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Original Article

Hair Biology and Hair Loss: A Comprehensive Review of Anatomy, Growth Cycle, Etiologies, and Therapeutic Interventions

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ABSTRACT

Hair is an integral component of human biology and identity, serving essential roles in protection, sensory perception, and personal aesthetics. Structurally, it comprises the hair follicle embedded in the dermis and the keratinized shaft that extends above the skin. Hair growth follows a complex cycle consisting of four phases—anagen (active growth), catagen (transition), telogen (resting), and exogen (shedding). Any disruption in these phases may result in hair disorders, most commonly hair loss. Hair loss, or alopecia, is a widespread concern affecting individuals regardless of age or gender, and can arise from genetic predisposition, hormonal imbalances, nutritional deficiencies, environmental factors, or stress. This review explores the anatomy and physiology of hair while highlighting the mechanisms and contributing factors behind various types of hair loss, including androgenetic alopecia, alopecia areata, telogen effluvium, and traction alopecia. Treatment options encompass both preventive and therapeutic approaches, ranging from dietary and lifestyle modifications to pharmacological interventions. Medications such as minoxidil, finasteride, and dutasteride are commonly used to manage androgenic hair loss, while newer therapies like JAK inhibitors show promise for autoimmune-related conditions. In addition to allopathic medicine, traditional herbal remedies have gained popularity due to their natural bioactive compounds that promote hair health. Ingredients such as Amla, Bhringraj, Hibiscus, Fenugreek, and Onion are known for their antioxidant and anti-inflammatory properties, which support follicular strength and scalp nourishment. Various hair care formulations—serums, oils, foams, sprays, and lotions—are also reviewed for their effectiveness and application suitability. Overall, this paper emphasizes a holistic and personalized approach to hair care, combining scientific understanding with natural and lifestyle-based strategies. Recognizing the multifactorial nature of hair loss is crucial for developing sustainable and effective solutions to improve both hair and scalp health.

Keywords: Probiotic,GUT Flora, Vitamin, GIT track, Microbs

INTRODUCTION

Hair is a unique and essential part of the human body, composed primarily of keratin—a fibrous protein also found in nails and skin. It grows from follicles embedded in the dermis and varies significantly in texture, color, and density among individuals. Beyond its protective role, hair contributes to thermoregulation and sensory input, while also serving as a marker of cultural identity, age, and health. The health of hair is influenced by genetic, hormonal, nutritional, and environmental factors. In recent years, increased attention has been given to hair care due to rising concerns over hair loss, damage, and scalp conditions. This paper aims to provide a comprehensive overview of the structure and function of human hair, examine common hair problems, and evaluate current treatments and maintenance strategies. [1]

Understanding Hair: A Defining Trait of Mammals

Hair is a filamentous biomaterial that grows from follicles located in the dermis, and is found exclusively in mammals, making it one of the defining characteristics of the mammalian class. The term "hair" typically refers to two distinct parts: (1) the portion beneath the skin, known as the hair follicle or the bulb when extracted which houses stem cells that

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enable hair regeneration after shedding or injury; and (2) the shaft, the visible, filamentous part that extends above the skin's surface [2].

Anatomy of Hair: Root and Shaft

Human hair is composed of two primary anatomical components: the hair root and the hair shaft. Anatomy of hair is depicted in figure1.The hair root lies beneath the surface of the skin and is the living part of the hair. It is embedded in the hair follicle, a tunnel-like structure that extends into the epidermis and dermis. In contrast, the hair shaft is the visible, non-living part that protrudes above the skin's surface. It consists of keratinized dead cells and does not engage in any biochemical activity [3].

