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Systematic Review: Causes and Treatments of Hair Loss

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Abstract:

Hair loss, or alopecia, is a prevalent dermatological condition that affects millions of people worldwide, with significant psychological and social implications. This systematic review evaluates the various causes of hair loss, including genetic predisposition, hormonal imbalances, autoimmune diseases, environmental factors, and nutritional deficiencies. Additionally, it explores treatment modalities ranging from pharmacological interventions, such as minoxidil and finasteride, to advanced techniques like platelet-rich plasma (PRP) therapy and hair transplantation. The review aims to provide a comprehensive understanding of the etiology of hair loss and assess the efficacy of current treatment options based on recent clinical studies. Future research should focus on optimizing therapeutic strategies and exploring novel interventions for improving hair regrowth outcomes.

Introduction

Background and Importance of Hair Loss Research

Hair plays a critical role in human appearance, self-esteem, and identity. The loss of hair, whether due to genetic, medical, or environmental factors, can significantly impact an individual's psychological well-being and social interactions. Hair loss, commonly referred to as alopecia, affects both men and women, with varying degrees of severity and underlying causes [1]. The global prevalence of hair loss has increased in recent years, possibly due to a combination of lifestyle changes, environmental pollutants, stress, and genetic predisposition [2].

Hair loss is broadly categorized into non-scarring (reversible) and scarring (irreversible) alopecia. The most common forms include androgenetic alopecia, telogen effluvium, alopecia areata, and traction alopecia [3]. While some forms of hair loss are temporary and can be reversed with treatment, others require long-term management strategies or surgical interventions [4]. Understanding the root causes of hair loss is essential for developing effective prevention and treatment plans.

Epidemiology of Hair Loss

Hair loss is a common problem, affecting millions of people globally, particularly in older populations. Approximately 80% of men and 50% of women will suffer from androgenetic alopecia (AGA) in their lifetimes [5]. In men, the typical pattern is that of a receding hairline combined with thinning in the crown region and in women the thinning is generally diffuse and does not usually involve the hairline [6].
Other types of hair loss, such as telogen effluvium, caused by stress, hormonal changes, or lack of

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nutrients, will affect around 30% of adults at some point in their lives [7]. Alopecia areata, an autoimmune condition, has a global prevalence rate of about 2%, with an equal gender distribution, affecting individuals of all ages [8].

A significant cause of hair loss is androgenetic alopecia, which affects up to 70% of men and 40% of women. Hair loss is therefore not only a cosmetic issue, but also has economic considerations as the global hair restoration and treatment industry is worth more than $10 billion per year [9]. As more awareness is created and more effective treatment modalities are developed, the demand for management, both medical and cosmetic, has grown.

The Hair Growth Cycle and Its Relevance to Hair Loss

What Does the Hair Growth Cycle Have to Do with Hair Loss?
Hair goes through three different phases, including the anagen (growth), catagen (transition) and telogen (resting) phases. During the anagen phase, which lasts for 2 to 7 years (depending on genetic and hormonal factors), the hair follicle produces the hair shaft, which will determine hair length. The catagen phase is a momentary transitioning time period of 2 to 3 weeks where the hair follicle contracts. The telogen phase is about 3 months long, before the hair falls out and repeats the cycle [10].
Hair loss occurs when the natural balance between hair growth and shedding is disrupted. For example, in androgenetic alopecia, DHT (dihydrotestosterone) shortens the anagen phase, leading to miniaturization of hair follicles and gradual thinning [11]. In contrast, telogen effluvium causes a **premature shift of hair follicles into the telogen phase**, leading to excessive shedding [12].

Psychological and Social Impact of Hair Loss

It can be psychologically impactful, hair loss can also cause anxiety, depression, and low self-esteem among those affected. Research indicates that as many as 60% of people who are losing their hair experience clinically significant emotional distress, with women more likely to experience anxiety-type symptoms compared to men [13].

It can shape social life, professional growth, and even self-esteem due to social stigma attached to baldness. The psychological implications of hair loss have led many individuals to seek medical or cosmetic treatments for hair restoration [14]. this is the concept behind psychodermatology, which explores the mind-skin connection and emphasizes the importance of an integrative approach in managing dermatological disorders and hair loss by considering psychological components further highlighting the need for a whole body approach that considers physical as well as emotional well-being [15].

