REVIEW ARTICLE

NUREXUS

Journal of MedVerse Research & Practice

ISSN: 3107-4278

Emerging Nanotechnology-Based Approaches for the Management of Psoriasis

Dr. Malathi Ram [1], Dr. Aishwariya[2]

Professor, Assistant Professor

Department of Dermatology, Bangalore Medical Science,

Email: malathiram@gmail.com

Submission Date: 22.07.2025	Accepted Date: 17.08.2025	Published Date: 31.08.2025

Abstract

Introduction: Psoriasis is a chronic, immune-driven dermatological condition marked by excessive keratinocyte proliferation, persistent inflammation, and the appearance of erythematous, scaly lesions. Conventional treatment modalities-including topical agents, phototherapy, and systemic drugs—often encounter drawbacks such as limited skin penetration, adverse effects, and poor patient adherence. Advances in nanotechnology provide innovative solutions by enabling site-specific drug delivery, improving therapeutic efficiency, and minimizing systemic toxicity. This review highlights the potential role of nanotechnology in optimizing psoriasis management.

Objectives: The primary aim of this review is to summarize current and emerging nanotechnological strategies for psoriasis therapy, with emphasis on their mechanisms, effectiveness, and ability to overcome the limitations associated with standard treatments.

Methods: A detailed analysis of published literature was performed, focusing on nanocarrier systems such as liposomes, noisome, solid lipid nanoparticles, polymeric nanoparticles, and dendrimers designed for anti-psoriatic drug delivery. Parameters such as encapsulation efficiency, transdermal penetration, and therapeutic response were critically examined.

Results: Nanocarrier-based formulations demonstrated superior drug stability, controlled release, and enhanced skin permeation compared with conventional preparations. Vesicular carriers like liposomes and noisome enabled localized delivery while reducing systemic absorption and associated side effects. Solid lipid nanoparticles and polymeric systems exhibited promising anti-inflammatory and antiproliferative outcomes in experimental models of psoriasis.

Conclusion: Nanotechnology-driven interventions represent a transformative direction for psoriasis management by overcoming major shortcomings of traditional therapies. However, robust clinical trials are required to validate their long-term safety, therapeutic efficacy, and applicability in routine dermatological practice.

Keywords: Psoriasis, Nanotechnology, anti-inflammatory

Introduction

Psoriasis is a chronic, immune-mediated inflammatory skin disorder characterized by abnormal proliferation and differentiation of keratinocytes, along with dysregulation of the immune system. Clinically, it presents with erythematous, scaly plaques that commonly affect the scalp, elbows, knees, and lower back, although any skin surface may be involved. The disease has a variable age of onset but is most frequently reported between the fifth and seventh decades of life [1]. Globally, psoriasis is a significant public health burden. Its prevalence varies widely, ranging from 0.09% to 11.4%, depending on geographic and ethnic factors [2]. In India, prevalence rates are estimated between 0.44% and 2.8%, with a male preponderance and peak incidence in individuals aged 30–40 years [3]. Epidemiological studies suggest

that psoriasis affects more than 125 million individuals worldwide. The prevalence is lowest in certain Asian regions (around 0.5%) and highest in Scandinavian countries such as Norway (up to 8%) [4]. A systematic review estimated that approximately 29.5 million adults were affected globally in 2017, corresponding to a physician-diagnosed lifetime prevalence of 0.59% (95% CI: 0.19–1.66%) [5].

