

Redrawing the Delivery Map: The Next Dosage Form Is One That Patients Barely Notice

In recent years, drug discovery has advanced rapidly to yield increasingly sophisticated medicines, yet our primary method of administering these drugs remains remarkably unchanged. Many of these new and advanced macromolecules still rely on standard liquid injections, a dependence that imposes a significant physical and financial burden on patients and healthcare systems alike. Liquid injections frequently require cold-chain transport, clinic visits, administration by trained professionals and the physical discomfort of a needle.

Translating complex molecular science into patient-centric healthcare requires drug developers to pair therapeutic innovation with equally advanced, patient-directed dosage forms. Dermal drug delivery through microneedle array patches (MAPs) offers a viable solution to these translational challenges. This approach restricts penetration to the non-vascular outer layer of the skin to avoid the pain and anxiety associated with injections and remove the safety risks that require professional clinical administration. This transition away from legacy drug delivery methods can directly improve patient compliance, clinical outcomes and global accessibility.

The Legacy of Liquid Injection

Biologics now represent approximately 40% of the global drug development pipeline and account for nearly half of all new drug approvals.¹ These complex macromolecular therapies are transforming treatment across chronic therapeutic areas, including autoimmune diseases, cancers, endocrine disorders and genetic conditions. Despite their therapeutic promise, these complex structures cannot survive oral administration, as gastric enzymes and the acidic environment of the stomach degrade the molecules before they can enter the bloodstream.²

While bypassing this gastric barrier has long made liquid subcutaneous or intramuscular injections the default pathway for systemic biologic delivery, this approach carries physical and logistical challenges:

- Clinic visits require travel, consume patient time and increase the overall cost of care.
- Self-injection demands a high degree of manual dexterity and patient training.

Beyond these administration challenges, liquid formulations often present significant shelf-life limitations due to their molecular instability at room temperature. These formulations remain highly vulnerable to thermal fluctuations, light and mechanical stress. This sensitivity necessitates a continuous cold chain from manufacture to administration, which limits medicine distribution in developing regions, increases carbon footprints and generates substantial waste when temperatures slip outside of safe limits.

How Direct Dermal Penetration Unlocks Large Molecule Therapies

Traditional transdermal patches rely exclusively on passive diffusion to slowly seep small-molecule drugs through the stratum corneum, the highly resilient outermost layer of the skin. Because the stratum corneum is designed to keep foreign substances out, only a very narrow class of lipophilic, low-molecular-weight drugs can use this route, making transdermal delivery unsuitable for large macromolecules, proteins and vaccines.³

MAPs operate on a fundamentally different delivery principle. A MAP uses an array of microneedles to create precise, microscopic gateways directly into the underlying epidermal and dermal layers of the skin, physically bypassing the stratum corneum. These needles do not reach the deeper pain receptors or blood vessels located in the lower dermis, allowing for a painless delivery experience.

The dermal layer itself is a valuable target for drug delivery. It is highly vascularised and rich in antigen-presenting cells, such as Langerhans cells and dermal dendritic cells, making it the ideal site for vaccine delivery.⁴ When an antigen is delivered directly to this immunologically active environment, the response is often far more robust than when the same antigen is injected into muscle tissue. Clinical studies also suggest that dermal vaccine delivery can support dose sparing, which allows developers to use less active

ingredient to achieve the same protective effect.⁴ It may also reduce or eliminate the need for adjuvants, which can be the cause of local injection-site reactions.

Beyond vaccines, the rich vascular network of the dermis enables rapid systemic absorption of therapeutic peptides and proteins, making it an excellent path for daily or weekly biologic regimens.

At-Home Autonomy: Overcoming Needle Anxiety

Needle phobia is a highly prevalent condition that affects a significant portion of the global population.⁵ This anxiety often leads to treatment avoidance, missed doses and eventually complete non-adherence. In chronic diseases such as severe osteoporosis or diabetes, inconsistent dosing can accelerate disease progression and increase hospitalisations.

By removing the needle from view and eliminating associated pain, microneedle patches redefine the patient experience through a simple and intuitive application process. Patients apply the patch to the skin using a customised applicator device that automatically ensures the correct force and velocity of insertion, resulting in only a sensation of slight pressure. This straightforward ease of use supports patient autonomy and allows individuals to manage chronic conditions in the comfort of their home.

