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Effectiveness of platelet-rich plasma in treating female hair loss: A systematic review and meta-analysis of randomized controlled trials

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Abstract

Background: Hair loss profoundly affects women's physical appearance and psychological health. Platelet-rich plasma (PRP) therapy has gained attention as a potential treatment for female hair loss. This systematic review and meta-analysis aim to evaluate the efficacy and safety of PRP in treating different forms of female hair loss.

Methods: A comprehensive search was conducted across PubMed, EMBASE, Scopus, Cochrane Library, Web of Science, and ClinicalTrials.gov from January 2000 to May 2024. The focus was on randomized controlled trials investigating PRP treatment for various types of hair loss in women. The research protocol is registered with International Prospective Register of Systematic Reviews (CRD42024556190). The quality of the studies was evaluated using the Cochrane risk of bias tool (RoB 2).

Results: A total of 21 studies comprising 628 participants were included in the analysis. PRP treatment was found to significantly enhance hair density and thickness. Additionally, there was a significant reduction in the number of hairs pulled in the PRP group. Adverse effects were generally mild and transient, with no notable difference in pain or discomfort between the PRP and control groups (risk ratio: 1.01; 95% CI: 0.87–1.18).

Conclusion: PRP therapy effectively enhances hair density and thickness in women with hair loss, with a favorable safety profile. However, the effects of PRP on hair density and thickness vary with dosage, injection duration, and ethnicity, indicating the need for tailored treatment protocols.

KEYWORDS
alopecia, female hair loss, hair density, platelet-rich plasma, randomized controlled trials

1 | INTRODUCTION

Hair loss, or alopecia, significantly impacts women both physically and psychologically. Unlike men, where hair loss is often socially accepted, women experiencing hair loss often face considerable emotional distress and a diminished quality of life.[1] Female pattern hair loss (FPHL) can result from various factors, including genetics, hormonal changes, and medical conditions.[2] The two primary types of hair loss in women are androgenetic alopecia (AGA) and telogen effluvium (TE). AGA, a genetic condition, leads to progressive thinning of the hair, predominantly affecting the crown and frontal scalp. TE, often triggered by stress or hormonal changes, results in diffuse hair shedding.[3] Platelet-rich plasma (PRP) therapy has emerged as a promising treatment for hair loss in males and females.[4,5] PRP is an autologous preparation of plasma with a high concentration of platelets, which are rich in growth factors.[6] These growth factors play a crucial role in tissue repair and regeneration by promoting cell proliferation, differentiation, and angiogenesis. PRP therapy involves drawing a patient's blood, processing it to concentrate the platelets, and injecting the platelet-rich concentrate into the scalp.[7] Compared to other hair loss treatments like minoxidil and finasteride, PRP offers several advantages. Minoxidil, a topical vasodilator, and finasteride, an oral 5-alpha reductase inhibitor, have shown efficacy in treating AGA but come with limitations and side effects. Minoxidil requires continuous use, and finasteride can cause sexual dysfunction especially in men.[8] PRP, on the other hand, is a natural, minimally invasive procedure with a favorable safety profile. The growth factors in PRP stimulate hair follicle stem cells, prolong the anagen (growth) phase of the hair cycle, and reduce hair follicle, apoptosis, leading to improved hair density and thickness.[9] While PRP's potential for treating hair loss is supported by some studies, existing reviews, and meta-analyses have limitations. Zhou et al. (2021) analyzed 42 studies on PRP for women with AGA but included a mix of randomized controlled trials (RCTs), non-RCTs, and observational studies, reducing reliability. The study did not separate data for men and women, lacked a registered International Prospective Register of Systematic Reviews (PROSPERO) protocol, and failed to meta-analyze key outcomes like hair thickness and the hair pull test (HPT). Incorrect effect size calculation for hair density, high heterogeneity, and potential publication bias further undermined its credibility.[10]

Also, Oliveira's 2022 study on PRP efficacy in women with AGA had methodological flaws, including mixing RCTs with non-RCTs, which introduced biases. The study included a meta-analysis of diverse PRP preparation methods and treatment protocols, which complicated the comparison of results. Additionally, it lacked a thorough analysis of adverse events and did not clearly stratify results by PRP concentration and application techniques. These issues underscore the need for a rigorous and high-quality systematic review and meta-analysis focused solely on RCTs to better understand PRP's effectiveness for different forms of female hair loss.[11] Given the limitations of previous studies, this systematic review and meta-analysis aim to exclusively analyze RCTs to assess the effectiveness of PRP in treating various types of hair loss in women. By focusing on high-quality trials, we intend to provide robust evidence regarding the efficacy and safety of PRP therapy for female hair loss, addressing a critical gap in the current literature.

2 | METHODS

All procedures used in this systematic review and meta-analysis complied with Preferred Reporting Items for Systematic Reviews and Meta-analyses standards. The research protocol is recorded in the PROSPERO database, with the identifier CRD42024556190.

2.1 | Search methodology

We performed a comprehensive literature search covering the period from January 1, 2000, to May 31, 2024, across the following databases: PubMed, EMBASE, Scopus, Cochrane Library, Web of Science, and ClinicalTrials.gov. The search strategy incorporated keywords and related terms such as "female," "PRP," "hair loss," "AGA," "female pattern hair loss," "FPHL," and "TE." Additionally, we manually reviewed the reference lists of the identified articles to find further relevant studies.

2.2 | Study selection

This study followed the PICO (Patient, Intervention, Comparison, Outcome) framework. Participants were female individuals aged ≤18 experiencing any type of hair loss. The intervention involved administering autologous PRP, prepared using various methods and concentrations, through local injection. The comparator group either received a different treatment or had the opposite half of the scalp treated with something other than PRP; this group was also exclusively female. Primary outcomes included HPT results, the number of hairs pulled in the HPT, hair density, hair count, and hair thickness, with adverse effects considered as secondary outcomes. Only English-language articles were included.

2.3 | Exclusion criteria

Studies were excluded if they evaluated treatment with PRP in men, involved pre-clinical models (animal studies), or in vitro studies. Further exclusions applied to studies not reporting at least one of the primary outcomes, those with alternative study designs such as case reports, case-control studies, or those lacking a separate control group. Reviews, abstracts, conference proceedings, and duplicate studies were not included either.

