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Microinfusion of medications into the skin as a drug delivery technique: a narrative review

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Abstract

Microinfusion of medications into the skin (MMP®) is an innovative method that employs tattoo devices to administer pharmaceuticals transdermally. This technique facilitates the formation of microchannels in the skin, allowing for localized drug deposition with minimal systemic absorption and fewer adverse effects.

A literature search was conducted using PubMed and Google Scholar to identify studies discussing the application of MMP® as a transdermal drug delivery method, covering publications up to October 2025. All studies identified through the literature search were summarized in chronological order from the earliest (2013) to the most recent (2025). This arrangement was chosen to illustrate the progressive evolution of the MMP® technique and its expanding clinical applications over time.

Our research found 14 studies that evaluated the effectiveness of the tattoo machine for transdermal drug administration. Eight studies focused on MMP® for alopecia treatments, demonstrating notable improvements in androgenetic alopecia, alopecia areata, and frontal fibrosing alopecia, with minimal adverse reactions reported. Six studies investigated its role in treating scars and striae, showing significant lesion improvement. One study examined its use with bleomycin in basal cell carcinoma treatment, and another assessed its impact on psoriasis vulgaris with cyclosporine A and methotrexate (MTX).

MMP® represents a promising, minimally invasive transdermal delivery system with a growing body of evidence supporting its application in alopecia, oncologic dermatology, and pigmentary disorders. The ability to uniformly distribute medications at targeted skin depths, combined with its favorable safety profile, highlights its potential as a valuable alternative to conventional delivery methods. Furthermore, the microneedling effect of the tattoo device itself may confer therapeutic benefits independent of pharmaceutical administration.

Introduction

The outermost layer of the skin, the stratum corneum, serves as a protective barrier that impedes drug penetration. Despite various transdermal drug delivery techniques being available, achieving effective absorption remains a challenge. Traditional methods, such as intralesional injections, offer direct drug administration into affected areas but pose challenges, including inconsistent diffusion into deeper layers, difficulty in microdosing large regions, and pain associated with the procedure.[1,2] Microinfusion of medications into the skin (MMP®) was initially introduced for administering bleomycin in keloid treatment.[1] Since then, numerous studies have explored its applicability in conditions such as alopecia,

scars, skin cancers, and psoriasis. This review aims to compile evidence on MMP® indications, drug compatibility, advantages, and safety considerations.

MMP® overview

MMP® (the Portuguese acronym for microinfusion of drugs into the skin) which was first described in 2013, is a potential drug delivery method that uses a tattoo machine to deliver medications.[1-17] The complete set of equipment consists of the tattoo machine (body), disposable tips, and needles, all of which are suitable for use in an outpatient setting. Many models are available, one has the Brazilian National Health Agency (ANVISA) certification to use in medical practice (Cheyenne®, Berlin, Germany). The machine has basic on and off operation buttons, powered by a single energy source, has an adjustable operation velocity and contains a set of solid needles in a sterile cartridge. The cartridge is filled with the medication by the dermatologist and initiates the drug delivery. The drug is actively delivered through needling regardless of the chemical nature of the medication. During each cycle, the medication is drawn through needles, and the skin is then punctured to reach the desired depth. The friction caused by the rapid penetration into the desired level creates shear stress and a turbulent swirl of the medication, which increases its diffusion in the desired level.[1-5] However, even when no medication is infused, the microchannels created by MMP® can induce an outcome like other microneedle devices.[7]

MMP® advantages

MMP®, besides its low cost and little complexity, is well tolerated by most patients. Although pain is an unwanted adverse effect of microneedling, it can be managed with topical anesthesia. It also proved to be quite safe. Compared with intralesional injections, MMP® needs a scanty amount of volume that can be infused uniformly into the desired depth of the dermis, thus enhancing medication delivery to the intended level and minimizing local adverse effects.[8] MMP® addresses several challenges commonly encountered with other drug delivery methods. The sterile medication is drawn by capillarity and is naturally diffused when the skin is deeply perforated by shear force. Unlike other techniques, post-procedure massaging is unnecessary, minimizing the risk of contamination from external organisms. Furthermore, the ability to regulate the speed and length of needling (from 0.1 mm to 2 mm) allows for a more uniform delivery to the desired level. The small size of the needle cartridges makes MMP® perfect to reach areas that are challenging to reach by larger techniques, such as derma rollers.[6] Alternative techniques, including fractional lasers, fractional radio frequency and certain microneedling techniques are available for transdermal drug delivery. However, these techniques lack MMP® effectiveness and

