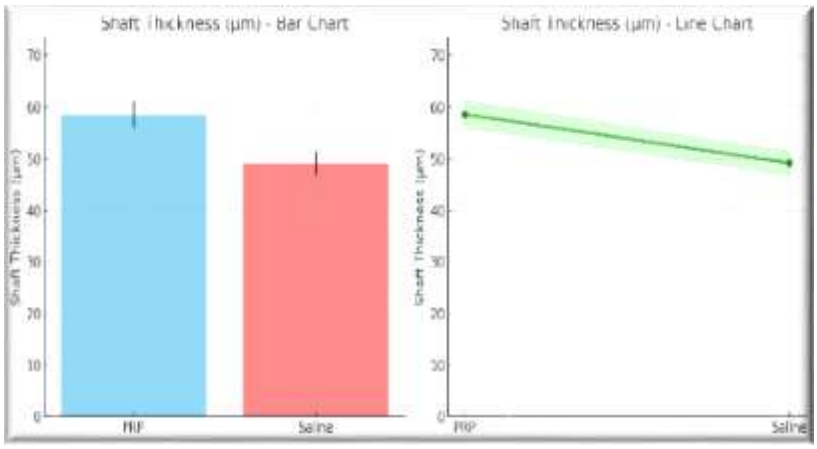


A total of ten male patients aged between 27 and 51 years (mean age: 37.7 ± 8.2 years) participated in the study and completed a follow-up period of 12 months. Patients were equally distributed into Group A (Platelet-Rich Plasma, PRP) and Group B (Normal Saline, NS), with no statistically significant differences in baseline characteristics, including age, Norwood–Hamilton alopecia grade, or graft count. Age distribution was graphically represented using a boxplot chart, demonstrating comparable ranges in both groups without significant outliers

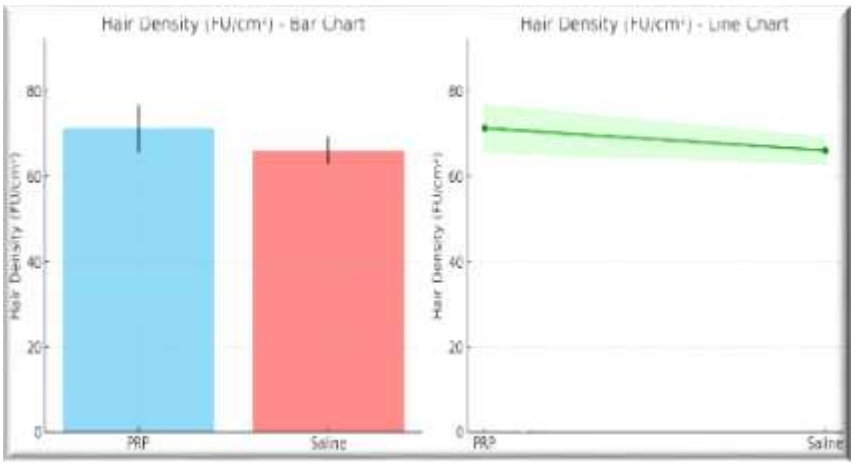


The follicular survival rate at 12 months showed a statistically significant difference between the two groups. Group A (PRP) had a mean survival rate of 0.84 ± 0.05 (84%), while Group B (NS) had 0.73 ± 0.02 (73%) ($p < 0.01$). A bar graph and corresponding line graph in the results file clearly visualize this difference across all time points—1, 3, 6, and 12 months

