Egypt, J. Plast. Reconstr. Surg., Vol. 49, No. 4, October: 321-329, 2025

Role of Hair Follicle Transplantation in Treatment of Chronic Ulcers: A Systematic Review Article

MOHAMED H. EL SHAHIDI, M.B.B.Ch.

Burns and Plastic Surgery Center, Mansoura University, Mansoura

Abstract

Background: With a prevalence rate of 2.21 per 1,000 individuals, patients affected by chronic wounds experience considerable economic, social, and psychological burdens. Moreover, the increasing prevalence of chronic medical conditions may limit the treatment options available for specific patient populations. Standard interventions for individuals suffering from chronic ulcers encompass compression therapy, negative pressure wound therapy, and skin grafting. Recently, multipotent stem cells derived from hair follicles have gained recognition as a feasible alternative for patients for whom conventional care is insufficient.

Objective: To systematically review the literature on the role of hair follicle transplantation in the treatment of chronic lesions.

Material and Methods: PubMed, Embase, Web of Science, Cochrane Library, and Scopus were searched from their inception until January 16, 2025. Clinical trials utilizing hair follicular unit transplantation for the treatment of chronic ulcers were included. After screening the titles and abstracts of 9,692 records, ten studies were included in this review.

Results: A total of 131 cases of various types of chronic ulcers were included, primarily affecting the lower limbs. The mean age of the cases ranged from 37 to 73 years, with a predominance of males. The mean size of the ulcers ranged from 6.72 to 82.49 cm^2, and the duration of chronicity varied from 6 weeks to 30 years. Sixty-eight percent of the cases reported complete wound healing over a period of 18 to 24 months. Histological examination confirmed the presence of increased remodelling, neovascularization, and the appearance of adnexal structures in the dermis. No significant complications were reported. However, there are concerns regarding the risk of bias in the included records.

Conclusion: With the need for new modalities for treating chronic ulcers, hair follicle unit transplantation may be a promising alternative for cases in which standard care is not successful. Also, larger and well-designed clinical trials are needed to expand our current understanding of the underlying mechanisms of HFUs' contribution to wound healing.

Key Words: *Hair follicle – Wound – Chronic ulcer – Skin graft.*

Disclosure: No disclosure, No conflict of interest.

Written Consent for Publication: The author consent to publication of this work.

Availability of Data and Material: All data are presented in the review. Further details can be requested from the author.

Introduction

The follicular unit (FU) is an ectodermal derivative that comprises the hair follicle (HF), its associated sebaceous gland, and the arrector pili muscle. The hair follicle is divided into three sections along its length: the infundibulum, isthmus, and a non-permanent inferior segment. The inferior segment extends from the bulge to the base of the follicle. The bulge is situated where the arrector pili muscle inserts, housing niches of multipotent stem cells. The base comprises the dermal papilla and matrix cells, which exhibit the highest mitotic rate in the body **[1]**. In the anagen phase, the dermal papilla interacts with the bulge, signaling the proliferation of multipotent stem cells along the outer root sheath (ORS). Additionally, the bulge is regarded as an immune-privileged site where stem cells exhibit reduced expression of MHC class I and II molecules and significant expression of immunoinhibitory signals as CD200 **[2,3]**. Moreover, the interfollicular epidermal stem cells (epiSC) are composed of a pool of cells that originate from the basal layer of the epidermis **[4]**. The undifferentiated phenotype of these cells is regulated by the Wnt/β-catenin signalling pathway **[5]**.

Correspondence to: Dr. Mohamed Issam El Shahidi,
E-Mail: mohamedissamelshahidi@gmail.com

A chronic ulcer is a disruption of the epithelium that shows no signs of healing after three months [6]. Chronic leg ulcers (CLU) account for 43% of chronic skin ulcer cases, with 59% of those affected being aged 75 years or older [7]. Venous leg ulcers (VLUs) account for up to 80% of chronic leg ulcers (CLUs), resulting in significant economic and social burdens [8].

Several studies have investigated the underlying processes of chronicity in such lesions. Elevated levels of mRNA for pro-inflammatory cytokines like IL-1β, IL-6, and TNF-α, along with reduced levels of VEGF, VEGFR2, SDF-1α, and CXCR4, have been implicated in the impaired healing of these lesions [9,10]. The current guidelines for managing chronic ulcers involve controlling the underlying condition: vein surgery for venous lesions, surgical revascularization for arterial ulcers, and management of underlying diseases such as diabetes mellitus [11].

