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From Hair to Healing: Follicular Unit Transplantation for Chronic Ulcer Management—A Case Series

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ABSTRACT

Scalp follicular unit (FU) transplantation is a highly effective yet underutilised minimally invasive technique for promoting healing in chronic and recalcitrant cutaneous wounds. In this case series, five patients with long-standing nonhealing leg ulcers of mixed etiologies were treated exclusively with single FU grafts harvested from the scalp with a 0.9–1-mm punch. Complete re-epithelialization occurred in three cases by 6, 3 and 1 month, respectively, while the remaining two cases showed marked partial improvement at 6 months, with reduction in ulcer area and pain. Overall, all five patients experienced a favourable clinical outcome. Case reports suggest that the transplantation of a minimum of 4 FU grafts/cm² is required to promote effective wound closure, with higher graft densities being associated with faster healing. However, the optimal graft density and placement, whether uniform distribution or targeting the wound edge to exploit an ‘edge effect’, require further investigation. Considered alongside prior reports, these results suggest that 1-mm single-FU grafting achieves wound healing comparable to, and often faster than, 2–3-mm punch grafts. Additionally, the technique is less invasive and causes less bleeding, overall supporting wider use as an adjunct in multidisciplinary wound care.

Level of Evidence: IV

1 | Introduction

One of the wound pathologies that requires more effective and less costly therapies is chronic leg ulceration [1]. Infection control, compression therapy for venous leg ulcers, and appropriate wound dressings (to protect the wound bed from trauma and absorb exudate) remain the mainstay of treatment for chronic leg ulcers in clinical practice. However, despite these measures, some ulcers remain unhealed and do not show signs of granulation tissue. In such cases, autologous split-thickness skin grafting (STSG) remains the gold standard reconstruction option for covering chronic wounds with a well-vascularized wound bed. The thighs are the most commonly chosen donor site, although

the scalp and plantar skin have also been proposed as alternative donor sites, offering excellent aesthetic and functional outcomes [2–4].

Another grafting strategy recently proposed as an alternative therapy of chronic leg ulcers is to transplant hair follicle (HF) grafts into the wound bed to stimulate healing. The rationale is based on abundant evidence demonstrating the role that HFs play in promoting cutaneous wound repair in both humans and animals. The classic 1945 study by Bishop demonstrated that re-epithelialization can originate not only from the wound edge but also from residual HFs within the wound bed, and that deep dermal injury triggers granulation tissue from follicle-associated

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Summary

- The exclusive use of follicular unit (FU) scalp grafts may promote healing in chronic cutaneous ulcers.
- FU grafts harvested with a 1-mm punch appear to be as effective as larger 2–3 mm punch hair grafts, while being less invasive, causing less bleeding and allowing faster recovery.
- For practical use, clinicians can transplant 1-mm FU grafts at a density of ≥ 4 FU grafts/cm².
- Higher densities are linked with quicker healing.
- Careful placement, strong postoperative care and strict infection-prevention steps are essential.

connective tissue [5]. Clinical experience similarly shows that wounds in areas lacking follicles, such as scars or irradiated skin, heal slowly, whereas identical injuries on hair-bearing scalp heal faster (e.g., ~5–6 days on the scalp vs. ~10–14 days on the thighs/abdomen) [3, 4].

Based on these clinical and experimental observations supporting the role of HFs in promoting wound healing, clinicians started to investigate the feasibility, technical methodology and efficacy of using HF punch grafts harvested from the scalp as a therapeutic tool for healing cutaneous wounds in clinical practice. Table 1 [6–19] summarises 14 clinical studies on HF transplantation for treating chronic ulcers of various etiologies, ranging from common venous ulcers to recalcitrant, difficult-to-heal ulcers.

All published studies have used autologous scalp follicle grafts; the main technical difference is punch diameter (1–3 mm). A 1-mm punch harvests individual follicular units (FUs), each containing one to four terminal HFs plus adnexal structures [20, 21]. Larger punches (2–3 mm) harvest multiple FUs with more interfollicular dermis. Although one might expect smaller grafts to be less effective, our experience indicates that single FU grafts can successfully promote healing while reducing invasiveness. We present five cases treated solely with 1-mm FUs, summarise the technique and discuss remaining open questions.

2 | Method

2.1 | Study Design and Patient Selection

This was a retrospective case series of five consecutive adult patients with chronic, non-healing lower-extremity ulcers (venous, diabetic or traumatic) who underwent adjunctive transplantation of single ~1-mm scalp FUs after failure of standard wound care. Patients were identified from clinical records and included if the ulcer had persisted despite guideline-directed local management and could be optimised preoperatively (sharp debridement, moisture balance, edema control and infection management as indicated). All patients provided written informed consent for the procedure, clinical photography and use

of de-identified data. The study conformed to the ethical principles of the Declaration of Helsinki.

