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Recipient-Site Optimization in Moustache Reconstruction for Cleft Lip Scars: A Narrative Review of Scar Conditioning, Microneedling, and Follicular Unit Transplantation

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Abstract

Background: Residual moustache alopecia associated with cleft lip repair is an uncommon but visually important secondary deformity. Although follicular unit transplantation can restore hair within the philtral and upper-lip region, mature cleft lip scars may constitute a challenging recipient bed because of altered tissue architecture, fibrosis and reduced pliability. These characteristics may affect recipient-site preparation and potentially influence graft establishment.



Objective: To review the evolution of moustache reconstruction in cleft lip scars and synthesize the available evidence regarding scar conditioning and recipient-site optimization, with particular emphasis on microneedling, hyaluronic acid and follicular unit transplantation/extraction.

Materials and Methods: This narrative review qualitatively synthesizes the 18 publications included in the reference list, covering cleft lip scars, moustache reconstruction, follicular unit transplantation/extraction, scar conditioning, microneedling, hyaluronic acid, wound healing and scar assessment. Publications were interpreted according to study design, directness to the clinical question and relevance. A reproducible database search and formal risk-of-bias assessment were not documented; accordingly, the review is not presented as systematic.

Results: The available cleft-specific literature consists predominantly of case reports and small clinical series. Early reports established the feasibility of microhair and single-follicular-unit transplantation into upper-lip scars. Later work described FUE and staged fat grafting with subsequent hair transplantation. A 2023 cohort study of 16 patients with cleft lip scars reported improvement in scar thickness and flexibility following four microneedling sessions combined with topical oil-based hyaluronic acid, using the Patient and Observer Scar Assessment Scale (POSAS). However, no cleft-specific study identified in the review directly establishes that microneedling or hyaluronic acid improves subsequent follicular graft survival.

Conclusion: Recipient-site optimization is a biologically plausible adjunct to moustache reconstruction in selected patients with cleft lip scars. Microneedling has direct cleft-specific evidence for improving scar characteristics, while fat-based conditioning and hair transplantation provide supportive evidence for staged reconstruction. The use of microneedling with hyaluronic acid before FUE should currently be regarded as a promising but investigational strategy rather than an established graft-survival protocol. Prospective comparative studies with objective hair and scar outcomes are required.

Keywords: Cleft lip; moustache reconstruction; follicular unit transplantation; scar conditioning; microneedling; recipient-site optimization.

1. Introduction

Cleft lip and palate are common congenital craniofacial anomalies with substantial functional, aesthetic and psychosocial consequences. A major review in *The Lancet* described cleft lip and palate as heterogeneous disorders with important effects on appearance and psychological well-being and emphasized the need for multidisciplinary care extending into adulthood. (1)

Genetic and environmental influences contribute to the development of orofacial clefts, and the clinical burden extends beyond the initial surgical repair. (2)

Primary cleft lip repair restores continuity of the lip but inevitably produces a scar. The mature scar may remain visible because of differences in pigmentation, contour, tissue thickness and pliability compared with adjacent skin. In male patients, disruption of the moustache across the upper-lip scar can further accentuate the deformity. The absence of hair within the scar is therefore an important component of the secondary aesthetic problem rather than merely an incidental finding.

The reconstructive management of cleft lip scars has evolved from contour camouflage toward restoration of both tissue quality and hair-bearing anatomy. Early work demonstrated that dermal micrografts could improve cleft lip scar camouflage, including correction of contour and colour abnormalities. (3) Subsequent reports demonstrated that microhair and single-follicular-unit transplantation could place functional hair directly into lip scars. (4,5)

The development of follicular unit extraction (FUE) expanded the options for facial hair restoration by allowing individual follicular units to be harvested with small punch excisions rather than a linear donor incision. (6) Facial hair transplantation requires particularly precise control of hair calibre, direction, angulation and density because small deviations are readily visible. A contemporary review of beard and moustache reconstruction describes FUE and follicular unit transplantation as established techniques for restoration of facial hair density. (7)