sterility. The delicate perforation process along with the potential to use it on small lesion areas, makes MMP® unique. Additionally, this technique has not been shown to cause shaft breakage, which is seen with other techniques. Fractional lasers, despite being expansive, induce a thermal effect on the perforation's walls, which impedes the absorption of medication. Thus, fractional radiofrequency involves the addition of ultrasound to enhance medication diffusion.[1,8]

Safety of the technique

After medication delivery by the tattoo machine, the administered active pharmaceutical would be absorbed and eliminated over a variable period. However, when assessing the pharmacokinetics of medications delivered through any transdermal drug delivery method, systemic absorption of the medication upon administration is undeniable. Although it is essential to consider variation in systemic absorption whether lymphatic or bloodstream, factors such as the chemical composition, the molecular weight and the amount of medication used are also crucial. A fundamental criterion upon transdermal drug delivery is whether the drug or its vehicle are already approved for systemic administration or safety studies have been conducted for intradermal administration.[1,2,5]

Arbache *et al.* conducted an experimental study to assess the safety of MMP® by measuring the medication delivered through weighing human skin samples before and after MMP® sessions. They utilized a Cheyenne® tattoo machine along with cartridges containing 27 needles, each with a diameter of 0.3 mm and a tip length of 5.5 mm. The needle depth was fixed at 300 microns, while the frequency was set at 120 Hz. A small quantity of medication (1,175 $\mu g/cm^2$) was diffusely scattered in the superficial dermis without causing an expansive effect. Modifying drug delivery depth led to an improvement in the safety of this technique.[2,8]

Materials and Methods

A comprehensive literature search was conducted using PubMed and Google Scholar databases to identify all publications discussing MMP® as a transdermal drug delivery technique. The search included all studies published up to October 2025, using the following key words and Boolean combinations: "microinfusion of medicines" OR "microinfusion of drugs" OR "MMP® technique" OR "tattoo machine drug delivery" OR "tattoo-assisted drug delivery" OR "dermal microinfusion" OR "transdermal drug delivery" OR "microneedling for drug delivery". All studies identified through the literature search were summarized in Table 1, which presents the included publications in chronological order from the earliest (2013) to the most recent (2025). Additional filters were not applied for language or study type to ensure

comprehensive coverage. No time restrictions were used and animal clinical trials were excluded. Reference lists of included articles were also screened to identify relevant studies not captured through database search.

Review of the indications

Alopecia

Neri *et al.* (2023) reported substantial improvement in the clinical condition of the patient with frontal fibrosing alopecia (FFA) treated with botulinum toxin type A using MMP®, characterized by inhibition of the inflammatory process, increased follicular density and growth of new hairs.[4]

Pitlovanciv *et al.* (2022) found significant reductions in frontal-glabella and frontal temporo-parietal measurements in the infused area with methotrexate (MTX) microinfusion, in contrast to the untreated areas where the FFA increased.[13]

Barletta *et al.* (2020) examined the effects of MMP® sessions with triamcinolone acetonide (TAC) in two patients with alopecia areata. A male patient with previous use of oral and intralesional corticosteroids and vitamins showed variable outcomes and reappearance of alopecia patches. But with MMP® 4-monthly sessions, significant hair regrowth in frontal and parietal regions and partial regrowth of the temporo-occipital areas was observed. The female patient was using 5% topical minoxidil and daily dose of biotin (10 mg) for four weeks with no changes in clinical condition. Topical minoxidil and 4-monthly tattoo machine sessions with triamcinolone acetonide resulted in complete hair regrowth in the frontal and parieto-occipital regions.[11]