2.4 | Study selection and data extraction

Each step was independently carried out by two reviewers (J.Y. and Y.H.). Titles and abstracts from the initially screened literature were rigorously assessed according to predefined criteria for inclusion or exclusion. A third reviewer (Y.G.) was contacted to reach a consensus when two reviewers could not agree. Extracted data included the first author's surname, publication year, participant demographics, details of the PRP application, outcomes measured, and follow-up duration. Data for studies with multiple experimental groups were extracted separately.

2.5 | Subgroup analysis

Subgroup analyses were conducted based on predetermined criteria, including the location, type of hair loss, number of participants, and duration and volume of PRP administration.

2.6 | Assessment of study quality and publication bias

Two independent reviewers rigorously assessed the validity and potential biases of the included studies (J.Y. and H.W.). Conflicts were adjudicated by a third reviewer (Y.G.). The Cochrane risk of bias tool (RoB 2) was used to assess the quality of RCTs. Funnel plots were visually inspected, and Egger's regression test was used to formally assess plot symmetry. In cases of detected asymmetry, the random trim and fill method was employed as a sensitivity analysis. A leave-one-out sensitivity evaluation was also performed to further assess how each study affected the overall meta-analysis findings.

2.7 | Statistical analysis

Versions 5.4 of Review Manager (RevMan) and 14 of Stata (College Station, TX, USA) software were employed for the statistical analysis. To compare the means of the control and intervention groups, the mean difference (MD) was computed. Also, for the HPT and adverse effects, risk ratio (RR) were calculated. Inter-study heterogeneity was evaluated using the I^2 statistics. We used the fixed effects model if we did not find any significant heterogeneity ($I^2 < 50\%$ or $p > 0.05$), and the random effects model otherwise. EndNote version 21 was used for reference management and data organization. A p-value ≤ 0.05 was considered statistically significant.

3 | RESULTS

3.1 | Study selection

After thorough database searches, a total of 10 810 records were identified. Following the removal of 578 duplicate records, 10 232 records remained for screening. During the initial screening phase, 7894 records were excluded due to various reasons: 2809 were review articles, 72 were non-English language studies, 12 were animal trials, 1874 were unrelated studies, and 127 were excluded due to other reasons. This left 5338 reports to be sought for retrieval. However, 5270 reports were not retrieved due to irrelevance (4972), unavailability of full-text (47), unpublished data (36), and other reasons (215). Consequently, 68 reports were assessed for eligibility. Out of these, 47 reports were excluded for the following reasons: undesirable population (35), intervention (3), outcome (7), and other factors (2). Ultimately, 21 studies [12–19] were incorporated into the qualitative analysis, while 19 studies were included in the quantitative analysis. The comprehensive study selection process is illustrated in Figure 1.

3.2 | Study characteristics

A total of 21 studies, published between 2015 and 2023, were included in the analysis. The types of hair loss conditions studied included AGA in 6 studies,[13–15,18] chronic TE (CTE) in 12 studies,[16] and FPHL in 3 studies.[12,17,19] Country distribution showed that 5 studies were conducted in the USA,[14,15,18] 13 in Egypt,[16] 2 in India,[12] 1 in Korea,[17] and 1 in Pakistan.[13] The types of studies included 20 RCTs and 1 clinical trials.[13] Therapies utilized were PRP in 19 studies, and PRP combined with minoxidil and polydeoxyribonucleotide in 2 studies.[12,17] The most studies (19) followed a monthly (Q4W) treatment protocol and follow-up periods were ≤6 months in 20 studies. Tools and scales used for evaluation included the Ludwig scale,[12–15,18,19] Hamilton Norwood scale,[13] Visual Analogue scale,[16] and trichoscopic evaluation[17] (Table S1).

3.3 | HPT positivity

The analysis of HPT positivity rates from two studies showed a reduced risk of positive HPT results with a RR of 0.51 (95% CI [0.04, 6.05]) for the PRP administration compared to the control group. ($I^2 = 77\%$) (Figure 2).

3.4 | Pulled hair number

The analysis of the number of hairs pulled during the HPT from four studies revealed a significant decrease in the PRP-treated group compared to the non-PRP intervention, with a MD of −3.91 (95% CI [−5.00, −2.81], $I^2 = 85\%$) (Figure 3).

3.5 | Hair count

The analysis from two studies indicated a reduction in hair count in the PRP group, with a MD of −16.82 (95% CI [−60.41, 26.77], $I^2 = 97\%$) (Figure 4).

3.6 | Hair thickness

Outcomes for hair thickness were extracted and analyzed from the 17 included studies. The meta-analysis revealed that PRP-based interventions significantly increased hair thickness compared to the control group, with an MD of 0.01 mm (95% CI [0.01, 0.01], $I^2 = 97\%$, $p < 0.00001$ (Figure 5).

3.7 | Hair density

An analysis of hair density from 17 studies demonstrated a substantial increase in the PRP group relative to the control counterpart. The observed difference was 405.26 hairs/cm^2 (95% CI [353.82, 456.69], $I^2 = 99\%$) (Figure 6).

3.8 | Sensitivity analysis

After excluding Agarwal (2022), the difference in hair density remained significant (MD = 456.11 [375.15, 537.07], $p < 0.00001$). Similarly,

