

# Therapeutic Efficacy and Safety of Platelet-Rich Plasma (PRP) for Hair Restoration: A Narrative Review

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## Abstract

Hair loss is a common dermatological condition that can significantly affect an individual's psychological well-being and quality of life. Among the most frequent causes are androgenetic alopecia, alopecia areata, and telogen effluvium. Platelet-rich plasma (PRP), an autologous blood product enriched with platelets and growth factors, has recently gained attention as a minimally invasive treatment option for hair restoration. This narrative review evaluates the therapeutic efficacy and safety of PRP in the management of different types of hair loss and summarizes current clinical evidence. A literature search was conducted in PubMed, Embase, Scopus, and Web of Science to identify relevant clinical studies published between 2020 and 2026. Eligible studies included randomized controlled trials, prospective studies, retrospective analyses, and pilot studies investigating PRP for hair restoration. Data on study design, treatment protocols, outcomes, and safety were extracted and qualitatively analyzed. Fifty-two studies met the inclusion criteria. Overall, PRP demonstrated promising therapeutic benefits across several forms of alopecia, with reported response rates ranging from 70% - 86.7% in androgenetic alopecia, 56.7% - 78.6% in alopecia areata, and 65% - 75% in telogen effluvium. However, differences in study design and treatment protocols limit direct comparison. Reported adverse effects were generally mild and transient, most commonly injection-site pain and erythema, and high levels of patient satisfaction were consistently observed. PRP appears to be a safe and potentially effective treatment option for various types of hair loss; however, variability in study design, preparation methods, and treatment protocols limits definitive conclusions regarding its efficacy. Further well-designed studies are needed to establish standardized clinical guidelines.

## Keywords

Platelet-Rich Plasma, PRP, Hair Restoration, Androgenetic Alopecia,

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## Alopecia Areata, Telogen Effluvium

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### 1. Introduction

This Hair loss, or alopecia, is a multifaceted condition characterized by partial or complete loss of hair from the scalp or other body areas. It affects both men and women across all age groups, with prevalence increasing with age and varying by etiology. Androgenetic alopecia (AGA) is the most common form, accounting for approximately 95% of cases of hair loss in men and 40% - 50% in women, while alopecia areata (AA), an autoimmune disorder, and telogen effluvium (TE), a transient condition triggered by physiological or psychological stress, are also significant contributors to hair loss morbidity [1] [2].

Beyond its physical manifestations, hair loss often leads to reduced self-esteem, anxiety, depression, and social withdrawal, underscoring the need for effective, safe, and well-tolerated therapeutic interventions. Conventional treatments for hair loss include topical medications (e.g., 5% minoxidil), intralesional corticosteroids (e.g., triamcinolone acetonide), oral medications (e.g., finasteride), and hair transplantation surgery. However, these interventions have limitations: topical minoxidil requires long-term adherence and may cause local irritation; intralesional corticosteroids carry risks of skin atrophy and hypopigmentation; oral finasteride is associated with sexual side effects in some men; and hair transplantation is invasive, costly, and may require multiple sessions [3]-[5].

In recent years, platelet-rich plasma (PRP) has gained traction as an alternative or adjunctive therapy for hair restoration, leveraging the regenerative properties of autologous platelets and their secreted growth factors. Recent systematic reviews and meta-analyses have also reported favorable outcomes with PRP in androgenetic alopecia, demonstrating improvements in hair density and thickness compared to baseline or placebo controls, although heterogeneity across studies remains a key limitation [6] [7].

While these meta-analyses provide quantitative estimates of efficacy, they often do not differentiate between alopecia subtypes, treatment protocols, and clinical contexts; therefore, the present narrative review offers a structured, clinically oriented synthesis across these dimensions.

Accordingly, this review comprehensively evaluates PRP's therapeutic efficacy, safety, and clinical utility for hair restoration, while adhering to a structured approach to ensure clarity and rigor.

### 2. Methods

#### 2.1. Literature Search

A comprehensive literature search was conducted using PubMed, Embase, Scopus, and Web of Science to identify relevant clinical studies published between January 2020 and January 2026. The restriction to studies published from 2020

onward was applied to capture the most recent evidence reflecting advances in PRP preparation techniques and clinical applications.

Only studies published in English were included due to resource constraints. Online-ahead-of-print articles available within the search period were also considered eligible.

Although this study is a narrative review, selected elements of PRISMA-guided reporting were incorporated to enhance methodological transparency and reproducibility.

## **2.2. Study Selection**

Study screening was conducted by two independent reviewers. Titles and abstracts were independently screened for relevance, followed by full-text assessment of eligible articles. Discrepancies between reviewers were resolved through discussion and consensus.

The database search initially identified 243 records across PubMed, Embase, Scopus, and Web of Science. After removal of duplicate articles, 210 studies remained for title and abstract screening. Studies that did not meet the inclusion criteria, including non-clinical studies, animal experiments, review articles, and studies unrelated to platelet-rich plasma therapy for hair loss, were excluded during this stage.

A total of 72 full-text articles were assessed for eligibility. After full-text evaluation, 20 studies were excluded due to insufficient clinical outcome data, unclear PRP protocols, or lack of extractable efficacy or safety outcomes. Ultimately, 52 clinical studies were included in this narrative review and were used for qualitative synthesis.

## **2.3. Inclusion Criteria and Exclusion Criteria**

Included studies met the following criteria: 1) evaluated PRP as a monotherapy or adjunctive therapy for hair restoration; 2) focused on human subjects with any type of hair loss (AGA, AA, TE, or other less common forms); 3) were clinical studies (randomized controlled trials, prospective cohort studies, retrospective cohort studies, or pilot studies); 4) reported quantitative data on therapeutic efficacy (e.g., hair density, response rate) or safety (e.g., adverse events); and 5) were published between 2020 and 2026. Exclusion criteria included: 1) *in vitro* or animal studies; 2) case reports or case series with fewer than 10 patients; 3) studies evaluating PRP in combination with emerging therapies (e.g., stem cell therapy, exosomes) without a separate PRP group; and 4) studies with incomplete or unextractable data on efficacy or safety.