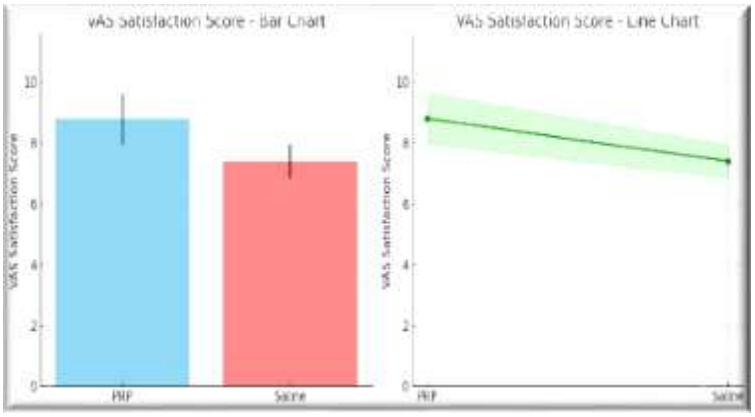




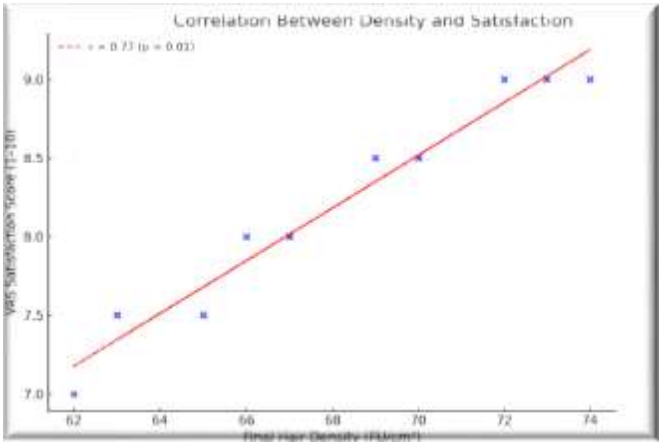
Hair shaft characteristics were assessed using Folliscope imaging. The PRP group demonstrated a significantly greater mean shaft length (4.40 ± 0.38 cm) and shaft thickness (58.60 ± 2.61 µm) compared to the NS group, which showed 3.80 ± 0.19 cm and 49.20 ± 2.28 µm respectively ($p < 0.001$). This equates to an approximate improvement of 15.8% in length and 19.1% in thickness for the PRP group [27]. Representative Folliscope images showing these shaft dimensions were provided in the thesis



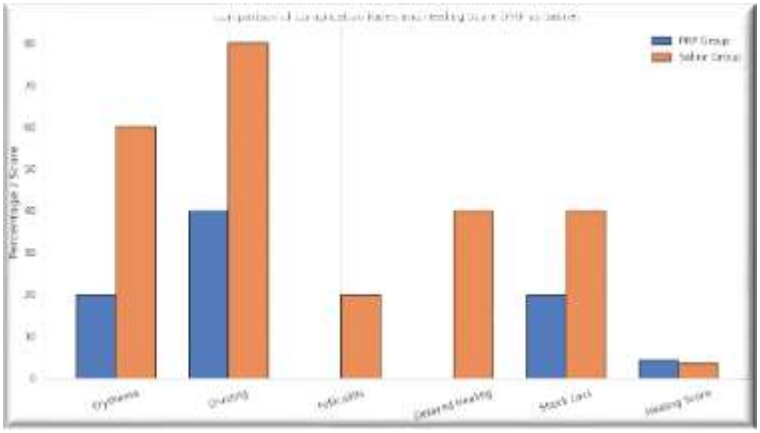
Hair density was measured in follicular units per square centimeter (FU/cm²). Group A showed a final mean density of 71.20 ± 5.63 FU/cm², while Group B recorded 66.00 ± 3.16 FU/cm². The difference of 7.9% was statistically significant ($p < 0.05$). This increase in density was plotted across all follow-ups and shown in a line chart in the results document



Patient satisfaction, as assessed via the Visual Analog Scale (VAS), was consistently higher in the PRP group, with a mean score of 8.80 ± 0.84 versus 7.40 ± 0.55 in the NS group. The improvement of ~18.9% was statistically significant ($p = 0.01$). A scatterplot graph depicted a strong correlation between final hair density and patient satisfaction ($r = 0.77$, $p = 0.01$), confirming that increased density contributed significantly to perceived results