2.2 | Surgical Technique of FU Transplantation Into Wounds

In FU transplantation, the FUs are the primary and exclusive element used as HF grafts and can be harvested in two ways: (1) through the microscopic dissection of a horizontal strip excised from the scalp (strip harvesting technique); or (2) directly harvested one at a time using a circular punch, the so-called follicular unit excision (FUE) technique. The minimal invasiveness of FUE makes it the most common harvesting technique in modern hair transplantation.

Before entering into technical details, it is important to differentiate between the concept of punch hair grafting (or punch hair transplantation) and FUE technique. The grafts in both cases are harvested with a surgical punch, but in FUE the punch used (normally between 0.9 to 1.0 mm in diameter) harvests only one single FU per graft with minimal interfollicular tissue, while in punch hair grafting the follicles are harvested with bigger punches (normally of 2 or 3 mm in diameter), and thus each graft contains several FUs per graft (3 FUs in a 2 mm punch, and up to 6 FUs in a 3 mm punch) and much more inter-follicular dermal tissue (Figures 1 and 2).

2.2.1 | Preoperative Measures

Prior to the surgery, the ulcer bed needs to be in the best possible clinical condition to ensure an appropriate receptive environment to hold the scalp FU grafts. Key goals include ruling out any active bacterial infection and stimulating the granulation tissue. The clinician must consider measures such as the rational use of sharp surgical debridement and/or the use of debridement creams to eliminate necrotic tissue, washing the wound with antiseptic solutions, wound dressing with active principles, antibiotic therapies in the event of confirmed infections, or even oral antibiotic prophylaxis based on each patient's ulcer status.

2.2.2 | Anaesthesia

Both the donor scalp area and the recipient ulcer bed need to be anaesthetised. The latter is more sensitive to the pain of the injections than the former. Therefore, applying in the wound area a topical anaesthetic under occlusion at least 30 min before the anaesthetic injection is highly beneficial. In the meantime, the donor area can be anaesthetised for harvesting. The most commonly used anaesthesia for both donor and recipient area is lidocaine 1% with epinephrine 1/100 000, administered using thin 30–32-gauge needles. Blunt microcannulas can also be used to infiltrate the anaesthesia in the donor area, as they significantly reduce the pain of multiple injections [22]. Following the anaesthesia and harvesting of the donor area, the occlusive topical anaesthetic is removed from the ulcer which is then anaesthetised as a ring block, injecting the anaesthetic solution into the healthy skin surrounding the ulcer. After 5 min, and especially

TABLE 1 | Clinical studies on hair follicle transplantation for treating chronic non-healing ulcers.

Study	Design and number	Pre-operative wound debridement	Wound type	Scalp follicular harvesting procedure	Average wound area (cm ²)	Total transplanted grafts	Transplanted density (grafts/cm ²)	Adverse effects or complications	Clinical outcome
Jansen et al. [6]	Case series (n = 28)	Yes	Venous (n = 4), arterial (n = 2), mixed (n = 3), PG (n = 3), necrobiosis lipoidica (n = 2), vasculitis (n = 2), Martorell ulcer (n = 2), scleroderma (n = 1), graft vs. host disease (n = 1), postoperative wound healing disorder (n = 8)	FUE (Punch 2–3 mm)	82.5	8.5	n/a	Donor site bleeding occurred in 1 of 28 patients, requiring electrocautery; no other surgical adverse events were reported.	Positive effect in 78.6% of patients, with 57.1% achieving full wound closure.
Belatti et al. [7]	Case series (n = not reported)	Yes	Venous, arterial, mixed, vasculitic, inflammatory, blistering, radiodermatitis, etc.	FUE (2-mm punch)	n/a	n/a	2	Not reported	Positive outcome (no statistics mentioned)
Silva and Oliveira Soares [8]	Case report (n = 1)	Not mentioned	Livedoid vasculopathy	FUT strip harvesting	3 cm ²	Not mentioned	—	Not reported	One week post-procedure, grafts covered over 50% of the wound, leading to near-complete healing of the wound bed within 2 months.
Wong et al. [9]	Case report (n = 1)	No (1st–2nd session); yes (3rd–8th session)	RDEB with failed STSG	FUE	n/a	30 (1st–2nd session); 360 (3rd–8th session)	—	An infection developed on the second day after the second FUE grafting session, attributed to poor wound bed preparation.	1st–2nd session: An 80% wound area reduction was observed within 1 month compared to the non-transplanted area. 3rd–8th session: An 85% wound reduction occurred within 6 years vs. the non-transplanted area.
Saha et al. [10]	Case series (n = 10 ^a)	Yes	Venous (8/14), venous and traumatic (1/14), venous, PG (3/14), diabetic (1/14), leprosy (1/14)	FUE (1-mm punch)	n/a	n/a	5	Not reported.	Positive outcome (no statistics mentioned)
Alam et al. [11]	Case series (n = 2)	Yes	Burn (1/2), formalin was mistakenly injected instead of tumescent anaesthetic (1/2)	FUE (patient-1)	5.72	100 (250 hairs)	17	Not reported	Healed completely within 3 weeks.

