# Combined Regenerative Technique: Tattoo Machine–Assisted Drug Delivery for Androgenetic Alopecia

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## ABSTRACT

Androgenetic alopecia (AGA) is the most common cause of hair loss, and while topical minoxidil and oral 5-α-reductase inhibitors remain first-line therapies, clinical results are often limited by transepidermal absorption, suboptimal follicular delivery and patient compliance. Tattoo machine–assisted drug delivery, also known as Microinfusion of Medicaments into the Skin (MMP®), is emerging as a useful technique that combines controlled scalp microneedling with direct intradermal deposition of therapeutic agents.

This article describes a combined regenerative technique (CRT) that integrates tattoo machine–assisted infusion of minoxidil sulfate, dutasteride, copper peptides, and platelet-rich plasma with concurrent oral minoxidil and topical finasteride. The biologic rationale, equipment, clinical protocol, and practical considerations are reviewed.

Early clinical experience suggests that this multimodal approach may enhance hair density and shaft thickness while maintaining a favorable safety profile. Tattoo machine–assisted drug delivery represents a promising adjunctive strategy for clinicians seeking to optimize medical management of AGA, though larger controlled studies are needed to further define its role.

## INTRODUCTION

Androgenetic alopecia (AGA) remains the most common cause of hair loss worldwide, with millions of men and women affected by its progressive course.[1-3] For decades, topical minoxidil and oral 5-α-reductase inhibitors have been the therapeutic backbone.[4,5] While effective in some patients, results are often incomplete and adherence can be a challenge.[6,7] This limitation has inspired the development of novel methods of drug delivery to the hair follicle. One such method is tattoo-machine assisted drug delivery, also called Microinfusion of Medicaments into the Skin (MMP®).[8-10] The technique employs a professional tattoo device to generate dense arrays of microchannels in the scalp while simultaneously infusing a compounded solution of active medications. This article aims to present the rationale, the technical considerations, and the clinical outcomes associated with this emerging approach, providing a practical reference for clinicians interested in adopting it in their practice.

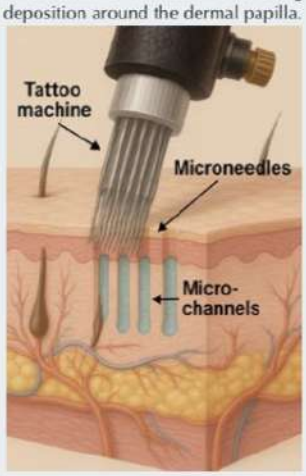
In this retrospective study, we evaluated the efficacy of a novel combined regenerative technique (CRT) that integrates transdermal drug infusion through scalp tattooing of minoxidil sulfate, dutasteride, copper peptides, and platelet-rich plasma (PRP), in combination with oral minoxidil (2.5mg for men, 0.5mg for women) and 1% topical finasteride. The protocol was applied to five patients (four males and one female) diagnosed with AGA.

## MECHANISM OF ACTION

The therapeutic benefit of tattoo machine–assisted delivery derives from a two-fold mechanism. First, the act of controlled microneedling initiates a cascade of biologic responses that stimulate follicular activity. Each needle puncture produces a micro-injury, which prompts a controlled wound healing process with release of platelet-derived growth factor, vascular endothelial growth factor, fibroblast growth factor, and epidermal growth factor. These mediators drive neovascularization and improve local nutrient delivery to follicles. The trauma also awakens multipotent stem cells in the bulge region and upregulates key Wnt proteins, including Wnt3a and Wnt10b, which are essential for transition into the anagen growth phase.

The second mechanism is the enhancement of drug delivery itself. Whereas topical therapies are limited by the barrier function of the stratum corneum, the tattoo needles breach this barrier and deposit medications precisely into the dermis at the level of the follicular papilla. Because the cartridge reservoir infuses the solution with each oscillation, the process ensures uniform distribution and avoids the peaks and troughs of passive topical absorption. The end result is a consistent, low but effective concentration of active drug directly in contact with its intended target (Figure 1).