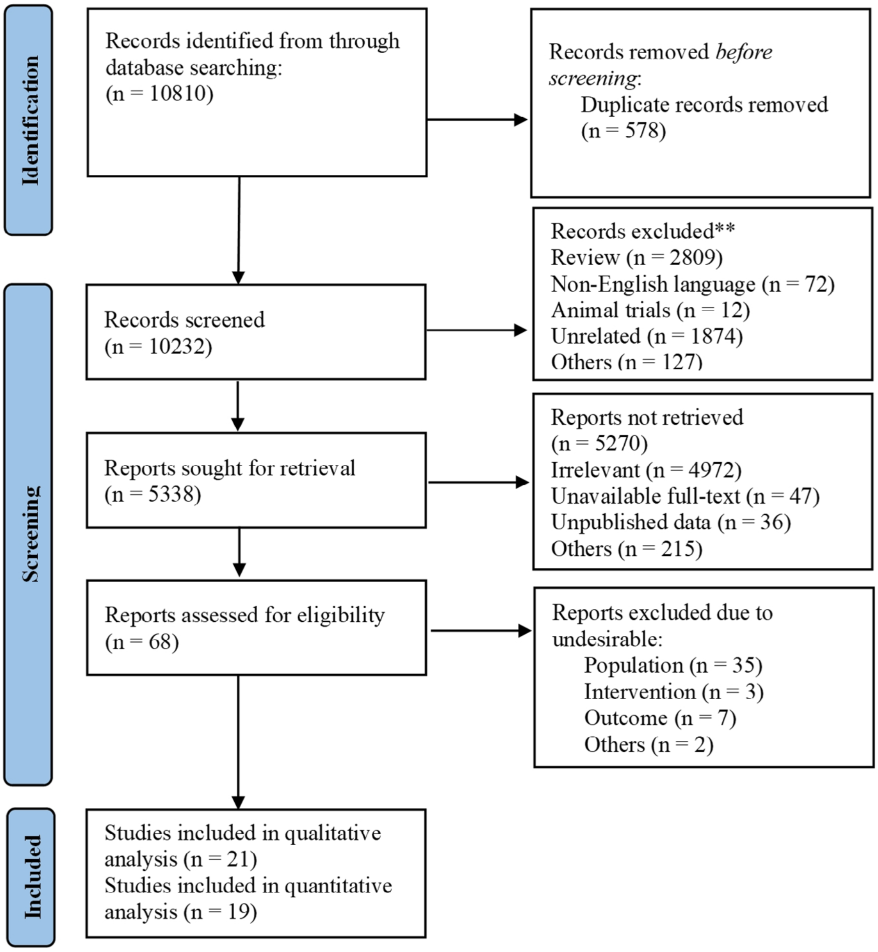

FIGURE 1 PRISMA flowchart depicting the study selection process. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

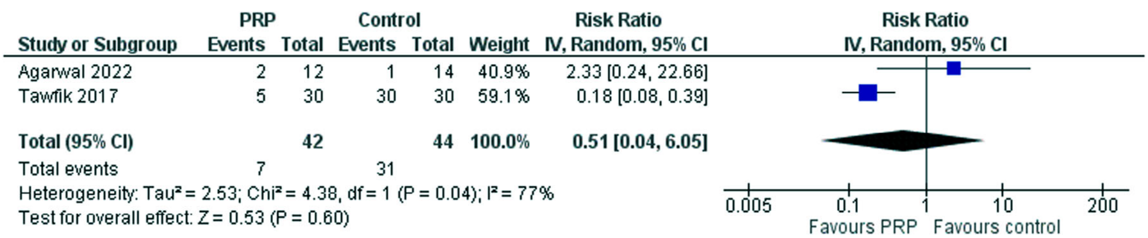

FIGURE 2 Forest plot presenting the aggregated RR estimate for HPT positivity post-PRP treatment. HPT, hair pull test; PRP, platelet-rich plasma; RR, risk ratio.

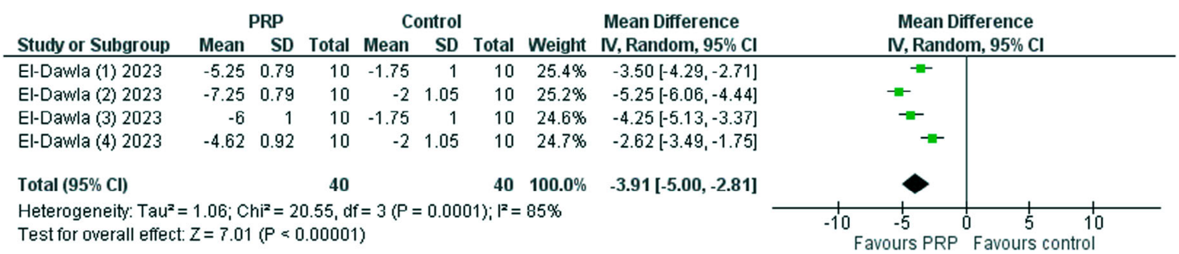

FIGURE 3 Forest plot of the pooled MD in the number of hairs pulled during HPT following PRP treatment. HPT, hair pull test; MD, mean difference; PRP, platelet-rich plasma.

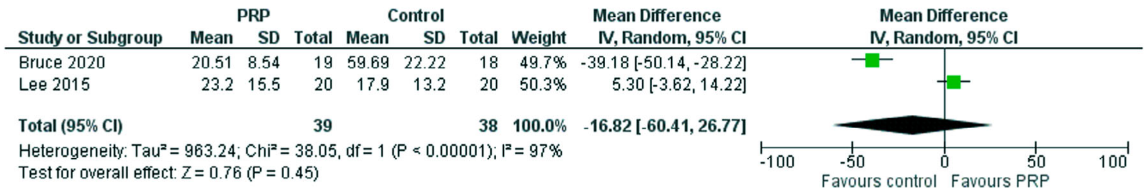

FIGURE 4 Forest plot of the pooled MD in hair count after PRP treatment. MD, mean difference; PRP, platelet-rich plasma.

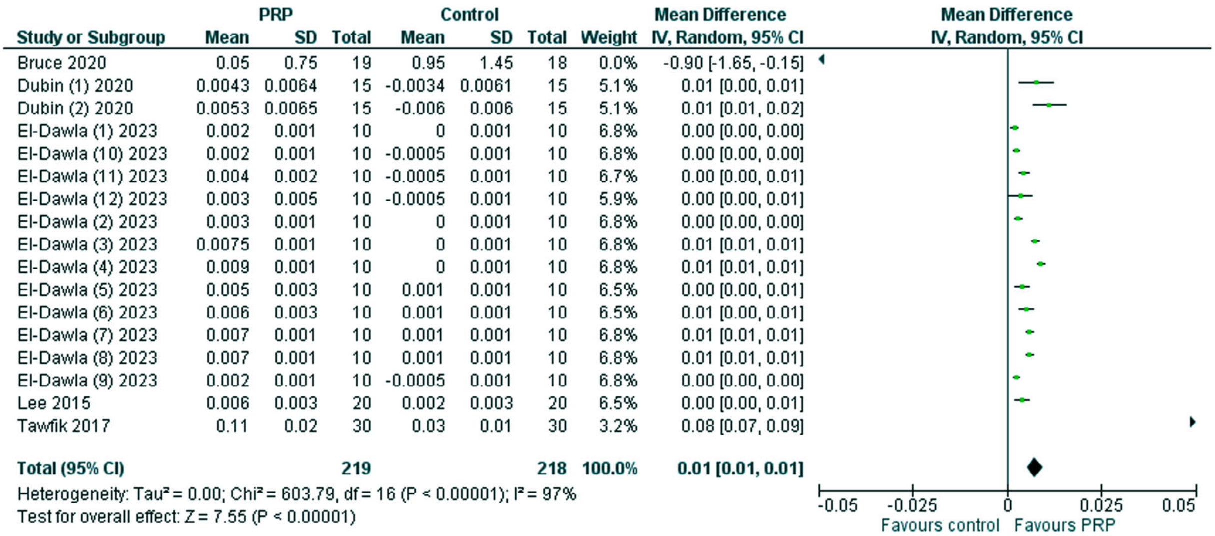

FIGURE 5 Forest plot showcasing the combined MD in hair thickness following PRP therapy. MD, mean difference; PRP, platelet-rich plasma.

