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"ADVANCES IN PSORIASIS TREATMENT: FROM CONVENTIONAL THERAPY TO TARGETED AND BIOLOGIC APPROACHES"

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ABSTRACT

Psoriasis is a chronic immune-mediated inflammatory skin disease characterized by features of abnormal keratinocyte proliferation and sustained skin inflammation. The pathogenesis is based on genetic, environmental, and immunological factors, especially TNF-α, IL-17, and IL-23 pathways. Conventional treatments encompass topical agents, phototherapy, and systemic medications; however, they often face limitations due to adverse effects and inadequate efficacy. by adverse effects and insufficient efficacy. Recently, biologic therapies, JAK inhibitors, PDE-4 inhibitors, and nanotechnology-based delivery systems for drugs have been developed, offering more targeted and effective treatment options. The pathophysiology, conventional treatment, and recent advances in pharmacologic and targeted treatment of psoriasis are reviewed, with emphasis on novel therapeutic approaches.

KEYWORDS: Psoriasis; Pathophysiology; Topical Therapy; JAK Inhibitors; Cytokines; Nanotechnology; Targeted Drug Delivery.

1. INTRODUCTION

Psoriasis is a chronic, recurrent, immune-mediated inflammatory disorder primarily affecting the skin and, in some patients, the joints. Clinically, it is characterized by well demarcated erythematous plaques covered by silvery-white scales. Commonly affected sites include the scalp, elbows, knees, and lumbosacral region; however, psoriasis may involve almost any area of the body. The disease results from an interaction between genetic predisposition, environmental factors, epidermal abnormalities, and dysregulated immune responses.

The pathogenesis of psoriasis involves complex communication between dendritic cells, T lymphocytes, keratinocytes, and various inflammatory cytokines. Activation of dendritic cells promotes the differentiation and expansion of pathogenic T-cell populations, particularly Th1 and Th17 cells. These immune cells release inflammatory mediators that stimulate keratinocyte proliferation and contribute to persistent cutaneous inflammation. The IL-23/Th17 axis, together with TNF-α and other cytokine pathways, plays a central role in the initiation and maintenance of psoriatic inflammation.

Psoriasis is associated with a considerable disease burden and may adversely affect patients' quality of life. In addition to cutaneous manifestations, patients may experience pruritus, pain, psychological distress, and social limitations. Psoriasis may also occur with systemic comorbidities, including psoriatic arthritis, metabolic abnormalities, and cardiovascular risk factors. Therefore, effective management requires an individualized and comprehensive therapeutic approach.

Historically, psoriasis treatment has relied on topical medications, phototherapy, and conventional systemic drugs. Although these approaches can provide substantial symptomatic relief, limitations related to efficacy, tolerability, long-term safety, and treatment adherence have encouraged the development of more selective therapeutic strategies. Advances in molecular immunology have subsequently led to the introduction of targeted biologic agents and small-molecule drugs capable of interfering with specific inflammatory pathways.

Recent developments in pharmaceutical sciences have further expanded the therapeutic landscape through nanotechnology-based drug delivery, advanced topical formulations, targeted delivery systems, and novel immunomodulatory agents. These approaches aim to improve drug penetration, enhance therapeutic efficacy, provide controlled drug release, reduce systemic exposure, and minimize adverse effects. Consequently, the treatment of psoriasis has progressed from nonspecific immunosuppression toward increasingly targeted and patient-centered therapeutic strategies.

2. Pathophysiology of Psoriasis

The pathophysiology of psoriasis is multifactorial and involves a complex interaction between genetic susceptibility, environmental stimuli, epidermal abnormalities, and immune-system dysregulation. Although the precise initiating event may differ among individuals, activation of the cutaneous immune system ultimately results in persistent inflammation and excessive proliferation of keratinocytes.

2.1 Activation of Dendritic Cells

Dendritic cells are important antigen-presenting cells involved in the initiation of the psoriatic immune response. Following activation by environmental or endogenous stimuli, dendritic cells produce inflammatory cytokines, including IL-12 and IL-23. These cytokines promote the activation and differentiation of T lymphocytes and contribute to the development of chronic inflammation.