Fig 1-Anatomy of hair

Structure of Hair Root

The hair root forms the foundation of hair growth and contains several essential structures that support its function. The hair follicle is a tube-like depression in the skin that encloses the root and anchors the hair into the scalp. At the base of this follicle lies the hair bulb, a rounded structure where actively dividing cells generate the hair strand through a process called keratinization. Below the bulb is the dermal papilla, a cone-shaped structure containing capillaries and nerve endings that supply the nutrients and signals necessary for hair growth. Attached to the follicle is the arrector pili muscle, a small involuntary muscle that causes the hair to stand upright when it contracts commonly referred to as goosebumps. Additionally, sebaceous glands are connected to the follicle and secrete sebum, an oily substance that keeps the hair and scalp moisturized and protected. [4]

Structure of the Hair Shaft

The hair shaft is made up of three concentric layers, each contributing to the hair's physical characteristics. The cuticle is the outermost layer and consists of transparent, overlapping scale-like cells that protect the inner layers. It plays a key role in determining the shine, smoothness, and overall resistance to damage. Beneath the cuticle is the cortex, which comprises about 90% of the hair's mass. This layer contains densely packed keratin fibers and melanin, which provide strength, elasticity, and natural color to the hair. At the core of the shaft is the medulla, the innermost layer, typically present only in coarse or thick hair. The medulla's function remains largely unclear and is often absent in finer hair types. [5]

Chemical Composition of Hair

Hair is primarily made of keratin, a tough and fibrous protein produced through the process of keratinization. As new cells in the hair bulb mature, they gradually fill with keratin, lose their nuclei, and die, forming a hardened strand that becomes the hair shaft. Chemically, hair is composed of five key elements, collectively known by the acronym

COHNS—Carbon, Oxygen, Hydrogen, Nitrogen, and Sulphur. These elements combine to form long chains of amino acids called polypeptides, which are critical to hair's structural strength and resilience. [6]

Side Bonds in the Cortex

The physical and chemical structure of the hair is further stabilized by side bonds in the cortex, which maintain the hair's shape, strength, and elasticity. There are three main types of these bonds. Hydrogen bonds are weak physical bonds that are easily broken by heat or water and are re-formed when the hair dries or cools, making them responsible for temporary styling. Salt bonds are also weak and can be disrupted by changes in pH; these too are temporary in nature. Disulfide bonds, on the other hand, are strong chemical bonds formed between sulphur atoms in cysteine amino acids. They are responsible for the hair's permanent shape and can only be broken by chemical treatments such as relaxers or perms, or by exposure to high heat. [7]

Hair Pigmentation

Hair colour is determined by melanin, a natural pigment produced by melanocytes located at the base of the hair follicle. There are two types of melanin that contribute to hair color. Eumelanin gives hair black and brown tones, while pheomelanin is responsible for red, orange, yellow, and blonde hues. The specific ratio and concentration of these pigments determine the wide range of natural hair colours found in humans. [8]

Hair growth cycle

Hair growth is the cumulative, physical consequence of coordinated process of cellular proliferation and differentiation within a hair follicle. The stem cells, which commit to the fate of a hair follicle, enter a period of massive proliferation that results in the formation of mature hair follicle. Hair follicles are primarily composed of epithelial and dermal components. Hair follicles are hair shaft-producing mini-organs and exhibit regular cycles of regeneration, known as the hair cycle. Different hair growth phases were depicted in figure 2. The hair follicle, undergoes successive cyclic periods of growth, involves four main phases [9]

