RESEARCH PAPER

Evaluating the Effectiveness of Non-Surgical Treatments for Androgenetic Alopecia in Men and Women: A Systematic Review and Meta-analysis

Evaluating the Effectiveness of Non-Surgical Treatments for Androgenetic Alopecia in Men and Women: A Systematic Review and Meta-analysis

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Abstract

Background: Androgenetic alopecia (AGA) is a common cause of hair loss, affecting a significant proportion of men and women. This review evaluates the efficacy of various non-surgical treatments for AGA in both genders.

Objectives: To evaluate and draw a comparison between the relative efficacies of non-invasive, non-surgical treatment modalities for AGA.

Methods: A systematic search of databases, including PubMed, Scopus, EMBASE, and Cochrane identified clinical trials on non-surgical AGA treatments published between 2016 and 2024.

Prospero registration number: CRD42024622318.

The analysis included trials with participants aged 18 years or older, and included MeSH terms- "Androgenetic Alopecia and therapy OR treatment". The inclusion criteria stated that the studies had to be any randomized or non-randomized clinical trials with participants who were at least 18 years old, of both genders.

Results: Eight studies, including one clinical trial, five randomised controlled trials (RCTs)and two non-RCTs, were reviewed. Four research investigations examined the effectiveness of five-alpha Reductase enzyme inhibitors, two dealt with minoxidil treatments, one with Low−Level Laser Therapy (LLLT) analysis, and the other three with PRP, PRF, and CGF.

Conclusion: Combination therapies, particularly those that employ PRP with LLLT, demonstrated superior results compared to standalone treatments.

Keywords : ***Androgenetic alopecia, Hair Loss, Randomised controlled trials, Low−Level Laser Therapy***

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1. Introduction

1.1 Background

Androgenetic alopecia (AGA), or male/female pattern baldness, is the most common cause of hair loss affecting 40% of women and 50% of men by age 70 [1, 2]. AGA is characterized by distinct patterns of hair loss in men (receding frontal hairline and crown thinning) and women (midline thinning with an intact hairline) [3]. Hair loss can have significant negative social, and psychological impacts, making effective treatments essential. AGA is assessed and attributed grade I through VII in males [4] and grade I-III in females,

corresponding to its severity. While various medical, surgical, and cosmetic treatments are available, no single approach has proven most effective, [5, 6] particularly for women. Treatment options include topical minoxidil, oral finasteride, and platelet-rich plasma (PRP) therapy, though long-term efficacy and side effects remain concerns [7]. There is ongoing debate regarding efficacy of oral finasteride therapy for female pattern hair loss (FPHL) [8, 9]. This systematic review explores nonsurgical, minimally invasive treatments for AGA.

1.2. Objective

The major objective of the study is to evaluate and draw comparison between the relative efficacies of non-invasive, non-surgical treatment modalities for AGA.

2. Materials and Methods

This thorough and methodical systematic study is devoted to investigating alopecia's non-surgical therapies, and was conducted as per the PRISMA guidelines.

Prospero registration number: CRD42024622318

- **Search Strategy**

Databases including PubMed, MEDLINE, EMBASE, CINAHL, PsycINFO and Cochrane databases were thoroughly searched, our main aim being evaluation of research on the wide range of non-surgical treatments of AGA.

The keywords used were:

Primary keywords	Secondary keywords
Androgenetic alopecia male pattern baldness female pattern hair loss Minoxidil finasteride Platelet-rich Plasma non-surgical treatment medical therapy placebo control group efficacy hair growth hair density Treatment outcome	low-level laser therapy LLLT laser therapy No treatment hair thickness hair diameter

The search strategy were as follows: - (("Alopecia"[MeSH] OR "Androgenetic Alopecia"[MeSH] OR 'androgenic alopecia'/exp OR androgenetic alopecia OR male pattern baldness OR female pattern hair loss OR patterned hair loss) AND ("Drug Therapy"[MeSH] OR "Minoxidil"[MeSH] OR "Finasteride"[MeSH] OR "Low-Level Light Therapy"[MeSH] OR 'drug therapy'/exp OR 'minoxidil'/exp OR 'finasteride'/exp OR 'low level laser therapy'/exp OR nonsurgical treatment OR medical therapy OR pharmacological treatment OR platelet rich plasma OR PRP OR microneedling OR laser therapy) AND ("Treatment Outcome"[MeSH] OR hair[MeSH] OR hair growth OR hair density OR hair thickness OR hair count OR efficacy)) AND ("Randomized Controlled Trial"[pt] OR "Clinical Trial"[pt].