Additionally, autologous split-thickness skin grafting is recommended as an alternative surgical option for cases that show little to no response to conservative treatment protocols [12]. However, a failure rate of up to 30% has been reported [13]. Mini-punch skin grafts have been shown to enhance the wound healing process by incorporating the associated stem cells in the dermis and subcutaneous tissue [14]. Recently, autologous bone marrow-derived mesenchymal stem cells (BM-MSCs) have been utilized as a cell-based therapy to assist tissue regeneration in chronic wounds [15].

The role of hair follicle-associated stem cells (HFSCs) has been observed in the rapid re-epithelialization rate of skin grafts from the scalp compared to skin grafts from non-hairy areas. Furthermore, the slow re-epithelialization rate in the palm, sole, and areas that have lost adnexal structures after irradiation highlights the importance of hair follicles and their associated stem cells in wound healing [16]. Additionally, trials of autologous epidermal equivalents of outer root sheath keratinocytes from plucked anagen hairs for treating chronic ulcers have shown satisfactory results [17]. This review aims to systematically search the literature and summarize the current available evidence regarding the feasibility, efficacy, and safety of hair follicle transplantation in the treatment of chronic ulcers.

Material and Methods

Guidelines:

This review is conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [18]. This review is registered in the PROSPERA database CRD420251012153.

Data sources and search strategy:

The search process was designed according to the methods outlined in Chapter 4 of the Cochrane Handbook for Systematic Reviews of Interventions (version 6.5) [19]. PubMed, Embase, Web of Science, Cochrane Library, and Scopus were searched from their dates of inception until January 16, 2025. The following search string was developed to retrieve relevant studies: (ulcer [Title/Abstract]) OR (wound [Title/Abstract]) OR ("diabetic ulcer" [Title/Abstract]) OR (varicose [Title/Abstract]) OR ("venous ulcer" [Title/Abstract]) AND (hair [Title/Abstract]) OR ("hair follicle" [Title/Abstract]) OR ("follicular unit" [Title/Abstract]) OR (FUT [Title/Abstract]) OR (FUE [Title/Abstract]) OR ("follicular unit extraction" [Title/Abstract]) OR ("follicular unit excision" [Title/Abstract]). The search string was translated to adapt to each database using the Polyglot tool [20]. In addition, references from the included studies and articles that cite these studies were retrieved and screened for potentially relevant articles using the Citation Chaser tool [21]. No language or publication period restrictions were applied. Duplicate records were removed using the deduplication tool [22].

Inclusion and exclusion criteria:

The retrieved records underwent screening in two stages: Title and abstract screening, followed by full-text review. Inclusion criteria included retrospective or prospective clinical studies that involved cases with chronic ulcers and specified the technique for hair follicle transplantation. Exclusion criteria comprised reviews, animal studies, in vitro studies, studies on epidermal equivalents or other skin substitutes, and studies on follicular dermal grafts.

Data extraction:

A data extraction form was created to collect the following information: Study ID (first author's name, year of publication), study duration, study country, intervention technique investigated, characteristics of the included chronic ulcer cases, and outcome measures.

Quality assessment:

The Risk of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool was used to assess the methodological quality of the included studies [23]. The ROBINS-I tool evaluates bias across five domains: bias from confounding, bias in participant selection, bias due to deviations from the intended

intervention, bias from missing data, and bias in the selection of reported results.

Data synthesis and analysis:

Due to the limited number of included studies and the anticipated high degree of heterogeneity resulting from the small sample sizes, a narrative review is presented. Quantitative measures were summarized where applicable.

Results

Search results and study selection:

The search process yielded 9,692 records. After screening titles and abstracts, followed by a full-text review of relevant articles, ten records were included in this review (Fig. 1). A summary of the included studies is presented in Table (1) **[24–33]**.

Characteristics of studies:

The ten studies included were published between 2012 and 2024, primarily from India and Spain, with contributions from China, Taiwan, and Argentina. Most of the studies did not specify the periods during which they were conducted. However, the study by Liu et al. (2015) was conducted between 2006 and 2009 **[32]**. The included studies varied in design, comprising two retrospective analyses, two randomized comparative studies, two case reports, and three prospective single-arm trials. The study by Belatti et al. (2023) presented expert opinions based on the experience of a single institution regarding hair follicle transplantation into chronic ulcers in Argentina **[25]**. However, it has not provided details about the characteristics of the included cases or the outcome measures.

Hair transplantation techniques:

The follicular unit excision (FUE) technique utilizing motorized punches was employed in most cases. However, the studies differ based on the size of the punch used. Four studies reported outcomes from using 1mm punches to extract hair follicular units (HFU) **[26-30]**. Two studies used punches ranging in size between 1-3mm to extract HFUs **[24,33]**. Two studies compared the efficacy of using 2mm punches of HFUs versus 2mm punches from the non-hairy parts of the abdomen **[25,31]**. One study compared 1mm punches of HFUs versus using split-thickness skin grafting (STSG) **[28]**. Half of the included studies transplanted 5 HFU per cm^2 of the chronic lesion **[26,28,30,31,33]**.