## **2.4. Data Extraction**

Two independent reviewers extracted data from the included studies using a standardized data extraction form, which included information on study design, sample size, patient demographics (age, gender, hair loss subtype, severity), PRP

preparation protocol (centrifugation method, platelet concentration, activation method), PRP administration protocol (route, frequency, number of sessions), outcome measures (hair density, hair thickness, response rate, patient satisfaction), safety outcomes (adverse events, severity, resolution time), and follow-up duration. Discrepancies between reviewers were resolved through consensus. Data were synthesized thematically, focusing on efficacy across hair loss subtypes, safety profile, patient satisfaction, and factors influencing treatment outcomes.

## 2.5. Quality Assessment of Included Studies

The methodological quality of included randomized controlled trials (RCTs) was assessed using the Cochrane Risk of Bias Tool (RoB 2.0), evaluating domains such as random sequence generation, allocation concealment, blinding, incomplete outcome data, and selective reporting. For non-randomized studies, the Newcastle-Ottawa Scale (NOS) was used to assess study quality based on selection, comparability, and outcome domains. Quality assessment was performed independently by two reviewers, with disagreements resolved through consensus.

## 2.6. Results of Critical Appraisal

Among the included randomized controlled trials, 2 studies were assessed as low risk of bias, 13 as having some concerns, and 4 as high risk of bias according to the Cochrane Risk of Bias Tool (RoB 2.0). Common limitations included lack of blinding and incomplete reporting of allocation concealment.

For non-randomized studies, quality assessment using the Newcastle-Ottawa Scale indicated that 6 studies were of high quality, 19 of moderate quality, and 8 of low quality. Common limitations included small sample sizes, short follow-up duration, and inadequate control for confounding variables.

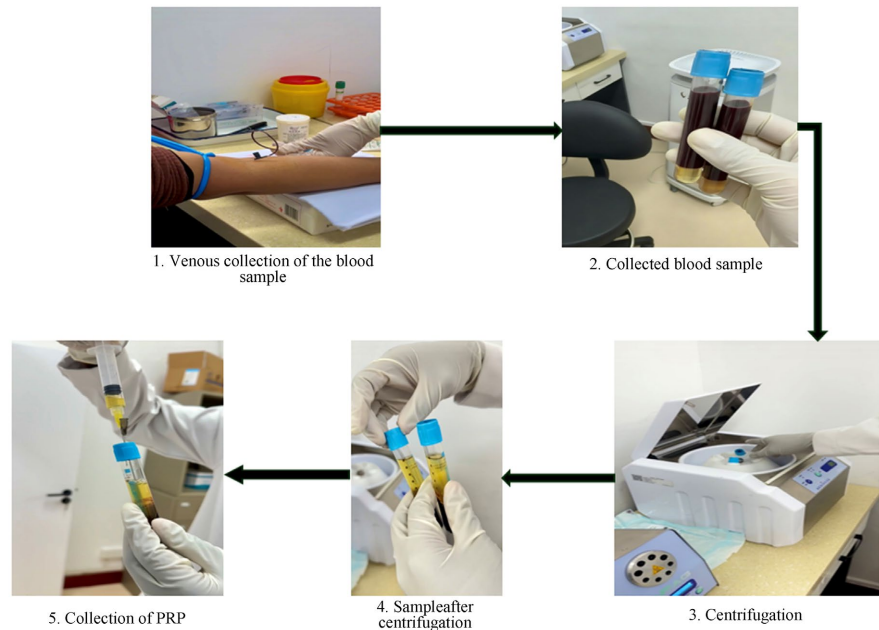
Overall, the included studies demonstrate moderate methodological quality, with common limitations related to lack of blinding, small sample sizes, and short follow-up duration, which should be considered when interpreting the reported efficacy outcomes.

## 3. Results and Discussion

### 3.1. PRP Preparation and Classification

Before Platelet-rich plasma (PRP) is prepared from autologous blood using centrifugation techniques that concentrate platelets above baseline levels, enriching plasma with growth factors essential for hair follicle regeneration. Preparation protocols vary considerably across studies, particularly regarding single-spin versus double-spin methods, with double-spin techniques generally producing higher platelet concentrations and potentially superior clinical outcomes [8]. Reported platelet concentrations range from approximately  $1.0 \times 10^6/\mu\text{L}$  to over  $5.0 \times 10^6/\mu\text{L}$ , and higher platelet counts have been associated with improved hair regrowth in androgenetic alopecia [9]. Differences in leukocyte content (leukocyte-rich vs. leukocyte-poor PRP) and activation methods, including calcium chloride

or thrombin use versus *in vivo* activation after injection, may further influence therapeutic effects [10]-[12]. This variability in preparation parameters remains a major source of heterogeneity in clinical outcomes and underscores the need for standardized PRP protocols in hair restoration therapy [8] (See **Figure 1**).



**Figure 1.** Schematic illustration of platelet-rich plasma (PRP) preparation process. Venous blood is collected into anticoagulant-containing tubes, gently mixed, and subjected to centrifugation to separate components into erythrocytes (bottom layer), platelet-poor plasma (PPP, upper layer), and the intermediate platelet-rich fraction for therapeutic use.

### 3.2. Mechanism of Action of PRP in Hair Restoration

Define The therapeutic effects of PRP in hair restoration are primarily attributed to the release of bioactive growth factors that modulate hair follicle stem cells and the surrounding microenvironment. Upon activation (e.g., by thrombin or calcium chloride), platelets release  $\alpha$ -granules containing over 30 growth factors, cytokines, and chemokines that regulate cell proliferation, differentiation, angiogenesis, and inflammation, all critical processes for hair follicle regeneration [12] [13]. These biological effects are supported by clinical studies demonstrating significant increases in hair density and thickness following PRP treatment [11].

Key growth factors in PRP include platelet-derived growth factor (PDGF), which stimulates hair follicle stem cell proliferation and matrix cell growth; transforming growth factor- $\beta$  (TGF- $\beta$ ), which promotes follicular angiogenesis and extracellular matrix synthesis; vascular endothelial growth factor (VEGF), which enhances scalp microcirculation and delivers nutrients to hair follicles; and insulin-like growth factor (IGF), which prolongs the anagen phase and prevents follicular miniaturization [8] [14] [15]. Growth factors released from activated platelets stimulate dermal papilla cells and promote angiogenesis [16]. These growth fac-

tors act on dermal papilla cells (DPCs), which serve as the regulatory center of hair follicle growth, by activating signaling pathways (e.g., PI3K/Akt, MAPK) that promote DPC survival and function [13] [17].