Nogueira *et al.* (2023) reported a 37-year-old female diagnosed with systemic lupus erythematosus and ophiasis pattern alopecia areata. After failure of topical treatment and intolerability of systemic treatment with MTX due to hepatotoxicity, the author used a single session tattoo machine with 20 mg of MTX in the affected areas, which was stopped due to transient elevation of aspartate transaminase and glutamate transaminase and subsides 2 weeks after stopping the treatment.[9]

Contin *et al.* (2016) evaluated MMP® with and without minoxidil in two male patients with androgenetic alopecia who did not tolerate finasteride. Results showed cosmetically satisfactory partial response in both cases but no superiority of MMP® with drug delivery.[12]

Ragi *et al.* (2023) examined MMP® with minoxidil and dutasteride in individuals with androgenetic alopecia with no improvement with topical minoxidil and oral 5-α-reductase inhibitors for a period exceeding six months. After three-month tattoo machine sessions 15 male patients experienced successful regrowth of 25% of the upper scalp area.[14]

In recent research, there has been growing focus on female pattern hair loss (FPHL). Corrêa *et al.* (2024) conducted a split-scalp, self-controlled pilot study comparing the efficacy of minoxidil 0.5% administered *via* MMP® microinfusion with the standard topical minoxidil 5% solution for treating FPHL. Sixteen women with trichoscopy-confirmed FPHL, who had received no prior treatment for at least six months, underwent four monthly MMP® sessions on the right frontal-parietal-vertex areas, while continuing topical 5% minoxidil once daily to both sides of the scalp beginning 72 hours post-procedure. Trichoscopic reassessment six weeks after the final session demonstrated that both interventions were effective overall, with comparable global improvement between sides.[18]

Building upon prior androgenetic alopecia studies, Gasques *et al.* (2025) conducted a pilot randomized controlled trial evaluating the efficacy and safety of dutasteride infusion *via* MMP® in men with androgenetic alopecia. Eight participants underwent three monthly sessions of MMP® using dutasteride 0.05% on one half of the scalp and saline on the other. Although blinded dermatologic assessments did not reveal a statistically significant difference between sides, patients reported subjective improvement at the vertex in the dutasteride-treated areas. Importantly, no sexual or systemic adverse effects were observed, suggesting that scalp-level delivery of dutasteride *via* MMP® may represent a safe, localized therapeutic approach for male pattern hair loss pending confirmation in larger trials.[19]

Scars and striae

Arbache *et al.* (2019) examined the tattoo machine with 5-fluorouracil (5-FU), in a patient who had 18 laser tattoo removal sessions which resulted in achromic scars. After five monthly MMP® sessions, the scars were completely repigmented for more than 2 years.[15] Arbache *et al.* (2021) evaluated the effect of MMP® sessions using 5-FU and/or bleomycin in eleven patients with hypochromic lesions. Among the patients, five received treatment with 5-FU, with three showing satisfactory results after one session, while the remaining patients did not see improvement until they received bleomycin in subsequent sessions. On the other hand, six patients were exclusively treated with bleomycin, and three of them experienced temporary hyperpigmentation. However, all patients demonstrated a significant improvement (>75%) in their lesions compared to baseline, and none of the eleven patients experienced any adverse effects.[16]

Arbache *et al.* (2023) evaluated the effectiveness and safety of administering 5-FU through MMP® in one limb and compared it with saline in the contralateral limb to repigment idiopathic guttate hypomelanosis (IGH) lesions on twenty-nine patients. It demonstrates a substantial reduction in achromic lesions compared to saline-treated limbs in patients with IGH.[3]

De Souza *et al.* (2023) studied eight patients who had mature atrophic and achromic scars located in various anatomical areas such as the face, thighs, abdomen, knee, and breast. The findings indicated a significant enhancement in scar pigmentation and texture following 2 to 3 monthly MMP® sessions. After six months, six out of eight patients expressed the highest level of satisfaction, rating the results as "very satisfied" on the Likert Scale, while the remaining two patients rated their outcome as "satisfied". Additionally, one patient experienced temporary post-inflammatory hyperpigmentation, which was completely resolved after the application of topical 4% hydroquinone cream.[17]