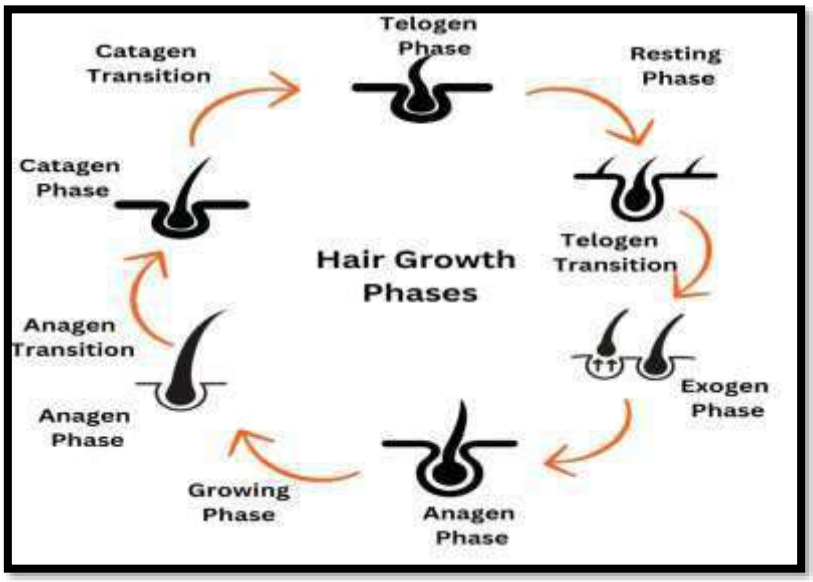

Fig 2- Different hair growth phases

The Anagen Phase: The Period of Active Growth:

The anagen phase is the period of active growth in the hair cycle, also known as the growth stage. During this phase, the hair follicle produces new cells, particularly epithelial cells, which cause the hair shaft to grow rapidly. In healthy individuals, approximately 90% of hairs are in the anagen phase at any given time. Factors such as genetics, age, and overall health influence the duration of the anagen phase, which varies from person to person. Some people experience faster hair growth due to a longer anagen phase, while others may have slower growth due to a shorter one. On average, hair grows about 1 centimetre every 28

days during this phase, driven by the continuous division and differentiation of cells in the lower part of the follicle. As the hair shaft lengthens, it eventually emerges from the scalp and becomes visible. The anagen phase lasts between 2 to 6 years, offering an extended window for active hair growth. Extending the duration of this phase is key to achieving long, healthy hair. Proper scalp care, a balanced lifestyle, and the use of targeted hair products can help support and prolong this phase.

The Catagen Phase: The Transition Period:

The catagen phase is the short transition period between the active growth (anagen) phase and the resting (telogen) phase. This phase typically lasts just a few weeks. During the catagen phase, the hair follicle undergoes structural changes it shrinks and detaches from the blood supply, marking the end of active growth. However, the hair remains anchored in the follicle, preparing for the next stage in the cycle. [10] Only about 3% of hairs are in the catagen phase at any one time, reflecting its brief and transitional nature. Despite its short duration, the catagen phase is essential for the natural cycling of hair. It allows the follicle to regress and remodel, setting the stage for shedding and the eventual growth of new hair. Proper scalp health, good nutrition, and a healthy lifestyle can support a smooth transition through this phase.

The Telogen Phase: The Resting Phase:

The telogen phase is the resting phase of the hair growth cycle. During this stage, the follicle is inactive, and hair growth comes to a temporary halt. This phase lasts around three months. While the follicle rests, the old hair remains in place, and the body begins preparing for new growth. Telogen effluvium refers to the natural shedding that occurs during this stage a normal part of the cycle and usually not a cause for concern. Approximately 10% to 15% of hairs are in the telogen phase at any time. This distribution supports a typical hair length of 18 to 24 inches, such as shoulder-length hair, before natural shedding begins. As old hair sheds, new hair starts forming within the follicle. Once the telogen phase ends, the follicle re-enters the anagen phase, and the growth cycle begins anew. This resting stage is vital for hair renewal and regeneration, keeping follicles active and capable of producing strong, healthy strands. [11]

The Exogen Phase: The Shedding Phase:

The exogen phase is the final part of the hair growth cycle, also referred to as the shedding phase. During this stage, old hairs fall out to make room for new growth from the same follicle. This natural shedding process is essential for maintaining healthy hair and ensuring that older strands are replaced by newer, stronger ones. Proper nutrition and hair care during the exogen phase can help promote healthy regrowth and minimize excessive hair loss. Understanding the exogen stage can help individuals take proactive steps to maintain strong, resilient hair by supporting the follicles through the shedding and renewal process.