Control group:

Five studies were conducted as proof-of-concept trials without the inclusion of a comparison or control group **[24,26,29,30,32]**. Two studies used intra-individual ulcers, which received phase-appropriate wound care, as controls **[27,33]**. Two studies examined ulcers by dividing them in half; one half was grafted with HFUs, while the other half received phase-appropriate wound care **[25,31]**. Only one study included two groups of patients in which HFUs transplantation was compared to STSG **[28]**.

Patient selection:

The total number of cases in the included studies was 131. The male gender predominates among these cases. The mean age of the cases ranged from 37 to 73 years. Five studies did not have exclusion criteria concerning the etiological nature of the chronic ulcer **[24–26,28,30]**. Three studies restricted their inclusion criteria to a single etiological cause of the chronic lesions **[27,29,31]**. The study by Jimenez et al. (2012) included three categories of chronic ulcers: venous, diabetic, and pressure **[33]**.

Ulcer characteristics:

The mean surface area of the examined ulcers ranged from 6.72 to 82.49cm^2. The duration of wound chronicity varied from 6 weeks to 30 years. Over 80% of the lesions are located on the lower limbs. The scalp is the second most common site for chronic lesions.

Outcome measure:

Nearly 68% of the chronic lesions treated by HFUs transplantation have shown complete wound closure, while 25% of the cases experienced favorable degrees of wound healing. Only one study reported data on patient satisfaction, with the majority of cases finding the trial's outcome satisfactory **[24]**. Additionally, Chougule et al. (2020) reported no significant association between the outcome and patients' body mass index (BMI). Three studies investigated the healed chronic lesions histologically **[27,29,32]**, reporting increased dermal remodelling, dermal neovascularization, and the appearance of adnexal structures. Liu et al. (2015) reported increased expression of type VII collagen, while Saha et al. (2021) noted boosted expression of PECAM-1, LYVE-1, and class III β-tubulin. Meanwhile, Chougule et al. (2020) reported improvements in scar remodelling in healed lesions following HFUs transplantation. In addition, four studies noted the phenomenon of hair shaft disappearance later in the course of the healing process **[29–31,33]**.

Quality assessment/Risk of bias assessment:

Based on the evaluation using the Risk of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool, most studies demonstrated a moderate risk of bias (Figs. 2,3).

Table (1): Summary of the included studies.

Study I.D.	Year	Duration	Study Design	Country	Technique	Intr-individual	Patient selection	FU/cm^2	No. of cases	M/F	Mean Age
Jimenez et al., 2012 **[33]**	2012	2010	Single-center trial	Spain	Experimental ulcers received 1-2 mm hair follicle punches	Two separated ulcers we involved	Diabetic, venous or pressure ulcers	5	10	3:07	72.2
Liu et al., 2015 **[32]**	2015	2006-2009	Retrospective case series study	China	FUT technique used	None	N/A	4	14	9:05	60.71
Martinez et al., 2016 **[31]**	2016	N/A	Randomized comparative study	Spain	2 mm punch with hair follicle from scalp vs 2 mm punch from abdominal skin without hair	Each ulcer is divided vertically into experimental and control groups	Venous ulcers	5	11	1:03	73
Budamakuntla et al., 2018 **[30]**	2018	N/A	Single-center trial	India	Single-arm study using 1 mm punches	None	All causes of ulcers	5	15	14:01	37.59
Alam et al., 2019 **[29]**	2019	N/A	Case report	Spain	Single-arm study using 1 mm punches	None	Traumatic and surgical wounds	10 to 17	2	Males	18 and 83 yo
Chougule et al., 2020 **[28]**	2020	2016-2018	Randomized comparative study	India	1 mm punch with hair follicle from scalp vs STSG	Comparative study	All causes of ulcers	5	40	3:1 in FUT group vs 4:1 in STSG group	20-50
Wong et al., 2021 **[27]**	2021	2013	Case report	China (Taiwan)	Single-arm study using 1 mm punches	Ulcers on the left upper back is used as control	Dystrophic epidermolysis bullosa	2	1	0	54
Saha et al., 2021 **[26]**	2021	N/A	Single-center trial	India	Single-arm study using 1 mm punches	None	All causes of ulcers	5	10	9	40.2
Belatti et al., 2023 **[25]**	2023	N/A	Single center experience	Argentina	2 mm punch with hair follicle from scalp vs 2 mm punch from abdominal skin without hair	Ulcer divided into 2 halves.	All causes of ulcers	2	N/A	N/A	N/A
Jansen et al., 2024 **[24]**	2024	2020-2022	Retrospective study	Germany	Single-arm study using 2-3 mm punches	None	All causes of ulcers	6	28	2.5	72.61

Table (1): Continued.