- **Inclusion and exclusion criteria**

The studies included in our analysis were selected based on clearly defined criteria focusing on the PICO (Population, Intervention, Comparison, Outcome) framework. We adopted a stringent selection process, prioritizing clinical research that directly evaluated the efficacy of non-surgical treatments for androgenetic alopecia (AGA), such as Platelet-Rich Plasma (PRP), Platelet-Rich Fibrin (PRF), Concentrated Growth Factor (CGF), Low-Level Laser Therapy (LLLT), topical or oral minoxidil, and alpha-reductase inhibitors. Studies were excluded if they met any of the following criteria:

- Non-human (animal or in-vitro) studies
- Review articles, meta-analyses, editorials, or conference abstracts
- Duplicate publications or overlapping datasets
- Studies involving surgical interventions, such as hair transplantation
- Articles not published in English
- Studies involving participants under the age of 18
- Reports with incomplete data, unclear methodology, or insufficient follow-up duration

This strict exclusion protocol ensured that only high-relevance, methodologically sound studies were included to evaluate the comparative effectiveness of non-surgical AGA treatments.

- **Data Extraction and collection**

The dataset contained a number of crucial elements, such as the primary author's information, the type of study, sample size, patient demographics, study design, methodology of assessment, PRP preparation process, and any potential issues. The study's main objective was to investigate non-surgical therapies.

- **Evaluation of level of evidence**

The level of evidence was calculated using the Grades of Recommendation, Assessment, Development and Evaluation Pro (GRADEpro GDT: GRADEpro Guideline Development Tool [Software], Available from gradepro.org.) software. This approach considers five aspects for overall risk of bias: directness of the evidence, consistency of the results, precision of the estimates, risk of publication bias and magnitude of the effect. The quality of the body of evidence was categorized as high, moderate, low or very low.

3. Results

During the course of our investigation, 983 items were found. The specified search terms were successfully used to obtain 745 items from this set. After that, 745 papers were eliminated after a thorough evaluation of the information in their abstracts; 289 more studies were eliminated after a thorough examination of the entire text. A careful and comprehensive evaluation was conducted on the remaining 456 papers, and 380 articles that were not accessible were excluded. After a stringent screening procedure 76 papers were selected for in-depth analysis. Of these, 68 articles were disqualified for not having the necessary information. In the end, eight papers that satisfied the pre-set inclusion criteria and offered enough data were included in our review. This commitment to our pre-established inclusion criteria guarantees the research's application and usefulness.

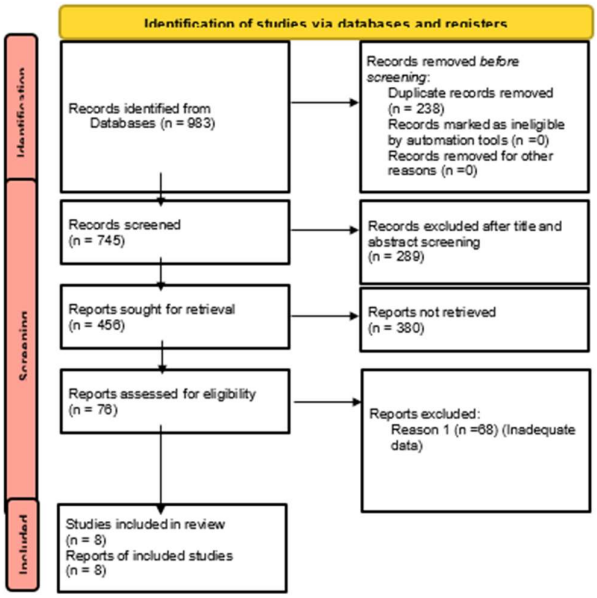

Figure 1- PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

3.1 Study selection

The thorough screening procedure that the chosen research went through was predicated on particular inclusion and exclusion standards. The titles and abstracts of every study were carefully read and only the studies that fulfilled the predetermined criteria were subjected to an extensive full-text review.