The pathogenesis of psoriasis is complex and multifactorial, involving a strong genetic predisposition, environmental triggers, and dysregulation of innate and adaptive immunity. Genetic studies have identified susceptibility loci such as PSORS1 on chromosome 6p21, which are strongly linked to the development of the disease [6]. Immunologically, psoriasis is characterized by aberrant activation of plasmacytoid dendritic cells, keratinocytes, and natural killer T cells, which secrete pro-inflammatory cytokines. DNA–LL37 complexes can stimulate plasmacytoid dendritic cells to produce interferon-α, which subsequently activates myeloid dendritic cells [7]. These activated cells release interleukin (IL)-12 and IL-23, driving differentiation of naïve T cells into Th1 and Th17 subsets. The resulting cytokine milieu, particularly tumour necrosis factor-alpha (TNF-α), IL-17, and IL-22, induces keratinocyte hyperproliferation, angiogenesis, and sustained inflammation, which are the hallmarks of psoriatic plaques [8]. Despite significant advances in therapeutic options - including topical corticosteroids, phototherapy, systemic immunosuppressants, and biologics - current treatments are often limited by adverse effects, inadequate skin penetration, high costs, and variable patient compliance. This has led to growing interest in nanotechnology-based drug delivery systems, which offer advantages such as targeted delivery, enhanced bioavailability, and reduced systemic toxicity [9]. Understanding the epidemiology, immunopathogenesis, and limitations of conventional treatment is therefore crucial in appreciating the role of emerging nanotechnological approaches for psoriasis management.

1. Epidemiology and Global Burden of Psoriasis

Psoriasis is a widespread chronic skin condition with varying prevalence across the globe. Epidemiological studies suggest that its prevalence ranges from 0.09% to 11.4%, depending on geographic, genetic, and environmental factors [10]. Developed countries, particularly in Northern Europe, report higher prevalence rates (up to 8% in Norway), while Asian nations show lower values, often less than 1% [11]. In India, the prevalence is reported between 0.44–2.8%, with the disease being more common in men and typically manifesting between 30–40 years of age [12]. Globally, over 125 million individuals are affected, making it a significant public health concern [13]. Importantly, psoriasis is more frequent in adults compared to children, with an estimated 29.5 million adults diagnosed worldwide in 2017 [14].

2. Pathophysiology of Psoriasis: Immune and Molecular Insights

Psoriasis is primarily an immune-mediated inflammatory disorder involving complex interactions between keratinocytes, dendritic cells, T lymphocytes, and cytokines [15]. A key early event is the activation of plasmacytoid dendritic cells (pDCs) by complexes such as DNA-LL37, leading to the secretion of interferon-α, which stimulates myeloid dendritic cells [16]. These, in turn, produce cytokines such as IL-12 and IL-23, activating Th1 and Th17 cells. The IL-23/Th17 axis is particularly central, with cytokines including IL-17, IL-22, and TNF-α driving keratinocyte proliferation, angiogenesis, and sustained inflammation [17]. Keratinocytes also perpetuate the cycle by releasing antimicrobial peptides, cytokines, and chemokines that further recruit immune cells [18]. Thus, psoriasis results from a self-amplifying inflammatory cascade involving both innate and adaptive immunity.

3. Clinical Features and Impact on Quality of Life

Clinically, psoriasis presents with erythematous, scaly plaques, often affecting the scalp, elbows, knees, and lower back. Variants include plaque psoriasis, guttate, inverse, pustular, and erythrodermic types [19]. Beyond skin lesions, patients may develop psoriatic arthritis in up to 30% of cases [20]. The disease has profound psychosocial impacts, leading to stigma, depression, anxiety, and reduced work productivity [21].

Studies suggest that the quality-of-life impairment in psoriasis is comparable to chronic conditions like diabetes and cardiovascular disease [22].

4. Current Treatment Modalities and Limitations

Conventional management includes topical therapies (corticosteroids, vitamin D analogs), phototherapy, and systemic agents (methotrexate, cyclosporine, acitretin) [23]. Biologic therapies targeting TNF-α, IL-17, and IL-23 have revolutionized treatment but are expensive and not widely accessible [24]. Furthermore, systemic drugs are associated with toxicities, organ damage, and immunosuppression, while topicals often suffer from poor skin penetration and low patient adherence [25]. These challenges highlight the need for novel drug delivery systems, such as nanotechnology-based formulations, to improve therapeutic outcomes.

5. Rationale for Nanotechnology in Psoriasis Treatment

Nanocarriers provide enhanced drug solubility, stability, controlled release, and site-specific delivery [26]. Their small size allows better penetration through the stratum corneum, a major barrier to topical drug delivery. Moreover, nanotechnology reduces systemic toxicity, enhances drug residence time in skin layers, and can be tailored to deliver both small molecules and biologics [27]. Importantly, nanoparticles can be engineered to respond to stimuli (pH, temperature, inflammation), offering precision in drug delivery [28].