Factors Influencing Hair Loss

Several intrinsic and extrinsic factors contribute to hair loss, including:

- ✓ **Genetics:** Hereditary factors play a dominant role in androgenetic alopecia [16].
- ✓ **Hormonal Imbalances:** Conditions such as hypothyroidism, hyperthyroidism, and PCOS can disrupt hair growth cycles [17].
- ✓ **Autoimmune Disorders:** Alopecia areata results from an immune-mediated attack on hair follicles [18].
- ✓ **Nutritional Deficiencies:** Lack of iron, vitamin D, zinc, and protein can contribute to excessive shedding [19].
- ✓ **Stress and Lifestyle:** Chronic stress elevates cortisol levels, which can negatively impact hair follicle function [20].
- ✓ **Medications:** Chemotherapy drugs, anticoagulants, and beta-blockers are known to cause hair thinning as a side effect [21].

Understanding these factors is crucial in determining the appropriate treatment for different types of hair loss.

Advances in Hair Loss Research

Recent scientific advancements have led to improved diagnostic techniques and innovative treatments for hair loss. **Trichoscopy**, a non-invasive diagnostic tool, allows for detailed examination of the scalp and hair follicles, aiding in early detection of hair disorders. Additionally, **biological therapies**, such as platelet-rich plasma (PRP) injections and stem cell therapy, have shown promising results in stimulating hair regrowth [21].

Genetic research has also revealed potential targets for treating hair loss, including the **Wnt signaling**

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pathway, which plays a crucial role in follicular regeneration. Clinical trials exploring **JAK inhibitors**, originally developed for autoimmune conditions, have demonstrated efficacy in treating alopecia areata [21]. These advancements offer hope for individuals seeking more effective and personalized hair restoration treatments.

Hair loss can be caused by several factors, including genetics, hormones, medications, and stress.

Genetics
Male pattern baldness: A hereditary condition that causes hair to thin and recede, usually starting at the temples and crown

Hormones
Pregnancy, childbirth, and menopause: Hormonal changes can cause hair loss
Thyroid disease: An overactive or underactive thyroid can cause hair loss

Medications
Chemotherapy and other drugs used to treat cancer, arthritis, depression, and other conditions can cause hair loss
Birth control pills, beta-blockers, calcium channel blockers, and some antidepressants can also cause hair loss

Stress
Severe emotional stress, such as the loss of a loved one, can cause hair loss
Telogen effluvium, a type of diffuse hair loss, can develop after a stressful event

Other causes
Alopecia areata, an immune system-related condition that causes patchy hair loss
Tinea capitis (ringworm), a scalp infection
Trichotillomania, a hair-pulling disorder
Nutritional deficiencies, especially of iron, protein, biotin, folate, and vitamin B12
Hairstyles that pull hair tight, such as braids, ponytails, and cornrows
Chemical treatments, such as perms and bleach

Management and Treatment

How is hair loss treated?
If your hair loss results from medication, hormonal imbalances, thyroid disease or diet, your provider will address the cause. Correcting the underlying problem is often all that's needed to help stop hair loss.

Most hair loss treatments are meant to help with androgenic alopecia (male and female pattern hair loss). These treatments include:

Medication: Over-the-counter medications you apply to your scalp (such as minoxidil, or Rogaine®) are usually the first course of treatment for thinning hair. A prescription oral medication (finasteride, or Propecia®) is approved only for men with male pattern baldness.

Hair transplant: During a hair transplant, your provider carefully removes strands of hair from an area of your scalp where the hair is thickest. The provider then transplants those strands, embedding them into your scalp where your hair is thinnest.

Platelet-rich plasma (PRP): After drawing your blood, your provider separates out the plasma. They then inject this platelet-rich plasma into your scalp. PRP treatment can help slow hair loss and encourage new hair growth.

Diagnosis and Tests

How is hair loss diagnosed?

In some cases, the cause of hair loss is obvious — for example, if you're losing hair while going through chemotherapy. Other times, your healthcare provider will need to do some detective work to figure out what's causing your hair loss.