Hair Loss: Causes, Mechanisms, And Contributing Factors

It is a controversial issue as there is no general agreement about what are the main factors that cause loss of hair. It is a universal problem having affected both sexes of all races to different extents for as long as humankind has existed. Various factors contributing to hair loss includes genetic predisposition, hormonal factors, and disease states such as typhoid, malaria, jaundice and use of chemotherapeutic agents [12]. It is a dermatologic disorder, and the surge for discovering natural products with hair growth. People typically lose 50 to 100 hairs a day. This usually isn't noticeable because new hair is growing in at the same time. Hair loss occurs when new hair doesn't replace the hair that has fallen out.

Is there a connection between hair growth phases and hair loss?

Yes, hair growth phases and hair loss are both connected. Hair loss can occur when hair follicles stay in the resting phase (telogen) for too long. The disrupted growth phase (anagen) also causes hair loss. Understanding these phases can help address hair loss concerns effectively. Hair loss is typically related to one or more of the following factors:

Family history (heredity):

The most common cause of hair loss is a hereditary condition that happens with aging. This condition is called androgenic alopecia, male-pattern baldness and female-pattern baldness. It usually occurs gradually and in predictable patterns — a receding hairline and bald spots in men and thinning hair along the crown of the scalp in women.

Hormonal changes and medical conditions:

A variety of conditions can cause permanent or temporary hair loss, including hormonal changes due to pregnancy, childbirth, menopause and thyroid problems. Medical conditions include alopecia aerate (al-o-PEE-she-uh ar-e-A-tuh), which is immune system related and causes patchy hair loss, scalp infections such as ringworm, and a hair-pulling disorder called trichotillomania (trik-o-til-o-MAY-nee-uh).

Medications and supplements:

Temporary or permanent hair loss can be caused by several medications, including those for blood pressure problems, diabetes, heart disease and cholesterol. Any that affect the body's hormone balance can have a pronounced effect: these include the contraceptive pill, hormone replacement therapy, steroids and acne medications [13]. Some treatments used to cure mycotic infections can cause massive hair loss. Medications (side effects from drugs, including chemotherapy, anabolic steroids, and birth control pills).

Hairstyles and treatments:

Excessive hairstyling or hairstyles that pull your hair tight, such as pigtails or cornrows, can cause a type of hair loss called traction alopecia. Hot-oil hair treatments and permanents also can cause hair to fall out. If scarring occurs, hair loss could be permanent.

Environmental Factors and Their Impact:

Environmental factors can affect the hair cycle by impacting hair follicle health. factors include exposure to pollutants, excessive heat styling, and harsh hair care practices. Pollutants can build up on your scalp, blocking hair growth. Regularly clean your scalp and use products to shield it from pollutants. Using too much heat on your hair weakens it. Protect it with heat products and limit styling tools. Harsh hair care can harm your hair. Tight styles and rough brushing damage follicles, causing breakage. To keep your hair healthy, switch to gentle care. Use wide-tooth combs and avoid tight hairstyles. These practices safeguard your hair follicles' health.

Pregnancy:

Hair loss often follows childbirth in the postpartum period without causing baldness. During pregnancy, the hair is thicker owing to increased circulating estrogens. Approximately three months after giving birth (typically between 2 and 5 months), estrogen levels drop and hair loss occurs, often particularly noticeably around the hairline and temple area. Hair typically grows back normally and treatment is not indicated. A similar situation occurs in women taking the fertility-stimulating drug clomiphene.

Trauma:

Trauma-induced hair loss can result from various physical and psychological factors. Traction alopecia occurs due to excessive pulling on hair from styles like ponytails or cornrows, as well as rigorous brushing and heat styling, which damage the hair cuticle and lead to breakage. Frictional alopecia arises from repeated rubbing, such as around the ankles from socks, often leading to permanent hair loss. Trichotillomania, a compulsive disorder involving hair pulling, typically begins around puberty and may cause lasting damage due to constant root extraction. Severe stress, childbirth, surgery, or poisoning can trigger telogen effluvium, where many hairs simultaneously enter the resting phase and shed. Additionally, treatments like chemotherapy and radiation can lead to significant hair loss by disrupting hair growth cycles or damaging scalp areas.

