

Title- Comprehensive Review of Androgenic Alopecia: Mechanisms, Diagnosis, and Management

**Lakhveer Singh, Shahbaz Rathor, Hemlata Sahu, Apurva Yadav,
Shweta Ramkar***

Kamla Institute of Pharmaceutical Sciences, Shri Shankaracharya
Professional University, Junwani, Bhilai, Durg (C.G.) 490020

Abstract- Androgenetic alopecia (AGA) is one of the most common diseases related to Pilosebaceous unit. Changes of circulating androgens (testosterone) to the more potent androgen (dihydrotestosterone) by the metabolism process are one of the causes of the AGA. In the AGA, follicles on the scalp undergo anagen (transformation from long growth) and telogen (short rest) cycles, to long rest and short growth cycles. This process causes the progressive miniaturisation of follicles. By far the most promising approaches to the treatment of baldness in men are drug therapies, such as topically used minoxidil and systemic administration of finasteride. The aim of the study is to management of drug that are synthetic and natural plant products, that are act on hair follicle region and also increases the drug concentration on the affected site.

Keywords- Androgenic alopecia, dihydrotestosterone, 5-alpha-reductase, androgen receptors, hair follicles

Introduction- Androgenic alopecia also known as male-pattern baldness in men and female-pattern hair loss in women, is a chronic and progressive hair loss condition primarily influenced by genetic and hormonal factors. It is characterized by the miniaturization of hair follicles due to the action of dihydrotestosterone (DHT), a potent androgen derived from testosterone through the enzyme 5-alpha-reductase. DHT binds to androgen receptors in hair follicles, shortening the anagen (growth) phase and prolonging the telogen (resting) phase of the hair cycle. Over time, this process leads to thinner, shorter, and less pigmented hair, eventually resulting in the follicles becoming dormant. In men, androgenic alopecia typically begins with a receding hairline and thinning at the crown, which may progress to complete baldness in some

areas. In women, it usually manifests as diffuse thinning across the scalp while sparing the frontal hairline. The condition is influenced by various factors, including age, hormonal changes, and family history (Jain et. al, 2017).

Causes

1. Genetic factor
2. Hormonal Changes
3. Age
4. Enzyme Activity
5. Hormonal Imbalance

Skin

The skin is the largest organ of the human body and acts as a protective barrier between the internal environment and the outside world. It is a complex structure that plays multiple vital roles, including protection from pathogens, regulation of body temperature, sensation, and prevention of water loss. Skin also helps in synthesizing vitamin D in response to sunlight and contains sensory receptors for pain, temperature, and touch.

Structurally, skin is composed of three main layers:

1. **Epidermis** – The outermost layer, responsible for protection and waterproofing.
2. **Dermis** – Beneath the epidermis, containing connective tissue, blood vessels, hair follicles, and sweat glands.
3. **Hypodermis** (subcutaneous tissue) – The deepest layer, made of fat and connective tissue, providing insulation and cushioning (Rawlings, 2006).

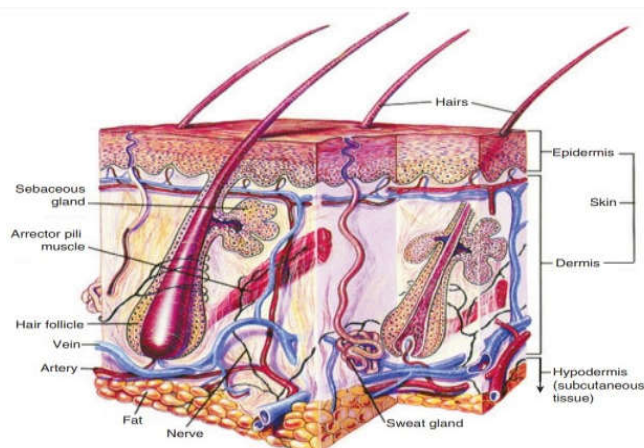
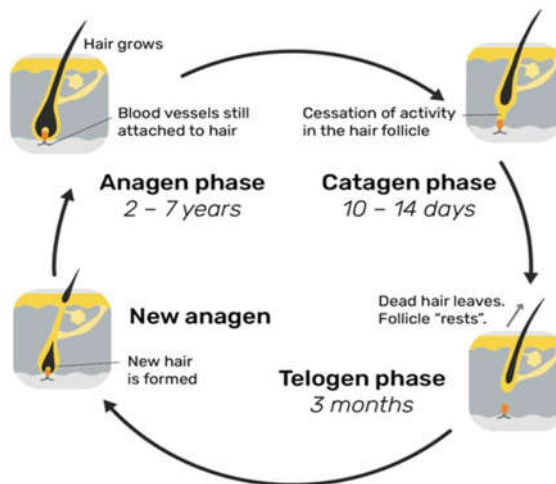