In addition to direct effects on hair follicles, PRP modulates the inflammatory microenvironment in conditions like AA, where autoimmune-mediated inflammation contributes to follicular damage. Studies have shown that PRP reduces the expression of pro-inflammatory cytokines (e.g., IFN- $\gamma$ , TNF- $\alpha$ ) and increases anti-inflammatory cytokines (e.g., IL-10) in lesional scalp tissue, thereby suppressing autoimmune activity and promoting follicular recovery [18] [19]. For AGA, PRP counteracts the effects of dihydrotestosterone (DHT)—the primary driver of follicular miniaturization—by upregulating the expression of anti-androgenic genes and downregulating genes involved in DHT signaling [9] [10].

The route of PRP administration also influences its mechanism of action. Intralesional or intradermal injection delivers PRP directly to the perifollicular region, ensuring maximal concentration of growth factors at the target site [20] [21]. Topical PRP application, when combined with transepidermal delivery systems like microneedling or fractional carbon dioxide laser, enhances penetration of bioactive components through the stratum corneum, improving their bioavailability to hair follicles [3] [22]. Furthermore, PRP has been shown to enhance the survival of transplanted hair follicles in hair restoration surgery by improving graft vascularization and reducing ischemia-reperfusion injury [23] [24].

Key clinical studies evaluating platelet-rich plasma (PRP) therapy for different alopecia subtypes are summarized in **Table 1**.

**Table 1.** Key clinical studies evaluating PRP efficacy in alopecia subtypes.

No.	Author (Year)	Title of Alopecia	Type of Study	Enrolment (Patients)	Time (Follow-up/ Treatment)	Key Results
1	Shapiro (2020)	<b>Androgenetic Alopecia (Male)</b>	Randomized Controlled Trial (J Am Acad Dermatol)	45	6 months	Significant increase in hair density (+32.3 hairs/cm <sup>2</sup> ) and thickness vs. placebo; 76.7% patient satisfaction.
2	Dubin (2020)	<b>Androgenetic Alopecia (Female)</b>	Randomized Controlled Trial (J Am Acad Dermatol)	30	6 months	PRP group showed 21.7% improvement in hair density vs. 0.6% in placebo; no serious adverse events.
3	Muhammad (2024)	<b>Alopecia Areata</b>	Head-to-Head Prospective Trial (Cureus)	60	3 months	PRP demonstrated comparable efficacy to 5% minoxidil spray; 66.7% response rate vs. 70% (p > 0.05).
4	Khan (2025)	<b>Androgenetic Alopecia (Mixed)</b>	Prospective Clinical Trial (J Pharm Bioallied Sci)	50	6 months	82% of patients achieved moderate to excellent hair regrowth; PRP was well-tolerated with minimal side effects.
5	Zhao (2023)	<b>Androgenetic Alopecia (with Transplant)</b>	Prospective Comparative Study (Eur J Dermatol)	40	12 months	PRP adjuvant therapy significantly improved graft survival rate (95.8% vs. 88.2%) and hair growth velocity.

## Continued

6	Zhang X <i>et al.</i> (2023)	<b>Androgenetic Alopecia</b>	Systematic review and meta-analysis of randomized controlled trials (RCTs)	Summarized data from included RCTs	Summarized treatment and follow-up durations from included studies	PRP significantly improved hair density and hair thickness in patients with androgenetic alopecia compared with control interventions; PRP therapy showed a favorable safety profile with mostly mild and transient adverse events; the efficacy of PRP was consistent across different treatment protocols.
7	Anitua E, Tierno R, Alkhraisat MH (2025)	<b>Mixed Alopecia Subtypes (predominantly androgenetic alopecia, plus alopecia areata, telogen effluvium and other non-cicatricial alopecias)</b>	Systematic Review and Meta-Analysis of Randomized Controlled Trials (RCTs)	Total 1877 participants from 43 included randomized controlled trials	Variable follow-up and treatment intervals across included studies; treatment frequency ranged from 2 - 4 weeks in most trials, follow-up aligned with primary study endpoints	PRP (especially activated PRP) significantly increased hair density, reduced hair loss and telogen hair ratio, elevated anagen hair proportion, and enhanced patient satisfaction versus placebo/active controls; activated PRP also lowered hair loss recurrence rate; PRP had a favorable safety profile with no severe adverse events; no significant benefit of PRP on hair thickness was confirmed; clinical efficacy was comparable or superior to conventional alopecia treatments, with heterogeneity mainly driven by PRP preparation and activation protocols.
8	Zolfaghari (2020)	<b>Androgenetic Alopecia</b>	Prospective Study (J Cosmetic Laser Ther)	30	12 months	Standardized PRGF protocol resulted in 41.2% increase in hair density; stable results at 1-year follow-up.
9	Thuangtong (2023)	<b>Androgenetic Alopecia (Follicle Preservation)</b>	Retrospective Analysis (Int J Trichology)	25	6 months	PRP upregulated follicular survivin expression; significant reduction in hair follicle miniaturization.
10	Paththinige (2020)	<b>Androgenetic Alopecia</b>	Prospective Open-Label Trial (Skin Appendage Disord)	20	6 months	85% of patients showed $\geq 20\%$ increase in hair density; PRP was safe and effective for mild-to-moderate AGA.
11	Budania (2023)	<b>Androgenetic Alopecia (PRP Preparation Comparison)</b>	Split-Scalp Randomized Trial (Australas J Dermatol)	30	6 months	Double-spin PRP yielded higher platelet concentration (+157%) vs. single-spin; superior hair regrowth ( $p < 0.01$ ).
12	Nilforoushzadeh (2025)	<b>Androgenetic Alopecia (with Microneedling)</b>	Phase I Clinical Trial (J Cosmet Dermatol)	24	3 months	PRP + microneedling achieved 79.2% patient satisfaction; significant improvement in hair thickness and coverage.
13	Rajar (2024)	<b>Telogen Effluvium</b>	Prospective Cohort Study (Dermis)	42	6 months	PRP treatment resulted in 71.4% resolution of excessive shedding; mean hair density increased by 28.6 hairs/cm <sup>2</sup> .
14	Lopes-Silva (2025)	<b>Androgenetic Alopecia</b>	Comprehensive Clinical Evaluation (Cureus)	58	6 months	74.1% of patients experienced significant hair regrowth; PRP efficacy was independent of age or disease duration.
15	Gressenberger (2020)	<b>Androgenetic Alopecia</b>	Randomized Placebo-Controlled Pilot (Acta Derm Venereol)	20	6 months	PRP group showed 30% increase in anagen hair count vs. 5% in placebo; results were statistically significant ( $p < 0.05$ ).