FIGURE 1. Schematic illustration of microchannel formation and drug deposition around the dermal papilla.




## EQUIPMENT AND THERAPEUTICS

The procedure depends on specialized equipment, though most devices are readily available in clinical practice. A professional rotary tattoo machine provides the precision and control needed. These machines typically run at frequencies between 66 and 199Hz, with the scalp protocols favoring around 70Hz. Needle depth is adjusted to 2.0mm, which corresponds to the reticular dermis where follicles reside. Disposable cartridges, most commonly with 27 fine needles arranged in rows, incorporate small reservoirs that can hold and gradually release the therapeutic solution. Importantly, a safety membrane in these cartridges prevents backflow and contamination. (See Figure 2.)

FIGURE 2. Sterile setup including cartridges, solution vials, and device assembly.

The infusion solution itself is com-

pounded in a sterile environment and may vary depending on patient needs. A commonly used formula includes 0.5% minoxidil sulfate, 0.05–0.1% dutasteride, and 1.2% copper peptides, and autologous PRP is incorporated to supply additional growth factors. All compounding should be performed by a qualified pharmacy under sterile conditions to minimize the risk of contamination

## CLINICAL TECHNIQUE

Patient comfort and sterility are central to the technique. After a thorough cleansing of the scalp with alcoholic chlorhexidine, anesthesia is provided. A circumferential ring block using 2% lidocaine is typically sufficient, and some operators employ a vibration device to distract from discomfort. The tattoo machine is then assembled with a new sterile cartridge, adjusted to a depth of 2.0mm, and filled with the prepared solution.

FIGURE 3. Intra-procedure image demonstrating cartridge placement at 90 degrees and visible pinpoint bleeding.

The scalp is often divided into small zones to ensure even coverage. The handpiece is held perpendicular to the scalp, and passes are performed along the hair combing direction to avoid hair shaft damage. It is important to lift the device periodically, allowing the reservoir to refill and ensuring consistent infusion. The endpoint of the procedure is faint pinpoint bleeding, or "blood dew," which signifies that the target dermal depth has been reached. On average, 6-8mL of solution is distributed over 80-100cm² per session. (See Figure 3.)

Following treatment, patients are advised that mild redness and desquamation are normal for 2-4 days. Gentle cleansing may begin after 12 hours, but strenuous exercise, heat exposure, and swimming should be avoided for 24 hours. Topical minoxidil and finasteride are usually resumed at 24 hours after the procedure, and oral minoxidil may be continued without interruption if prescribed. Figure 4 shows patient before-and-after photos taken at 6 months post-procedure.

## EVIDENCE AND OUTCOMES

Several small but encouraging studies support the use of tattoo machine–assisted delivery. A cohort of 15 men who underwent three monthly sessions of minoxidil-dutasteride tattooing achieved clinically meaningful regrowth, with over half of patients demonstrating more than a 10% increase in top scalp area regrowth.[9] An enhanced protocol adding copper peptides and extending to five sessions improved results further, with a median regrowth of 26.5% and the majority surpassing the 10% threshold.[10] More recently, the CRT that integrated tattoo-device assisted infusion of minoxidil sulfate, dutasteride, copper peptides, and PRP alongside oral minoxidil and topical finasteride, produced striking improvements in both density and thickness.[8] In

FIGURE 4. The five patients' clinical and trichoscopy before-and-after photographs at six months.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4 men and 1 woman, AI-assisted trichoscopy measured increases exceeding 46% in density and 62% in shaft thickness across all scalp regions. Paired t-tests analysis revealed significant improvement across all scalp regions in both density and thickness after treatment ($p < 0.001$) (Table 1). In the frontal region median increases were 74% in density (IQR: 40.5%–135.5%) and 83% in thickness (IQR: 53.5%–169%). The mid-scalp showed median gains of 74% in density (IQR: 33.5%–115%) and 72% in thickness (IQR: 35%–144.5%). At the vertex, median improvements were 67 % in density (IQR: 44%–290%) and 68% in thickness (IQR: 48.5%–403%).