3.2 Qualitative data synthesis

Alpha Reductase Inhibitors

Finasteride, a 5-alpha reductase inhibitor, was effective in reducing dihydrotestosterone (DHT) levels, which is responsible for hair follicle miniaturization, and for reducing the detrimental effects of DHT on papilla of hair follicle. Studies confirmed the efficacy of oral finasteride in treating male AGA, although it is not recommended for women of reproductive age due to teratogenic risks [10].

Minoxidil

Concentrations of 2% and 5% are commonly used, with the latter showing more significant results in both men and women. Hyaluronic acid may be used as part of a transdermal drug delivery system along with Nitric oxide (NO), which is also implicated as a promoter of angiogenesis, and cell proliferation. It is used to extend duration of action and increase bioavailability of minoxidil [11].

Minoxidil was found to promote hair growth by causing vasodilatation of scalp blood vessels, and is commonly employed topically and sometimes orally, although it may initially cause more severe telogen hair loss in initial stages of use [12]. Interestingly, it was originally employed as treatment for hypertension before it was transformed as a treatment for hair loss [13].

Though higher concentrations (above 5%) are more effective, they may cause irritation. It is available in various forms like shampoo, foam and solutions, and low-dose oral minoxidil is now considered a safe and effective option for AGA[14]

Platelet-Rich Plasma (PRP) treatment

Research shows that PRP at 4–6 times higher platelet concentrations is ideal for hair restoration due to its growth factors that support follicle survival and tissue healing [15]. Studies[16] show increased hair follicles, vascularisation, and epidermal thickening in PRP-treated areas compared to placebo. PRP is a safe, steroid-free treatment for androgenetic alopecia and alopecia areata, used alone or with other therapies [17]. Mesotherapy with PRP has shown clinical improvement in hair loss, though more extensive studies are needed [18].

PRP treatments involve injecting concentrated platelets to stimulate hair growth. Several studies highlighted the potential of PRP to prolong the anagen (growth) phase of hair follicles. Combination therapies, such as PRP with LLLT, were particularly effective.

Table 1: Information table related to PRP for

Reference	Study design	Number of subjects	Age	Gender and AGA grade	Intervention group	Control group	Follow up	Remarks

[19]	RCT	55	23-70	34M (III-VI) 21F (II-III)	PRP (50)	Placebo (50)	6 months	Thicker hair seen only in male subjects
[20]	RCT	30	21-48	25M (III-V) 0 F	PRP (10)	Placebo (15)	4 months	Use of PRP produced a positive outcome in males
[21]	RCT	80	21-40	58M (III-IV) 11F (V-VI)	PRP (50)	Placebo (30)	3 months	PRP (activated) increased hair thickness after 6 months, greatly improved hair density after 4 months
[22]	RCT	30	19-47	20M (III,IV, VI) 10F (I,II,III)	PRP (10)	-	6 months	PRP improves global assessment scores and hair density in AGA patients
[23]	RCT	54	18-50	27M (I-VI) 27F (I-VII)	PRP (15)	Placebo (10)	3 months	Topical 5% minoxidil solution found to be less effective than PRP

Platelet rich fibrin (PRF) treatment

More clinical research is needed to fully understand PRF's impact on AGA. The studies considered in this review used fixed-angle centrifugation, leaving questions about the effectiveness of horizontal centrifugation [23]. While most studies employed low centrifugation speeds (700–800 rpm for 3–6 minutes), a few used higher speeds (1500–3000 rpm), with one study filtering the plasma after centrifugation and another using only the central layer [24]. Hair loss was assessed using the Hamilton & Norwood and Ludwig grading schemes, with most studies conducting four therapy sessions every 2–4 weeks. One study found that PRF significantly improved hair growth when applied before and after a hair transplant [25]. Another study using a 15-point rating system showed that 51.8% of the treatment group experienced significant improvement compared to 0% in the control group.