(Continues)

TABLE 1 | (Continued)

Study	Design and number	Pre-operative wound debridement	Wound type	Scalp follicular harvesting procedure	Average wound area (cm ²)	Total transplanted grafts	Transplanted density (grafts/cm ²)	Adverse effects or complications	Clinical outcome
Budamakuntla et al. [12]	Case series (n = 15) ^b	Yes	Chronic venous ulcers (9/17), traumatic (2/17), leprosy (2/17), PG (2/17)	FUE (1-mm punch)	6.72	n/a	5	Not reported	Within 18 weeks, a 48.8% decrease in wound area was observed in 13 patients. Two patients did not respond to the treatment.
Martinez et al. [13]	Randomised controlled trial (intraindividual comparison) (n = 12)	Yes	Chronic venous ulcers	FUE (2-mm punch)	23.34	n/a	5	Two patients experienced infectious complications, which were resolved after antibiotic treatment.	At week 18, the FU-transplanted area showed a 75.15% reduction in wound area compared to 33.07% in the non-hairy skin graft area ($p = 0.002$). All patients reported reduced wound pain.
Fox et al. [14]	Case report (n = 1)	n/a	Chronic venous ulcer	FUE (2-mm punch)	6.7	20	2.9	Not reported	Wound area decreased by 91% over a 6-week period
Yang et al. [15]	Retrospective clinical cohort study (n = 20)	Yes	Traumatic wounds surgical defects	FUE (unknown size)	7.33	n/a	4	No treatment-related complications were reported.	All patients (20/20) achieved complete healing within 12 weeks. Scar elasticity also improved.
Liu et al. [16]	Case series (n = 14)	Yes	Chronic skin wounds of unspecified aetiology	FUT	74.14	n/a	4	No treatment-related complications were reported.	Complete healing and increased scar elasticity were achieved in all patients within 8 weeks (14/14). Wound border reactivation and reduced exudation were seen in most cases (12/14), with enhanced ambulation in one case (1/14).
Jimenez et al. [17]	Randomised controlled trial (intraindividual comparison) (n = 10)	Yes	Diabetic, pressure, chronic venous ulcer	FUE (1–2-mm punch)	36.8	20	5	No complications directly linked with the hair grafting technique were reported.	At week 18, the transplanted area showed a 27.1% reduction in wound area compared to 6.5% in the non-transplanted area ($p = 0.046$).

(Continues)

TABLE 1 | (Continued)

Study	Design and number	Pre-operative wound debridement	Wound type	Scalp follicular harvesting procedure	Average wound area (cm ²)	Total transplanted grafts	Transplanted density (grafts/cm ²)	Adverse effects or complications	Clinical outcome
Narushima et al. [18]	Case report (n = 2)	n/a	Scalp defect with artificial dermis	FUT (n = 1)	42	80	2	One patient temporarily experienced hair loss in the implantation area, which was followed by an increase in hair growth and volume.	Complete re-epithelialization was achieved within 1 month
Navsaria et al. [19]	Case report (n = 1)	n/a	Third-degree burn with tissue-engineered dermal template reconstruction	FUT	80	700	2	The patient developed a superficial wound infection, treated with topical antimicrobials and antiseptics.	Complete re-epithelialization was achieved within 37 days. A 1-year post-hair follicle grafting biopsy revealed normal skin histology.

Abbreviations: FUE, follicular unit excision; FUT, follicular unit transplantation; n/a, not assessed; PG, pyoderma gangrenosum; RDEB, recessive dystrophic epidermolysis bullosa; STSG, split-thickness skin graft.
*Ten patients with 14 ulcers.
†fifteen patients presented with a total of 17 ulcers.

in large ulcers, anaesthetic solution also needs to be injected into the recipient wound bed.

2.2.3 | FU Harvesting

The donor area should be a scalp segment with a good density of terminal HFs, normally the mid or lateral occipital area. Shaving the hair to a length of 1 mm improves visualisation and facilitates FU harvesting. The size of the shaved area logically depends on the number of FUs that need to be harvested. Ideally, the width of the shaved area should be as small as possible so that it can be covered by the upper hair combed over, thus keeping the area clinically unnoticeable and maintaining donor aesthetics.