Study I.D.	Mean Ulcer size	Chronicity duration	Lower limb	Complete closure	Partial closure	No effect	Duration for closure	Histological evidence	Phenomenon
Jimenez et al., 2012 **[33]**	36.8	1-30 years	10	0	10	0	Significant 27.1% reduction in the experimental group in comparison with 6.5% in the control group at wk 18.	Improved dermal organization and neovascularization	Lesser amount of exudate, improved granualtion tissue, wound border reactivation. Disappearance of hairs by wk 4
Liu et al., 2015 **[32]**	74.14	Up to 13 years	11	11	0	0	Re-epithelization started at wk. 5 and completed at 2 months	At wk 16, epidermis, dermis and adnexal structures were observed	Recipient scar tissue was more elastic
Martinez et al., 2016 **[31]**	Average of the half 12 cm^2	6 years	11	0	11	0	Significant 75.15% (23.03%) reduction in experimental group, 33.07% (46.17%) reduction in control group at wk. 18	N/A	Improvement in granulation tissue, wound border reactivation and disappearance of hair shafts by week 9
Budamakuntla et al., 2018 **[30]**	6.72	9 months	15	7	6	2	18 weeks	N/A	Later disappearence of hair shafts from the recipient area
Alam et al., 2019 **[29]**	5.7 and 40.5	3 months	0	2	0	0	1 month in traumatic wound, 5 months in surgical wounds	More dermal remodeling in the central part of the scar than the periphery	Central part of the scar is more red, fibrotic and covered by hairs than the periphery
Chougule et al., 2020 **[28]**	10 to 40	N/A	0	40	0	0	5 wks. in HFUT vs 4 wks. in STSG	N/A	N/A
Wong et al., 2021 **[27]**	N/A	54 years	0	1	0	0	6 months	Positive expression of Type VII collagen	N/A
Saha et al., 2021 **[26]**	10	6 weeks- 40 years	10	10	0	0	Up to 3 months	Re-emergence of blood vessels (PECAM-1), lymph vascular structures (LYVE-1), class III β-tubulin	N/A
Belatti et al., 2023 **[25]**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jansen et al., 2024 **[24]**	82.49	22.46 years	21	16	6	6	Variable up to 14 months	N/A	N/A