Despite technical advances, transplantation into a mature cleft lip scar remains biologically different from transplantation into normal skin. Fibrosis, altered extracellular-matrix architecture, tissue rigidity and variable vascularity may influence recipient-site creation and graft establishment. Evidence from hair transplantation in scarring alopecia suggests that outcomes are heterogeneous and should be interpreted cautiously because the available literature is small and subject to publication bias. (8)

This has led to increasing interest in recipient-site conditioning before hair transplantation. Staged approaches involving autologous fat have been described in cleft lip scar reconstruction, while microneedling has emerged as a minimally invasive technique capable of inducing controlled dermal injury and remodelling. (9,10)

Of particular relevance, Alghazzawi and Almodalal studied microneedling combined with topical oil-based hyaluronic acid in 16 patients with visible cleft lip scars. Four



sessions were performed at three-week intervals, and scar outcomes were assessed using POSAS. Improvement was reported in both scar thickness and flexibility. (11) This provides direct evidence that microneedling can modify cleft lip scar characteristics, but it does not demonstrate improved follicular graft survival after subsequent hair transplantation.

This narrative review integrates the available evidence concerning cleft lip scars, moustache reconstruction, scar biology, transplantation into scarred tissue and recipient-site conditioning. Its specific objective is to distinguish evidence of scar improvement from evidence of subsequent follicular graft survival and to identify the clinical research needed to test whether conditioning before FUE improves outcomes.

2. Study Design and Review Methodology

2.1 Study design

This article was designed as a narrative literature review. The objective was to synthesize evidence across several interconnected clinical domains rather than to estimate a pooled treatment effect. The review therefore integrates direct evidence from cleft lip scar and moustache reconstruction studies with indirect evidence from facial scars, cicatricial alopecia and microneedling literature.

The review does not involve new human participants, clinical intervention, patient recruitment or collection of unpublished clinical data. Ethical approval and informed consent were therefore not applicable.

2.2 Literature source and search concepts

The reference base comprised the 18 publications listed in this manuscript, spanning cleft lip epidemiology and surgical sequelae, moustache reconstruction, microhair transplantation, FUE, scarred recipient beds, scar conditioning, wound healing, microneedling, hyaluronic acid, autologous fat grafting and scar assessment. The original database sources, dates of searching and screening counts were not recorded; these details should be supplied by the authors if a documented search was performed. No exhaustive or systematic search is claimed.

The principal search concepts represented in the source literature were: cleft lip AND moustache reconstruction; cleft lip scar AND hair transplantation; cleft lip AND follicular unit extraction; moustache AND follicular unit transplantation; scar

alopecia AND hair transplantation; microneedling AND cleft lip scar; microneedling AND hyaluronic acid; recipient site AND hair transplantation; and scar vascularity AND hair transplantation.

Reference lists of relevant publications informed the source base. No registered protocol, formal systematic-review screening, meta-analysis or quantitative risk-of-bias synthesis was undertaken. Selection may therefore have missed relevant studies.

2.3 Eligibility and evidence interpretation

Publications were considered relevant when they addressed at least one of the following: cleft lip scars; moustache or beard reconstruction; follicular unit transplantation or FUE in scarred tissue; recipient-site vascularity or tissue quality; scar conditioning; microneedling/percutaneous collagen induction; hyaluronic acid; autologous fat or microfat; wound-healing biology; or validated scar assessment.

Case reports, case series, cohort studies, reviews and foundational publications were considered because the cleft-specific literature is limited. Greater weight was assigned to studies directly involving cleft lip scars or moustache reconstruction. Evidence from other scar types was treated as indirect or mechanistic evidence and was not assumed to have the same quantitative effect in cleft lip scars.