2.2 Activation of T Lymphocytes

T lymphocytes, particularly Th1 and Th17 cells, play a central role in psoriasis. Activated T cells migrate into the skin and release several pro-inflammatory cytokines. Among these, IL-17 is particularly important because it acts on keratinocytes and promotes the production of additional inflammatory mediators and chemokines.

2.3 Role of Inflammatory Cytokines

The inflammatory response in psoriasis is mediated by a network of cytokines rather than a single inflammatory mediator. TNF-α, IL-17, and IL-23 constitute important therapeutic targets because of their contribution to the maintenance and amplification of psoriatic inflammation.

The IL-23/Th17 signaling pathway is considered a major immunological axis in psoriasis. IL-23 supports the survival and activity of Th17 cells, while IL-17 promotes inflammatory responses in keratinocytes. TNF-α further amplifies inflammation by stimulating the expression of inflammatory genes and mediators.

2.4 Keratinocyte Hyperproliferation

Under normal physiological conditions, epidermal keratinocytes undergo a regulated process of proliferation, differentiation, and shedding. In psoriasis, inflammatory cytokines stimulate excessive keratinocyte proliferation and alter their normal differentiation process. This results in epidermal thickening, accumulation of immature keratinocytes, and formation of characteristic psoriatic plaques.

2.5 Major Cytokines Associated with Psoriasis

Important inflammatory mediators involved in psoriasis include:

- Tumor necrosis factor-α (TNF-α): Promotes and amplifies inflammatory responses.
- Interleukin-17 (IL-17): Stimulates keratinocytes and contributes to inflammatory signaling.
- Interleukin-23 (IL-23): Supports the differentiation, survival, and expansion of Th17 cells.
- Interleukin-12 (IL-12): Participates in Th1-cell differentiation and immune activation.
- Interleukin-6 (IL-6): Contributes to inflammatory signaling and immune-cell activation.

- Interferon-γ (IFN-γ): Participates in Th1-mediated inflammatory responses.

Overall, activation of dendritic cells followed by T-cell activation and cytokine release leads to sustained inflammation, abnormal keratinocyte proliferation, epidermal hyperplasia, and development of psoriatic lesions.

3. Immune Mechanism in Psoriasis

Genetic and Environmental Triggers
↓
Activation of Dendritic Cells
↓
Release of IL-23 and Other Pro-inflammatory Cytokines
↓
Activation and Differentiation of Th17 Cells
↓
Release of IL-17A, IL-17F and TNF-α
↓
Keratinocyte Activation and Hyperproliferation
↓
Epidermal Hyperplasia and Inflammation
↓
Formation of Psoriatic Plaques