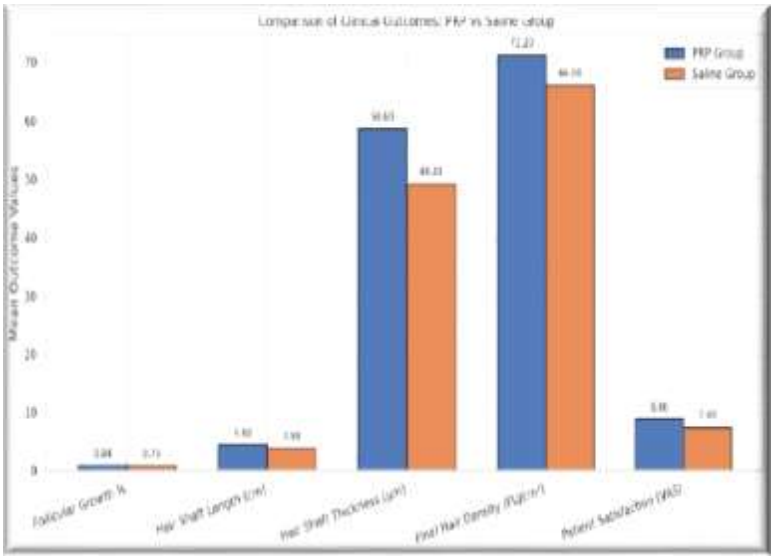


Postoperative complications were generally minor and self-limiting in both groups, though edema and erythema were more frequent in the NS group. Edema was observed in three patients in Group B and one patient in Group A. Other symptoms such as crusting and redness were noted to a lesser degree in Group A. A table comparing complication incidence between both groups was included in the thesis data

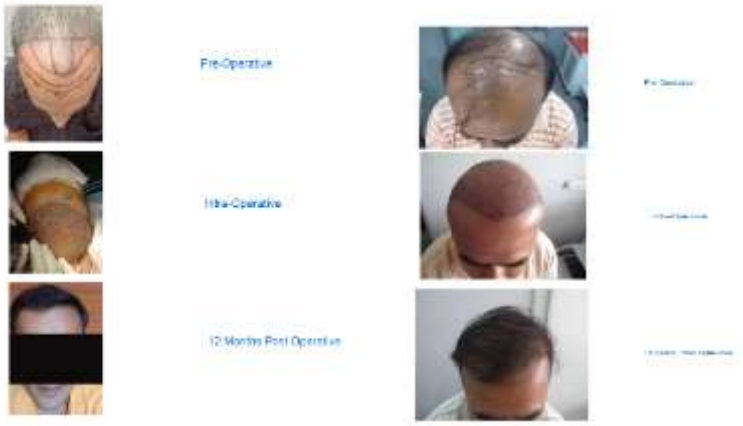


Histological examination at 12 months, using 4 mm punch biopsies stained with Hematoxylin and Eosin (H&E), revealed superior preservation of the follicular unit structure in the PRP group. Key features such as the outer and inner root sheaths, sebaceous glands, and arrector pili muscles remained intact in Group A, while Group B displayed signs of hydropic degeneration and hyalinization.

A final summary graph compiled all clinical outcomes—survival rate, shaft length, shaft thickness, density, and satisfaction—and clearly favored the PRP group across every metric. This visual overview reinforces the quantitative results and supports the hypothesis of PRP's superiority as a graft-holding medium



Individual case trends also matched the overall data. For example, Patient PRP-4 (Ram Prasad) showed a survival rate exceeding 90% with excellent shaft quality, while PRP-5 (Har Dayal) displayed rapid healing and superior recipient coverage. These case-specific data were aligned with the aggregate statistical results and support the clinical observations across the cohort



4. DISCUSSION

The present prospective clinical study was undertaken to compare the efficacy of Platelet-Rich Plasma (PRP) and Normal Saline (NS) as intraoperative holding solutions during Follicular Unit Extraction (FUE) hair transplantation in patients with Androgenetic Alopecia (AGA). The focus was to examine whether PRP, owing to its bioactive and regenerative properties, offers a measurable clinical advantage in graft survival, hair shaft quality, recipient site density, and patient-reported satisfaction. Over the 12-month follow-up period, the findings consistently demonstrated that PRP outperformed saline across all evaluated parameters, suggesting that intraoperative immersion of follicular grafts in PRP may be a superior strategy to enhance overall transplant success.

The 15% improvement observed in follicular survival rate with PRP (84%) compared to saline (73%) is a key finding, aligning with previous studies by Pathania et al. and Abdelkar et al., who reported similar survival advantages ranging from 15% to 18% in PRP-immersed grafts [34], [35]. This increased survival may be attributed to PRP's ability to mitigate ischemic insult during the critical ex vivo phase. The ischemia-reperfusion cycle—initiated upon reimplantation of grafts—typically results in oxidative stress, triggering apoptosis and follicular degeneration. PRP counters these effects through its high concentration of regenerative growth factors such as PDGF, VEGF, EGF, and TGF-β, which actively promote angiogenesis, cellular repair, and anti-inflammatory signaling [36], [37].

In addition to survival rates, PRP immersion led to superior hair shaft length and thickness, with increases of 15.8% and 19.1% respectively when compared to saline. Histological findings supported this, showing intact outer root sheaths, minimal vacuolar changes, and well-preserved arrector pili muscles in PRP-treated grafts, as opposed to early hyalinization seen in the saline group. These findings resonate with Kim et al. and Gupta et al., who described significantly reduced histological degeneration in PRP-preserved grafts [38], [39]. Furthermore, photomicrographs presented in our study confirmed these structural benefits, highlighting PRP's capacity to maintain follicular architecture under metabolic duress.