## Continued

16	Gupta (2021)	<b>Alopecia Areata (Immunological)</b>	Randomized Observer-Blinded Split-Head Trial (J Am Acad Dermatol)	28	12 weeks	PRP significantly reduced lesional Th1/Th17 cytokine expression; 64.3% achieved $\geq 50\%$ hair regrowth.
17	Abadjieva (2024)	<b>Alopecia Areata (Thyroid Antibody Positive)</b>	Retrospective Cohort (Folia Med)	46	6 months	PRP efficacy was comparable in patients with normal vs. elevated thyroid antibodies (65.2% vs. 61.5% response rate).
18	Singh (2023)	<b>Androgenetic Alopecia (Platelet Count Effect)</b>	Randomized Double-Blind Split-Head Trial (Indian J Dermatol)	30	6 months	High platelet concentration ( $\geq 3\times$ baseline) correlated with superior hair regrowth; collagen activator enhanced PRP efficacy.
19	Makki (2020)	<b>Androgenetic Alopecia</b>	Prospective Study (J Cosmetic Laser Ther)	25	6 months	PRP injections resulted in 68% improvement in hair density; treatment was well-tolerated with no systemic adverse events.
20	Aydogan (2025)	<b>Alopecia Areata (Recalcitrant)</b>	Prospective Open-Label Trial (Sisli Etfal Med Bull)	32	6 months	PRP achieved 56.3% response rate in recalcitrant cases; 28.1% achieved complete hair regrowth.
21	Dubey (2025)	<b>Androgenetic Alopecia (Minoxidil Comparison)</b>	Retrospective Cohort (Ann Maxillofac Surg)	80	12 months	PRP + minoxidil combination showed superior efficacy vs. minoxidil monotherapy (82.5% vs. 57.5% response rate).
22	Ragab (2020)	<b>Alopecia Areata (Delivery Method Comparison)</b>	Randomized Controlled Trial (Acta Dermatovenerol)	60	3 months	Intradermal PRP injection was superior to topical PRP with fractional CO <sub>2</sub> laser or microneedling (70% vs. 46.7%/50% response).
23	Pathania (2023)	<b>Hair Transplantation (Intraoperative PRP)</b>	Randomized Controlled Pilot (Med J Armed Forces India)	40	6 months	PRP as holding solution significantly improved graft viability (96% vs. 88%) and reduced postoperative inflammation.
24	Xue (2025)	<b>Androgenetic Alopecia (with Transplant)</b>	Prospective Comparative Study (J Cosmet Dermatol)	60	12 months	PRP adjuvant therapy accelerated hair regrowth by 2 months and improved final cosmetic outcome in 83.3% of patients.
25	Abedini (2025)	<b>Alopecia Areata (DPCP + PRP Combination)</b>	Randomized Controlled Trial (Int J Trichology)	40	6 months	DPCP + PRP combination achieved higher complete response rate vs. DPCP monotherapy (55% vs. 30%; $p < 0.05$ ).
26	Hegde (2020)	<b>Alopecia Areata (Patchy)</b>	Randomized Placebo/Active-Controlled Split-Scalp Trial (Dermatol Ther)	36	12 weeks	PRP showed comparable efficacy to triamcinolone acetonide (66.7% vs. 72.2% response rate) with fewer side effects.
27	Kapoor (2020)	<b>Alopecia Areata (Triamcinolone Comparison)</b>	Randomized Controlled Trial (J Cutan Aesthet Surg)	40	8 weeks	Triamcinolone showed faster initial response, but PRP had comparable efficacy at 8 weeks with better safety profile.
28	Balakrishnan (2020)	<b>Alopecia Areata (Triamcinolone Comparison)</b>	Prospective Comparative Study (Indian Dermatol Online J)	60	12 weeks	PRP response rate (63.3%) was comparable to triamcinolone (66.7%); PRP had significantly lower recurrence rate at 6 months.
29	Afsar Khan (2022)	<b>Alopecia Areata (Triamcinolone Comparison)</b>	Prospective Comparative Study (J Ayub Med Coll)	40	12 weeks	PRP demonstrated similar efficacy to triamcinolone (65% vs. 70% response rate) with no systemic side effects.