Arbache *et al.* (2013) evaluated the use of MMP® with saline and bleomycin to treat keloids in two separate cases. In the first case, the keloid lesion was divided into three segments: bleomycin was infused on the left side, no treatment was given to the center, and 0.9% NaCl was infused on the right side. Two infusions were administered with a 30-day interval between each. The lesion in the second case was divided into two parts, with bleomycin infused on the right side and 0.9% NaCl on the left side. A single infusion was carried out. The study reported a significant reduction in keloid thickness and improvement in consistency in the bleomycin treated keloids in contrast to those treated with 0.9% NaCl, as confirmed microscopically.[1]

Gasques *et al.* (2023) investigated the effects of MMP® treatment on stretch marks in ten females with striae alba, focusing on various body areas such as the buttocks, thighs, abdomen, and breasts. The participants received 3-monthly sessions using a sterile product containing elastin, chondroitin, ascorbic acid, and hyaluronic acid. Following the treatment, patients evaluated their satisfaction using a visual analogue scale. The feedback provided by all patients fell within the range of moderate to good.[6]

Skin cancer

In the oncologic setting, Pacola *et al.* (2023) provided the largest prospective study to date investigating bleomycin delivery *via* MMP® for the treatment of basal cell carcinoma. The study included 98 lesions treated with bleomycin microinfusion, yielding an impressive six-month cure rate of 96.9%, with only expected, manageable local reactions such as transient erythema, edema, and crusting. The authors highlighted the precision of drug delivery across tumor margins and the practicality of treating multiple lesions within a single session, underscoring MMP®'s potential as a minimally invasive alternative for patients unfit for surgery or those with multiple low-risk lesions. Nevertheless, long-term follow-up remains necessary to evaluate recurrence rates and define ideal candidates for this modality.[5]

Psoriasis vulgaris

Okita *et al.* (2018) reviewed MMP® sessions using cyclosporine or MTX in four psoriasis cases (two cases for every drug). The paper evaluated patients who had moderate to severe psoriasis and lesions that proved refractory to previous treatment. The findings indicated favorable tolerability among the participants, rapid response, lack of adverse effect with no methotrexate or cyclosporine serum levels detected.[10]

Discussion

Physicians are increasingly turning to transdermal drug delivery techniques as a method to bypass the stratum corneum that impedes the absorption of topical medications. MMP® is characterized by the advantage of creating micropunctures through needling in addition to the spontaneous delivery of a small amount of medication actively to its site of action with fewer local side effects. Tattoo machines penetrate the dermis through needling and induce micropunctures with columns of superficial bleeding, initiating a controlled inflammatory reaction that results in the release of various growth factors such as transforming growth factor-alpha, transforming growth factor-beta, platelet-derived and vascular endothelium-derived growth factor, ultimately resulting in angiogenesis, neocollagenesis, and elastin synthesis. The extent to which the retrograde blood flow is actively expelled through the micropunctures created by other needling methods that impede the passive penetration of drugs remains unknown. This shows the advantage of MMP®, as it delivers the drug actively to its site of action.[6,7] The literature describes the use of MMP® to treat various dermatological conditions such as alopecia areata, frontal fibrosing alopecia, androgenetic alopecia, psoriasis vulgaris, basal cell carcinoma, hypochromic scars, idiopathic guttate hypomelanosis, linear scars, keloid lesions and striae alba with promising results and no severe side effects reported. However, Nogueira *et al.* (2022) reported a transient elevation in transaminase levels one week after a single session of tattooing with a tattoo machine and MTX in a patient with ophiasis-pattern alopecia areata associated with systemic lupus erythematosus. This was observed after excluding lupus-related alopecia and other potential confounding factors, in a patient with a prior history of hepatotoxicity due to systemic MTX treatment. On the other hand, Okita *et al.* (2018) used the same intervention and reported favorable tolerability, absence of adverse events and quick response among psoriasis patients who were unable to tolerate systemic therapy.