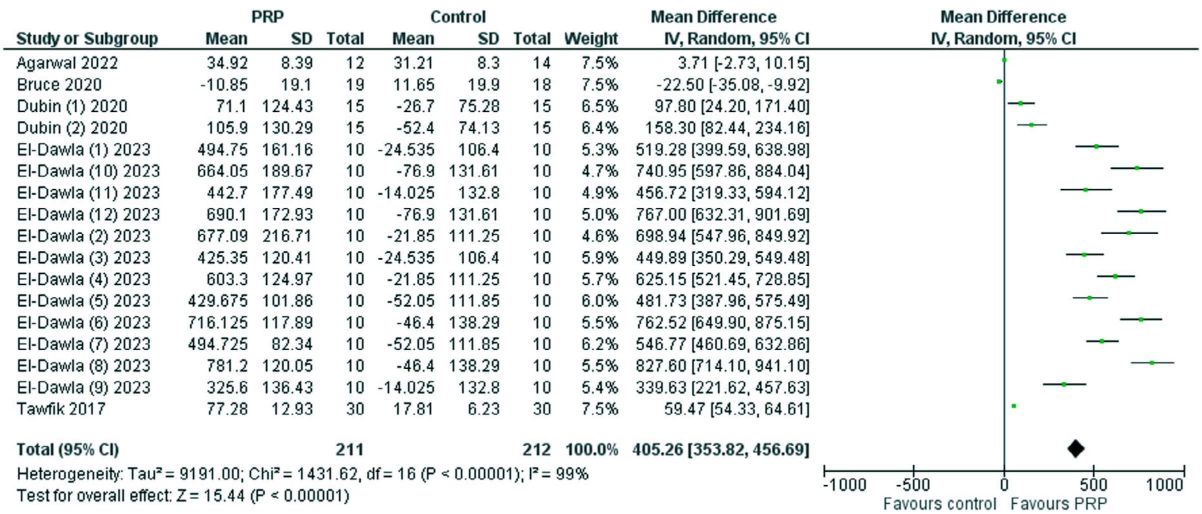

FIGURE 6 Forest plot illustrating the aggregated MD in hair density (hairs/cm^2) post-PRP treatment. MD, mean difference; PRP, platelet-rich plasma.

removing the study by Tawfik (2017) resulted in a significant MD in hair thickness post-PRP treatment (MD = 0.01 [0.00, 0.01], $p < 0.00001$ (Figure 7).

3.9 | Publication bias

For hair density, the funnel plot revealed noticeable asymmetry, suggesting potential publication bias. Further, this observation was supported by Egger's test (slope: −2.86, 95% CI [−4.45, −1.27]; $p = 0.002$). However, the trim and fill analysis showed that five studies were trimmed, resulting in an adjusted MD of 3.01 (95% CI [2.03, 3.99]), indicating that the adjusted results still suggest a significant effect. Similarly, for hair thickness, the funnel plot also displayed asymmetry, reinforcing the likelihood of publication bias. Egger's test further corroborated this with significant results (slope: −1.99, 95% CI [−3.51, −0.48]; $p = 0.013$). The trim and fill analysis trimmed two studies, resulting in an adjusted MD of 2.91 (95% CI [2.01, 3.81]),