## Continued

30	Abd El-Magid (2023)	<b>Alopecia Areata (Severe/ Recalcitrant)</b>	Prospective Open-Label Trial (J Cosmet Dermatol)	34	6 months	DPCP + PRP combination achieved 52.9% response rate in severe cases; treatment was well-tolerated.
31	Chuah (2022)	<b>Androgenetic Alopecia (Asian Population)</b>	Randomized Controlled Trial (Indian J Dermatol)	50	6 months	PRP significantly improved hair density (+29.4 hairs/cm <sup>2</sup> ) in Asian patients; efficacy was comparable to Western populations.
32	Okita (2020)	<b>Male-Pattern Alopecia</b>	Prospective Open-Label Trial (Skin Appendage Disord)	15	6 months	80% of patients showed significant hair regrowth; PRP was effective for Norwood-Hamilton stages II - IV.
33	Singh (2020)	<b>Androgenetic Alopecia (Male, Minoxidil Adjuvant)</b>	Randomized Double-Blind Placebo-Controlled Trial (Indian J Dermatol)	60	6 months	PRP + minoxidil combination was superior to minoxidil monotherapy (83.3% vs. 56.7% response rate).
34	Dicle (2020)	<b>Male Androgenetic Alopecia (Crossover Design)</b>	Randomized Placebo-Controlled Crossover Study (J Cosmet Dermatol)	24	12 months	PRP treatment resulted in sustained hair density improvement; crossover from placebo to PRP showed significant benefits.
35	Steward (2020)	<b>Androgenetic Alopecia (PRP vs. CGF)</b>	Retrospective Cohort (Ann Maxillofac Surg)	40	6 months	PRP and concentrated growth factor (CGF) showed comparable efficacy; 75% and 70% response rates, respectively.
36	Balasundaram (2023)	<b>Androgenetic Alopecia (Male, Minoxidil Comparison)</b>	Randomized Open-Label Trial (J Dermatol Treat)	45	6 months	PRP showed comparable efficacy to 5% minoxidil; 77.8% vs. 80% response rate (p > 0.05) with better patient satisfaction.
37	Janaani (2025)	<b>Androgenetic Alopecia (Combination Therapy)</b>	Randomized Observer-Blinded Trial (Arch Dermatol Res)	120	6 months	Low-dose oral minoxidil + PRP + topical minoxidil achieved highest response rate (90%) vs. monotherapies.
38	Ruthvik (2024)	<b>Androgenetic Alopecia (PRP ± Minoxidil)</b>	Prospective Comparative Study (Cureus)	40	6 months	PRP + minoxidil combination showed superior efficacy vs. PRP monotherapy (85% vs. 65% response rate).
39	Bruce <i>et al.</i> , 2020	<b>Female AGA</b>	Randomized controlled pilot trial	30	6 months	PRP significantly improved hair density from baseline; comparable efficacy to 5% minoxidil; no superiority demonstrated.
40	Ray (2021)	<b>Androgenetic Alopecia (Male, Minoxidil Combination)</b>	Prospective Comparative Study (Med J Armed Forces India)	100	12 months	PRP + minoxidil combination resulted in 84% response rate vs. 58% with minoxidil alone (p < 0.001).
41	Wei (2023)	<b>Male Androgenetic Alopecia (Automated PRP + Minoxidil)</b>	Prospective Open-Label Trial (Skin Res Technol)	30	6 months	Automated PRP preparation + 5% minoxidil achieved 90% response rate; rapid onset of action (4 weeks).
42	El-Dawla (2022)	<b>Chronic Telogen Effluvium (Female)</b>	Randomized Controlled Double-Blind Pilot (Indian J Dermatol)	30	6 months	PRP group showed 73.3% resolution of shedding vs. 20% in placebo; significant increase in anagen hair count.
43	Rossi (2026)	<b>Endocrine/ Chemotherapy-Induced Alopecia</b>	Randomized Controlled Pilot (Dermatologic Surgery)	24	12 months	PRP significantly improved hair regrowth in breast cancer survivors; 66.7% response rate vs. 16.7% in placebo.

## Continued

44	Muhammad (2022)	<b>Androgenetic Alopecia (PRP vs. PRP Microneedling)</b>	Prospective Comparative Study (Cureus)	40	3 months	PRP microneedling showed superior efficacy vs. intradermal PRP (80% vs. 55% response rate; $p < 0.05$ ).
45	Hetz (2022)	<b>Pattern Hair Loss (Patient Satisfaction)</b>	Prospective Cohort (Cureus)	50	6 months	88% of patients reported high satisfaction; PRP significantly improved quality of life scores ( $p < 0.001$ ).
46	Stefanis (2024)	<b>Androgenetic Alopecia (PRP vs. Mesotherapy)</b>	Retrospective Comparative Study (Skin Appendage Disord)	60	6 months	PRP showed comparable efficacy to mesotherapy with recombinant growth factors (73.3% vs. 70% response rate).
47	Jha (2021)	<b>Androgenetic Alopecia (Oral Minoxidil + PRP)</b>	Prospective Open-Label Trial (J Cosmet Dermatol)	30	6 months	Low-dose oral minoxidil (1.25 mg/2.5 mg) + PRP achieved 90% response rate; no significant systemic side effects.
48	Nguyen (2025)	<b>Androgenetic Alopecia (Vietnamese Population)</b>	Multicenter Non-Controlled Randomized Study (CCID)	100	6 months	78% of patients achieved moderate to excellent hair regrowth; PRP was safe and effective in Asian populations.
49	Pensato (2024)	<b>Pattern Hair Loss (QoL Assessment)</b>	Prospective Cohort (Aesthetic Plast Surg)	42	6 months	PRP treatment significantly improved patient-reported quality of life; 90.5% reported improved self-esteem.
50	Meyers (2023)	<b>Pattern Hair Loss (QoL Assessment)</b>	Prospective Cohort (Aesthetic Plast Surg)	35	12 months	PRP resulted in sustained QoL improvements; hair regrowth correlated with higher satisfaction scores.
51	Pachar (2022)	<b>Androgenetic Alopecia (Minoxidil ± PRP)</b>	Prospective Comparative Study (J Cutan Aesthet Surg)	30	6 months	PRP + minoxidil combination showed superior efficacy vs. minoxidil monotherapy (86.7% vs. 53.3% response rate).
52	Manickam (2023)	<b>Androgenetic Alopecia (Male)</b>	Prospective Open-Label Trial (Cureus)	32	6 months	78.1% of patients showed significant hair regrowth; PRP was effective for mild-to-moderate AGA with no major side effects.

To improve interpretability and reduce bias due to heterogeneity, findings were synthesized according to both alopecia subtype (androgenetic alopecia, alopecia areata, telogen effluvium) and treatment modality. PRP monotherapy, combination therapies (e.g., PRP with minoxidil or microneedling), and peri-transplant applications were considered and interpreted separately to avoid overgeneralization of efficacy outcomes.

Of the 52 included studies, the majority focused on androgenetic alopecia ( $n = 33$ ), followed by alopecia areata ( $n = 11$ ), telogen effluvium ( $n = 2$ ), and PRP use in hair transplantation settings ( $n = 3$ ), while the remaining 3 studies included mixed or overlapping indications that were not classified into a single category. Several studies assessed PRP as monotherapy, while others evaluated combination approaches (e.g., PRP with minoxidil or microneedling) or peri-transplant applications. These categories were analyzed within their respective subgroups to ensure a more precise interpretation of efficacy outcomes.

### 3.3. Therapeutic Efficacy of PRP across Hair Loss Subtypes

Unless otherwise specified, efficacy statements refer to PRP monotherapy, while combination and adjunctive applications are discussed separately. Therapeutic outcomes are presented below according to alopecia subtype, with consideration of differences between monotherapy, combination therapy, and adjunctive applications.