There are two ways of using the FUE punch to harvest the FU: manual or motorised. In the manual technique, the punch is held by the thumb, index and middle fingers and placed on the epidermis, with the hair shafts centred into the punch and aligned parallel to the longitudinal axis of the hair shaft. With

a quick oscillating movement, the punch is introduced into the scalp without changing the angle of penetration in order to minimise follicular transection. With the motorised technique, the punch is attached to a device that makes it rotate or oscillate. In both techniques, the depth of the incision should be around 3–4 mm, sufficient to penetrate the entire dermis and reach the subcutaneous tissue, but not so deep as to reduce follicular transection and avoid damaging larger blood vessels and nerves. At this incision depth, the graft is attached only at the bottom by fat tissue and can be easily extracted with fine-tipped forceps (jeweller's forceps or similar).

After extraction, the FU grafts are immediately placed in a container, like a Petri dish, immersed in physiologic saline and kept hydrated in this solution until their implantation in the recipient wound bed.

No sutures are needed for the healing of the donor wounds made with FUE punches, and the circular or oval wounds can be left to heal in 3–4 days by secondary intention, leaving pinpoint scars that are not visible when the surrounding hair grows back. An antibiotic ointment containing fusidic acid or mupirocin can be applied to the donor sites, with the patient instructed to apply the ointment once a day after washing the hair with regular neutral shampoo.

2.2.4 | Implantation of FU Grafts Into the Wound Bed

A 1 mm FU graft can be implanted in the wound bed by mean of the 'stick and place' technique, which consists of making an incision with a 20- or 21-gauge needle and then inserting the FU with fine-tipped jeweller's forceps. An alternative way is to use a specifically designed tool known as a 'hair implanter', a device that makes the incision and inserts the FU graft at the same time. The FU graft is first loaded into the hollow needle of the implanter, and then the sharp tip of the implanter is inserted 3–4 mm into the wound bed. When the piston of the implanter is pressed, the graft is deposited into the slit made in the ulcer bed by the implanter needle.

The implantation density depends on the size of the ulcer. Implantation densities of 5–20 grafts per cm² have been

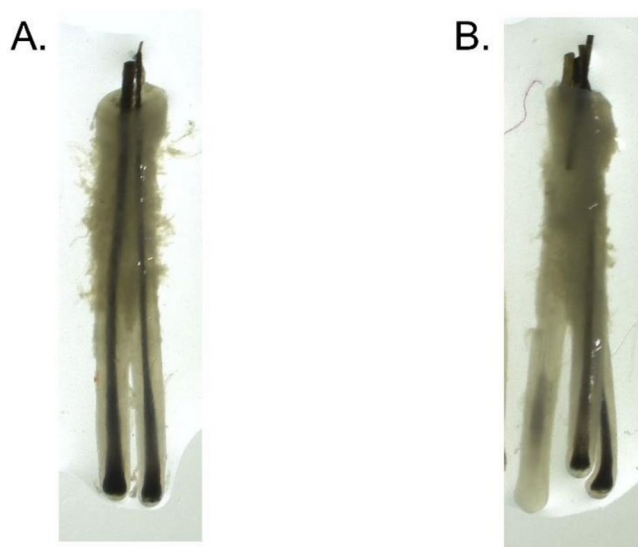


FIGURE 1 | Representative images of follicular units (FUs) extracted using a 1 mm FUE punch. (A) A two-hair FU. (B) A three-hair FU.

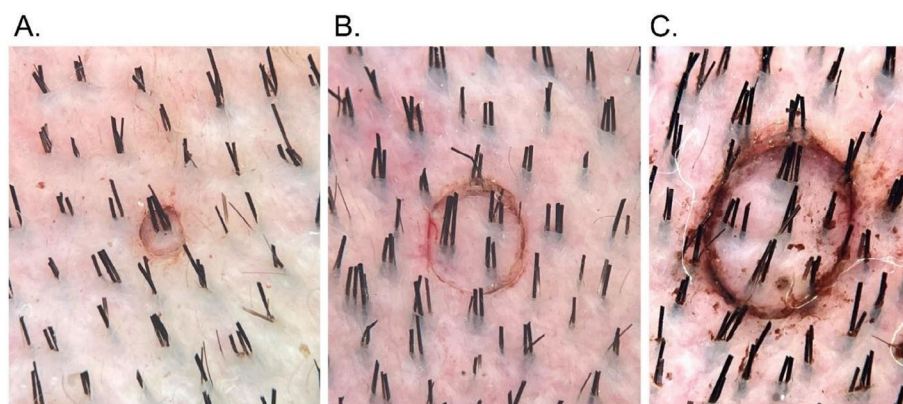


FIGURE 2 | Number of follicular units (FUs) harvested depending on the punch diameter (A) A 1 mm FUE punch extracts a single FU containing on average 2–3 terminal hairs. (B) A 2 mm punch harvests approximately three FUs containing on average 6–9 terminal hairs. (C) A 3 mm punch harvests around six FUs containing on average 10–15 terminal hairs.