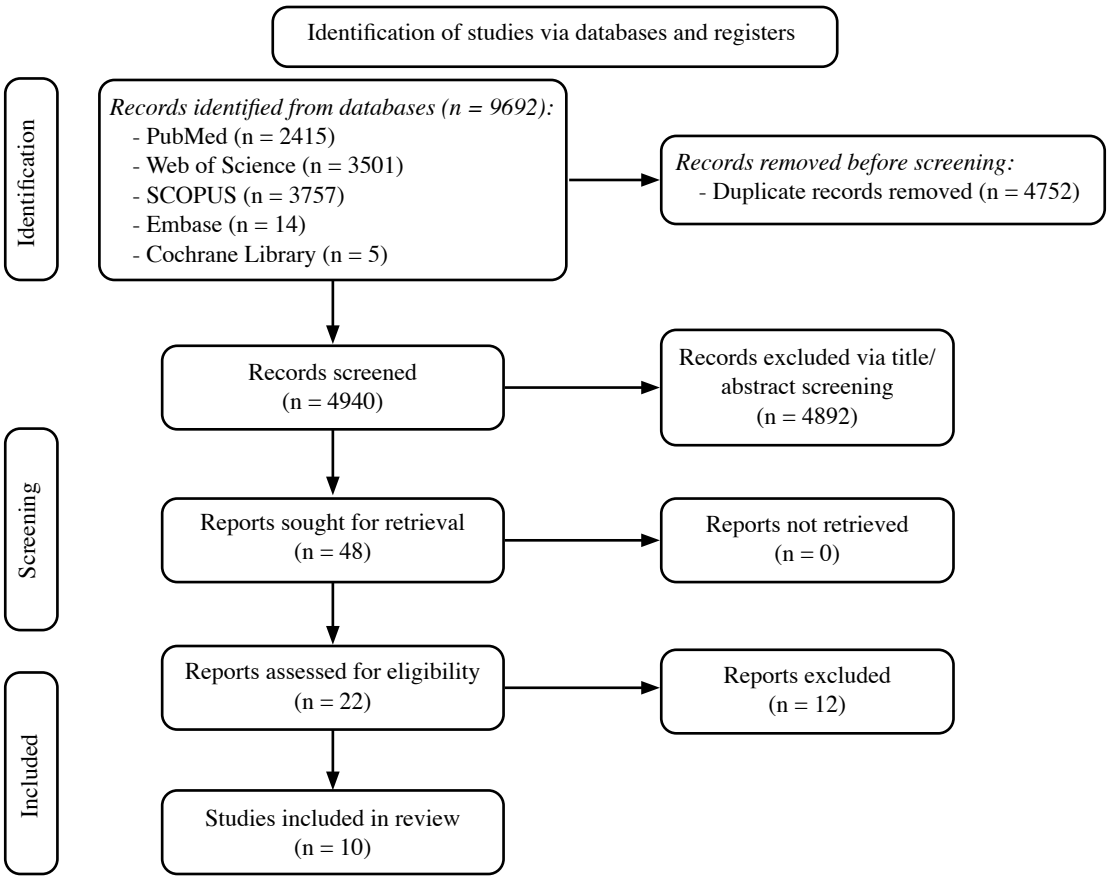

Fig. (1): PRISMA flowchart of the search process.

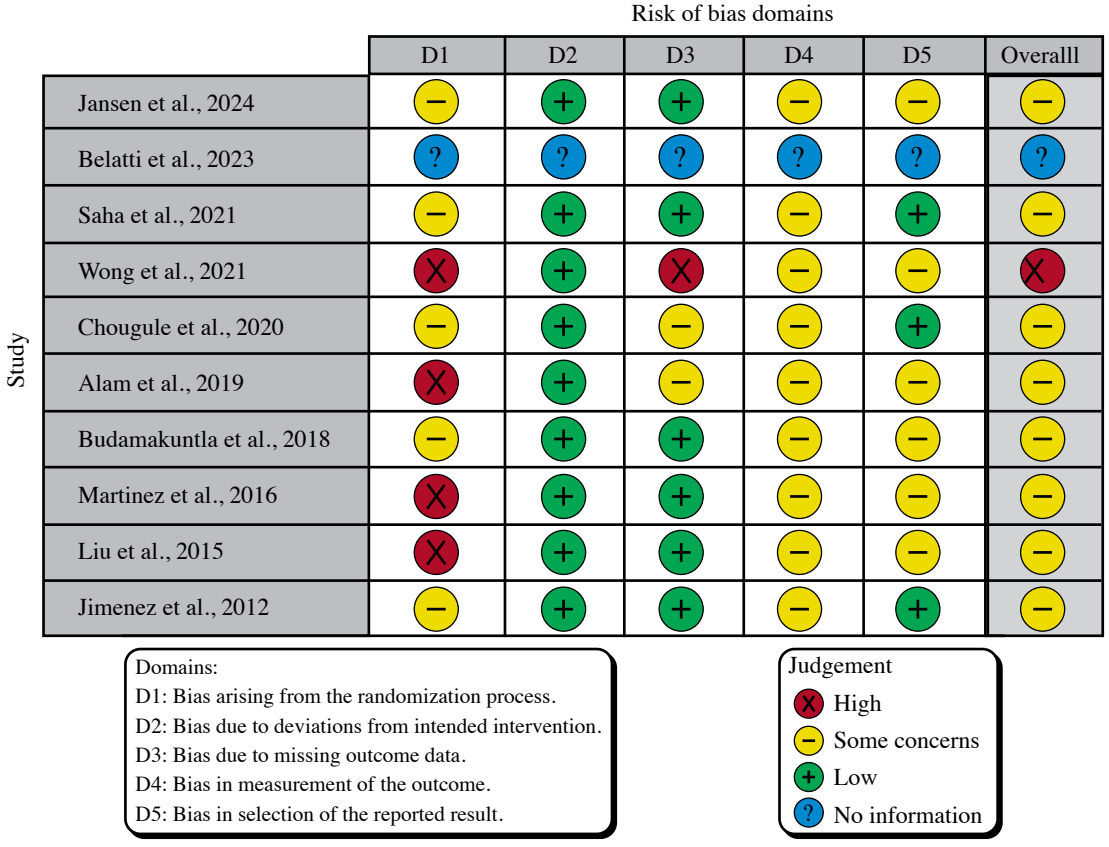

Fig. (2): Risk of bias chart of the included studies.

