Review Article

SYSTEMATIC REVIEW ON MICRONEEDLES DRUG DELIVERY IN THE MANAGEMENT OF VARIOUS DISORDERS

Seema Mudhol[1, *], Venkat Rao N.[1], Hanumanthachar Joshi[2]
[1] Department of Pharmacology, Sarada Vilas College of Pharmacy, K. M. Puram, Mysuru – 570008
[2] Department of Pharmacognosy, Sarada Vilas College of Pharmacy, K. M. Puram, Mysuru – 570008
***Corresponding Author:** Dr. Seema Mudhol, Associate Professor, Department of Pharmacology
Sarada Vilas College of Pharmacy, K. M. Puram, Mysuru- 570008

ABSTRACT:
Microneedle transdermal distribution is a method of providing medicinal substances to specific organs or tissues that involves inserting very small needles into the stratum corneum, the skin's outermost layer. Many people feel that this procedure could eventually replace the more common practice of administering medication to patients by injection. Microneedles (MNs) are a revolutionary form of drug administration that allows for the least invasive entry of medicinal substances into a variety of tissues, including skin. This review delves deeply into the use of microneedles in the diagnosis and treatment of a variety of medical conditions, including cancer, diabetes, obesity, neuropathic pain, neurological disorders, respiratory problems, wounds, acne, ophthalmic illnesses, and wound healing.

KEYWORDS:
Microneedles, Transdermal drug delivery, Targeted therapy, Drug delivery systems, Biomedical applications

1.INTRODUCTION:

MICRONEEDLES IN OBESITY MANAGEMENT

Obesity, a chronic illness that can cause a variety of health concerns, is defined by an excessive buildup of fat [1]. Traditional treatments to obesity therapy, such as dietary changes, medication, and bariatric surgery, have limited success and frequently result in unpleasant side effects [2].

MICRONEEDLES AND THEIR USES:

- Local Drug Delivery: Microneedles can be used to deliver anti-obesity medications such as phentermine or liraglutide to the dermal or subcutaneous layers, ensuring localised action with less systemic side effects [3].
- Leptin Therapy: In this treatment, the hormone leptin is delivered by microneedles. Leptin regulates appetite and
- can modulate hunger signals, which may lead to better weight management.
- Fat Metabolism: Microneedle-delivered gene therapy aimed at fat metabolism pathways may improve fat breakdown and reduce obesity [4].

BENEFITS:

Compared to oral treatments, there are less gastrointestinal side effects, and weight loss medications can be delivered more accurately, resulting in fewer unpleasant effects overall.

MICRONEEDLES IN DIABETES MANAGEMENT:

Diabetes is a metabolic condition marked by consistently elevated blood sugar levels due to insulin resistance or insufficient insulin synthesis. Microneedles are a promising method for administering insulin and non-insulin medicines to regulate blood glucose levels [5].

MICRONEEDLE APPLICATIONS:

- Transdermal Insulin Delivery: Microneedles improve patient compliance by administering insulin without the need for several injections.
- Microneedle injection of GLP-1 agonists, such as liganduide, can increase insulin production and sensitivity in type 2 diabetes [6].

Insulin that responds to changes in blood glucose levels: Microneedles can be used to create smart insulin systems that release insulin in response to blood glucose fluctuations.

BENEFITS:

The benefits include improved insulin

administration without the need for regular blood tests, as well as a less intrusive and uncomfortable alternative to injections [7].

MICRONEEDLES IN CANCER MANAGEMENT:

Cancer is defined by the unregulated proliferation of aberrant cells. Radiation, chemotherapy, and surgery are common therapies, but each has its own set of hazards. Microneedles provide a fresh approach to cancer treatment by enabling targeted drug delivery [8].

MICRONEEDLE APPLICATIONS:

- Chemotherapy Delivery: Two chemotherapy medications, paclitaxel and cisplatin, can be delivered locally using microneedles to reduce systemic toxicity.
- Immunotherapy: Cancer vaccines and immunomodulatory drugs can be delivered directly to the skin or tumour microenvironment using microneedles, boosting the immune response.
- The use of microneedles to administer gene editing tools such as CRISPR/Cas9 has the potential to transform gene therapy by increasing immune surveillance and detecting cancer-specific mutations [9].

BENEFITS:

Reduced systemic toxicity and improved cancer cell targeting are two advantages, while less intrusive administration increases the likelihood that patients would report feeling comfortable throughout therapy.

MICRONEEDLES IN VACCINE DELIVERY:

Traditional vaccination procedures requiring needles can be uncomfortable and require educated medical experts, but they are vital to prevent the spread of hazardous diseases. Microneedles offer a viable method for administering vaccines [10].

MICRONEEDLE APPLICATIONS:

- Microneedles allow vaccines (such as the COVID-19 and flu vaccines) to be delivered intradermally or transdermally with minimum discomfort.
- Microneedles can be used to deliver adjuvants and immunisations simultaneously, which can boost immune response.
- Self-administration: Microneedles enable self-administration of vaccines, making them more accessible to impoverished and rural communities [11].

BENEFITS:

It is cost-effective and appropriate for large-scale immunisation efforts; Patients find it simple to use; and It is non-invasive.