Clinical photos, trichoscopy images, conventional hair growth evaluation survey, and patient outcomes were evaluated in a study where patients had previously undergone a year of PRP and derma roller treatments. [51] The study found improvements in hair growth, with trichoscopy showing reduced shaft diameter variability, increased vellus hair regrowth, fewer yellow spots, and more hairs per follicular unit. Patient satisfaction was high, with an average score of 7.46 ±1.02, and 80% of

patients reported reduced hair loss [26]. However, the study only provided qualitative data, without quantitative measurements of follicular unit hair count or shaft diameter.

Concentrated growth factor (CGF)

Concentrated Growth Factor (CGF), a third-generation autologous platelet concentrate, has a high growth factor concentration and softer fibrin lattices [27]. A study showed that CGF sprays improved hair density in AGA patients after three months of treatment. CGF contains more growth factors than PRP, with fibrin adhering and stretching more easily. Another trial found that combining PRP with CGF gel and microneedling enhanced microcirculation and hair growth [28]. Additionally, hair density and growth rate were significantly higher with CGF and minoxidil compared to minoxidil alone, suggesting a more effective treatment for alopecia [28].

Low-Level Laser Therapy (LLLT)

A 1967 study found that low-level laser treatment (LLLT) with a ruby laser promoted hair growth, leading to FDA approval of LLLT devices for male and female baldness in 2007 and 2011. LLLT uses red or near-infrared light (650-1200 nm) to stimulate hair growth when applied three times a week for six months [29]. RCTs show LLLT increases hair density and diameter, though mild side effects like dry skin and scalp irritation have been reported. LLLT is also effective for chemotherapy-induced hair loss, extending the anagen phase and promoting hair regrowth, although its exact mechanism remains unclear [30]. While adverse effects are rare, mild reactions such as itching and erythema have been noted. One study reported temporary telogen effluvium, which resolved after two months. I n a trial with 45 women with AGA, combining 5% minoxidil with LLLT resulted in significantly faster and more effective hair regrowth than either treatment alone [31]. Additional studies confirmed that LLLT (650-660 nm) improved hair coverage and thickness compared to control group [32].

Table 2: Study characteristics of included studies

S. NO.	Reference	Participant	Study design	Hair density (PRP)	Hair density (placebo)	Hair diameter (PRP)	Hair diameter (Placebo)	Conclusion
1	[33]	68	Randomised controlled study	0.20000 ± 0.40334	-	0.05000± 0.2198	-	LLLT has proven beneficial in improving scalp health and stimulating hair growth
2	[34]	35	Randomised placebo controlled split scalp trial	151 ± 39.82 hairs/cm2 to 170.96± 37.14 hairs/cm2	151.04 ± 41.99 hairs/cm2 to 166.72 ± 37.13 hairs/cm2	56.75 ± 11.62 µm to 61.23 ± 13.12 µm	56.43 ± 10.63 µm to 62.63 ± 31.41 µm	PRP might be useful for boosting the hair density
3	[18]	19	Clinical trial	170.70± 37.81	156.25± 37.75	153.70± 39.92	149.72 ± 39.92	PRP is a novel, safe treatment that has the potential to be beneficial in AGA

								patients
4	[35]	26	RCT	P-value = 0.012	P-value = 0.171	P-value = 0.00144	P-value = 0.364	PRP is a useful therapeutic agent for AGA patients
5	[36]	10	Randomised, blinded placebo-controlled pilot study	12.76	0.99	-16.22	-19.46	Variability in PRP may impact hair growth
6	[37]	27	Randomised double blinded placebo-controlled and half-head study	106.48 ± 29.93	119.29± 24.61	104.85. ± 27.29	120.56. ± 26.86	Additional research required to determine how well topical minoxidil combined with PRP fares in treatment of AGA
7	[27]	15	Retrospective study	1.54 ± 0.10	0.8 ± 0.77	1.93 ± 0.88	0.47 ±0.64	No serious adverse effects reported, and CGF injection may help enhance hair density and count in AGA

								patients
8	[38]	30	Prospective study	149.7 ± 13.7 hairs/cm2	153.6 ± 16.8 hairs/cm2	139.7 ± 2.3	157 ± 18.3	Foreskin derived exosomes improved hair density in the first and third month after application without reported side effects

3.3 Quantitative data synthesis

The quantitative synthesis was performed for different study outcomes like Hair density, Abnormal hair loss and Hair thickness/diameter. Across the studies included in the systematic review; about 2 studies and 1 study each presented quantitative outcomes; Hair density, Abnormal hair loss and Hair thickness/diameter in Mean and SD respectively. So, the meta-analysis was performed for only one outcome; Hair density. Table 3 represents the above mentioned outcomes; as presented for each study for intervention group (PRP) and control group (placebo).