Hair Problems

Common hair problems range from cosmetic concerns to medical conditions. Pigmentation fading often results in dull or gray hair due to aging, nutritional deficiencies, or environmental damage. Dandruff, characterized by flaking and itching, is typically caused by scalp dryness or fungal infections. Hair shedding (falling) is a routine process, but

excessive shedding can indicate underlying stress or nutritional issues [14]. Hair loss, leading to balding, may be temporary or permanent. Permanent baldness includes male and female pattern baldness (androgenetic alopecia), caused by genetic and hormonal factors—males often show bitemporal recession, while females experience diffuse thinning over the crown. Temporary baldness includes conditions like alopecia areata (autoimmune circular hair loss), telogen effluvium (stress-induced diffuse shedding), and traction alopecia (mechanical damage from tight hairstyles). Understanding the cause is key to effective treatment, which can range from lifestyle changes and topical treatments to medications and surgical options [15].

Anagen Effluvium is a rapid hair loss condition caused by cytotoxic agents such as thallium, bismuth, arsenic, or chemotherapy drugs. These substances inhibit cell division in hair follicles, leading to sudden and widespread loss of scalp hair. A potential treatment includes scalp cooling during chemotherapy to reduce hair follicle damage.

Telogen Effluvium involves the premature shedding of hair in the telogen (resting) phase and typically occurs after stressors like high fever, surgery, or crash dieting. It presents as a uniform decrease in scalp hair density with a positive hair pull test. Management includes reducing hair washing frequency, and recovery may take months to years.

Alopecia Areata is an autoimmune condition often influenced by genetic factors. It manifests as circular patches of hair loss, and regrown hair may appear white initially. Treatment commonly includes intralesional corticosteroid injections such as Kenalog.

Traction Alopecia results from prolonged tension on the hair due to tight hairstyles like ponytails. Over time, this tension damages hair follicles, potentially causing permanent hair loss. Treatment may involve avoiding tight styles and considering hair grafts for restoration.

Androgenic Alopecia, or pattern baldness, affects both men and women, beginning typically with bitemporal recession or a crown bald spot. Treatments include topical Minoxidil (Rogaine), oral Finasteride (Propecia), and surgical hair transplants [16].

Trichotillomania is a psychological disorder marked by compulsive hair pulling, leading to patchy hair loss. It is chronic and requires behavioral therapies such as self-monitoring, stimulus control, and habit-reversal training for effective management.

Management of hair loss

Lifestyle changes

Diet and Nutrition:

Maintaining healthy hair requires adequate intake of essential nutrients such as iron, zinc, biotin, vitamin D, and protein. A balanced diet that includes plenty of fruits, vegetables, and lean proteins helps nourish hair follicles and support overall hair health [17].

Supplements:
Supplements like biotin and collagen may promote healthier hair, but it's important to consult a healthcare provider before starting any supplement regimen to ensure they are appropriate and safe for individual needs.

Stress Management:

Chronic stress can trigger hair loss, particularly a condition called telogen effluvium. Incorporating relaxation techniques such as meditation, yoga, or mindfulness into daily routines can help manage stress levels and potentially reduce hair loss.

Avoiding Harsh Hair Treatments:

Frequent use of chemical treatments, heat styling tools, and tight hairstyles can lead to hair damage and breakage. To maintain healthy hair, it's best to avoid harsh treatments, be gentle while styling, and use sulfate-free, scalp-friendly hair care products.

Herbal Drugs for Hair Growth

Amla (*Phyllanthus emblica*):

Amla, from the *Phyllanthaceae* family, is a potent source of vitamin C and contains phenolic compounds like flavonoids, tannins, and alkaloids [18]. These constituents help nourish hair follicles and improve

scalp health. Its strong antioxidant properties combat oxidative stress. This reduces free radical damage that can impair hair growth. Regular use supports stronger, healthier hair from the roots. Amla is depicted in fig 3.