To determine the correct diagnosis, your provider may:
Ask about your family history, including if any relatives experienced hair loss and at what age.
Look at your medical history.
Order blood tests to measure thyroid function and iron levels.
Examine your scalp for signs of infection.
Take a scalp biopsy to check for skin disease.

What are the symptoms of hair loss?

People experience hair loss in different ways, depending on the type of hair loss and what's causing it. Common symptoms include:
Receding hairline (typical of male pattern baldness).
Thinning hair all over the head (typical of female pattern hair loss).

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Loss of small patches of hair on the scalp.
Loss of hair on the scalp and body.
Symptoms and Causes

Overview

What is hair loss?

Most healthy people lose up to 100 strands of hair per day. As part of your hair's growth cycle, new strands grow and take the place of the ones you shed

When you start to shed more strands — and fewer or none grow back — the condition is considered alopecia (hair loss). There are several types of hair loss, and it can affect adults of either sex and even children. You may lose hair just on your head or from your body as well.

What are the types of hair loss?

Some types of hair loss are permanent, while others are temporary. The most common types of hair loss include:

Androgenic alopecia: This type of hereditary baldness can affect anyone (male pattern baldness or hair loss in women).

Alopecia areata: Alopecia areata is an autoimmune disease that results in hair loss from the head and body.

Telogen effluvium: This type of hair loss involves rapid shedding of hair in a short amount of time. It typically happens a few months after your body goes through something physically or emotionally stressful. It can also result from sudden hormonal changes.

Anagen effluvium: This very rapid hair loss occurs due to certain medical treatments, such as chemothera

Symptoms and Causes

What causes hair loss?
Hair loss has many possible causes. The most common include:
Hereditary hair loss from genetics (genes you inherit from your parents).
Fungal infections on the scalp.
Hairstyles that pull the hair tightly (such as braids, hair extensions or tight ponytails).

Haircare that may cause damage due to processing (including perms and bleach).
Hormonal changes (such as pregnancy, childbirth or menopause).
Medical treatment (such as chemotherapy and certain medications).
Nutritional deficiencies (especially not getting enough iron or protein).
Stressful events (like having surgery or losing a loved one).
Thyroid disease.

Methods

Search Strategy

This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A thorough systematic literature search was performed within the electronic databases PubMed, Scopus, Web of Science, and Google Scholar for peer-reviewed studies published between 2000 and 2024. The search employed keywords and MeSH terms of "hair loss," "alopecia," "androgenetic alopecia," "hair regrowth treatments," "minoxidil," "finasteride," "platelet-rich plasma (PRP)," "hair transplantation," and "nutritional deficiencies and hair loss." Refinement of search results was achieved by using Boolean operators (AND, OR). We also screened the reference lists of included studies for relevant publications.

Inclusion and Exclusion Criteria

To ensure the selection of high-quality studies, specific inclusion and exclusion criteria were applied.

Inclusion Criteria:
• Studies examining the causes, mechanisms, and treatments of hair loss.
• Clinical trials, meta-analyses, systematic reviews, and observational studies.
• Research involving both male and female participants.
• Studies published in peer-reviewed journals.
• Articles available in English.

Exclusion Criteria:
• Non-peer-reviewed articles, case reports, and opinion pieces.

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- Studies focusing solely on animal models.
- Articles with incomplete methodologies or insufficient sample sizes.
- Duplicate publications.
- Studies not providing clear diagnostic criteria for hair loss.

Data Extraction and Quality Assessment

Two independent reviewers screened the titles and abstracts of all identified studies. Full-text screening was conducted for potentially relevant articles. Disagreements were resolved through discussion or consultation with a third reviewer. Data extraction was performed using a standardized template to collect information on study design, population characteristics, diagnostic methods, treatment interventions, and primary outcomes.

Quality assessment of selected studies was conducted using the **Cochrane Risk of Bias Tool** for randomized controlled trials (RCTs) and the **Newcastle-Ottawa Scale (NOS)** for observational studies. Studies were graded as low, moderate, or high risk of bias based on parameters such as selection bias, blinding, outcome assessment, and loss to follow-up.

PRISMA Flowchart

A PRISMA flowchart was developed to outline the systematic selection process. The number of studies screened, assessed for eligibility, and included in the final review is summarized in Table 1.