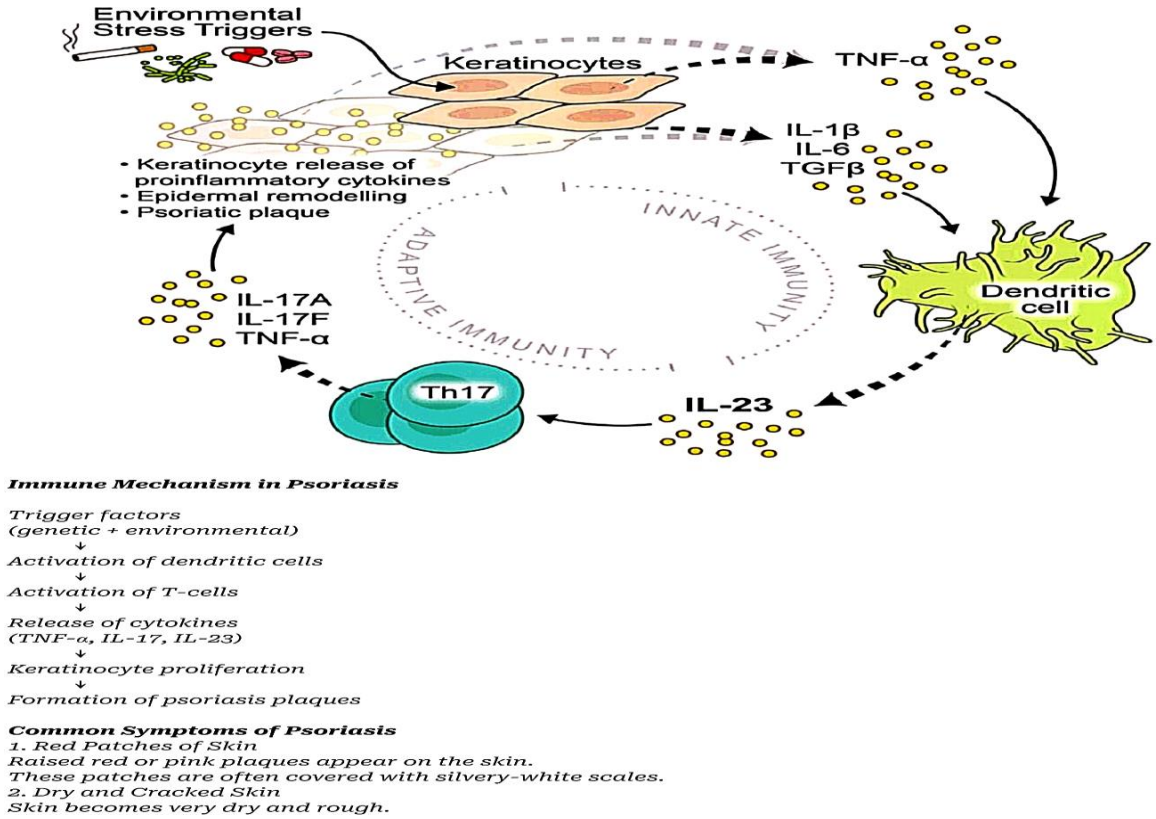

Fig No. 1 Immune Mechanism in Psoriasis.

4. Nanotechnology-Based Drug Delivery in Psoriasis

Nanotechnology-based drug delivery systems have emerged as promising approaches for improving the topical and transdermal delivery of therapeutic agents in psoriasis. These systems can enhance drug solubility, stability, skin penetration, retention, and controlled release. By improving localization of the drug within the affected skin, nanocarriers may enhance therapeutic efficacy while potentially reducing systemic exposure.

General mechanism

Drug incorporation into nanocarrier

↓

Enhanced penetration through the skin barrier

↓

Localization within inflamed psoriatic skin

↓

Controlled and sustained drug release

↓

Modulation of inflammatory pathways

↓

Reduction in inflammation and psoriatic lesions

5. Need for Nanotechnology in Psoriasis Treatment

Conventional drug-delivery approaches may face several limitations, particularly for topical treatment. The stratum corneum acts as an effective barrier and can restrict the penetration of many therapeutic molecules into deeper skin layers. In addition, poor aqueous solubility, inadequate drug retention, chemical instability, frequent application, and systemic adverse effects may limit therapeutic effectiveness.

Nanocarrier-based systems may help overcome these limitations through:

- Enhanced drug solubility and stability
- Improved penetration and deposition within the skin
- Increased drug retention at the target site
- Controlled and sustained drug release
- Reduced frequency of administration
- Potential reduction in systemic drug exposure
- Improved therapeutic efficacy

6. Types of Nanocarriers Used in Psoriasis Drug Delivery

- **Liposomes:** Phospholipid vesicles that encapsulate and deliver therapeutic drugs to the skin.
- **Solid Lipid Nanoparticles (SLNs):** Solid lipid-based carriers that provide controlled drug release and improve skin penetration.
- **Nanostructured Lipid Carriers (NLCs):** Nanocarriers containing solid and liquid lipids that offer higher drug-loading capacity and enhanced skin delivery.
- **Polymeric Nanoparticles:** Polymer-based carriers that protect drugs and provide controlled and targeted drug release.
- **Nanoemulsions:** Nanosized oil–water dispersions that improve drug solubility, stability, and skin penetration.
- **Nanocrystals:** Pure drug particles in nanometer size that enhance drug dissolution and topical bioavailability.
- **Niosomes:** Non-ionic surfactant vesicles that improve drug stability and facilitate skin penetration.
- **Transferosomes:** Highly deformable vesicular carriers designed to enhance drug penetration through the skin.
- **Ethosomes:** Phospholipid vesicles containing a high concentration of ethanol that enhance transdermal drug delivery.
- **Dendrimers:** Highly branched, nanosized polymeric structures that can encapsulate or conjugate drugs for controlled delivery.