Fig 3-Amla

Fenugreek (*Trigonella foenum-graecum*):

Fenugreek, part of the *Leguminaceae* family, is rich in active compounds like flavonoids, saponins, and alkaloids such as diosgenin and trigonelline. It exhibits 5-alpha-reductase inhibitory activity, which lowers DHT levels linked to androgenic alopecia. This makes it beneficial in reducing hair thinning and shedding [19]. Additionally, its nutrients improve scalp hydration and strength. Consistent use may promote thicker, fuller hair. Fenugreek is depicted in fig 4.

Fig 4-Fenugreek

Hibiscus *(Hibiscus rosa-sinensis):*

Hibiscus, from the *Malvaceae* family, contains a variety of bioactive compounds such as tannins, phenols, flavonoids, and saponins. These ingredients help in enlarging hair follicles and extending the anagen (growth) phase of the hair cycle [20]. It supports hair density and reduces premature shedding. The plant also provides deep nourishment to the scalp. This leads to better hair volume and texture. Hibiscus is depicted in fig 5.

Fig 5-Hibiscus

Bhringraj *(Eclipta alba):*

A herb from the *Asteraceae* family, Bhringraj is packed with coumestan derivatives like wedelolactone and other flavonoids. It is traditionally known for stimulating hair follicle growth and prolonging the active growth (anagen) phase. This helps prevent early hair fall and supports new hair development [21]. It also enhances scalp circulation and nourishment. Regular application results in stronger and shinier hair. Bhringraj is depicted in fig 6.

Fig 6-Bhringraj

Curry Leaves *(Murraya koenigii):*

Curry leaves belong to the *Rutaceae* family and are enriched with alkaloids like mahanimbine, essential oils, and flavonoids. These compounds help in neutralizing free radicals and protecting the scalp from oxidative stress. They also improve blood circulation, enhancing nutrient delivery to hair roots [22]. This leads to healthier and more resilient hair strands. Curry leaves are especially effective in preventing premature greying and thinning. Curry leaves is depicted in fig 7.

Fig 7-Curry leaves

Onion *(Allium cepa):*

From the *Liliaceae* family, onion is known for its rich content of sulphur compounds like allicin and essential minerals such as zinc and magnesium. These components boost keratin production, which is essential for strong hair. Onion juice helps nourish the scalp and reduce inflammation. It can also stimulate dormant follicles for regrowth. The result is improved hair texture and reduced hair fall [23]. Onion is depicted in figure 8.

Fig 8-Onion

Flaxseed *(Linum usitatissimum):*

Flaxseed, part of the *Linaceae* family, contains beneficial nutrients like alpha-linolenic acid (ALA), lignin, mucilage, and vitamin E. These ingredients hydrate the scalp and strengthen hair strands. It has natural anti-inflammatory and antioxidant properties that support scalp health [24]. Flaxseed also helps remove buildup and keeps follicles clear. With regular use, it can improve shine and reduce breakage. Flaxseed is depicted in figure 9.

Fig 9-Flaxseed

Currently Approved Treatments for Hair Loss

Several pharmacological treatments are approved for managing hair loss disorders, with minoxidil, finasteride or dutasteride, and JAK inhibitors being the most commonly used Although these medications demonstrate varying levels of effectiveness, each comes with certain limitations that restrict their overall success and broader adoption.

Rogaine (Minoxidil)

Minoxidil is an FDA-approved topical medication originally developed as an oral antihypertensive [25]. It works by opening ATP-sensitive potassium channels in vascular smooth muscle, causing vasodilation and increased blood flow to hair follicles. It also stimulates the proliferation of dermal papilla cells, inhibits collagen synthesis (which may prevent fibrosis), and promotes VEGF expression, which supports follicular vascularization. Minoxidil extends the anagen (growth) phase and enlarges miniaturized follicles [26]. Available in 2% and 5% topical solutions or foams, it is safe for both men and women, though the 2% formulation is typically advised for women to avoid hypertrichosis (unwanted hair growth). Side effects are generally mild and include scalp irritation, dryness, and itching. Consistent use is essential, as stopping treatment can lead to the resumption of hair loss within months [27].