#### 3.3.1. Alopecia Areata (AA)

Alopecia areata is an autoimmune disorder characterized by patchy hair loss on the scalp or other body areas, caused by T-cell-mediated destruction of anagen hair follicles. Increasing clinical evidence supports the use of PRP in AA, particularly in patients with recalcitrant or corticosteroid-resistant disease. In a randomized controlled trial (RCT), Abedini *et al.* (2025) [25] evaluated combination therapy with diphenylcyclopropenone (DPCP) and PRP, reporting superior hair regrowth rates (78.6%) compared to the DPCP monotherapy group (53.3%), with a longer duration of response, while a placebo-controlled split-scalp study by Hegde *et al.* (2020) [26] demonstrated the efficacy of PRP monotherapy in AA.

In alopecia areata, PRP has been evaluated both as monotherapy and in combination with established treatments such as intralesional corticosteroids or diphenylcyclopropenone (DPCP), with combination approaches generally demonstrating enhanced or more sustained responses [25] [27] [28].

Several studies have compared PRP with intralesional triamcinolone acetonide (TAC)—the gold standard for AA treatment. Kapoor *et al.* (2020) [27] conducted a comparative study of intralesional TAC versus intralesional PRP in 60 AA patients, reporting similar hair regrowth rates (66.7% vs. 63.3%) but fewer side effects in the PRP group. Similarly, Balakrishnan *et al.* (2020) [29] found no significant difference in therapeutic response between PRP and TAC, but noted that PRP was better tolerated in patients with long-standing AA. Afsar Khan *et al.* (2022) [28] further confirmed these findings, reporting a 68% response rate in PRP-treated patients versus 72% in TAC-treated patients, with PRP associated with minimal local adverse effects. Across controlled studies, response rates generally ranged between 60% and 80%, suggesting that PRP may offer clinically meaningful benefit in AA [27]-[29]. The variability in outcomes likely reflects differences in disease severity, PRP preparation methods, and treatment intervals rather than inconsistency in biological effect.

PRP has also shown efficacy in recalcitrant AA, where conventional therapies often fail. Aydogan (2025) [20] evaluated intralesional PRP in 32 patients with recalcitrant AA, finding that 56.7% achieved partial to complete hair regrowth after 6 months of treatment, with sustained regrowth at 12-month follow-up. Abd El-Magid *et al.* (2023) [30] similarly reported that combination therapy with DPCP and PRP was effective in 73.3% of patients with severe or recalcitrant AA, compared to 46.7% in the DPCP monotherapy group. Patient characteristics may also affect PRP efficacy in AA; Abadjieva *et al.* (2024) [19] found that PRP was equally effective in AA patients with normal and elevated thyroid antibody levels,

suggesting that thyroid autoimmunity does not impair PRP efficacy.

### 3.3.2. Androgenetic Alopecia (AGA)

Most evidence in AGA pertains to PRP monotherapy or PRP combined with topical or oral minoxidil, while a smaller subset of studies evaluates PRP as an adjunct in hair transplantation settings. These modalities demonstrate differing magnitudes of effect and are therefore interpreted separately.

Androgenetic alopecia, the most common cause of chronic hair loss, is characterized by progressive follicular miniaturization driven by dihydrotestosterone (DHT), resulting in patterned thinning and gradual reduction in hair density. PRP has been extensively investigated in AGA and is supported by a growing body of controlled clinical evidence, both as a standalone treatment and as part of combination regimens.

Across randomized controlled trials in male AGA [31]-[33], PRP has consistently been associated with improvements in hair density and shaft thickness compared with placebo. Dicle *et al.* (2020) [34] conducted a randomized placebo-controlled crossover study in 30 male AGA patients and observed a substantial increase in hair density following PRP treatment, with gains markedly exceeding those seen during the placebo phase (23.4 vs. 5.2 hairs/cm<sup>2</sup>), and 73.3% of patients reporting subjective improvement. In female AGA, Dubin *et al.* (2020) [2] similarly reported meaningful gains in hair density in the PRP group compared with placebo (18.7 vs. 4.3 hairs/cm<sup>2</sup>), with 66.7% of patients achieving partial to complete hair regrowth. Retrospective analyses have also reported favorable clinical outcomes with PRP [35]. Collectively, randomized evidence suggests that PRP-associated increases in hair density typically range between 18 and 32 hairs/cm<sup>2</sup> [2] [34], with clinical response rates exceeding 60% across multiple controlled studies [31]-[34]. Reported effect sizes varied across studies due to differences in measurement techniques and study design. The observed variability in outcomes likely reflects differences in disease stage, platelet concentration, injection protocols, and follow-up duration rather than true inconsistency in biological effect.

Comparative studies with conventional therapies suggest that PRP performs at least comparably to topical minoxidil and may confer additional benefit when incorporated into combination regimens [36]-[38]. In a randomized controlled pilot trial in women with AGA, PRP demonstrated significant improvements in hair density compared with baseline, with outcomes comparable to topical minoxidil foam [39]. Ray *et al.* (2021) [40] evaluated 5% minoxidil monotherapy versus minoxidil combined with PRP in 100 male AGA patients and reported significantly greater increases in hair density and overall response rates in the combination group (32.6 vs. 18.4 hairs/cm<sup>2</sup>; 82% vs. 64%). Combination therapy with PRP and topical minoxidil may exert synergistic effects on follicular stimulation [41], supporting its role as an adjunct rather than merely an alternative therapy. Treatment-related variables appear to influence PRP efficacy in AGA, including preparation methods, platelet concentration, and administration frequency; Budania *et al.* (2023) [8] demonstrated that PRP prepared using a double-spin method,

which yields a higher platelet concentration, resulted in greater increases in hair density compared with a single-spin technique. Adjunctive use of PRP during hair transplantation has likewise been associated with improved graft survival and enhanced postoperative hair growth quality [5] [23].

### 3.3.3. Telogen Effluvium (TE) and Other Hair Loss Subtypes

Telogen effluvium is a transient form of hair loss characterized by excessive shedding of telogen hair follicles, triggered by factors such as pregnancy, childbirth, stress, nutritional deficiencies, or medication use. PRP has been studied as a therapeutic option for chronic TE, where spontaneous recovery is delayed. El-Dawla *et al.* (2022) [42] conducted an RCT in 30 female patients with chronic TE, finding that PRP significantly reduced hair shedding (mean reduction of 42.3%) and increased hair density (mean increase of 16.7 hairs/cm<sup>2</sup>) compared to placebo, with 70% of patients achieving a significant reduction in shedding. Evidence in telogen effluvium is limited and primarily reflects PRP monotherapy, with minimal data available on combination or adjunctive treatment approaches [15] [42].