Step	Number of Articles
Identified through database search	3,500
Screened after duplicates removed	2,200
Full-text articles assessed for eligibility	500
Studies included in final review	120

Table 1: *This Systematic review includes a total of 120 studies, comprising 45 systematic reviews, 38 randomized controlled trials (RCTs), and 37 original research studies, to provide a comprehensive analysis of the causes and treatments of hair loss.*

Statistical Analysis

Meta-analyses were performed when appropriate for studies reporting quantitative outcomes. RevMan (Review Manager) software was used for the calculation of effect sizes for treatment outcomes. Pharmaceutical and surgical interventions were examined through clinical trial outcomes based on treatment efficacy, adverse effects, and sustainable long-term hair regrowth.

Outcomes were compared based on different treatments (minoxidil vs. PRP therapy, finasteride vs. hair transplantation) by means of subgroup analysis. A sensitivity analysis to account for potential bias in individual studies was carried out. Statistical significance was defined as $p < 0.05$, and heterogeneity among studies was assessed using the I^2 statistic.

Ethical Considerations

As this study involved the synthesis of previously published data, no ethical approval was required. However, all included studies were assessed to ensure compliance with ethical guidelines such as informed consent, institutional review board (IRB) approval, and adherence to clinical research protocols.

Limitations of the Study

While this systematic review provides a comprehensive analysis of hair loss causes and

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treatments, certain limitations must be acknowledged:

➤ Variability in study methodologies and patient populations may affect the comparability of results.
➤ Some treatments, such as emerging biologic therapies, have limited long-term follow-up data.
➤ The exclusion of non-English studies may have resulted in language bias.
➤ The quality of evidence in some included studies may be influenced by sample size and study design constraints.

Future research should focus on large-scale randomized controlled trials (RCTs) to validate the efficacy and safety of novel hair loss treatments.

Results

Prevalence and Demographics of Hair Loss

The most common type is hereditary hair loss that affects men and women of all ages and ethnicities. Androgenetic alopecia (AGA) is the most common form of hair loss, with studies showing that it can affect up to 80% of men and 50% of women during their lifetime [21]. The prevalence rises with age, with manifestations occurring earlier in men than in women. While telogen effluvium is often closely associated with physiological stress, alopecia areata has a population incidence rate of 2% globally [22]. A comprehensive analysis of global studies highlights that hair loss is more commonly reported in industrialized countries due to environmental stressors, dietary changes, and lifestyle factors.

Additionally, data suggests that African and Asian populations tend to have lower prevalence rates of AGA compared to Caucasian populations, although alopecia areata and traction alopecia rates are higher in African-descendant individuals due to hairstyling practices [23].

Common Causes and Risk Factors for Hair Loss

Several intrinsic and extrinsic factors contribute to hair loss. Genetic predisposition remains the strongest determinant in **androgenetic alopecia**, with **polygenic inheritance patterns** playing a significant role in hair follicle sensitivity to **dihydrotestosterone (DHT)** [24]. Hormonal imbalances, particularly elevated **androgens** in conditions such as **polycystic ovary syndrome (PCOS)** and **thyroid disorders**, are major contributors to diffuse hair thinning [25].

Nutritional deficiencies also play a crucial role. Studies indicate that **iron deficiency, vitamin D insufficiency, and protein malnutrition** are linked to increased hair shedding and poor follicular health [26]. Psychological stress has been identified as a **trigger for telogen effluvium**, leading to premature transition of hair follicles into the shedding phase. Additionally, environmental pollutants, ultraviolet (UV) exposure, and **excessive hairstyling practices** contribute to hair damage and loss [27].

Effectiveness of Pharmacological Treatments

Pharmacological interventions remain the cornerstone of hair loss treatment. The **two FDA-approved drugs for androgenetic alopecia**, **minoxidil and finasteride**, have demonstrated significant efficacy in clinical trials [28].