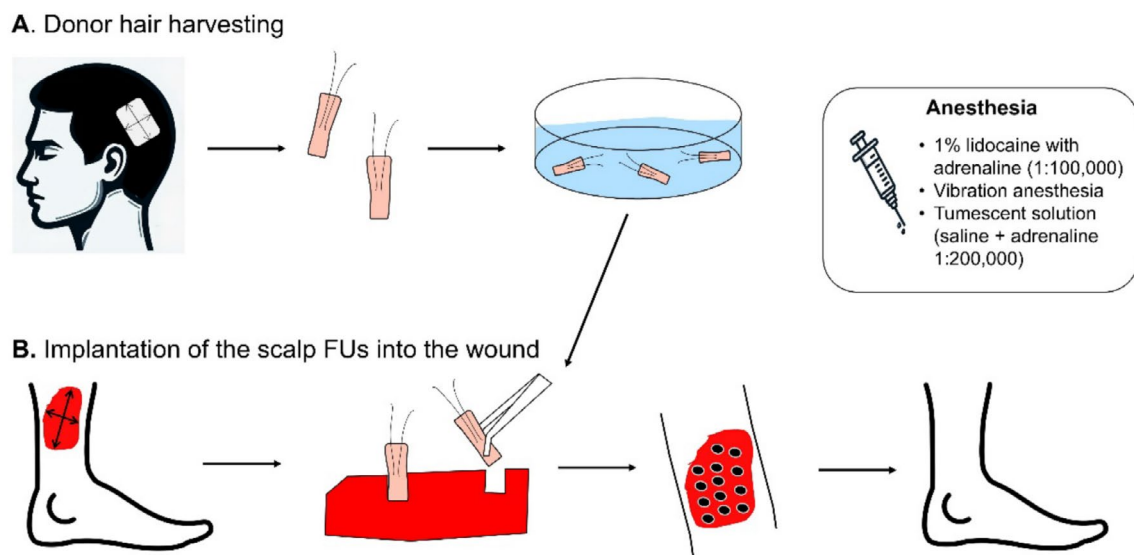


FIGURE 3 | The sequential steps of scalp follicular unit transplantation into a leg ulcer. (A) Hair follicles are harvested from the scalp. Prior to harvesting, the donor and recipient areas are anesthetised. Shaving the donor site to a length of 1 mm enhances visualisation. Follicular units (FUs) are extracted using either manual or motorised 0.9–1 mm FUE punches. The harvested grafts are immediately placed in physiological saline solution to keep them hydrated until implantation. (B) FU grafts are implanted using either forceps or a hair implanter device into 1 mm recipient sites created in the wound bed. Implantation density ranges from 5 to 20 FU grafts/cm². After implantation, the area is covered with sterile vaseline gauze and a multilayer dressing, with follow-up dressing changes recommended after 3–5 days.

recommended in the literature (Table 1), although most authors do not mention a specific density and judge the density by experience or common sense.

2.2.5 | Postoperative Management

Once the grafts have been implanted in the recipient wound area, the site area is covered with sterile vaseline gauze and a multilayer adapted dressing, secured with an elastic wrap. Relative rest is indicated for the first 7 days. The multilayer dressing can be removed and renewed 3–5 days after the procedure. Figure 3 summarises the technique of FU transplantation into wounds/ulcers.

3 | Results and Outcome

3.1 | Clinical Case 1

A 42-year-old woman was referred for a non-healing skin ulcer on the left lateral pre-tibial surface after a fall 4 months earlier. Treatment at a local wound healing clinic, which included occlusive dressings and wet-to-dry dressings, failed to result in healing of the wound beyond its current state. The patient noted there had been no visible improvement over the previous 2 months. The wound measured 8 cm × 5 cm with a 2-mm depth and showed no clinical infection (Figure 4, Table 2). The patient's medical history included significant alcohol consumption and tobacco use, but no diabetes or hypertension.

The FU hair transplantation procedure was offered as a novel method to stimulate wound repair. After obtaining informed consent, a 4 cm × 0.8 cm strip in the occipital scalp

was anaesthetised and surgically excised, and the wound was closed with chromic gut suture. The FUs were dissected under the stereomicroscope as in the standard FU transplantation technique and kept in saline solution. The leg wound was anaesthetised with 0.5% bupivacaine with 1:100 000 epinephrine and sharply debrided with a blade. Approximately 150 FU grafts were implanted using the 'stick-and-place' technique with 19- and 20-gauge needles to make the incisions (Figure 4). Prior to implantation, the grafts were coated with MatriStem UBM fine particulate (ACell Inc.; Columbia, MD) dissolved in saline, as previously described [23]. Following implantation, the patient was instructed to frequently spray a solution containing liposomal ATP 1:10 in isotonic saline (Energy Delivery Solutions; Jeffersonville, IN) over the ensuing week while keeping the wound covered in cellophane and elastic wrap.