The safety profile across published studies is favorable. Mild erythema, discomfort, and flaking are expected and transient. No infections, scarring, or worsening alopecia have been reported. Systemic absorption appears limited, though a small but statistically significant drop in diastolic blood pressure has been observed in some patients, warranting caution in those with cardiovascular comorbidities. Contraindications mirror those of the individual drugs used, such as pregnancy in the case of dutasteride, as well as general exclusions such as active infection or uncontrolled bleeding disorders.

TABLE 1. Individual Patient Response to Combined Regenerative Technique

| | | | NUMBER OF TERMINAL UNITS PER SQ² (SUM OF HAIR THICKNESS IN MM PER CM²) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PATIENT NUMBER | SEX | AGE | Baseline frontal | Post frontal | % improvement | Baseline mid | Post mid | % improvement | Baseline vertex | Post vertex | % improvement |
| 1 | F | 35 | 79 (4,526) | 143 (8,543) | 81% (89%) | 141 (7,983) | 175 (10,420) | 24% (31%) | 138 (8,125) | 181 (10,700) | 31% (32%) |
| 2 | M | 54 | 125 (8,573) | 188 (11,730) | 34% (37%) | 107 (6,374) | 185 (10,966) | 73% (72%) | 104 (5,368) | 174 (9,022) | 67% (68%) |
| 3 | M | 31 | 96 (6,002) | 167 (10,227) | 74% (70%) | 78 (3,881) | 180 (10,069) | 131% (159%) | 87 (3,231) | 176 (9,212) | 102% (185%) |
| 4 | M | 56 | 116 (5,400) | 171 (9,682) | 47% (83%) | 75 (3,149) | 149 (7,252) | 99% (130%) | 27 (1,017) | 156 (7,331) | 478% (621%) |
| 5 | M | 36 | 52 (2,531) | 151 (8,840) | 190% (249%) | 98 (6,435) | 140 (8,937) | 43% (39%) | 115 (6,894) | 181 (11,352) | 57% (65%) |

## CURRENT STUDY

For this previously unpublished analysis, we retrospectively evaluated 10 consecutive patients—5 treated with the CRT and 5 receiving oral minoxidil alone—who had comparable treatment intervals between initiation of therapy and final follow-up, ranging from four to six months. The CRT group served as the intervention cohort, while the oral minoxidil–only group functioned as the control arm. This design allowed us to directly compare quantitative trichometric changes between groups over a similar treatment duration, thereby minimizing temporal confounding and enabling a focused assessment of the added benefit of CRT beyond standard medical therapy.

Quantitative analysis demonstrated consistent and robust improvements across all scalp regions following treatment. Paired baseline-to-follow-up comparisons showed statistically significant increases in nearly every measured trichometric parameter, including hair density, terminal width sum, and average hair shaft diameter. In the frontal region, hair density increased by an average of 53.6 units ($p = 0.0039$), terminal width sum rose by 4,177µm ($p = 0.000295$), and shaft thickness increased by 13.4µm ($p = 0.000116$), while the increase in follicular unit counts did not reach significance. Similar improvements were observed in the mid-scalp, where density increased by 45.1 units ($p = 0.00185$), terminal width sum by 2,532µm ($p = 0.0298$), and shaft diameter by 8.9µm ($p = 0.0056$). Follicular units increased by 9.6 ($p = 0.0313$), though the Wilcoxon test approached but did not meet significance. Vertex measurements followed the same pattern, with density rising by 28.8 units ($p = 0.0093$), terminal width sum increasing by 2,593µm ($p = 0.000723$), and shaft diameter improving by 8.5µm ($p = 0.00116$), while follicular unit changes were not statistically significant. Overall, 11 of the 12 quantitative measures demonstrated significant within-patient improvement, underscoring the consistency of the effect across regions.