Treatment	Mechanism of Action	Effectiveness
Minoxidil	Vasodilator that prolongs the anagen phase	40-60% hair regrowth after 6 months
Finasteride	5α-reductase inhibitor that reduces DHT levels	60-80% hair regrowth in men
Spironolactone	Anti-androgen that blocks DHT receptors	Effective in women with AGA
Dutasteride	More potent 5α-reductase inhibitor than finasteride	80-90% improvement in hair density

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Studies indicate that **combination therapy** (minoxidil + finasteride) provides superior results compared to monotherapy, particularly in cases of **moderate-to-severe AGA**. Additionally, **topical finasteride formulations** have been developed to minimize systemic side effects while maintaining efficacy [29].

Role of Platelet-Rich Plasma (PRP) Therapy

PRP therapy has gained traction as an **emerging treatment for hair loss**, particularly in individuals who experience poor response to pharmacological treatments. PRP involves **injecting autologous platelets** into the scalp to stimulate hair follicle regeneration through growth factors such as **platelet-derived growth factor (PDGF)** and **vascular endothelial growth factor (VEGF)** [30].

A meta-analysis of **15 randomized controlled trials** demonstrated that PRP therapy resulted in a **30-50% increase in hair density** within six months of treatment. However, results were highly dependent on injection frequency, platelet concentration, and individual response [31].

Surgical Interventions and Hair Transplantation

For patients with **advanced hair loss**, surgical options such as **follicular unit transplantation (FUT)** and **follicular unit extraction (FUE)** provide **permanent solutions** to restore hair density. These techniques involve **harvesting donor hair follicles** from the back of the scalp and implanting them in bald areas.
Recent advancements in robotic-assisted FUE techniques have improved **precision and graft survival rates**, making transplantation an increasingly viable option for many individuals suffering from **permanent hair loss** [32].

Nutritional and Lifestyle Modifications

In addition to medical treatments, **lifestyle changes and dietary modifications** play a crucial role in supporting hair health. Clinical trials indicate that **dietary supplementation with biotin, omega-3 fatty acids, and zinc** has shown positive outcomes in hair regrowth and follicular strength. Additionally, stress management techniques, such as meditation and cognitive-behavioral therapy (CBT), have been associated with **reduced incidence of telogen effluvium** and improved hair density.

Summary of Findings

➢ **Androgenetic alopecia** is the most common cause of hair loss, affecting up to 80% of men and 50% of women [21].
➢ **Minoxidil and finasteride** remain the most effective pharmacological treatments, with combination therapy yielding superior results [28].
➢ **PRP therapy** offers promising results, particularly in individuals with early-stage hair loss, with a **30-50% improvement in density** [30].
➢ **Hair transplantation** remains the gold standard for **irreversible alopecia**, with success rates exceeding **90%** in FUE procedures [32].
➢ **Dietary and lifestyle modifications**, including supplementation and stress management, play a **preventive role in hair loss progression** [32].

Discussion

Comparative Analysis of Hair Loss Treatments

The effectiveness of each hair loss treatment depends on their cause and severity. Minoxidil and finasteride, both pharmacological interventions have shown high effectiveness in androgenetic alopecia, although they mandate long-term adherence to preserve outcomes [33]. In fact, PRP provides a new hope for patients resistant to traditional pharmacological therapy. It has been shown that PRP injections yield 30-50% increases in hair density, but varied treatment response is still an apprehension [34].
Hair transplantation is the best treatment for permanent hair restoration for advanced cases of alopecia. Follicular unit transplantation (FUT) and follicular unit extraction (FUE) have success rates of over 85-90%, and the latter is being preferred more and more because of its minimally invasive nature and shorter recovery period [35]. But prohibitive costs and limited supply restrict access for many patients.

Patient Adherence and Treatment Challenges

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Despite the availability of various treatments, adherence remains a critical factor influencing treatment success. Studies indicate that **more than 40% of patients discontinue minoxidil within the first year due to side effects or lack of immediate results** [36]. Similarly, **finasteride discontinuation rates are high** due to concerns about sexual side effects and hormonal imbalances [37].

For non-pharmacological interventions like PRP therapy, the necessity of multiple sessions and the high cost often deter patients from completing the full treatment regimen. Additionally, the variability in PRP preparation techniques across clinics affects standardization, leading to inconsistent outcomes [38].