Fig 1.- Schematic Diagram of Skin**Hair growth and cycle**

The hair development undergoes a repetitive cycle the place the Anagen section followed by using the Catagen and the Telogen phase. Within the Anagen section, the hair is actively growing at the same time within the catagen segment it is characterized by the degeneration and resorption of the lower region of the HF. The anagen segment is the progress cycle most commonly the past 3-5 years. On a healthful scalp, there are roughly 100,000 hair and 90% of the follicles are consistently within the anagen segment of hair development. The catagen stage follows the end of the development interval when a follicle begins to end up dormant. The resting section, the place the hair is inactive, is called Telogen phase, after this segment the growth of the HF restarts. When the dormant section ends, a historical hair falls out. A HF then returns to the anagen stage and new hair begins to develop (Rawlings, 2006).

**Fig 2.- Schematic Diagram Hair Growth Cycle**

A natural fee of hair progress is about 1/2 an inch per 30 days relying on HF's and age of a character. On normal, 50-60 scalp hairs are lost day-to-day in a normal hair growth cycle and new hairs begin to grow from these follicles. Hair loss starts of evolved when much less new hair starts the re-growth stage (Jain et. al.,2017).

Disease related with hair follicle

Folliculitis: Inflammation of the hair follicles, often caused by bacterial (e.g., *Staphylococcus aureus*) or fungal infections. It can cause small, red bumps or pustules around hair follicles, sometimes leading to itching or pain.

Alopecia Areata: An autoimmune disorder where the immune system attacks hair follicles, leading to patchy hair loss on the scalp or other parts of the body.

Acne (including Acne Vulgaris): A common skin condition where hair follicles become clogged with oil and dead skin cells, leading to pimples, blackheads, and, in severe cases, cystic lesions.

Hidradenitis Suppurativa: A chronic skin condition characterized by painful lumps under the skin, often around hair follicles in areas where skin rubs together (like the armpits, groin, and under breasts).

Trichotillomania: A psychological disorder where individuals have a compulsion to pull out their own hair, which can lead to damaged hair follicles and potential scarring.

Pseudofolliculitis Barbae: Commonly known as "razor bumps," this condition occurs when hair curls back or grows sideways into the skin, leading to inflammation, often in areas subjected to shaving.

Telogen Effluvium: A temporary condition where hair follicles prematurely enter the resting phase, leading to increased hair shedding and thinning. This can be triggered by stress, hormonal changes, medications, or illness.

Pilar Cyst (Trichilemmal Cyst): These are non-cancerous lumps that form from hair follicle cells, commonly found on the scalp and filled with keratin. (Gu et. al., 2022)

Management of androgenic alopecia

Beyond treatment, the androgenic alopecia increasing day by day. Researchers found that approximately the rate is near about 5% per year. There are many disguises and surgical management procedures are available but, in this paper, we have discussed the therapeutic management procedures. Figuring out the functional sequence alternate in or around the AR gene will lead to the dedication of the exact variation in AR proteins between bald and non-bald people. By this proficiency, treatments can be arranged that the point

and reverse these inequalities, through that impeding exact hair loss mechanism (Ashique et. al., 2020).

FDA approved drug for alopecia

- 1. Minoxidil**
- 2. Finasteride**

Drugs that are approved by the FDA for the treatment of alopecia are shown in and their respective chemical structures are in Only two approved drugs by the FDA still are there for Alopecia are Finasteride and Minoxidil. The patent of Finasteride was filed in 1984 and accepted for medical purposes in 1982 and was available in generic form. Whereas Minoxidil was developed in the 1950s by the Upjohn Company (now as Pfizer). Then the company had synthesized many derivatives and in 1963 named Minoxidil. In 1979 it was authorized by FDA for the treatment of high BP in tablet form with Loniten trade name. In 1988 FDA approved it for treating male pattern baldness in men with the trade name of 'Rogaine'. In 1998, 5% of Minoxidil formulation was allowed by the FDA. In the year 1998 minoxidil came for sale non-prescription ally by FDA and in 2014 it was the only topical choice by FDA approved for treating androgenic alopecia. The drug is available in the topical formulation in the UK, US, Sweden, and Germany.

Drugs used in androgenic alopecia

Minoxidil- At first, Minoxidil was used to treat high BP due to its systemic side effects. The formulation changed to the topical formulation used to treat baldness. Minoxidil is present as a 2%, 5% topical solution approved by USFDA. In 1998 it was approved first for male pattern baldness and then for female in 2001 as 2% minoxidil solution and 5% minoxidil was approved in 2007 for male androgenic alopecia. 5% Foam minoxidil also approved by FDA in 2006 but only in men, not in case of women's hair loss purpose, it was off label treatment formulation. 2% and 5% Topical solution indicated twice a day as 1 mL of the solution (Ramkar et.al. 2022).