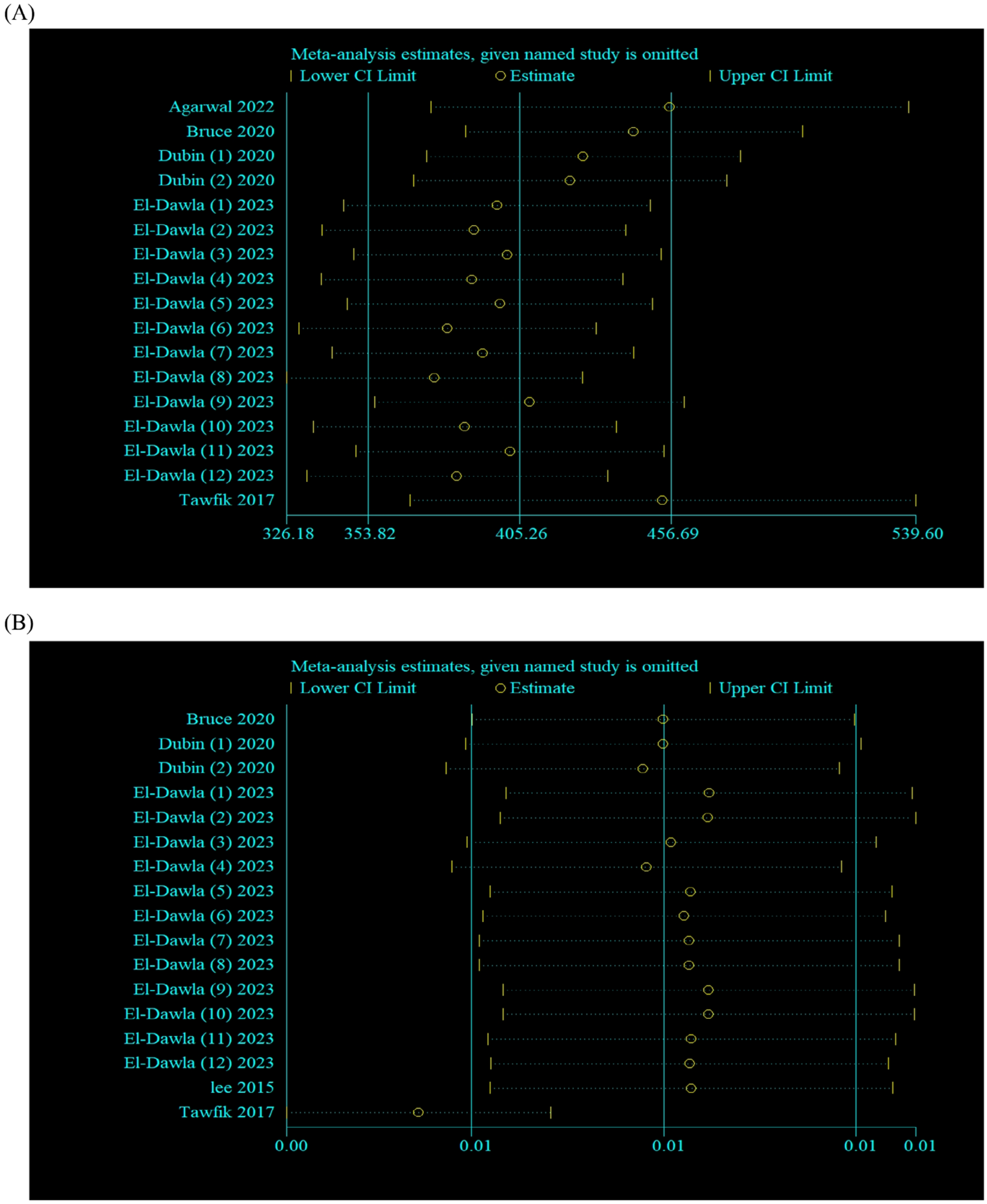

FIGURE 7 Sensitivity analysis of studies evaluating (A) hair density and (B) hair thickness outcomes post-PRP administration. PRP, platelet-rich plasma.

suggesting that the adjusted results continue to show a significant effect (Figure 8).

3.10 | Risk of bias assessment

Most studies exhibited low risk across key domains, including selection of reported results, missing outcome data, and outcome measurement. However, there were some concerns related to deviations from intended interventions, with high risk observed in a study. Moreover, bias arising from the randomization process was generally low, with only one study rated as high risk. In general, some concerns were noted for bias due to deviations from intended interventions and randomization process, while bias in other aspects remained predominantly low risk (Figure 9).

3.11 | Subgroup analysis

The greatest effect of PRP on hair thickness was observed in patients with FPHL (MD = 0.04 [−0.03, 0.12], p = 0.27) and in

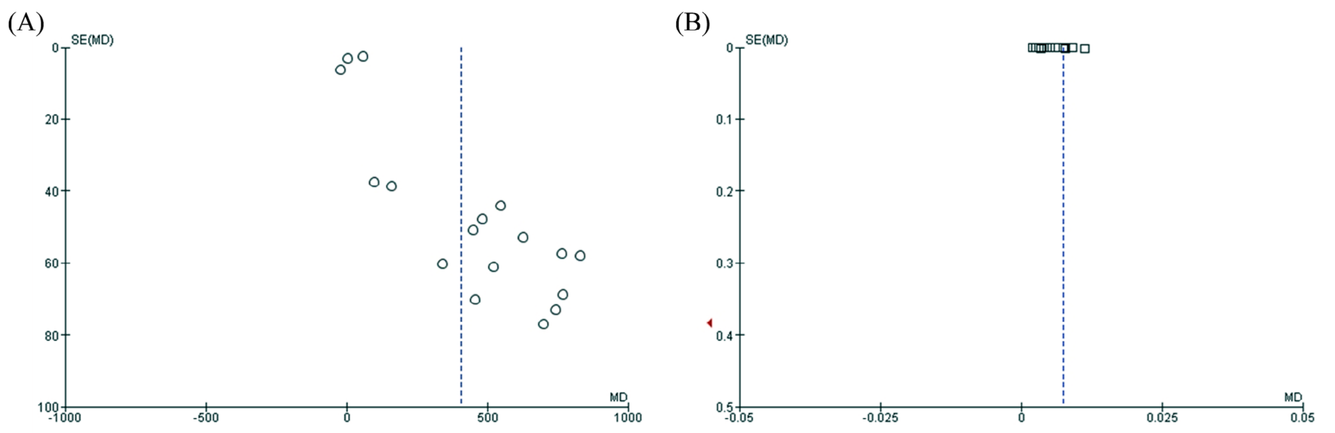

FIGURE 8 Funnel plot assessment of studies examining the effects of PRP administration on (A) hair density and (B) hair thickness. PRP, platelet-rich plasma.

those who received treatment for <6 months (MD = 0.01 [0.01, 0.01], $p < 0.00001$). Additionally, the highest increase in hair thickness was noted in studies with >30 participants (MD = 0.03 [−0.04, 0.11], $p = 0.39$), and the best results were seen in Egyptian patients (MD = 0.01 [0.01, 0.01], $p < 0.00001$). The greatest effect on hair density was observed in patients with CTE (MD = 598.77 [512.65, 684.90], $p < 0.00001$) and in those who received treatment for ≥6 months (MD = 581.95 [348.13, 815.77], $p < 0.00001$). Additionally, the highest increase in hair density was noted in studies with ≤30 participants (MD = 496.25 [312.39, 680.10], $p < 0.00001$), and the best results were seen in Egyptian patients (MD = 558.32 [348.76, 767.88], $p < 0.00001$). Moreover, the volume of PRP injected also had a significant impact, with injections >5 mL showing a notable increase in hair density (MD = 598.77 [512.65, 684.90], $p < 0.00001$) (Table S2).

3.12 | Adverse events

The meta-analysis of three studies found no significant difference in pain/discomfort RR between PRP-treated patients and the control group (RR = 1.01, 95% CI [0.87, 1.18], $p = 0.89$, $I^2 = 66\%$). Additionally, the most commonly reported adverse effects included headache, scalp tightness, swelling, redness, post-injection bleeding, and tingling. These adverse effects were all mild and resolved spontaneously within 24 h (Figure 10).

4 | DISCUSSION

The effectiveness of PRP therapy in addressing hair loss among women has garnered substantial interest due to its potential regenerative properties. Hair loss in women, whether due to AGA, TE, or other factors, significantly impacts physical appearance and psychological well-being.[21] This systematic review and meta-analysis evaluated the impacts of PRP therapy on various aspects of hair restoration. By synthesizing data from RCTs, this study provides a nuanced understanding of PRP therapy's efficacy and safety, offering insights into its potential as a promising option for managing female hair loss.