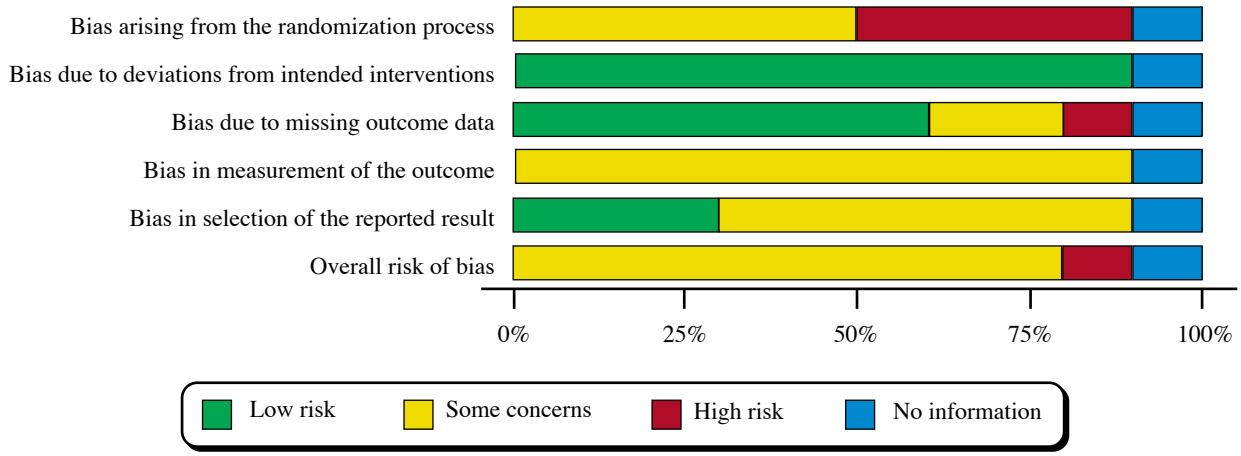

Fig. (3): Summary diagram of the risk of bias of the included studies.

Discussion

This review offers a systematic summary of the current literature regarding the potential healing effects of hair follicle transplantation in chronic lesions. It encompasses ten studies from five different countries. The heterogeneity in the methodological approaches employed by each study complicates the determination of the effect of hair follicles in the chronic wound bed. Additionally, various sizes of punches were utilized. As a result, it is still unclear whether the healing effects observed in these trials were attributable to the multipotent stem cells found in the hair follicular units or the interfollicular stem cells from the basal layer of the epidermis located between the hair follicles **[34]**. Moreover, the ability to perform the procedure of HFU transplantation into chronic wounds in a single session and by a single team makes this technique a valuable alternative for patients with comorbid conditions. Additionally, the number of HFUs required per square centimeter, which can alter the chronic wound microenvironment and provide the necessary stem cells and growth factors for healing, has not been established on solid reasoning. Furthermore, the control groups used to compare the outcome measures could not be standardized. Moreover, the limited number of cases involved in these trials increases the risk of bias in the reported results and diminishes their quality. Additionally, including cases at the extremes of age may have affected the ability to generalize the reported outcome measures to the broader population of patients with chronic wounds. Including cases with specific etiological factors for chronicity may also have influenced the reported outcome measures. Furthermore, the effect of the duration of chronicity on the wound bed and its subsequent effects on the transplanted hair follicles could not be investigated. Obesity is also a contributing factor that affects the healing capacity of chronic wounds. Despite the increase in adipocyte size, this growth does not typically see a corresponding increase in the number of blood vessels for adequate vascularization **[35]**. Only one study has investigated the effect of BMI on wound healing after HFUs transplantation. Furthermore, the histopathological changes that accompany the healing of chronic wounds after HFUs transplantation require further investigation.

The increasing percentage of elderly individuals with chronic wound conditions makes chronic wounds an intriguing scientific topic to explore. In the United States, 2% of the population is affected by chronic wounds, which accounts for a total annual cost of 20 to 25 billion USD **[36,37]**. In Europe, 2-3% of the total healthcare budget is dedicated to treating patients with chronic wounds, with 27-50% of acute hospital beds occupied by patients with a wound on any given day **[38]**. This anticipated rise in cases of chronic wounds will place additional burdens on healthcare systems, highlighting the need to explore new and innovative techniques for managing these wounds.

To the best of my knowledge, this narrative review on the clinical application of hair follicle transplantation in chronic wounds is the first to examine the available studies in this area of interest. Due to limitations in the included studies, this review also has several restrictions. First, it is confined to studies published in the literature. Ongoing trials and larger studies may significantly impact our understanding of the efficacy of HFUs transplantation in chronic lesions. Additionally, publication bias may affect the results, as studies reporting negative outcome measures might be underrepresented in the literature.

Conclusion:

Hair follicle transplantation using the follicular unit excision technique shows promising results for alleviating the burden on patients with chronic, intractable wounds. The ease of use and prompt availability make HFU transplantation a suitable alternative for cases with limited efficacy of the usual standards of care. However, well-designed, large-scale trials are needed to enhance our understanding of the underlying molecular and cellular mechanisms involved in the healing of chronic wound beds after HFU transplantation.