Finasteride

The 5 α -reductase inhibitor finasteride blocks the conversion of testosterone to

dihydrotestosterone (DHT), the androgen responsible for male pattern hair loss (androgenic alopecia) in genetically predisposed men. Finasteride, another FDA approved drug has been reported effective in 0.25% and 0.5% topical solution compared to an oral 1 mg/dose. Oral Finasteride tablet have different systemic side effects, to overcome these problems topical formulation of Finasteride now-a-days successfully applied on male pattern alopecia. % Drug effectiveness for the FDA are elaborated (Varothi et. al., 2014; Mysore, 2012).

Some Formulation Used in Androgenic Alopecia

1. Minoxidil

S.N.	Formulation	Conclusion	References
1.	Liposome	Liposomes enhance minoxidil delivery, highlighting their potential for hair loss treatment.	(Mura et. al., 2007)
2.	Niosome	Niosomes enhance minoxidil skin targeting but are less effective than smaller liposomes.	(Mura et. al., 2007)
3.	Nano-structured lipid carriers	Minoxidil-loaded NLC gel ensures stable, sustained delivery with effective therapeutic skin concentration.	(Mura et. al., 2007)
4.	Gel	Minoxidil gel formulations offer stable, effective, and skin-friendly alternatives for alopecia treatment with sustained drug release.	(Uprit et. al., 2013)

2. Finasteride

S.N.	Formulation	Conclusion	References
1.	Liposomes	Liposomes improve finasteride delivery and efficacy in androgenetic alopecia.	(Khan et. al., 2018)

2.	Niosome	Niosomes enhance finasteride skin targeting but are less efficient than liposomes	(Khan et. al., 2018)
3.	Nano structured lipid carriers	NLCs enhance finasteride delivery with controlled release and reduced side effects, promising for alopecia treatment.	(Ramkar et. al., 2023; Pittella et. al. 2020)
4.	Gel	Topical gels improve finasteride delivery, reduce side effects, and provide sustained release for androgenetic alopecia.	(Ramkar et. al., 2023)

Some Herbs Used in Hair Growth

S. No.	Biological source	Vernacular name	Family	Reference
1	<i>Aloe barbadensis</i>	Ghritkumari	Liliaceae	(Surjushe et. al. 2008)
2	<i>Rosmarinus officinalis</i>	Rosemary	Labiate	(Panahi et. al. 2015)
3	<i>Hibiscus rosa-sinensis</i>	Hibiscus	Mallows	(Adhirajan et. al., 2003)
4	<i>Phyllanthus emblica</i>	Amla	Phyllanthaceae	(Roy et. al., 2008)
5	<i>Eclipta alba</i>	Bhringraj	Asteraceae	(Gu et. al., 2022)
6	<i>Trigonella foenum-gbraecum</i>	Methi	Fabaceae	(Shrivastava et. al., 2015)

7	<i>Serenoarepens</i>	Saw palmetto	Areaceae	(Evron et. al., 2020)
8	<i>Camellia sinensis</i>	Chai	Theaceae	(Schotz et. al., 2007)
9	<i>Cucurbita pepo</i>	Pumpkin seed oil	Cucurbitaceae	(Haihashemi et. al., 2019)
10	<i>Ocimum sanctum</i>	Tulsi	Lamiaceae	(Joseph et. al.)

Conclusion

Hair loss, particularly androgenic alopecia, is a widespread concern affecting both men and women globally. Although the exact etiology of hair loss remains uncertain, genetic factors and hormonal imbalances play a significant role. Androgenic alopecia is driven primarily by androgens like dihydrotestosterone (DHT), which binds to androgen receptors in scalp follicles, leading to hair thinning and loss. Current treatments, such as FDA-approved drugs like minoxidil and finasteride, focus on inhibiting these hormones but do not provide a complete cure. Additionally, natural remedies and herbal treatments have gained attention for their potential in promoting hair growth. While therapeutic options continue to evolve, understanding the mechanisms of hair growth and the role of various agents in stimulating hair follicles will be essential for advancing more effective treatments. Further research into both pharmaceutical and natural remedies may help address this growing concern more comprehensively, providing better solutions for those affected by hair loss.

Acknowledgement-

The authors are thankful to the Kamla Institute of Pharmaceutical Sciences, Shri Shankaracharya Professional University, Bhilai for the infrastructure and library facility.