The results indicated that PRP therapy significantly increased hair density in women with AGA, TE, and FPHL. This finding aligns with previous studies, which reported substantial improvements in hair density following PRP treatment.[22] This increase involves the growth factors in PRP, which stimulate hair follicle stem cells, prolong the anagen phase of the hair cycle, and reduce follicle apoptosis. These processes collectively enhance hair density, providing a robust therapeutic effect.[23] Studies have shown similar mechanisms at play, emphasizing the role of platelet-derived growth factor (PDGF) and vascular endothelial growth factor (VEGF) in promoting hair growth.[24]

Additionally, our analysis revealed a notable increase in hair thickness in PRP-treated groups, consistent with findings in the literature.[25] The growth factors in PRP, such as PDGF and VEGF, play crucial roles in promoting cell proliferation, differentiation, and angiogenesis, leading to improved hair thickness. This improvement highlights PRP's potential as an effective treatment for enhancing hair quality.[26] The reduction in HPT positivity rates further underscores the efficacy of PRP therapy. The analysis showed a significant decrease in the number of hairs pulled out in PRP-treated groups, indicating enhanced hair follicle stability and strength. This outcome is consistent with other studies, which also observed reduced hair shedding following PRP treatment. The stability provided by PRP helps maintain hair density and reduce hair loss, offering a practical solution for women suffering from hair thinning and shedding.[27] Although our analysis could not demonstrate that PRP treatment significantly increased overall hair count. This lack of significant increase could be attributed to the high variability in PRP preparation methods, application protocols, and the limited number of studies available, potentially leading to inconsistent treatment outcomes. In terms of safety, PRP therapy demonstrated a favorable profile, with mild and transient side effects such as local pain, scalp sensitivity, and pinpoint bleeding being the most commonly reported. The meta-analysis found no significant difference in pain or discomfort RR between PRP-treated patients and the control group, further supporting PRP's favorable safety profile. These findings align

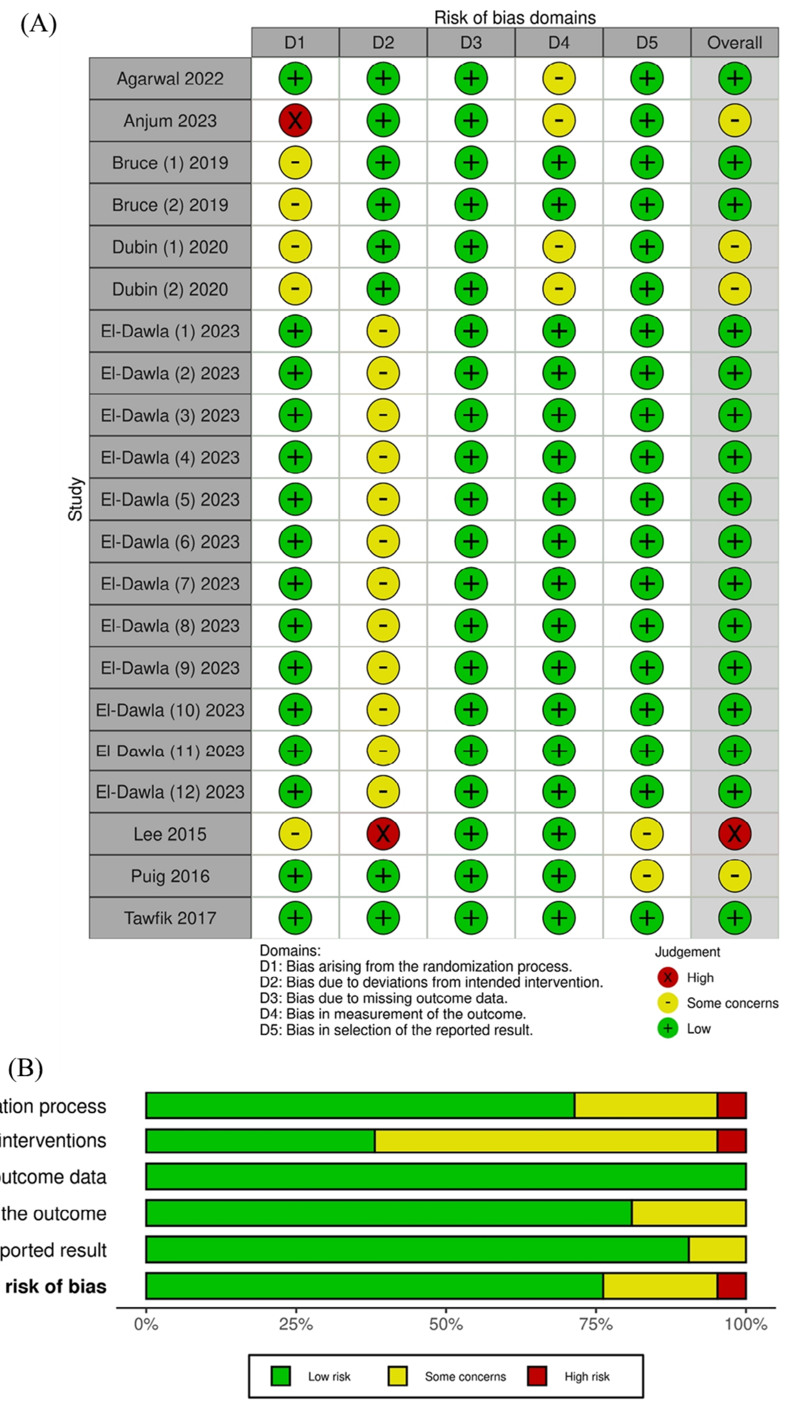

FIGURE 9 Visualization of risk of bias using the *robvis* tool. (A) Individual risk of bias evaluations for each included study. (B) Aggregated assessments of risk of bias items, displayed as percentages across all included studies.[20]

with previous research, which highlighted the minimal adverse effects associated with PRP therapy. The natural and minimally invasive nature of PRP makes it a preferable option for many patients compared to conventional treatments like minoxidil and finasteride, which can have more severe side effects.[28] Emerging therapies, including low-level laser therapy (LLLT), microneedling, and oral spironolactone, have also been investigated for hair loss. LLLT promotes hair growth by stimulating hair follicles with laser light but requires frequent sessions and has mixed efficacy results, particularly in women.[29] Microneedling involves creating tiny punctures in the scalp to stimulate hair growth, but it can be uncomfortable and requires multiple treatments to see results.[30] Oral spironolactone, an anti-androgen medication, has shown promise in treating hair loss in women by reducing androgen levels. However, it carries the risk of side effects such as menstrual irregularities, breast tenderness, and potential impacts on blood pressure, limiting its versatility compared to PRP.[31] Furthermore, advanced treatments like