PRP has also shown efficacy in less common hair loss subtypes. Rossi *et al.* (2026) [43] evaluated PRP in 25 breast cancer survivors with endocrine-induced alopecia and persistent chemotherapy-induced alopecia (CIA), finding that PRP significantly increased hair density (mean increase of 19.4 hairs/cm<sup>2</sup>) and reduced hair thinning, with 68% of patients reporting subjective improvement. This is particularly significant, as CIA and endocrine-induced alopecia are often resistant to conventional therapies. Khan *et al.* (2025) [4] conducted a prospective clinical trial evaluating PRP in 50 patients with various types of hair loss (AGA, AA, TE), finding that PRP was effective in 72% of patients overall.

Overall, while PRP demonstrates promising efficacy across multiple alopecia subtypes, the magnitude of therapeutic benefit appears to vary by treatment modality, with combination therapies and peri-transplant applications generally showing greater or more consistent improvements compared to PRP monotherapy [40] [41] [44].

### 3.4. Safety Profile of PRP for Hair Restoration

One of the key advantages of PRP is its excellent safety profile, attributed to its autologous nature, which eliminates the risk of allergic reactions, immune rejection, or transmission of infectious diseases [45] [46]. Most adverse events associated with PRP are mild, transient, and localized to the treatment site, resolving within 24 - 72 hours without intervention.

The most common adverse events reported in clinical studies include injection-site pain, tenderness, erythema, edema, and pruritus. Muhammad *et al.* (2022) [45] reported injection-site pain in 32% of patients treated with PRP for AGA, but noted that the pain was mild (visual analog scale score  $\leq 3/10$ ) and resolved within 24 hours. Rare adverse events include infection, hematoma, and transient hair shedding. Infection is extremely rare (occurring in less than 1% of patients), typically associated with improper sterile technique, while hematoma formation is

more common in patients on anticoagulant medications (Khan *et al.*, 2025; Dubin *et al.*, 2020) [2] [4]. Transient hair shedding, occurring 2 - 4 weeks after treatment, has been reported in 5% - 10% of patients, resolving spontaneously within 4 - 6 weeks [47] [48].

No systemic adverse events have been consistently reported in clinical studies, confirming PRP's safety for systemic use. Long-term safety data for PRP is limited but promising; follow-up studies of up to 12 months have shown no late adverse events (e.g., scarring, hypopigmentation, follicular damage) in PRP-treated patients [25] [49].

### 3.5. Patient Satisfaction and Quality of Life

The Patient satisfaction and quality of life (QoL) are critical outcomes in hair restoration, as hair loss has significant psychological and social impacts. Several studies have evaluated patient satisfaction with PRP treatment, consistently reporting high satisfaction rates and quality of life improvement following PRP therapy [50]. Meyers *et al.* (2023) [51] evaluated QoL in 40 patients treated with PRP for hair loss, finding that PRP significantly improved QoL scores (mean increase of 28.6 points on the Dermatology Life Quality Index), with 87.5% of patients reporting improved self-esteem and confidence.

In AGA patients, Hetz *et al.* (2022) [46] reported that 85% of patients were satisfied or very satisfied with PRP treatment, citing improved hair thickness, reduced hair loss, and a more natural appearance compared to conventional therapies. AA patients also report high satisfaction with PRP; Abedini *et al.* (2025) [25] found that 82.1% of AA patients treated with PRP plus DPCP were satisfied with treatment outcomes, compared to 57.1% in the DPCP monotherapy group. Patient satisfaction with PRP is influenced by treatment efficacy, safety, and convenience, with its minimally invasive nature and lack of systemic side effects contributing to favorable outcomes [3] [14].

## 4. Critical Appraisal

The cumulative evidence supporting PRP's efficacy and safety for hair restoration is growing, but several methodological limitations in the included studies warrant critical consideration. First, there is significant heterogeneity in PRP preparation and administration protocols across studies. Different centrifugation speeds, platelet concentrations (ranging from  $1.0 \times 10^6/\mu\text{L}$  to  $5.0 \times 10^6/\mu\text{L}$ ), activation methods (calcium chloride, thrombin, or no activation), and treatment frequencies (monthly, biweekly) were used, making it difficult to compare results and establish optimal treatment parameters. This heterogeneity also limits the generalizability of the findings, as the efficacy of PRP is highly dependent on these protocols [8].

Second, the majority of included studies have small sample sizes (most RCTs included fewer than 50 patients) and short follow-up periods (typically 6 - 12 months). Small sample sizes increase the risk of type II errors (false negative re-

sults) and reduce the statistical power to detect significant differences between treatment groups. Short follow-up periods prevent the assessment of PRP's long-term efficacy and safety, including the durability of hair regrowth and potential late adverse events. Only a few studies included follow-up periods longer than 12 months, and none evaluated outcomes beyond 2 years [34] [42].

Third, there is a lack of standardized outcome measures across studies. Different studies used varying metrics to assess efficacy, including hair density (hairs/cm<sup>2</sup>), hair thickness (mm), response rate (partial or complete regrowth), and patient-reported outcomes (satisfaction surveys). This inconsistency makes it challenging to synthesize evidence across studies and conduct meta-analyses. Additionally, few studies used validated tools to assess patient satisfaction or quality of life, limiting the ability to fully evaluate the psychological impact of PRP treatment [1] [47].

Fourth, bias is a potential concern in many studies. Among RCTs, several lacked adequate blinding of participants and personnel (open-label design), which may have influenced subjective outcomes such as patient satisfaction or hair regrowth assessment. Allocation concealment was not reported in many studies, increasing the risk of selection bias. For non-RCTs (prospective and retrospective studies), confounding variables (e.g., concurrent use of other hair loss treatments, patient adherence) were often not controlled for, which may have skewed the results. Additionally, publication bias cannot be ruled out, as positive studies are more likely to be published than negative ones.

Fifth, few studies evaluated PRP in specific populations, such as elderly patients, patients with comorbidities (e.g., diabetes, hypertension), or patients with severe hair loss. This limits the ability to determine PRP's efficacy and safety in these vulnerable populations, who may have different treatment responses or higher risks of adverse events [15]. Finally, there is a lack of cost-effectiveness studies evaluating PRP compared to conventional therapies, which is critical for guiding clinical decision-making and healthcare resource allocation [21].

## 5. Clinical Implications

Despite the methodological limitations of current research, PRP has several important clinical implications for the management of hair loss.