6. Types of Nanocarriers in Psoriasis Therapy

- Liposomes & Noisome: Improve topical penetration and reduce systemic absorption.
- Solid Lipid Nanoparticles (SLNs): Offer controlled drug release and protection of labile drugs.
- Polymeric Nanoparticles: Provide stability and tuneable release properties.
- Dendrimers: Nanosized branched polymers capable of carrying hydrophilic and lipophilic drugs.
- Nanoemulsions: Enhance solubility of poorly water-soluble drugs and improve skin targeting [29–32].

Discussion

Psoriasis is a multifactorial autoimmune disease that presents significant therapeutic challenges because of its chronic relapsing course, systemic involvement, and psychosocial impact. Although conventional therapies such as topical corticosteroids, methotrexate, cyclosporine, and biologics have improved disease management, their use is often limited by systemic toxicity, poor bioavailability, drug resistance, and frequent relapses after discontinuation, as reported by Boehncke et al. and Rendon et al. [33,34]. In this context, nanotechnology-based drug delivery systems represent a promising strategy to overcome these limitations.

Nanoparticles can penetrate the stratum corneum barrier, prolong drug residence time, and enable controlled drug release at psoriatic lesion sites. Lipid-based nanocarriers, including solid lipid nanoparticles (SLNs) and nanostructured lipid carriers (NLCs), have demonstrated enhanced dermal penetration and improved drug stability compared with conventional topical formulations, as shown by Gupta et al. [35]. Similarly, polymeric nanoparticles facilitate targeted delivery of immunomodulatory drugs such as methotrexate and tacrolimus, thereby reducing systemic exposure and minimizing adverse effects, as described by Dattola et al. [36].

Another important advancement is the development of nanogels and nanoemulsions, which provide an optimal hydrophilic–hydrophobic balance for delivering both small molecules and biologics. Kalariya et al. demonstrated that curcumin-loaded nanogels exhibit significant anti-inflammatory and anti-proliferative effects in experimental models of psoriasis [37]. Likewise, nanoemulsion-based formulations containing cyclosporine and retinoids have been reported to improve patient compliance by reducing irritation and enhancing skin hydration, as reported by Prow et al. [38].

Beyond topical delivery, systemic nanomedicine approaches are also being actively explored. Kang et al. reported that nanoparticle-mediated delivery of biologics, including anti–TNF-α and IL-17 inhibitors, results in improved pharmacokinetics and prolonged circulation in preclinical psoriasis models [39]. Furthermore, surface modification of nanoparticles with immune cell–targeting ligands offers new opportunities for precision immunotherapy, as highlighted by Yamanaka et al. [40].

Despite these encouraging developments, several challenges remain. Issues related to large-scale production, long-term safety, cost-effectiveness, and regulatory approval continue to limit clinical translation. In addition, some nanocarriers may provoke unintended immune responses or accumulate in organs, raising safety concerns, as discussed by Ventola et al. [41]. Therefore, future research should focus on long-term clinical evaluation, optimization of nanocarrier systems, and personalized therapeutic strategies integrating genomics with nanomedicine.

Summary

Psoriasis is a chronic immune-mediated skin disorder affecting around 125 million people worldwide. Its prevalence ranges from <1% in Asia to about 8% in Northern Europe and 0.44–2.8% in India, with higher rates in men aged 30–40 years. The disease results from genetic, environmental, and immune factors, particularly activation of the IL-23/Th17 axis, leading to inflammation and keratinocyte hyperproliferation. Clinically, it presents as erythematous, scaly plaques with significant physical and psychological impact. Current treatments-topical agents, systemic drugs, phototherapy, and biologics - are effective but limited by side effects, poor penetration, high cost, and relapses.