7. Therapeutic Management of Psoriasis

The treatment of psoriasis is selected according to disease severity, lesion location, extent of skin involvement, previous treatment response, comorbidities, and patient preference. Therapeutic approaches can broadly be classified into topical therapy, phototherapy, conventional systemic therapy, biologic therapy, small-molecule targeted therapy, and emerging drug-delivery approaches.

- **Topical Therapy**

Topical therapy is generally considered an important first-line approach for patients with mild-to-moderate psoriasis. Commonly used topical agents include corticosteroids, vitamin D analogues, topical retinoids, calcineurin inhibitors, and keratolytic agents.

- **Phototherapy**

Phototherapy involves controlled exposure of affected skin to specific wavelengths of ultraviolet radiation. Narrowband ultraviolet B (NB-UVB) phototherapy is widely used for patients with more extensive disease or inadequate response to topical treatment. Phototherapy can reduce inflammatory activity and inhibit excessive epidermal proliferation.

- **Conventional Systemic Therapy**

Patients with moderate-to-severe psoriasis may require systemic treatment. Conventional systemic agents include methotrexate, cyclosporine, and systemic retinoids. These agents can produce significant clinical improvement but may require careful monitoring because of potential organ toxicity and other adverse effects.

- **Biologic Therapy**

The development of biologic medicines represents a major advancement in psoriasis treatment. These agents selectively interfere with specific cytokines or immune pathways involved in disease pathogenesis. Important classes include:

- TNF-α inhibitors
- IL-17 inhibitors
- IL-12/23 pathway inhibitors
- IL-23 inhibitors

- **Small-Molecule Targeted Therapy**

Small-molecule drugs have emerged as another important therapeutic category. These agents can interfere with intracellular signaling pathways involved in inflammatory responses. Janus kinase (JAK) inhibitors and phosphodiesterase-4 (PDE-4) inhibitors represent important examples of targeted small-molecule approaches being investigated or used in inflammatory dermatological disorders.

- **Emerging Therapeutic Approaches**

Recent pharmaceutical research has focused on developing treatment strategies that provide greater selectivity, improved drug delivery, enhanced skin penetration, and reduced systemic exposure. Nanoparticle-based systems, nanostructured lipid carriers, liposomes, polymeric nanoparticles, nanoemulsions, and other advanced delivery systems have attracted considerable research interest.

Nanotechnology may improve the delivery of poorly soluble drugs, enhance drug deposition within targeted skin layers, provide controlled release, and potentially improve therapeutic

effectiveness. Such systems may be particularly valuable for drugs whose conventional topical formulations demonstrate inadequate skin penetration.

Future Perspectives

The future management of psoriasis is expected to increasingly emphasize targeted therapy, personalized treatment, advanced drug-delivery systems, and improved long-term safety. Better understanding of disease-associated molecular pathways may facilitate the identification of new therapeutic targets and biomarkers for treatment selection.

Nanotechnology-based delivery systems may provide opportunities for localized drug delivery and controlled release, while emerging immunomodulatory agents may offer additional treatment options for patients who do not adequately respond to existing therapies. Integration of pharmacological advances with patient-specific disease characteristics may ultimately contribute to more effective and safer psoriasis management.

CONCLUSION

Psoriasis is a complex chronic inflammatory skin disorder involving interactions among immune cells, cytokines, keratinocytes, genetic factors, and environmental triggers. Although conventional topical, phototherapeutic, and systemic treatments remain important components of clinical management, advances in understanding the immunological mechanisms of psoriasis have led to the development of targeted biologic and small-molecule therapies. In parallel, pharmaceutical innovations such as nanotechnology-based drug delivery and advanced topical formulations offer promising opportunities to improve drug localization, controlled release, therapeutic efficacy, and patient compliance. Continued research into molecular targets, novel drug-delivery systems, and personalized therapeutic approaches is expected to further improve the management of psoriasis.

Conflict of Interests

- The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

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