Ell-Cranell (α-Tradiol)

Ell-Cranell contains α-tradiol, a non-hormonal estrogen isomer that exhibits mild anti-androgenic effects. It works by reducing dihydrotestosterone (DHT) levels in the scalp and promoting the synthesis of 17β-estradiol, which supports hair follicle health. Its minimal hormonal activity makes it particularly suitable for women and men who may be sensitive to stronger hormonal agents. However, α-tradiol is not considered a powerful monotherapy, and its ability to stimulate new hair growth is limited. It is mostly used to stabilize hair loss rather than reverse it [28]. The safety profile is favorable, with few side effects, making it a good option for patients who prefer gentle, hormone-free treatments.

Propecia (Finasteride)

Finasteride is a widely used oral medication for male pattern baldness. It works by selectively inhibiting the type II isoenzyme of 5α-reductase, which converts testosterone into the more potent androgen DHT. Elevated DHT levels are a primary contributor to follicle miniaturization and hair loss in androgenetic alopecia [29]. By reducing DHT, finasteride prevents further hair loss and, in many cases, promotes regrowth, particularly on the crown of the scalp. It is taken orally at a dose of 1 mg per day. Despite its effectiveness, about 1–2% of users report sexual side effects such as decreased libido, erectile dysfunction, and ejaculation disorders. Finasteride is not approved for use in women and must be used continuously to maintain its benefits.

Avodart (Dutasteride)

Dutasteride is a more potent oral 5α-reductase inhibitor than finasteride, blocking both type I and type II isoenzymes. This results in a more significant suppression of DHT production throughout the body, including the scalp, potentially offering better results in treating androgenetic alopecia. While it is not FDA-

approved for hair loss in the United States, it is approved for this use in countries like Japan and South Korea. Dutasteride has a long half-life (~4–5 weeks), which contributes to stable DHT suppression but also means that any side effects may persist for a longer duration after stopping the drug. Like finasteride, potential side effects include sexual dysfunction, gynecomastia, and mood changes [30]. Due to its potency, dutasteride may offer more significant regrowth, especially in patients unresponsive to finasteride.

Finjuve (Topical Finasteride)

Finjuve is a topical formulation of finasteride designed to reduce systemic absorption and minimize side effects while delivering the drug directly to hair follicles in the scalp. It inhibits the 5α-reductase enzyme locally, reducing scalp DHT levels, inactivating androgen receptors, and potentially preventing fibrosis. While studies suggest that topical finasteride is nearly as effective as oral forms with lower systemic DHT suppression, it has recently come under FDA scrutiny. Some users of compounded topical finasteride products have reported systemic effects, including sexual dysfunction and cognitive disturbances, prompting safety warnings [31]. Though promising as a safer alternative, more data is needed to fully understand its safety profile.

Olumiant (Baricitinib)

Baricitinib is a JAK inhibitor that targets JAK1 and JAK2 pathways involved in immune signaling. It is approved by the FDA for the treatment of severe alopecia areata, an autoimmune condition where the immune system attacks hair follicles. By inhibiting JAK1/2, Baricitinib reduces T-cell activity and inflammatory cytokine production, helping to restore the immune privilege of hair follicles [32]. This leads to hair regrowth in patients with moderate to severe alopecia areata, with many seeing noticeable results within 3–6 months. Side effects include a higher risk of infections, increased cholesterol levels, and elevated liver enzymes, necessitating blood monitoring. It is not typically used for androgenetic alopecia.

Litfulo (Ritlecitinib)

Ritlecitinib is a highly selective inhibitor of JAK3 and TEC family kinases, making it unique among JAK inhibitors for its narrower immunosuppressive action [33]. It is FDA-approved for the treatment of severe alopecia areata in individuals aged 12 and older. By targeting JAK3, which is involved in the development and function of immune cells, Ritlecitinib effectively halts the autoimmune response attacking hair follicles, allowing regrowth. It is generally well-tolerated and may offer fewer systemic side effects compared to broader JAK inhibitors due to its selectivity. Like other JAK inhibitors, it can cause mild to moderate side effects such as infections and blood test abnormalities, but it shows promise as a safe and effective long-term option.