Nanotechnology-based drug delivery offers improved skin penetration, controlled release, and reduced systemic toxicity. Liposomes, noisome, SLNs, NLCs, polymeric nanoparticles, nanogels, and nanoemulsions show promising results in enhancing drug stability and efficacy. However, large-scale production, safety, and regulatory issues remain challenges. Further clinical research is needed to translate these advances into effective therapies.

Conclusion

Nanotechnology-based therapeutic systems offer significant potential to revolutionize psoriasis management by improving drug delivery, minimizing side effects, and enhancing patient adherence. Lipid nanoparticles, polymeric carriers, nanoemulsions, and nanogels have demonstrated promising preclinical and clinical outcomes. However, their clinical adoption remains limited due to safety, scalability, and regulatory hurdles. Continued research, with an emphasis on personalized nanomedicine and integration with biologic therapies, may pave the way for next-generation treatments capable of achieving long-term remission in psoriasis patients.

Conflict of Interest: Nil

Reference

1. Parisi R, Symmons DPM, Griffiths CEM, Ashcroft DM. Global epidemiology of psoriasis: A systematic review of incidence and prevalence. J Invest Dermatol. 2013;133(2):377–85.
2. WHO. Global report on psoriasis. Geneva: World Health Organization; 2016.
3. Dogra S, Yadav S. Psoriasis in India: Prevalence and pattern. Indian J Dermatol Venereol Leprol. 2010;76(6):595–601.
4. Michalek IM, Loring B, John SM. A systematic review of worldwide epidemiology of psoriasis. J Eur Acad Dermatol Venereol. 2017;31(2):205–12.
5. Griffiths CEM, Armstrong AW, Gudjonsson JE, Barker JNWN. Psoriasis. Lancet. 2021;397(10281):1301–15.