In general, there are potential benefits of this technique including a potent local effect, minimized toxicity through bypassing the hepatic first-pass metabolism, the ability to administer lower drug dosages due to efficient dermal permeation and reaching the systemic circulation at a minimal and unnoticeable level.[9,10]

Recent evidence has further validated the versatility of the MMP® technique across distinct dermatologic conditions. In androgenetic alopecia, a pilot randomized trial using dutasteride MMP® demonstrated favorable patient-reported improvement with excellent tolerability, highlighting its potential as a localized alternative to systemic 5-α-reductase inhibitors. Likewise, a split-scalp study using MMP®-delivered minoxidil showed efficacy comparable to topical 5% minoxidil, with superior response in vertex and parietal areas, suggesting enhanced drug bioavailability in less advanced disease.[18] In the oncologic field, bleomycin microinfusion achieved a 96.9% six-month cure rate for basal cell carcinoma, confirming the method's capacity for uniform and effective intradermal chemotherapeutic delivery.[5] Collectively, these data reinforce the safety and clinical potential of MMP® as a versatile transdermal platform applicable to both inflammatory and neoplastic skin conditions.

When it comes to safety of MMP® technique, the main issue is the amount of drug infused. Although there are discrepancies in various studies, Arbache *et al.* (2019) determined the mean value to be 1,175 μg/cm^2. Highlighting the advantage of the procedure as it allows such a small amount of medication to be injected onto a surface of 1 cm^2 compared to using syringes.[2] However, no studies further describe the depth of application needed, the frequency of sessions, the optimal time gap between sessions necessary for initial results to be perceived, elimination of drugs, potential contraindications and complications associated with the procedure.

Conclusions

MMP® is a simple, cost-effective, and well-tolerated technique that allows precise intradermal drug delivery with minimal systemic absorption. Recent studies using dutasteride and minoxidil for alopecia and bleomycin for basal cell carcinoma highlight its expanding therapeutic potential. Even without medication, the microneedling effect contributes to clinical improvement. Overall, MMP® offers a promising, minimally invasive transdermal delivery method, warranting further research to standardize protocols and confirm long-term efficacy.

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Table 1. Review of studies reporting the use of MMP® for delivering drugs (chronological order).

Author (Year)	Country, Type	Sample	Indication	Intervention	Results
Arbache *et al.* (2013)[1]	Brazil, Case Report	2 females	Keloid lesions	Infusion of bleomycin sulfate using MMP® technique *vs.* infusion of saline	Significant reduction in thickness of keloid areas infused with bleomycin and improvement in the consistency was observed compared to saline infused areas. Histological analysis showed decreased density of collagen fibers, reduced number of fibroblasts and decreased lymphocytic inflammatory infiltrate.
Contin *et al.* (2016)[12]	Brazil, RCT	2 males	Androgenetic alopecia	4-monthly MMP® sessions with drug infusion of minoxidil 0.5% *vs.* 3-monthly MMP® sessions without infusion at 1.5 mm needle depth	Satisfactory partial response. No superiority of MMP® with drug delivery.
Okita *et al.* (2018)[10]	Brazil, Case Series	2 males	Psoriasis vulgaris	MMP® sessions with application of CYA or MTX	Treatment with the MMP® technique using MTX or CYA solution demonstrated good tolerability, lack of adverse effects, rapid response (within 2 weeks), and effectiveness both in lesions that have been treated isolatedly and in distant lesions that did not undergo the application.
Arbache (2019)[15]	Brazil, Case Report	1 male	Achromic scar repigmentation	5-monthly sessions of 5-FU using the MMP® drug delivery technique	Substantial improvement in patient's clinical condition with complete repigmentation of scars. Appearance remained unchanged 3 years after the last session.
Barletta *et al.* (2020)[11]	Brazil, Case Report	1 male, 1 female	Alopecia areata	4-monthly MMP® sessions of 2.5 mg/mL and 10 mg/mL of TA concentrations at 1.0 mm needle depth	Promising intervention that stimulated hair growth in the alopecia areata patches.
Arbache *et al.* (2021)[16]	Brazil, Case Series	11 patients	Hypochromic lesions repigmentation	Injection of 5-FU and/or bleomycin using the MMP® drug delivery technique	Significant improvement (>75%) of lesions compared to baseline after 1 to 6 MMP® sessions. No procedure-related adverse effects.
Pitlovanciv *et al.* (2022)[13]	Brazil, RCT	17 females	Frontal fibrosing alopecia	Three applications of methotrexate by MMP® method every 30 days, in a total of 3 applications	Significant reduction in frontal glabella and frontal temporo-parietal measurements at treated site compared to untreated site where the frontal fibrosing alopecia increased. About 95% of the participants were satisfied