2.4 Data extraction and narrative synthesis

Information was organized under five domains: (1) cleft lip scar characteristics; (2) moustache and facial hair reconstruction; (3) recipient-site conditioning; (4) hair-transplantation outcomes; and (5) scar and patient-reported outcome assessment.

The evidence was interpreted according to study design, directness to the clinical question, consistency of findings and biological plausibility. Particular care was taken to distinguish evidence demonstrating scar improvement from evidence demonstrating improved follicular graft survival.

Methodological limitation: Because the database search dates, search outputs, screening decisions and excluded-study counts were not documented, the comprehensiveness and reproducibility of this narrative synthesis cannot be independently established. The conclusions should be interpreted in that context.



Table 1. Summary of the principal evidence relevant to recipient-site optimization.

Intervention / evidence	Directness	Main finding	Key limitation
Microhair / single-follicular-unit transplantation (Kiliç et al.; Reed and Grayson) (4,5)	Direct cleft-lip moustache evidence; early clinical reports; sample sizes to verify	Feasible restoration of hair within upper-lip scars.	Early reports; limited objective graft-survival data.
FUE + autologous fat grafting (Akdag et al., 2018) (9)	Direct cleft-lip scar reconstruction; n = 20	Reported favorable scar camouflage and graft survival after staged treatment.	No direct comparison with immediate FUE; combined intervention cannot isolate the effect of fat.
Microneedling + topical hyaluronic acid (Alghazzawi and Almodalal, 2023) (11)	Direct cleft-lip scar evidence; n = 16	Improved scar thickness and flexibility in a 16-patient cohort.	No hair-transplantation endpoint; no microneedling-only control.
Microneedling / percutaneous collagen induction (10,15–17)	Indirect evidence from other scar types	Supports dermal remodeling and scar-texture improvement.	Different scar types; cannot establish improved follicular graft survival.
Hair transplantation in primary scarring alopecia (Ekelem et al., 2019) (8)	Indirect evidence; systematic review of 15 reports involving 34 patients	Outcomes are heterogeneous, supporting cautious patient selection.	Primary scarring alopecia is not equivalent to mature cleft-lip scars.

3. Cleft Lip Scars and Moustache Alopecia

The mature cleft lip scar is a dynamic structure influenced by wound-healing processes, collagen deposition and remodelling. Wound healing involves overlapping inflammatory, proliferative and remodelling phases, with extracellular-matrix organization and collagen maturation continuing long after wound closure. (12)

Hypertrophic and abnormal scars differ from normal scars in their clinical behavior and extracellular-matrix characteristics. Although cleft lip scars are not necessarily hypertrophic, the broader scar literature illustrates how altered collagen organization and tissue mechanics can influence the final physical properties of a scar. (13)

The upper lip is particularly demanding for reconstruction because the scar is located within a region of constant movement and because the direction of facial hair varies over a small anatomical area. A successful moustache reconstruction therefore requires more than hair growth alone; the transplanted follicles must integrate visually with adjacent native hair.

Early hair-restoration reports provided proof of concept. Kiliç and colleagues reported microhair transplantation for upper-lip scars, while Reed and Grayson described single-follicular-unit transplantation specifically for cleft lip moustache alopecia. (4,5) These reports established the feasibility of placing small

follicular units into scar tissue but did not provide modern objective measurements of graft survival.

Subsequent adoption of FUE expanded the technical possibilities for facial hair reconstruction. Rassman and colleagues described harvesting individual follicular units through small punch excisions, avoiding a linear donor incision. (6) In moustache reconstruction, careful selection and orientation of a relatively small number of grafts may be particularly important.

The later use of FUE made facial hair restoration increasingly flexible. Rassman and colleagues introduced FUE as a minimally invasive method of harvesting individual follicular units through small punch excisions, avoiding a linear donor incision. (6) In moustache reconstruction, this approach is particularly useful because relatively small numbers of carefully selected grafts may be required.