Leqselvi (Deuruxolitinib)

Deuruxolitinib is a recently approved oral JAK1/JAK2 inhibitor developed specifically for the treatment of severe alopecia areata. Similar in action to baricitinib, it suppresses inflammatory immune signaling pathways that trigger autoimmune destruction of hair follicles. Clinical trials show that it is effective in restoring hair growth in patients with extensive hair loss. It is generally well-tolerated, with side effects including mild infections, headaches, and changes in blood tests [34]. As a newly launched drug, long-term data is limited, but its approval marks a significant addition to the treatment options for alopecia areata.

Different Hair Growth Formulations:

Various topical formulations are available for promoting hair growth and managing hair loss, each differing in texture, composition, and mode of application. These formulations are designed to deliver active ingredients directly to the scalp to stimulate hair follicles, nourish the roots, and improve scalp health. The table below provides a comparative overview of common formulation types used in hair care, highlighting their descriptions, typical ingredients, advantages, and limitations. This comparison can help in selecting the most suitable product based on individual scalp conditions and treatment goals [35-41]. Different hair growth formulations were depicted in table 1.

Table 1-Different Hair growth formulations

Formulation Type	Description	Common Ingredients	Pros	Cons
Solutions	Liquid-based formulations applied directly to the scalp.	Minoxidil 2%, 5%; Redensyl	Easy to apply, well-studied efficacy.	May cause scalp irritation or dryness.
Foams	Aerosolized foam that is massaged into the scalp.	Minoxidil 5%	Less greasy, quick absorption.	Slightly more expensive than solutions.
Serums	Lightweight, non-greasy formulations with concentrated actives.	Redensyl, Anagain, Capixyl	Targeted treatment, cosmetic appeal.	May require prolonged use for results.
Oils	Viscous formulations, often with herbal extracts.	Onion oil, Bhringraj, Amla	Nourishes scalp, traditional remedies.	Greasy texture, may require washing out.
Lotions/Creams	Emulsion-based, thicker consistency.	Herbal extracts, corticosteroids	Moisturizing, suitable for dry scalps.	May be heavy for oily scalps.
Sprays/Mists	Fine mist for easy application.	Caffeine, peptides	Convenient, even distribution.	May have lower concentration of actives.
Gels	Water-based, non-oily formulations.	Aloe vera, herbal infusions	Cooling effect, easy absorption.	Often cosmetic, less potent.

CONCLUSION:

Hair loss represents a significant dermatological and psychological concern affecting millions worldwide, with profound impacts on self-esteem and quality of life. This comprehensive review has elucidated the complex physiology of hair growth, highlighting how disruptions in the anagen, catagen, telogen, and exogen phases can lead to various forms of alopecia. We've examined the diverse etiological factors contributing to hair loss, from genetic predispositions in androgenetic alopecia to autoimmune mechanisms in alopecia areata, as well as the role of environmental stressors and nutritional deficiencies. The therapeutic landscape offers multiple approaches, including conventional treatments like minoxidil and finasteride that target specific pathways, and innovative biologics such as JAK inhibitors that show remarkable promise for autoimmune-related hair loss. Simultaneously, traditional herbal remedies - including Amla, Bhringraj, and onion extracts - continue to gain recognition for their hair-nourishing properties, providing gentler alternatives with fewer side effects. However, significant challenges remain, particularly regarding treatment accessibility, individual variability in response, and the need for long-term management strategies. The future of hair loss treatment lies in personalized medicine approaches that combine pharmacological interventions with lifestyle modifications, nutritional support, and stress management techniques. Further research should focus on developing more targeted therapies with improved safety profiles, while also validating the efficacy of traditional remedies through rigorous clinical studies. By adopting this integrative perspective, we can advance toward more effective, sustainable solutions for hair restoration and scalp health.

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