					or very satisfied with the results and none had alteration in laboratory tests.
Arbache *et al.* (2023)[3]	Brazil, RCT	29 patients (28 females)	Idiopathic guttate hypomelanosis	MMP® technique used to deliver 5-FU in IGH lesions of one limb and saline in the contralateral limb	Significant reduction in achromic lesions in 5-FU-treated limbs compared to saline-treated limbs. High patient satisfaction. No adverse events were observed.
Gasques *et al.* (2023)[6]	Brazil, Case Series	10 females	Striae alba in different body sites	3-monthly sessions of MMP® using a sterile product composed of elastin, chondroitin, ascorbic acid and hyaluronic acid	Moderate to good improvement in patients' clinical condition measured by VAS. Significant reduction in the density of stretch marks observed.
Neri *et al.* (2023)[4]	Brazil, Case Report	1 female	Frontal fibrosing alopecia	Three monthly sessions of 30 units/session of botulinum toxin type A administered by MMP® technique	After three months of treatment, a substantial improvement was observed, characterized by inhibition of inflammation and increased follicular density and resistance to traction.
Nogueira *et al.* (2023)[9]	Brazil, Case Report	1 female	Alopecia areata	MMP® session with microinfusion of 20 mg of MTX in alopecia patches	Transient elevation of transaminases after 1 week of treatment.
Ragi *et al.* (2023)[14]	United States, Retrospective Cohort	15 males	Androgenetic alopecia	3-monthly sessions of minoxidil and dutasteride drug delivery through rotatory tattoo machine (Cheyenne®)	A successful 25% top scalp area regrowth was observed after 3 sessions of minoxidil and dutasteride delivery through tattooing.
Pacola *et al.* (2023)[5]	Brazil, Prospective Study	32 patients (14 males, 18 females)	Basal cell carcinoma	MMP® technique to administer and uniformly distribute bleomycin throughout the lesion and safety margin	Cure rate after six months was 96.94%. Adverse effects were expected and manageable.
De Souza *et al.* (2023)[17]	Brazil, Case Series	8 patients (1 male, 7 females)	Linear atrophic scars	Two to three sessions of MMP® associated with drug delivery of 5-FU	Marked improvement in scar pigmentation and texture six months after treatment; high patient satisfaction on Likert Scale.

Corrêa *et al.* (2024)[18]	Brazil, Split-Scalp Self-Controlled Pilot Study	16 females	Female pattern hair loss	Minoxidil 0.5% *via* MMP® microinfusion, 4 monthly sessions on right frontal-parietal-vertex areas *vs.* topical minoxidil 5% once daily on both sides of the scalp	Both treatments are effective; better density gains in parietal-vertex regions with MMP® minoxidil, especially in early-stage FPHL.
Gasques *et al.* (2025)[19]	Brazil, Pilot RCT	8 males	Androgenetic alopecia	Three monthly sessions of MMP® at 1.0 mm; dutasteride 0.05% (1 mL) *vs*. MMP® with saline (placebo)	No significant difference on blinded clinical scoring *vs*. placebo; patient self-assessment favored dutasteride at the vertex; well tolerated; no sexual adverse events or lab abnormalities reported.

TA, triamcinolone acetonide; 5-FU, 5-fluorouracil; VAS, Visual Analogue Scale; CYA, cyclosporine A; MTX, methotrexate; IGH, idiopathic guttate hypomelanosis; FPHL, female pattern hair loss.