Between-group comparisons further revealed that patients in the combined regenerative intervention arm experienced markedly greater percent-change improvements than controls. Significant differences favoring the intervention were observed for frontal density, frontal terminal width sum, mid-scalp density, mid-scalp hair shaft diameter, vertex density, and vertex terminal width sum, with p-values ranging from 0.00126 to 0.0454. These findings confirmed not only within-patient improvement but also a clear superiority of the intervention relative to standard treatment.

Baseline-adjusted ANCOVA models demonstrated that the intervention retained an independent positive effect, particularly in the vertex region where the adjusted increase in hair density remained significant ($\beta = 42.6$, $p = 0.022$). Mid-scalp density also showed a strong trend toward significance after adjustment ($\beta = 38.7$, $p = 0.0585$). While other parameters showed numerical advantages favoring the intervention, these did not achieve statistical significance after controlling for baseline variation. Together, these quantitative findings complement the clinical and photographic improvements described previously and provide rigorous evidence supporting the efficacy of the CRT.

## PRACTICAL PEARLS

Experience with this technique has yielded several practical insights. Uniformity is key: cross-hatching prevents uneven dosing and avoids areas of under-treatment. The desired endpoint is "blood dew," not active bleeding, which signals excessive depth. Precise photography with standardized lighting and parting allows objective tracking of progress, especially when paired with trichoscopy or AI-based assessment. Clinicians should also consider recording baseline and post-session blood pressure when patients are taking oral minoxidil. Finally, while early results are promising, the field would benefit greatly from larger controlled studies that clarify the contribution of each solution component and the durability of outcomes.

### *References*


1. Carman TP, Rassman W. Follicular unit excision donor area management and considerations of the scalp. *Facial Plast Surg.* 2023 Dec 4;40:195-204.
2. Jimenez F, Alam M, Vogel JE, et al. Hair transplantation: basic overview. *J Am Acad Dermatol.* 2021 Oct;85(4):803-814.
3. Epstein GK, Epstein J, Nikolic J. Follicular unit excision: current practice and future developments. *Fac Plast Surg Clin North Am.* 2020 May 1;28(2):169-176.

4. Okochi M, Fukushima T, Okochi H, et al. Donor site of follicular unit excision hair transplantation: the relationship between appearance and actual hair density, and hair diameter. *J Plast Surg Hand Surg*. 2020 Jan 6;172-176.
5. Arbache S, Godoy CE. Microinfusion of drugs into the skin with tattoo equipment. *Surg Cosmet Dermatol*. 2013;5(1):704.
6. Vañó-Galván S, Bisanga CN, Bouhanna P, et al. An international expert consensus statement focusing on pre and post hair transplantation care. *J Dermatolog Treat*. 2023 Dec;34(1):2232065.
7. Penha MA, Miot HA, Kasprzak M, et al. Oral minoxidil vs topical minoxidil for male androgenetic alopecia: a randomized clinical trial. *JAMA Dermatol*. 2024 Jun 1;160(6):600-605.
8. Kuceki G, Coppinger AJ, Ragi SD, et al. Enhanced hair regrowth with five monthly sessions of minoxidil-dutasteride-copper peptides tattooing for androgenetic alopecia assessed by artificial intelligence and blinded evaluators. *JAAD Int*. 2025 Jun 1;20:38-40.
9. Contin LA. Male androgenetic alopecia treated with microneedling alone or associated with injectable minoxidil by microinfusion of drugs into the skin. *Surg Cosmet Dermatol*. 2016 May 13;8(2):158-161.
10. Ragi SD, Ghanian S, Rogers N, et al. Evaluation of hair regrowth after minoxidil and dutasteride tattooing in men with androgenetic alopecia. *JAAD Int*. 2023 May 20;12:103-104. ■