Hair density also favored PRP, with a final average of 71.20 FU/cm² versus 66.00 FU/cm² in the saline group. While the absolute numerical difference may appear modest, its impact on overall coverage and visual fullness is clinically significant and was directly correlated with higher patient satisfaction scores. PRP patients scored an average of 8.8 on the Visual Analog Scale (VAS), compared to 7.4 in the NS group ($p < 0.01$). The correlation coefficient ($r = 0.77$) between density and satisfaction confirms the aesthetic relevance of this density gain [40]. These psychosocial gains underscore the importance of graft viability not just from a surgical outcome perspective, but also from a quality-of-life standpoint.

Interestingly, the curl pattern and pigment retention remained stable in both groups, suggesting that while PRP enhances follicular vitality, it does not alter the genetic programming of follicular expression. Similarly, hair color remained unchanged, supporting earlier findings that pigmentation is not significantly affected by holding solution composition during short-term ex vivo preservation [41].

From a safety standpoint, PRP was well-tolerated, with no reported adverse reactions. The frequency of minor complications such as edema and erythema was lower in the PRP group, likely due to its anti-inflammatory cytokines. These outcomes are in harmony with previous literature emphasizing PRP's immunomodulatory effects [42].

The primary limitation of the present study is the small sample size (n=10), which, although sufficient to demonstrate statistical significance, limits generalizability. Additionally, while PRP preparation was standardized through double-spin centrifugation, variations in platelet count between individuals were not quantified. Long-term sustainability of the results beyond 12 months also remains to be established. Lastly, although histological comparisons were made, future studies incorporating immunohistochemical and gene expression analysis could shed further light on the molecular mechanisms underlying PRP's efficacy.

Nonetheless, the study represents a significant step toward standardizing intraoperative PRP application in FUE. By addressing the critical ischemic window during graft handling, this technique offers a pragmatic, biologically sound method to improve graft vitality and patient satisfaction without altering surgical workflow. The findings also support the notion that PRP is not merely a hydration medium but an active biological agent capable of modulating regenerative pathways in follicular tissue.

5. CONCLUSION

This prospective comparative clinical study evaluated the efficacy of Platelet-Rich Plasma (PRP) versus Normal Saline (NS) as intraoperative holding solutions during Follicular Unit Extraction (FUE) in patients with Androgenetic Alopecia (AGA). The results demonstrated that PRP significantly outperforms saline across key clinical domains including follicular survival, hair shaft maturation, recipient site density, histological preservation, and patient satisfaction. Grafts preserved in PRP showed approximately 15% higher survival rates at 12 months compared to saline, along with increased shaft length and thickness by 15.8% and 19.1% respectively. Final density in PRP-treated grafts exceeded that of the NS group by 7.9% and was associated with a statistically significant improvement in patient satisfaction scores on the Visual Analog Scale [43], [44]. Microscopic and histopathological analysis confirmed reduced hydropic degeneration, better root sheath integrity, and preservation of adnexal structures in PRP-stored grafts, supporting the regenerative properties of platelet-derived growth factors such as PDGF, VEGF, and TGF-β [45], [46].

The findings validate that PRP is not just a neutral storage medium but a biologically active agent capable of improving graft viability and aesthetic outcomes in hair restoration surgery. Its application is safe, autologous, and easily integrable into standard FUE workflows without substantial increase in time or cost. While sample size and long-term follow-up remain limitations, the clinical and histological benefits observed in this study affirm PRP's potential to redefine intraoperative protocols in hair transplantation [47].

RECOMMENDATIONS

Based on the findings of this study, the following recommendations can be proposed:

Platelet-Rich Plasma (PRP) should be considered as a preferred intraoperative graft-holding solution during FUE, especially in high-density or revision hair transplant cases where graft survival is critical. Clinics equipped with standard centrifugation systems can adopt PRP protocols with minimal infrastructural modifications. Training of surgical staff in PRP preparation, handling, and immersion timing should be emphasized to maintain consistency in outcomes. Moreover, future clinical guidelines and postgraduate surgical curricula should incorporate PRP-based graft preservation as an evidence-supported

enhancement to traditional FUE methods [48].

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