References

1. Adhirajan N, Kumar TR, Shanmugasundaram N, Babu M. In vivo and in vitro evaluation of hair growth potential of *Hibiscus rosa-sinensis* Linn. *Journal of ethnopharmacology*. 2003 Oct 1;88(2-3):235-9.
2. Ashique S, Sandhu NK, Haque SN, Koley K. A systemic review on topical marketed formulations, natural products, and oral supplements to prevent androgenic alopecia: a review. *Natural products and bioprospecting*. 2020 Dec; 10:345-65.
3. Evron E, Juhasz M, Babadjouni A, Mesinkovska NA. Natural hair supplement: friend or foe? Saw palmetto, a systematic review in alopecia. *Skin appendage disorders*. 2020 Aug 23;6(6):329-37.
4. Gu Y, Bian Q, Zhou Y, Huang Q, Gao J. Hair follicle-targeting drug delivery strategies for the management of hair follicle-associated disorders. *Asian Journal of Pharmaceutical Sciences*. 2022 May 1;17(3):333-52.

5. Gu Y, Bian Q, Zhou Y, Huang Q, Gao J. Hair follicle-targeting drug delivery strategies for the management of hair follicle-associated disorders. *Asian Journal of Pharmaceutical Sciences*. 2022 May 1;17(3):333-52.
6. Hajhashemi V, Rajabi P, Mardani M. Beneficial effects of pumpkin seed oil as a topical hair growth promoting agent in a mice model. *Avicenna journal of phytomedicine*. 2019 Nov;9(6):499.
7. Jain PK, Das DE, Das C. Prospect of herbs as hair growth potential. *Innovare Journals of Medical Sciences*. 2017;5(1):25-33.
8. Joseph JM, Saji A, Thambi G, Joseph T. A Brief Study of Certain Anti-Hairfall Plants in 7th and 8th Wards of Thalappalam Panchayath in Kottayam District.
9. Khan MZ, Khan SA, Ubaid M, Shah A, Kousar R, Murtaza G. Finasteride topical delivery systems for androgenetic alopecia. *Current drug delivery*. 2018 Oct 1;15(8):1100-11.
10. Mura S, Pirot F, Manconi M, Falson F, Fadda AM. Liposomes and niosomes as potential carriers for dermal delivery of minoxidil. *Journal of Drug Targeting*. 2007 Jan 1;15(2):101-9
11. Mysore V. Finasteride and sexual side effects. *Indian dermatology online journal*. 2012 Jan 1;3(1):62-5.
12. Panahi Y, Taghizadeh M, Marzony ET, Sahebkar A. Rosemary oil vs minoxidil 2% for the treatment of androgenetic alopecia: a randomized comparative trial. *Skinmed*. 2015 Jan 1;13(1):15-21.
13. Pittella F, Palmieri MG, Ferreira KC, Valle AB, Aleixo DT, Tavares GD, Corrêa JO. Development of nanostructured lipid carriers containing finasteride. *Brazilian Journal of Health and Pharmacy*. 2020 Apr 9;2(1):20-7.
14. Ramkar S, Sahu HK, Hemnani N, Parashar R, Suresh PK. Oxidative stress: Insights into the Pathogenesis and Treatment of Alopecia. *Journal of Ravishankar University*. 2022 Dec 30;35(2):44-61
15. Ramkar S, Suresh P. Targeting Potential of Zinc Oxide Nanoparticles and Finasteride-loaded Nano Lipidic Carriers-infused Topical Gel-In vitro and In vivo Skin Permeation Studies. *International Journal of Pharmaceutical Sciences and Nanotechnology (IJPSN)*. 2023 Nov 15;16(6):7030-7.
16. Rawlings AV. Ethnic skin types: are there differences in skin structure and function. *International journal of cosmetic science*. 2006 Apr;28(2):79-93.

17. Roy RK, Thakur M, Dixit VK. Hair growth promoting activity of *Eclipta alba* in male albino rats. *Archives of dermatological research*. 2008 Aug;300(7):357-64.
18. Schötz K, Nöldner M. Mass spectroscopic characterisation of oligomeric proanthocyanidins derived from an extract of *Pelargonium sidoides* roots (EPs® 7630) and pharmacological screening in CNS models. *Phytomedicine*. 2007 Mar 5; 14:32-9.
19. Shrivastava SR, Shrivastava PS, Ramasamy J. Mainstreaming of Ayurveda, Yoga, Naturopathy, Unani, Siddha, and Homeopathy with the health care delivery system in India. *Journal of Traditional and Complementary Medicine*. 2015 Apr 1;5(2):116-8.
20. Surjushe A, Vasani R, Saple D. Aloe vera: a short review. *Indian journal of dermatology*. 2008 Oct 1;53(4):163-6.
21. Uprit S, Sahu RK, Roy A, Pare A. Preparation and characterization of minoxidil loaded nanostructured lipid carrier gel for effective treatment of alopecia. *Saudi Pharmaceutical Journal*. 2013 Oct 1;21(4):379-85.
22. Varothai S, Bergfeld WF. Androgenetic alopecia: an evidence-based treatment update. *American journal of clinical dermatology*. 2014 Jul; 15:217-30.