Healing was noted to occur at a rapid pace over the 2 months following the procedure. The patient was seen 6 months post-operatively when healing was observed to be complete (Figure 4).

3.2 | Clinical Case 2

A 56-year-old woman had a 15-year chronic venous ulcer (20 cm × 12 cm) despite two split-thickness skin grafts (Figure 4, Table 2). The wound bed was confirmed infection-free before hair transplantation. She underwent FUE hair transplantation harvesting 1200 FUs from the occipital scalp with a 0.9-mm punch. Grafts were implanted by stick-and-place using a 21-gauge needle. Postoperative care was an occlusive dressing for 5 days and relative rest for 1 week. At 6 months, the ulcer had decreased to 8 cm × 4 cm, and pain improved from 9/10 to 2/10.

3.3 | Clinical Case 3

A 55-year-old woman had a 6-month diabetic ulcer (10 cm × 5 cm) (Figure 4, Table 2). Previous treatments included surgical

debridement, negative-pressure therapy at −80 mmHg, and a 1-week cephalosporin course. After confirming a clean wound bed, 1000 FUs were harvested from the occipital scalp with a 0.9-mm punch under 1% lidocaine with epinephrine and implanted

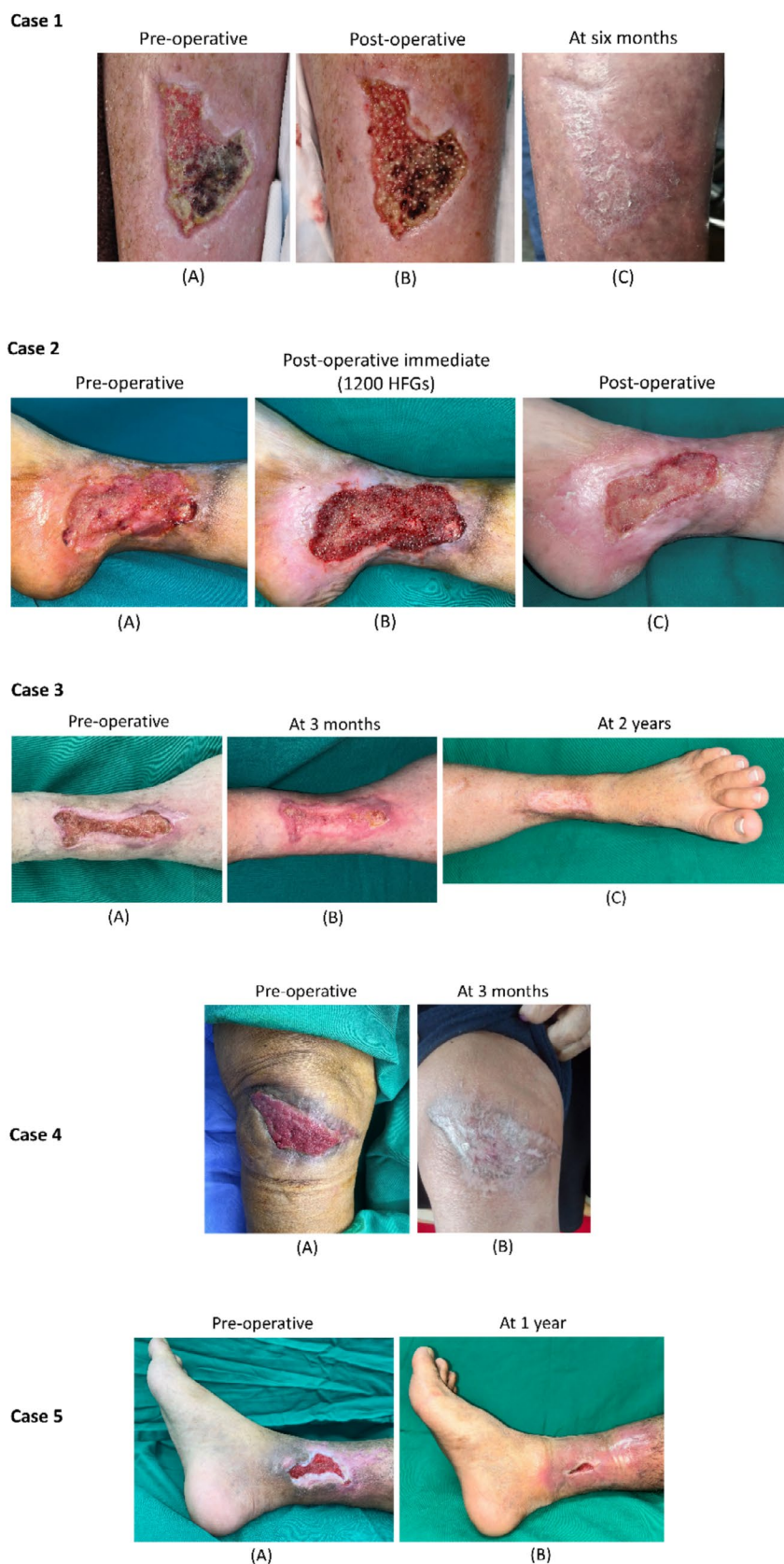


FIGURE 4 | Legend on next page.