Table 3 – Quantitative data depicting Mean and SD values of Hair density, Abnormal hair loss and Hair thickness/diameter in intervention group and control group amongst included studies

Sr. no	Included studies	Intervention group (PRP)			Control group (Placebo)		
		Mean	SD	Total	Mean	SD	Total
Outcome – Hair density							
1	Shapiro J et al	170.96	37.14	35	166.72	37.13	35
2	Verma S et al	119.29	24.61	27	120.55	26.86	27
Outcome – Abnormal hair loss							
1	Wang YF et al	0.05	0.2198	60	0.375	0.5157	8
Outcome – Hair thickness/diameter							
1	Shapiro J et al	61.23	13.12	35	62.23	13.41	35

Forest plot distribution

The forest plot compares the effect of the intervention (PRP) with the control (placebo) across two included studies (Shapiro J et al. and Verma S et al.) using mean difference as the effect measure. Both studies show point estimates favoring the intervention, as their effect sizes lie on the side of the plot favoring PRP. However, the confidence interval for Shapiro et al. is wide and crosses the line of no effect, indicating that its result is not statistically significant and has lower precision, likely due to variability or smaller effective sample contribution. In contrast, Verma et al. contributes a larger weight (61.6%) and has a narrower confidence interval, though it still crosses the line of no effect, suggesting that even this study does not demonstrate a statistically significant difference individually.

The pooled effect size (Mean Difference = 0.85) also has a confidence interval ranging from −9.93 to 11.64, which crosses zero. This indicates that, overall, there is no statistically significant difference between the PRP and placebo groups. The diamond representing the combined estimate is centered close to the line of no effect and overlaps it, further confirming the lack of statistical significance. Thus, it can be stated that although both individual studies trend toward a beneficial effect of PRP, the combined evidence does not show a statistically significant advantage over placebo. The wide confidence intervals and overlap with the null value suggest uncertainty and possible heterogeneity, indicating that current evidence is insufficient to draw a definitive conclusion regarding the effectiveness of PRP.

	Intervention (PRP)			Control (Placebo)			
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Wei
Shapiro J et al	170.96	37.14	35	166.72	37.13	35	38.
Verma S et al	119.29	24.61	27	120.55	26.86	27	61.
Total (95% CI)			62			62	100.

Heterogeneity: Chi² = 0.24, df = 1 (P = 0.63); I² = 0%
Test for overall effect: Z = 0.16 (P = 0.88)

Figure 2: Forest Plot Distribution for Outcome: Hair density

3.4 GRADE FINDINGS

The evidence for the effect of PRP on hair density is derived from two randomized controlled trials involving a total of 124 participants (62 in the PRP group and 62 in the placebo group). The pooled analysis demonstrated a mean difference (MD) of 0.85 higher hair density in the PRP group compared to placebo; however, the 95% confidence interval (CI) ranged from 9.93 lower to 11.64 higher. This wide confidence interval crosses the line of no effect, indicating that the true effect may range from a meaningful benefit to a possible lack of effect or even harm. Therefore, although the point estimate slightly favors PRP, the result is statistically non-significant and clinically uncertain. In terms of GRADE domains, the certainty of evidence was judged as moderate. There were no serious concerns regarding risk of bias or inconsistency, suggesting that the included studies were methodologically sound and showed relatively consistent findings. Imprecision was also not considered serious despite the wide confidence interval, likely due to predefined thresholds. However, the evidence was downgraded by one level for indirectness, primarily due to the lack of a gold standard reference for measuring hair density. This limitation may affect the accuracy and comparability of outcome assessment across studies, thereby reducing confidence in the estimated effect.

Overall, while PRP shows a slight trend toward improving hair density, the evidence is not definitive. The moderate certainty indicates that further well-designed studies, particularly those employing standardized and validated outcome measures, are likely to have an important impact on the confidence in the estimate and may change the conclusion.