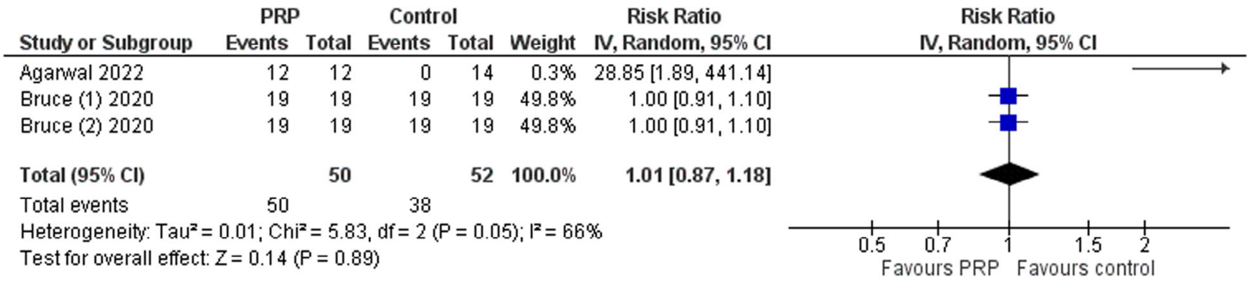

FIGURE 10 Forest plot of pooled estimate for RR of pain/discomfort following PRP treatment. PRP, platelet-rich plasma; RR, risk ratio.

stem cell therapy and exosome therapy present potential benefits but also have significant limitations. Stem cell therapy aims to regenerate hair follicles by injecting stem cells into the scalp, but it is still in the experimental stages and carries risks related to cell migration and tumor formation. Exosome therapy involves using cell-derived vesicles to promote hair growth, but it is expensive and lacks long-term safety data.[32] Compared to these alternatives, PRP offers several distinct advantages. PRP is a natural, minimally invasive procedure with a favorable safety profile. It utilizes the body's natural healing mechanisms, reducing the risk of allergic reactions or immune responses. PRP is also versatile and effective without the significant side effects or discomfort associated with other treatments, making it a promising alternative or complementary treatment for hair loss, especially for women.[33] Although for hair density, the greatest effects were seen in patients with CTE and those treated for >6 months, suggesting PRP therapy's long-term efficacy. Larger studies and those involving Egyptian patients demonstrated more pronounced increases, indicating potential genetic or environmental influences. Injecting volumes >5 mL significantly improved hair density. For hair thickness, the most substantial effects occurred in patients with FPHL treated for <6 months, highlighting PRP's short-term effectiveness. Studies with over 30 participants and those involving Egyptian patients showed greater improvements, again suggesting genetic or environmental factors play a role. Also, injecting up to 5 mL of PRP was crucial for noticeable thickness enhancement. However, the pronounced results in Egyptian individuals may be due to the higher number of studies conducted in Egypt, but ethnicity likely also influences treatment response. Thus, those aiming to increase hair density and thickness should consider these factors for optimal outcomes.

Despite the promising findings, this study has some limitations that should be considered in future research. The high heterogeneity among the included studies suggests variability in PRP preparation and application methods, which could affect the generalizability of the results. Additionally, potential publication bias indicated by funnel plot asymmetry and Egger's test results might have influenced the findings. The lack of long-term follow-up data limits the understanding of the sustained effects of PRP therapy. Future research should standardize PRP preparation methods, concentrations, and treatment protocols to improve efficacy and consistency. Large-scale, multicenter RCTs are needed to confirm these findings and explore PRP therapy's long-term effects on hair restoration. Studies should also investigate combining PRP with treatments like minoxidil and finasteride to determine the most effective regimens for female hair loss. Additionally, exploring PRP's efficacy in diverse populations and genetic backgrounds will optimize hair loss treatments for women. Addressing these research gaps will help clinicians better understand PRP therapy's role in managing hair loss and develop more targeted and effective treatment strategies.

5 | CONCLUSION

PRP therapy has emerged as a highly effective treatment for female hair loss, significantly enhancing hair density and thickness with minimal side effects. Its favorable safety profile and natural approach make it a superior alternative to traditional treatments like minoxidil and finasteride. Future research should focus on refining preparation methods, exploring combination treatments, and assessing long-term effects to further validate and optimize PRP therapy. These efforts will help establish PRP as a reliable and mainstream solution for female hair loss. Moreover, based on the primary goals of women with hair loss to increase hair thickness or density, treatment should be adapted according to concentration and duration.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

CONSENT FOR PUBLICATION

Not applicable.