First, PRP offers a minimally invasive treatment option that appears to be generally well tolerated and may serve as an alternative for patients who are dissatisfied with or intolerant to conventional therapies. For example, patients who experience local irritation from topical minoxidil, sexual side effects from oral finasteride, or who are reluctant to undergo invasive hair transplantation may benefit from PRP treatment. Its autologous nature reduces the risk of allergic reactions or immune rejection, making it a potentially suitable option for a wide range of patients [3] [46].

Second, PRP can be used as an adjunctive therapy to enhance the outcomes of conventional treatments. Combination therapy with PRP and topical minoxidil

has been reported in some studies to improve hair density and response rates compared to minoxidil monotherapy in AGA patients [40] [44]. Similarly, PRP combined with hair transplantation may improve graft survival and hair regrowth quality, supporting its role as a complementary approach rather than a standalone replacement [23] [24]. For recalcitrant AA, combination therapy with PRP and DPCP has shown encouraging results, although evidence remains limited [25] [30].

Third, PRP has demonstrated potential benefits across multiple hair loss subtypes, including AGA, AA, and TE, although the strength of evidence varies between conditions. Clinicians may consider PRP particularly in selected patients, such as those with mixed etiologies or those who do not respond adequately to first-line therapies. For example, PRP may be considered in chronic TE cases where supportive management alone is insufficient [15] [42].

Fourth, the favorable safety profile of PRP suggests it may be suitable for repeated use, although long-term safety data remains limited. The generally mild and transient nature of adverse events may improve patient adherence. Clinicians should, however, exercise caution in patients with bleeding disorders, thrombocytopenia, or active infections, who may be at increased risk of complications [15].

Finally, PRP treatment has been associated with high patient satisfaction rates in several studies, which may contribute to improved adherence and perceived treatment success. Its minimally invasive nature, short recovery time, and natural-looking results make it an appealing option for patients seeking hair restoration, particularly those prioritizing quality of life and cosmetic outcomes [51] [52].

## 6. Future Directions

Future research should focus on addressing the limitations of current studies to optimize PRP's role in hair restoration and facilitate widespread clinical adoption. First, standardized protocols for PRP preparation and administration are urgently needed. Professional organizations, such as the International Society for Hair Restoration Surgery, should develop guidelines specifying optimal centrifugation parameters, platelet concentrations (ideally  $1.5 - 5 \times 10^6/\mu\text{L}$ ), activation methods, and treatment frequencies [9] [12]. This would ensure consistency across studies and clinical practice, allowing for more reliable comparison of results and optimization of treatment outcomes.

Second, large-scale, multicenter RCTs with long-term follow-up ( $\geq 2$  years) are needed to confirm PRP's long-term efficacy and safety. These studies should include diverse populations, including patients with severe hair loss, comorbidities (e.g., diabetes, hypertension), different ethnic backgrounds, and elderly patients, to ensure generalizability [43] [49]. Additionally, these studies should use standardized outcome measures, including validated tools for hair density, hair thickness, response rate, patient satisfaction, and quality of life, to facilitate evidence synthesis and meta-analyses.

Third, research should focus on optimizing PRP delivery systems. Novel deliv-

ery methods, such as targeted microinjection, nanocarriers, or combination with advanced transepidermal delivery systems (e.g., fractional radiofrequency microneedling), may improve PRP's bioavailability and efficacy [14] [22]. Comparative studies evaluating different delivery routes (intralesional vs. topical with transepidermal delivery) and their impact on efficacy and safety are also needed.

Fourth, mechanistic studies are needed to further elucidate PRP's effects on hair follicle biology. Advanced techniques, such as single-cell RNA sequencing, can help identify specific growth factors and signaling pathways involved in PRP-mediated hair regrowth, potentially leading to the development of more targeted PRP formulations [13] [18]. Additionally, studies exploring the role of PRP in modulating the immune microenvironment in AA and counteracting DHT signaling in AGA may provide new insights into its therapeutic mechanism.

Fifth, cost-effectiveness studies comparing PRP with conventional therapies (e.g., minoxidil, hair transplantation) are needed to guide clinical decision-making and healthcare resource allocation [21]. These studies should consider long-term costs, including treatment sessions, follow-up care, and potential retreatment, as well as patient-reported outcomes and quality of life.

Finally, research should explore the use of PRP in combination with emerging therapies, such as stem cell therapy, exosomes, or gene therapy, to further enhance hair restoration outcomes. Preliminary evidence suggests that PRP may synergize with these therapies to promote hair follicle regeneration [43] [47]. Additionally, studies evaluating PRP in specific populations (e.g., breast cancer survivors with CIA, patients with comorbidities) are needed to expand its clinical utility.

## 7. Conclusions

Platelet-rich plasma (PRP) has emerged as a promising and generally well-tolerated, minimally invasive therapeutic option for hair restoration, with encouraging evidence supporting its use across various hair loss subtypes, including androgenetic alopecia, alopecia areata, and telogen effluvium. PRP's mechanism of action is mediated by its rich content of platelets and growth factors, which stimulate hair follicle stem cell proliferation, prolong the anagen phase, improve scalp microcirculation, and modulate inflammation. Some clinical studies suggest that PRP may demonstrate outcomes similar to those of conventional therapies in selected settings, although this evidence remains limited, heterogeneous, and largely derived from small-scale studies. Most adverse events associated with PRP are mild, transient, and localized, with no consistently reported serious systemic adverse effects.

However, current research has several limitations, including the lack of standardized PRP preparation and administration protocols, small sample sizes, short follow-up periods, inconsistent outcome measures, and potential bias. These limitations limit the strength and generalizability of current evidence and make it difficult to compare results across studies. Despite these limitations, PRP may have important clinical implications, offering a potentially versatile treatment op-

tion for patients who are dissatisfied with or intolerant to conventional therapies, and may serve as an adjunct to enhance outcomes of existing treatments.

Future research focusing on standardization of protocols, large-scale long-term trials, optimization of delivery systems, mechanistic insights, cost-effectiveness, and combination with emerging therapies will be critical to better defining PRP's role in hair restoration. With further research and standardization, PRP may emerge as a first-line or adjunctive therapy pending confirmation from high-quality, standardized clinical trials, improving the quality of life for millions of individuals worldwide affected by this distressing condition.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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