Outcome	Certainty assessment								№ of patients		Effect	Certainty
	№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		PRP	placebo	Absolute (95% CI)	
Hair density	2	randomized trials	not serious	not serious	Serious[a]	not serious	none		62	62	MD **0.85 higher** (9.93 lower to 11.64 higher)	⊕⊕⊕◯ Moderate[a]

CI: confidence interval; **MD:** mean difference

Explanation – a – lack of Gold standard

4. Discussion

Thick hair is widely regarded as a symbol of health and aesthetic appeal across cultures, and androgenetic alopecia (AGA) can significantly affect an individual's psychological well-being. Based on the present analysis,

non-surgical monotherapies for AGA in both males and females were ranked in descending order of effectiveness as follows: bimatoprost, low-level laser therapy (LLLT), finasteride (1 mg), dutasteride (0.5 mg), 5% minoxidil, 2% minoxidil, and platelet-rich plasma (PRP). Among these, LLLT, 5% minoxidil, and 2% minoxidil emerged as the most commonly utilized non-surgical interventions for female AGA. Notably, LLLT demonstrated the greatest mean improvement in treatment outcomes when compared to other therapies. Furthermore, comparative analysis revealed that finasteride (1 mg), dutasteride, minoxidil (2% and 5%), and PRP exhibited relatively similar effects on hair count improvement. However, minoxidil—particularly at concentrations of 2% and 5%—was associated with a higher incidence of adverse events. While the included trials adhered to strict inclusion criteria and provide preliminary support for LLLT as a highly effective intervention for AGA, the overall quality of evidence remains limited. This underscores the need for future high-quality, randomized controlled trials to validate these findings and establish clearer clinical guidance.

Our review evaluated studies investigating the effectiveness of PRP in treating hair loss among both male and female participants; however, studies that did not meet our inclusion criteria were excluded. For instance, a 2019 study examining the impact of PRP on hair density in female AGA patients was omitted due to its non-randomized study design [39] . Furthermore, randomized controlled trials (RCTs) published in languages other than English were excluded, which represents a limitation of this review. The treatment recommendations presented align closely with those of the 2017 European Dermatology Forum guidelines for AGA, which assess treatment outcomes based on hair density (hairs/cm²). It is also important to note that hormonal therapies, such as oral estrogens commonly recommended for female AGA, were beyond the scope of this review and therefore not included [40]. With its high-quality evidence rating, 5% minoxidil has shown to be the most effective treatment option for both male and female AGA, as our analysis has conclusively demonstrated. The strong evidence for this therapy technique was also highlighted by [40], who promised its ability to stop hair loss and promote hair growth in both genders. Our assessment of PRP highlights the need for additional study because the available data on it is of low quality. As a result, in accordance with established standards, we are unable to make definitive recommendations regarding the use of PRP for either male or female AGA at this time. Continued research in this area remains essential. According to V. Kanti et al., Low-Level Laser Therapy (LLLT) holds considerable promise as an adjunctive treatment for AGA. While current guidelines neither endorse nor discourage its use beyond six months, its potential merits further exploration. Moreover, although newer therapeutic modalities such as LLLT appear promising when compared to well-established treatments like 5% minoxidil, our network meta-analysis (NMA) underscores the need for more robust evidence. A key conclusion of this review is the critical need for high-quality, rigorously designed randomized controlled trials (RCTs). Such studies, with methodological rigor and minimal bias, are essential for producing more precise and reliable estimates of treatment efficacy and enabling more accurate comparisons among various therapeutic options.

5. Conclusion

Hair loss affects a large population annually, often impacting self-esteem and mental well-being. Non-surgical treatments are gaining popularity due to their affordability and lower risk compared to surgical options. Among them, minoxidil, finasteride, and low-level laser therapy (LLLT) are well-established for their safety and efficacy in promoting hair growth, reducing further loss, and improving scalp health. Emerging therapies like Platelet-Rich Plasma (PRP), Concentrated Growth Factors (CGF), Platelet-Rich Fibrin (PRF), and alpha-reductase inhibitors show promising potential, with some—like LLLT—possibly surpassing traditional treatments. However, further research is needed to confirm their long-term effectiveness.

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