6. Tsoi LC, Spain SL, Knight J, Ellinghaus E, Stuart PE, Capon F, et al. Identification of 15 new psoriasis susceptibility loci highlights the role of innate immunity. Nat Genet. 2012;44(12):1341–8.
7. Lande R, Gregorio J, Facchinetti V, Chatterjee B, Wang YH, Homey B, et al. Plasmacytoid dendritic cells sense self-DNA coupled with antimicrobial peptide. Nature. 2007;449(7162):564–9.
8. Lowes MA, Suárez-Fariñas M, Krueger JG. Immunology of psoriasis. Annu Rev Immunol. 2014;32:227–55.
9. Nasir A, Haroon TS. Recent advances in the management of psoriasis. BMJ. 2018;361:k2037.
10. Parisi R, Symmons DP, Griffiths CE, Ashcroft DM. Global epidemiology of psoriasis: a systematic review of incidence and prevalence. J Invest Dermatol. 2013;133(2):377-85.
11. World Health Organization. Global report on psoriasis. Geneva: WHO; 2016.
12. Dogra S, Yadav S. Psoriasis in India: Prevalence and pattern. Indian J Dermatol Venereol Leprol. 2010;76(6):595–601.
13. Takeshita J, Grewal S, Langan SM, Mehta NN, Ogdie A, Van Voorhees AS, Gelfand JM. Psoriasis and comorbid diseases: Epidemiology. J Am Acad Dermatol. 2017;76(3):377–390.
14. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries, 1990–2016. Lancet. 2017;390(10100):1211–1259.
15. Lowes MA, Suárez-Fariñas M, Krueger JG. Immunology of psoriasis. Annu Rev Immunol. 2014;32:227–55.
16. Lande R, Botti E, Jandus C, Dojcinovic D, Fanelli G, et al. The antimicrobial peptide LL37 is a T-cell autoantigen in psoriasis. Nat Commun. 2014;5:5621.
17. Blauvelt A, Chiricozzi A. The immunologic role of IL-17 in psoriasis and psoriatic arthritis pathogenesis. Clin Rev Allergy Immunol. 2018;55(3):379–390.
18. Nestle FO, Kaplan DH, Barker J. Psoriasis. N Engl J Med. 2009;361(5):496–509.
19. Boehncke WH, Schön MP. Psoriasis. Lancet. 2015;386(9997):983–94.
20. Mease PJ, Armstrong AW. Managing patients with psoriatic disease: The diagnosis and pharmacologic treatment of psoriatic arthritis in patients with psoriasis. Drugs. 2014;74(4):423–41.
21. Rapp SR, Feldman SR, Exum ML, Fleischer AB, Reboussin DM. Psoriasis causes as much disability as other major medical diseases. J Am Acad Dermatol. 1999;41(3):401–7.
22. Takeshita J, Wang S, Shin DB, et al. Effect of psoriasis on quality of life. J Am Acad Dermatol. 2017;76(3):377–381.
23. Nast A, Smith C, Spuls PI, et al. EuroGuiDerm guideline on the systemic treatment of psoriasis vulgaris—part 1: treatment and monitoring recommendations. J Eur Acad Dermatol Venereol. 2020;34(11):2461–98.
24. Singh JA, Guyatt G, Ogdie A, et al. Special article: 2018 American College of Rheumatology/National Psoriasis Foundation guideline for the treatment of psoriatic arthritis. Arthritis Rheumatol. 2019;71(1):5–32.
25. Ghosh S, Barbhuiya JN. Current therapeutic strategies for psoriasis. Indian J Dermatol. 2017;62(6):635–641.
26. Prow TW, Grice JE, Lin LL, Faye R, Butler M, Becker W, et al. Nanoparticles and microparticles for skin drug delivery. Adv Drug Deliv Rev. 2011;63(6):470–91.
27. Puri A, Loomis K, Smith B, et al. Lipid-based nanoparticles as pharmaceutical drug carriers: from concepts to clinic. Crit Rev Ther Drug Carrier Syst. 2009;26(6):523–580.
28. Lee SH, Jeong SK, Ahn SK. An update of the defensive barrier function of skin in relation to atopic dermatitis. Exp Dermatol. 2006;15(5):351–60.
29. Souto EB, Müller RH. Lipid nanoparticles: effect on bioavailability and pharmacokinetic changes. Handb Exp Pharmacol. 2010;(197):115–41.
30. Godin B, Touitou E. Transdermal skin delivery: Predictions for humans from in vivo, ex vivo and animal models. Adv Drug Deliv Rev. 2007;59(11):1152–61.
31. Choudhury H, Pandey M, Chatterjee LA, et al. Emerging role of nanosystems in treatment of psoriasis. Curr Drug Targets. 2020;21(11):1064–1076.
32. Raj S, Khurana S, Choudhury H, et al. Application of nanotechnology in dermatology: A review. J Cosmet Dermatol. 2020;19(2):270–277.
33. Boehncke WH, Schön MP. Psoriasis. Lancet. 2015;386(9997):983–94.
34. Rendon A, Schäkel K. Psoriasis pathogenesis and treatment. Int J Mol Sci. 2019;20(6):1475.
35. Gupta PN, Kumar V, Mishra V. Nanotechnology in the management of psoriasis: progress, challenges, and future prospects. Drug Discov Today. 2021;26(8):1891–902.
36. Dattola A, Silvestri M, Bennardo L, Del Duca E, Longo C, Bianchi L, et al. Emerging role of nanotechnology in psoriasis. Int J Nanomedicine. 2020;15:1–11.

37. Kalariya M, Padhi BK, Patel A, Bhatia D, Karri S. Curcumin nanogel for psoriasis: formulation development, in vitro and in vivo evaluation. Colloids Surf B Biointerfaces. 2019;182:110352.
38. Prow TW, Grice JE, Lin LL, Faye R, Butler M, Becker W, et al. Nanoparticles and microparticles for skin drug delivery. Adv Drug Deliv Rev. 2011;63(6):470–91.
39. Kang H, Hu S, Cho MH. Nanotechnology-based strategies for psoriasis treatment. Int J Mol Sci. 2020;21(23):8529.
40. Yamanaka K, Mizutani H. The role of cytokines/chemokines in the pathogenesis of psoriasis. Curr Probl Dermatol. 2018;54:63–75.
41. Ventola CL. Progress in nanomedicine: approved and investigational nanodrugs. P T. 2017;42(12):742–55.