FIGURE 4 | Case 1. A 42-year-old woman with a non-healing skin ulcer on the left lateral pre-tibial surface. (A) Pre-operative showing the ulcer; (B) Implantation of 150 FU grafts; (C) Complete healing (6 months post-op). Case 2. A 56-year-old woman with a 15-year history of a chronic venous ulcer. (A) Pre-operative appearance of the ulcer; (B) Immediate post implantation of 1200 FU grafts; (C) Post-operative outcome showing significant healing. Case 3. A 55-year-old woman with a 6-month history of a diabetic ulcer. (A) Pre-operative appearance; (B) Complete re-epithelialization 3 months post-op; (C) Complete healing sustained 2 years post-op. Case 4. A 58-year-old woman with a 3-month history of a traumatic ulcer. (A) Preoperative appearance; (B) Complete healing 3 months post-op. Case 5. A 45-year-old man with a 3-month history of a non-healing venous leg ulcer. (A) Preoperative appearance; (B) Significant healing (1 year post-op).

TABLE 2 | Quantitative outcomes of the ulcers pre- and post-treatment with follicular unit transplantation.

Clinical case	Baseline size (cm ²)	Estimated baseline area (cm ²)	Follow-up area (cm ²)	Area reduction (%)	Follow-up time	Pain score change ^a
1	8×5	40	Healed	100	6 months	NR
2	20×12	240	32	86.7	6 months	9 → 2
3	10×5	50	Healed	100	3 months	9 → 0
4	12×6	72	Healed	100	1 month	5 → 0
5	7×5	35	6	82.9	6 months	9 → 2

Abbreviation: NR, not reported.

^aPain score (0–10 numeric rating scale; 0 = no pain, 10 = worst imaginable pain).

TABLE 3 | Technical differences between 1 mm FU grafting and 2–3 mm punch grafting.

Feature	Follicular unit grafting	Punch hair grafting
Puch size	Small (0.9–1.0 mm punch; single FU per graft)	Large (2–3 mm punch; multiple FUs per graft)
Stem cell delivery	Maximises number of stem cell-rich units per area; bulge region stem cells actively stimulate re-epithelialization	Also delivers stem cells, but more bulk inter-follicular tissue per graft
Donor site trauma	Minimal trauma and scarring; rapid healing; minimally invasive procedure	Greater trauma, slower healing, more visible scarring at donor site
Recipient site healing	Rapid re-epithelialization, improved granulation	Also stimulates healing, but larger grafts may integrate less efficiently
Technical complexity	Requires precision for FU isolation and placement; allows dense, even distribution	Technically simpler but more invasive; less control over graft placement

by stick-and-place using a 21-gauge needle (~20 FU/cm²). Postoperative care involved occlusive dressing for 5 days and 1-week rest. At 3 months, the ulcer was fully re-epithelialized, and pain fell from 9/10 to 0/10.

3.4 | Clinical Case 4

A 58-year-old woman had a 3-month traumatic ulcer (12×6 cm) (Figure 4, Table 2). Her medical history included obesity and Cushing's syndrome on corticosteroids. Prior care involved topical debriding creams and antibiotics. After confirming a clean wound bed, FUE hair transplantation was performed: 800 occipital FUs harvested with a 0.9-mm punch; local anaesthesia (1% lidocaine with epinephrine) was used for stick-and-place implantation via 21-gauge needle at ~11 FU/cm². Postoperative care included occlusive dressing for 5 days and 1-week rest. At 1 month, the ulcer was fully re-epithelialized; pain improved from 5/10 to 0/10.

3.5 | Clinical Case 5

A 45-year-old man had a 3-month nonhealing venous leg ulcer (7 cm×5 cm) despite local topical care (Figure 4, Table 2). FUE hair transplantation was performed: 200 occipital FUs harvested with a 0.9-mm punch under 1% lidocaine with epinephrine, then implanted by stick-and-place using a 21-gauge needle at ~6 FU/cm². Postop care included occlusive dressing for 5 days and relative rest for 1 week. At 6 months, the ulcer measured 3 cm×2 cm, and pain improved from 9/10 to 2/10.