This opportunity for self-management is particularly advantageous for therapeutic classes that traditionally demand highly frequent, invasive dosing regimens to achieve therapeutic efficacy. In the rapidly expanding field of glucagon-like peptide-1 (GLP-1) receptor agonists, patient adherence remains highly dependent on overcoming the physical discomfort and anxiety of needles. Introducing a daily or weekly microneedle patch for GLP-1 delivery eliminates the need for regular subcutaneous injections, converting a potentially painful medical task into a routine wellness habit. Similar clinical benefits apply to daily therapies for osteoporosis, where elderly patients often struggle with the physical demands of preparing and administering liquid injections. By simplifying the administration process across these diverse indications, MAPs

empower patients to take control of their health, which directly leads to higher adherence and better long-term clinical outcomes.

The Potential for Solid-State Stability

One of the most profound advantages of solid-coated microneedle technology is the transition from liquid to solid-state chemistry. To create a solid-coated MAP, formulation scientists transfer a biologic from a liquid format to a specialised coating solution that can then be deposited as droplets on the tips of the microneedles. Once dried, the active biologic molecule is held in a stable, solid-state matrix.

Liquid formulations are highly dynamic environments where molecules are free to move, aggregate and degrade. The solid-state matrix of a coated microneedle immobilises the biologic, which restricts molecular movement and drastically reduces the rate of chemical degradation. Through this immobilisation, biologics that would normally denature within hours at room temperature can remain stable on a patch for months or even years without refrigeration.⁶

The commercial and humanitarian implications of this stability are vast. From a logistics perspective, eliminating the cold chain simplifies the distribution network. Pharmaceutical companies can ship vaccines and biologics through standard postal services directly to patients, bypassing the expensive infrastructure of refrigerated shipping and specialised clinic storage. In developing nations or disaster zones where refrigeration is unavailable, room-temperature stable patches can be distributed safely to remote populations. This stability also reduces the risk of medicine waste, ensuring that stockpiles of critical therapies remain viable for extended periods without ongoing energy costs.

Designing for the Patient Experience

Creating a successful patient-centric MAP requires a deep understanding of both formulation chemistry and mechanical design. The physical design of the microneedle array must be optimised for both skin penetration and drug release. At Kindeva, this micro-architecture is engineered using a proprietary liquid crystalline polymer (LCP) platform. LCP is an exceptionally strong, biocompatible material that maintains its structural integrity during skin insertion, ensuring that the needles do not bend or break during use.

Every aspect of the array architecture can be customised to suit the specific therapeutic target:

- **Needle length:** Determining the precise length ensures the needles target either the shallow epidermis for local therapies or the deeper dermis for rapid systemic absorption.
- **Needle spacing and density:** Optimising the distance between needles ensures the application force is concentrated effectively to penetrate the skin barrier without causing unnecessary tissue displacement.
- **Formulation concentration:** Maximising API concentration in the coating droplet allows us to deliver the target dose within a very limited physical surface area.

While customising this micro-architecture optimises the patch, clinical success ultimately relies on pairing the array with an applicator device that overcomes natural variations in skin physiology. Because skin elasticity varies significantly across age groups and body types, a reusable or single-use applicator is essential to ensure consistent drug delivery. By applying the patch at a standardised velocity and force, this integrated mechanism guarantees that the microneedles penetrate the skin to the exact target depth every single time, regardless of whether the user is an elderly patient or a young caregiver.

The Industrial Horizon

Scaling microneedle arrays beyond laboratory benchtop environments represents a sizable industrial challenge, as many early architectures performed reliably in controlled R&D settings but proved impossible to reproduce consistently at high volumes.

To overcome this industrialisation bottleneck, developers must design with manufacturability in mind from the very beginning of a programme. This means understanding the constraints of commercial assembly lines and engineering backward to the early design phase. Translating this early design philosophy into a scalable reality requires specialised, highly automated production lines that integrate advanced robotics, isolated cleanroom environments and machine vision systems to guarantee that every patch meets strict regulatory and quality standards.

By establishing this end-to-end manufacturing pathway, developers can significantly de-risk the scale-up process. Biopharma companies can initiate feasibility studies with the confidence that the same formulation and process can be scaled seamlessly to commercial production. This industrial maturity is the final, essential step in turning

the promise of microneedle technology into a commercial reality.

Embracing the Future of Patient-Centric Medicine

Prioritising the patient's daily experience is becoming the defining requirement for modern drug delivery. By combining the clinical efficacy of injections with the ease and stability of a dry patch, MAPs offer an unparalleled opportunity to modernise healthcare. This technology eliminates needle pain, enables at-home self-administration, can remove cold-chain restrictions and ensures precise, automated dosing.

For biopharma innovators looking to differentiate their products, serve patients more effectively and secure their pipelines, MAPs represent the path to progress. The dermal revolution is here, and the future of medicine is ready to be applied.

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