References

1- Martel J.L., Miao J.H., Badri T. and Fakoya A.O.: Anatomy, Hair Follicle. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, 2025 [cited 2025 Feb 1]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK470321/.

2- Paus R. and Bertolini M.: The Role of Hair Follicle Immune Privilege Collapse in Alopecia Areata: Status and Perspectives. J. Investig. Dermatol. Symp. Proc., Dec. 1; 16 (1): S25–7, 2013.

3- Bertolini M., McElwee K., Gilhar A., Bulfone-Paus S. and Paus R.: Hair follicle immune privilege and its collapse in alopecia areata. Exp. Dermatol., Aug. 29 (8): 703–25, 2020.

4- Blanpain C. and Simons B.D.: Unravelling stem cell dynamics by lineage tracing. Nat. Rev. Mol. Cell Biol., Aug. 14 (8): 489–502, 2013.

5- Nusse R.: Wnt signaling and stem cell control. Cell Res., May 18 (5): 523–7, 2008.

6- Dissemond J.: [Chronic leg ulcers]. Hautarzt Z Dermatol Venerol Verwandte Geb. Aug., 68 (8): 614–20, 2017.

7- Charles J., Harrison C. and Britt H.: Chronic skin ulcers. Aust. Fam Physician, Sep. 43 (9): 587, 2014.

8- Probst S., Saini C., Gschwind G., Stefanelli A., Bobbink P., Pugliese M., et al.: Prevalence and incidence of venous leg ulcers A systematic review and meta-analysis. Int. Wound J., Jun. 9; 20 (9): 3906–21, 2023.

9- Jing L., Li S. and Li Q.: Akt/hypoxia-inducible factor-1α signaling deficiency compromises skin wound healing in a type 1 diabetes mouse model. Exp. Ther. Med., Jun. 1; 9 (6): 2141–6, 2015.

10- Mahmoud N.N., Hamad K., Al Shibitini A., Juma S., Sharifi S., Gould L., et al.: Investigating Inflammatory Markers in Wound Healing: Understanding Implications and Identifying Artifacts. ACS Pharmacol Transl Sci., Jan. 12; 7 (1): 18–27, 2024.

11- Kahle B., Hermanns H.J. and Gallenkemper G.: Evidence-Based Treatment of Chronic Leg Ulcers. Dtsch Ärztebl Int., Apr. 108 (14): 231–7, 2011.

12- Serra R., Rizzuto A., Rossi A., Perri P., Barbetta A., Abdalla K., et al.: Skin grafting for the treatment of chronic leg ulcers - a systematic review in evidence-based medicine. Int Wound J., Feb. 14 (1): 149–57, 2017.

13- Long Z., Tuttle V., McKinney J., Andolina P., Ettlinger H. and Kells A.: Rates of Skin Graft or Flap Failure in Patients who have Received Osteopathic Manipulative Medicine Treatment: A Retrospective Study. The New York Medical Journal. 2019. Available from: https://newyorkmedicaljournal.org/articles/rates-of-skin-graft-or-flap-failure-in-patients-who-have-received-osteopathic-manipulative-medicine-treatment-a-retrospective-study/

14- Carducci M., Bozzetti M., Spezia M., Ripamonti G. and Saglietti G.: Treatment of a Refractory Skin Ulcer Using Punch Graft and Autologous Platelet-Rich Plasma. Case Rep. Dermatol. Med., 2016 (1): 7685939, 2016.

15- Farabi B., Roster K., Hirani R., Tepper K., Atak M.F. and Safai B.: The Efficacy of Stem Cells in Wound Healing: A Systematic Review. Int. J. Mol. Sci., Jan. 25 (5): 3006, 2024.

16- Mühlstädt M., Thomé C. and Kunte C.: Rapid wound healing of scalp wounds devoid of periosteum with milling of the outer table and split-thickness skin grafting. Br. J. Dermatol., Aug. 167 (2): 343–7, 2012.

17- Ortega-Zilic N., Hunziker T., Läuchli S., Mayer D.O., Huber C., Baumann Conzett K., et al.: EpiDex® Swiss Field Trial 2004–2008. [cited 2025 Feb 1]; Available from: https://dx.doi.org/10.1159/000321333.

18- Page M.J., McKenzie J.E., Bossuyt P.M., Boutron I., Hoffmann TC, Mulrow C.D., et al.: The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, Mar. 29; 372: n71, 2021.

19- Cochrane Handbook for Systematic Reviews of Interventions [Internet]. [cited 2025 Feb 3]. Available from: https://training.cochrane.org/handbook/current.

20- Clark J.M., Sanders S., Carter M., Honeyman D., Cleo G., Auld Y., et al.: Improving the translation of search strategies using the Polyglot Search Translator: A randomized controlled trial. J. Med. Libr Assoc. JMLA, Apr. 108 (2): 195–207, 2020.