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REFERENCES

1. Gkini M-A, Joliffe V. Hair disorders and impact on quality of life. *Psychodermatology in Clinical Practice*. Springer; 2021:283-302.
2. Shapiro J, Sicco KL, Otberg N, Cummins D, Tuan H-H. *Hair Loss and Restoration*. CRC Press; 2024.
3. Ramadan AA, Khaleel HM. Trichoscopic comparison between telogen effluvium and androgenic alopecia *Duhok Med J*. 2023;17(1):51-63.
4. Wei W, Zhang Y, Long B, Zhang Y, Zhang C, Zhang S. Injections of platelet-rich plasma prepared by automatic blood cell separator combined with topical 5% minoxidil in the treatment of male androgenetic alopecia. *Skin Res Technol*. 2023;29(7):e13315.
5. Behrangi E, Rahimi ST, Zare S, et al. Evaluation of the effects of adding an adipose tissue-derived stromal vascular fraction to platelet-rich plasma injection in the treatment of androgenetic alopecia: a randomized clinical trial. *Skin Res Technol*. 2024;30(4):e13700.
6. Pixley JN, Cook MK, Singh R, Larrondo J, McMichael AJ. A comprehensive review of platelet-rich plasma for the treatment of dermatologic disorders. *J Dermatolog Treat*. 2023;34(1):2142035.
7. Sun Y, Yang L, Du L, et al. Duo-role platelet-rich plasma: temperature-induced fibrin gel and growth factors' reservoir for microneedles to promote hair regrowth. *J Adv Res*. 2024;55:89-102.
8. Gupta AK, Talukder M, Shemar A, Piraccini BM, Tosti A. Low-dose oral minoxidil for alopecia: a comprehensive review. *Skin Appendage Disord*. 2023;9(6):423-437.
9. Anastassakis K. Platelet-Rich Plasma (PRP). *Androgenetic Alopecia From A to Z: Vol. 3 Hair Restoration Surgery, Alternative Treatments, and Hair Care*. Springer; 2023:665-692.
10. Zhou S, Qi F, Gong Y, et al. Platelet-rich plasma in female androgenic alopecia: a comprehensive systematic review and meta-analysis. *Front Pharmacol*. 2021;12:642980.
11. de Oliveira AFQ, Arcanjo FPN, Rodrigues MRP, Rosa e Silva AA, Hall PR. Use of autologous platelet-rich plasma in androgenetic alopecia in women: a systematic review and meta-analysis. *J Dermatolog Treat*. 2023;34(1):2138692.
12. Agarwal A, Mendiratta V. Comparative efficacy of topical minoxidil alone against combination of topical minoxidil and platelet rich plasma in women with female pattern hair loss—a pilot, open randomised trial. *Indian J Dermatol*. 2023;68(1):121.
13. Anjum R, Hassan T, Shahzad MK, Hanif N, Anjum Z. Efficacy differences of platelet rich plasma for treatment of androgenetic alopecia between men and women. *Pak J Med Health Sci*. 2023;17(04):85-87.
14. Bruce AJ, Pincelli TP, Heckman MG, et al. A randomized, controlled pilot trial comparing platelet-rich plasma to topical minoxidil foam for treatment of androgenic alopecia in women. *Dermatol Surg*. 2020;46(6):826-832.
15. Dubin DP, Lin MJ, Leight HM, et al. The effect of platelet-rich plasma on female androgenetic alopecia: a randomized controlled trial. *J Am Acad Dermatol*. 2020;83(5):1294-1297.
16. El-Dawla RE, Abdelhaleem M, Abdelhamed A. Evaluation of the safety and efficacy of platelet-rich plasma in the treatment of female patients with chronic telogen effluvium: a randomised, controlled, double-blind, pilot clinical trial. *Indian J Dermatol Venereol Leprol*. 2023;89(2):195-203.
17. Lee SH, Zheng Z, Kang JS, Kim DY, Oh SH, Cho SB. Therapeutic efficacy of autologous platelet-rich plasma and polydeoxyribonucleotide on female pattern hair loss. *Wound Repair Regen*. 2015;23(1):30-36.
18. Puig CJ, Reese R, Peters M. Double-blind, placebo-controlled pilot study on the use of platelet-rich plasma in women with female androgenetic alopecia. *Dermatol Surg*. 2016;42(11):1243-1247.
19. Tawfik AA, Osman MAR. The effect of autologous activated platelet-rich plasma injection on female pattern hair loss: a randomized placebo-controlled study. *J Cosmet Dermatol*. 2018;17(1):47-53.
20. McGuinness LA, Higgins JP. Risk-of-bias VISualization (robvis): an R package and Shiny web app for visualizing risk-of-bias assessments. *Res Synth Methods*. 2021;12(1):55-61.
21. Dhami L. Psychology of hair loss patients and importance of counseling. *Indian J Plast Surg*. 2021;54(4):411-415.
22. Meyers A, Jin A, Kwiecien GJ, Gatherwright J, Khetarpal S, Zins JE. Platelet-rich plasma for treatment of hair loss improves patient-reported quality of life. *Aesthet Plast Surg*. 2023;47(4):1528-1534.
23. Liu D, Xu Q, Meng X, Liu X, Liu J. Status of research on the development and regeneration of hair follicles. *Int J Med Sci*. 2024;21(1):80.
24. Jun X, Huifeng L, Cuiying L. The differential of growth factor expression profile in platelet-rich plasma lysate and platelet gel. *J Clin Transfus Lab Med*. 2023;25(4):450.
25. Li C, Pan L, Yang L, Kong J, Zhang L. An umbrella review of the use of platelet-rich plasma in the treatment of androgenetic alopecia. *J Cosmet Dermatol*. 2023;22(5):1463-1476.
26. Paichitrojjana A, Paichitrojjana A. Platelet rich plasma and its use in hair regrowth: a review. *Drug Des Devel Ther*. 2023;16:635-645.
27. Gentile P, Garcovich S, Bielli A, Scioli MG, Orlandi A, Cervelli V. The effect of platelet-rich plasma in hair regrowth: a randomized placebo-controlled trial. *Stem Cells Transl Med*. 2015;4(11):1317-1323.
28. Roohaninasab M, Goodarzi A, Ghassemi M, Sadeghzadeh-Bazargan A, Behrangi E, Najar Nobari N. Systematic review of platelet-rich plasma in treating alopecia: focusing on efficacy, safety, and therapeutic durability. *Dermatol Ther*. 2021;34(2):e14768.
29. Kaiser M, Abdin R, Gaumond SI, Issa NT, Jimenez JJ. Treatment of androgenetic alopecia: current guidance and unmet needs. *Clin Cosmet Investig Dermatol*. 2023;16:1387-1406.
30. Gupta AK, Quinlan EM, Venkataraman M, Bamimore MA. Microneedling for hair loss. *J Cosmet Dermatol*. 2022;21(1):108-117.
31. Anastassakis K. Spironolactone. *Androgenetic Alopecia From A to Z: Vol. 2 Drugs, Herbs, Nutrition and Supplements*. Springer; 2022:97-103.
32. Gupta AK, Wang T, Rapaport JA. Systematic review of exosome treatment in hair restoration: preliminary evidence, safety, and future directions. *J Cosmet Dermatol*. 2023;22(9):2424-2433.
33. White C, Brahs A, Dorton D, Witfill K. Platelet-rich plasma: a comprehensive review of emerging applications in medical and aesthetic dermatology. *J Clin Aesthet Dermatol*. 2021;14(11):44.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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