4 | Discussion

Transplantation of scalp HFs into chronic or difficult-to-heal skin ulcers has been reported to be an effective therapy for promoting wound healing [6, 19]. The therapeutic rationale of HF grafts differs fundamentally from that of other surgical grafting

strategies. HF grafts are not intended merely as units for epithelial and dermal coverage, but rather as biologically active mini-organs with regenerative properties attributed to their rich content of epithelial and mesenchymal stem cell populations, as well as signalling components capable of enhancing angiogenesis, promoting neurogenesis, modulating inflammation and stimulating regeneration of key cutaneous structures within chronically impaired wound beds. This concept is strongly supported by the study of Saha et al. [10], who obtained wound biopsies before and after FU transplantation in 10 patients with chronic leg ulcers, demonstrating that HF grafts not only stimulated re-epithelialization but also induced the reappearance of other structures essential for cutaneous healing and function, including blood and lymphatic vessels, nerves, increased adipose tissue and sweat glands.

The objectives of this case series are to describe our experience and to discuss that the exclusive use of single FU grafts harvested with a small 1-mm punch appears to be at least as effective as using larger 2–3-mm punch grafts, while offering practical advantages (Table 3) [7, 10, 24–26]. In principle, based on the biologic rationale outlined above, it seems preferable to transplant the greatest possible amount of follicular tissue. This supports the exclusive use of single 1 mm FU grafts, which are composed predominantly of follicular tissue, whereas larger 2–3 mm punch grafts contain considerably more inter-follicular dermis than 1-mm FU grafts. However, this assumption remains hypothetical and requires confirmation through well-designed comparative studies evaluating the same type of ulcers treated with different punch sizes. Regarding the practical advantages, single FU grafts are supported by a well-standardised procedure refined over decades of hair-restoration practice, as well as the availability of motorised devices and FUE punches that enable rapid harvesting of intact FUs with minimal transection. Dedicated hair implanters further speed placement and reduce bleeding compared with 2–3-mm grafts, which require larger recipient sites. In contrast, harvesting 1-mm FU grafts requires a greater number of grafts, longer operative time and more specialised technical skills than harvesting 2- or 3-mm punch hair grafts, which likely explains why the latter technique is commonly performed by physicians outside the field of hair restoration.

One of the questions that remains to be resolved concerns the ideal number of FU grafts/cm² to be transplanted into the recipient wound bed (the recipient density) in order to ensure inter-epidermal connections and promote granulation tissue to stimulate healing. Belatti et al. [7], using 2-mm punch grafts, recommend a recipient density of 2–3 grafts/cm². Our experience, using exclusively 1-mm FU grafts, seems to indicate that the higher the density of FU grafts transplanted into the wound bed, the more rapid the healing, and that 4 FU grafts per cm² would be the minimum number necessary to stimulate healing. This can be seen in our set of 5 cases, with the patients of Case 3 and Case 4, who received 20 FU grafts per cm² and 11 FU grafts per cm², respectively, achieving a more rapid complete healing than the patient of Case 1, who received only 4 FU grafts/cm². However, some caveats apply to this recommendation, as the available evidence is limited, and outcomes depend on variables such as postoperative care, patient metabolic status and infection risk. Another open question is placement: should grafts be distributed uniformly across the wound bed or concentrated

near the ulcer edge to exploit the re-epithelialization ‘edge effect’?

An additional clinical observation worth noting in our case series is the minimal hair shaft growth retained within the healed scar of transplanted ulcers (Figure 4), compared with what would be expected in a standard hair transplant procedure for androgenetic alopecia using the same number of FU grafts. This finding, which has also been reported by other authors [2, 10, 13, 15, 16, 25], supports the notion that the ulcer wound microenvironment influences or directs the fate of transplanted follicles towards wound healing rather than hair shaft production. This hypothesis was first proposed by Jahoda in 2001 [27]. This phenomenon has also been observed in mice, where during wound healing, mesenchymal cells from the follicular dermal papilla and dermal sheath migrate towards the wound and do not participate in HF formation [28].

Finally, the limitations of this study—including its retrospective, uncontrolled design and small sample size—should be acknowledged when interpreting our findings. Nevertheless, the consistent clinical outcomes observed, together with similar reports from other authors, suggest that HF grafting may represent a promising regenerative approach for chronic wounds and provide a strong rationale for future controlled trials. Future studies should focus on careful patient selection, standardised wound-bed preparation, optimisation of background care and direct comparison with established treatment modalities for chronic ulcers, particularly STSG. They should also help define the patients most likely to benefit from this approach.

5 | Conclusion

In summary, we believe that the transplantation of exclusively single FUs into chronic wounds using 1-mm FUE punches offers several advantages over the use of larger 2- or 3-mm hair punch grafts. This minimally invasive surgical approach broadens the indications for hair transplantation beyond purely cosmetic purposes (i.e., androgenetic alopecia) [29] and should encourage closer collaboration between hair transplant surgeons and physicians working in wound care units. Though some issues remain to be clarified, this underrecognized technique deserves greater visibility and wider clinical application.

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The authors have nothing to report.

Ethics Statement

The patients in this manuscript have given written informed consent to publication of their case details.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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