21- Haddaway N.R., Grainger M.J. and Gray C.T.: Citationchaser: An R package and Shiny app for forward and backward citations chasing in academic searching [Internet]. Zenodo, 2021 [cited 2025 Feb 3]. Available from: https://zenodo.org/records/4543513.

22- Forbes C., Greenwood H., Carter M. and Clark J.: Automation of duplicate record detection for systematic reviews: Deduplicator. Syst. Rev., Aug 2; 13 (1): 206, 2024.

23- Chapter 25: Assessing risk of bias in a non-randomized study [Internet]. [cited 2025 Feb 3]. Available from: https://training.cochrane.org/handbook/current/chapter-25

24- Jansen T.M, Janßen S., Bölke E., Homey B. and Hoff N.P.: Hair follicle punch grafts in hard-to-heal wounds: A monocenter study and patient survey. Health Sci. Rep., 7 (8): e2319, 2024.

25- Belatti A., Bertarini F., Pombo V., Mazzuoccolo L. and Ferrario D.: Follicular unit grafting in chronic ulcers: A valuable technique for integrated management. An Bras Dermatol., 99 (4): 568–77, 2024.

26- Saha D., Thannimangalath S., Budamakuntla L., Loganathan E. and Jamora C.: Hair Follicle Grafting Therapy Promotes Re-Emergence of Critical Skin Components in Chronic Nonhealing Wounds. JID Innov., Jul. 9; 1 (3): 100041, 2021.

27- Wong T.W., Yang C.C., Hsu C.K., Liu C.H. and Yu-Yun Lee J.: Transplantation of autologous single hair units heals chronic wounds in autosomal recessive dystrophic epidermolysis bullosa: A proof-of-concept study. J. Tissue Viability, Feb. 30 (1): 36–41, 2021.

28- Journal of cardiovascular Disease Researchs [Internet]. [cited 2025 Feb 3]. Available from: https://jcdronline.org/paper.php?slug=treatment-of-ulcer-by-hair-follicular-unit-transplantation-and-split-thickness-skin-grafting

29- Alam M., Cooley J., Plotczyk M., Martínez-Martín M.S., Izeta A., Paus R., et al.: Distinct Patterns of Hair Graft Survival After Transplantation Into 2 Nonhealing Ulcers: Is Location Everything? Dermatol. Surg., Apr. 45 (4): 557–65, 2019.

30- Budamakuntla L., Loganathan E., Sarvajnamurthy S.A., Nataraj H.V.: Follicular Unit Grafting in Chronic Nonhealing Leg Ulcers: A Clinical Study. J. Cutan Aesthetic Surg., 10 (4): 200–6, 2017.

31- Martínez M.L., Escario E., Poblet E., Sánchez D., Buchón F.F., Izeta A., et al.: Hair follicle-containing punch grafts accelerate chronic ulcer healing: A randomized controlled trial. J. Am. Acad. Dermatol., Nov. 75 (5): 1007–14, 2016.

32- Liu J.Q., Zhao K.B., Feng Z.H. and Qi F.Z.: Hair follicle units promote re-epithelialization in chronic cutaneous wounds: A clinical case series study. Exp. Ther. Med., Jul. 10 (1): 25–30, 2015.

33- Jiménez F., Garde C., Poblet E., Jimeno B., Ortiz J., Martínez M.L., et al.: A pilot clinical study of hair grafting in chronic leg ulcers. Wound Repair Regen Off Publ Wound Heal Soc. Eur. Tissue Repair Soc., 20 (6): 806–14, 2012.

34- Vagnozzi A.N., Reiter J.F. and Wong S.Y.: Hair follicle and interfollicular epidermal stem cells make varying contributions to wound regeneration. Cell Cycle Georget Tex., 14 (21): 3408–17, 2015.

35- Corvera S., Solivan-Rivera J. and Yang Loureiro Z.: Angiogenesis in adipose tissue and obesity. Angiogenesis, 25 (4): 439–53, 2022.

36- Gould L., Abadir P., Brem H., Carter M., Conner-Kerr T., Davidson J., et al.: Chronic Wound Repair and Healing in Older Adults: Current Status and Future Research. Wound Repair Regen Off Publ Wound Heal Soc. Eur. Tissue Repair Soc., Jan. 23 (1): 1–13, 2015.

37- Schneider C., Stratman S. and Kirsner R.S.: Lower Extremity Ulcers. Med. Clin. North Am., Jul. 105 (4): 663–79, 2021.

38- Green J., Jester R., McKinley R. and Pooler A.: The impact of chronic venous leg ulcers: A systematic review. J. Wound Care, Dec. 23 (12): 601–12, 2014.