MICRONEEDLES IN NEUROLOGICAL DISORDERS:

The blood-brain barrier (BBB) blocks many therapeutic drugs from reaching the brain, making it difficult to treat neurological illnesses such as MS, PD, and Alzheimer's [12].

MICRONEEDLE APPLICATIONS:

- Microneedles can deliver neuroprotective drugs or dopamine agonists straight to the brain, bypassing the blood-brain barrier.
- Gene therapy: Microneedles can administer gene-editing tools to treat hereditary neurological illnesses by repairing mutations at the molecular level.
- Transdermal microneedle injection can alter brain activity and reduce symptoms in Parkinson's disease[13].

BENEFITS:

Minimal invasiveness, reducing the requirement for brain surgery. Direct and targeted delivery of neuroactive medications.

MICRONEEDLES IN RESPIRATORY DISORDERS:

Inhalers are used to treat a variety of respiratory illnesses, including asthma, COPD, and pulmonary fibrosis. However, the difficulty of properly targeting the lungs limits their efficacy [12].

MICRONEEDLE APPLICATIONS:

- Microneedles can administer bronchodilators and anti-inflammatory medications directly to lung tissue through the skin, a technique known as pulmonary drug administration.
- Microneedles containing gene editing tools can be utilised to treat genetic respiratory illnesses such cystic fibrosis as part of gene therapy [14].

BENEFITS:

One advantage is the potential for increased drug absorption and effectiveness, as well as the ease of delivery to the lungs or other specific parts of the respiratory system.

MICRONEEDLES IN NEUROPATHIC PAIN MANAGEMENT:

Because it involves both the central and peripheral neural systems, neuropathic pain produced by nerve injury can be difficult to treat [15].

MICRONEEDLE APPLICATIONS:

- Local Anaesthetics (e.g., lidocaine) or Anti-Inflammatory Medications: Microneedles can deliver local anaesthetics or anti-inflammatory medications directly to the affected area, alleviating pain.
- Neurostimulation: Microneedles can be used to provide capsaicin or other neurostimulatory drugs, which desensitise pain receptors and relieve chronic pain [16].

BENEFITS:
One of the advantages is that it relieves pain quickly and specifically. Systemic side effects are less common than with oral painkillers[17].

MICRONEEDLES IN DIAGNOSIS AND TREATMENT:
Microneedles have a wide range of medicinal uses due to their ability to detect biomarkers or infections [18].

MICRONEEDLE APPLICATIONS:
- Microneedles and their uses: Microneedles can be used to collect interstitial fluid for biomarker sensing, which is the process of identifying biomarkers associated with inflammation, infection, or diabetes.
- Diagnostic instruments: Adding microneedles to diagnostic tools can aid in illness detection at an early stage [19].

BENEFITS:
Being non-invasive and enabling for real-time monitoring; minimising the need for invasive diagnostic procedures and blood draws. [20].

MICRONEEDLES IN ACNE MANAGEMENT:
Acne is a common inflammatory skin illness that typically responds to topical therapies, oral medicines, or laser therapy [21].

MICRONEEDLE APPLICATIONS:
- Microneedles can be used for topical drug delivery, which entails delivering antibiotics (such as benzoyl peroxide), retinoids, or anti-inflammatory pharmaceuticals directly to the acne-affected skin layers.
- Gene therapy: Microneedles can carry gene-editing tools that can regulate skin cell turnover or prevent excessive sebum production, which is the primary cause of acne [22].

BENEFITS:
Advantages include targeted therapy for acne-prone areas and reduced systemic negative effects from oral acne medicines [23].

MICRONEEDLES IN OCULAR DISEASES:
Specialized treatment for eye disorders such as glaucoma, diabetic retinopathy, and macular degeneration is difficult due to limited medication absorption across ocular barriers [24].

MICRONEEDLE APPLICATIONS:
- One potential application for microneedles is ocular drug delivery, which entails increasing the bioavailability of growth hormones or anti-glaucoma medications by delivering them directly to eye tissues.
- Microneedles enable the delivery of gene therapies, which have the potential to treat retinal degenerative disorders [25].

BENEFITS:
In addition to having a larger concentration of medicine in ocular tissues, this treatment is non-invasive, which means patients feel less pain than with invasive procedures such as injections or surgery [26].

MICRONEEDLES IN WOUND HEALING:
Because illnesses such as diabetes or persistent wounds can impede the healing process, it is vital to discover innovative techniques to stimulate tissue regeneration [27].

MICRONEEDLE APPLICATIONS:
- One proposed application for microneedles is to distribute growth factors such as vascular endothelial growth factor (VEFG), which can aid in tissue repair and regeneration [28].
- Antimicrobial Treatment: Microneedles can be used to provide antibiotics or antiseptics to help manage infections in chronic wounds [29].

BENEFITS:
The benefits of localized drug delivery include a lower risk of infection, faster wound healing and tissue regeneration, and better overall health [30].

CONCLUSION:
Microneedles, as a versatile and potentially successful pharmaceutical delivery method, hold considerable promise for treating a wide range of ailments. The ability to precisely and minimally inject medications into specified regions has transformed therapeutic methods. Microneedles may increase pharmaceutical efficacy, patient adherence to treatment programs, and overall care results for a variety of conditions, including diabetes, obesity, cancer, and neurological disorders. As technology progresses, microneedles are poised to play an increasingly essential role in focused and customised treatment across a wide range of medical sectors.

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