Psychological and Social Impacts of Hair Loss

Hair loss extends beyond a mere cosmetic issue, significantly affecting self-esteem, confidence, and mental health. Studies indicate that **up to 60% of individuals with hair loss experience psychological distress, including anxiety and depression** [39]. Women, in particular, report **higher levels of emotional distress** due to social perceptions and beauty standards related to hair [40].

In addition to medical treatments, cognitive-behavioral therapy (CBT) and psychological counseling have been suggested as helpful measures in being able to cope with the emotional burden of hair loss. In addition, scalp micropigmentation and hair prosthetics have been increasingly utilized in a non-invasive manner for individuals wishing to undergo cosmetic intervention without medical help [41].

Role of Emerging Therapies

The field of hair restoration has seen significant advancements in **stem cell therapy and regenerative medicine**. Clinical trials suggest that **stem cell-derived exosomes and growth factor serums** have the potential to rejuvenate dormant hair follicles and improve hair density without the side effects associated with traditional pharmacological treatments [42].

Low-level laser therapy (LLLT) is another emerging treatment that has shown **modest improvements in hair growth** by stimulating follicular activity through photobiomodulation.

Although **LLLT is non-invasive and well-tolerated**, its effectiveness remains inferior to pharmacological and surgical treatments [43].

Nutritional and Lifestyle Interventions

Nutritional deficiencies are a well-documented contributor to hair loss. **Iron, zinc, vitamin D, and protein deficiencies** have been strongly linked to hair thinning, and supplementation has been shown to **restore hair density in individuals with nutrient-related alopecia** [44].

Additionally, the impact of lifestyle factors on hair health cannot be ignored. Chronic stress has been identified as a trigger for **telogen effluvium**, while poor scalp hygiene and excessive heat styling exacerbate follicular damage. Mindfulness practices such as meditation and yoga have been explored as **non-invasive methods to reduce stress-related hair loss** [45].

Future Directions in Hair Loss Treatment

The **future of hair loss treatment** lies in personalized medicine and advanced biotechnology. Recent genetic research has identified key markers associated with **hair follicle longevity**, opening the door for **targeted gene therapy approaches**. Clinical trials investigating the efficacy of **JAK inhibitors** for treating alopecia areata have demonstrated **promising results in hair regrowth**, although concerns remain about long-term immunosuppressive effects.

Artificial intelligence (AI)-assisted diagnostics and **trichoscopy advancements** are improving the accuracy of early-stage alopecia detection, allowing for **earlier interventions** and better treatment planning. The integration of AI in dermatology is expected to **enhance clinical decision-making** and improve patient outcomes in the coming years.

Summary of Discussion

✓ **Combination therapy (minoxidil + finasteride)** remains the most effective pharmacological approach, but patient adherence remains a challenge due to side effects [33].

✓ **PRP therapy shows promise**, though standardization and cost remain barriers to widespread adoption [34].

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✓ **Hair transplantation (FUE) offers the most permanent solution**, with success rates exceeding 90% [35].
✓ **Psychological support and counseling are crucial**, as up to 60% of patients experience distress related to hair loss [39].
✓ **Stem cell therapy and JAK inhibitors represent the next frontier** in hair restoration research [42,47].
✓ **AI-driven diagnostics and personalized medicine approaches** will likely shape the future of hair loss treatment.
✓ **Nutritional and lifestyle changes**, including supplementation and stress reduction, continue to be important adjuncts in treatment strategies [44,45].

Conclusion

Hair loss is a multifactorial condition influenced by genetic, hormonal, autoimmune, environmental, and lifestyle factors. While various treatments exist, ranging from pharmacological agents like minoxidil and finasteride to surgical options such as hair transplantation, the effectiveness of these treatments varies among individuals. Patient adherence, cost, and long-term maintenance remain significant challenges in hair restoration therapy. Emerging treatments, including stem cell therapy, JAK inhibitors, and AI-driven diagnostics, offer promising avenues for the future. Additionally, psychological support and lifestyle modifications play a crucial role in managing hair loss-related distress. Further research should focus on personalized treatment approaches, optimizing regenerative medicine applications, and improving early diagnostic tools to enhance therapeutic outcomes. A comprehensive, multidisciplinary approach combining medical, surgical, nutritional, and psychological interventions is essential for effectively addressing hair loss and improving patient quality of life.

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