4. Technical Principles of Moustache Reconstruction

Facial hair transplantation differs from scalp transplantation because the recipient area is highly visible and the hair direction is anatomically specific. Single-hair follicular units are often desirable in the moustache region, especially along the free margin, to reproduce the fine appearance of native facial hair. (7)

Recipient-site angulation is critical. Native moustache hairs emerge at shallow angles relative to the skin, and the angle



changes according to anatomical position. A technically viable graft may nevertheless appear unnatural if it is inserted too vertically or in an incorrect direction.

Density must also be individualized. The objective is not necessarily to reproduce the density of normal skin with a single procedure, particularly when the recipient bed is scarred. Excessive packing may increase mechanical trauma to the scarred tissue and may be unnecessary if the surrounding moustache is sparse.

The donor source should be selected according to follicular calibre, colour, curl and growth characteristics. Scalp and submental/beard donor hairs may both be considered depending on the clinical situation. (7) The available literature emphasizes meticulous handling and accurate placement as important technical determinants of aesthetic success.

5. The Scarred Recipient Bed

Scar tissue may present a different biological and mechanical environment from normal skin. Dense collagen deposition, altered extracellular-matrix organization and reduced tissue elasticity can make recipient-site creation more difficult. The vascular characteristics of scar tissue are also variable, and this may be relevant during the period between graft implantation and revascularization.

These considerations provide a rationale for investigating staged recipient-site conditioning alongside precise follicular implantation; they do not establish that conditioning increases graft survival.

The practical implication is that successful moustache reconstruction should be viewed as a combination of two processes: precise follicular implantation and optimization of the recipient environment. This creates the rationale for staged conditioning.

6. Recipient-Site Conditioning

6.1 Autologous fat grafting

Autologous fat grafting has been explored as a method of improving the quality of scar tissue before hair transplantation. In a cleft lip scar series, Akdag and colleagues combined autologous fat grafting with FUE hair transplantation. Twenty patients underwent fat grafting followed three months later by hair transplantation, with follow-up to 12 months. The authors reported improved scar camouflage and favorable graft survival and patient satisfaction. (9)

The study is clinically relevant because it provides a direct example of staged recipient-site conditioning in cleft lip

scars. However, the design does not establish whether the improvement resulted from fat grafting itself, the hair-transplantation technique, or their combination. It also does not provide a direct comparison with immediate FUE without conditioning.

Fat grafting has additional limitations, including donor-site morbidity, variable graft retention and the need for a separate procedure. Consequently, less invasive conditioning methods remain attractive.

6.2 Microneedling

Microneedling, also termed percutaneous collagen induction, creates controlled microscopic injuries within the skin. The technique is based on initiating a wound-healing response while minimizing extensive epidermal destruction. Aust and colleagues reported clinical experience with percutaneous collagen induction for scars, wrinkles and skin laxity, supporting its role as a dermal remodelling technique. (10)

Microneedling has subsequently been used for a wide range of indications including acne scars, post-traumatic scars and other forms of dermal remodelling. Reviews have emphasized its minimally invasive nature and potential applications in collagen induction and transdermal delivery. (15,16)

A study of 60 patients with post-acne scarring across different skin phototypes reported improvement following three monthly sessions of percutaneous collagen induction and found no short- or long-term dyschromia in the studied cohort. (17) These data are indirect with respect to cleft lip scars but support the broader capacity of microneedling to modify scar texture.

The proposed mechanism involves controlled tissue injury followed by release of wound-healing mediators, fibroblast activity and extracellular-matrix remodelling. The technique also creates temporary microchannels that may facilitate topical delivery. (16) These mechanisms provide a biologically plausible basis for using microneedling as a preparatory intervention in a scarred recipient bed.

6.3 Microneedling with hyaluronic acid

Hyaluronic acid is a naturally occurring glycosaminoglycan within the extracellular matrix and has important roles in tissue hydration and cellular interactions. Its use with microneedling is attractive because the microchannels created during needling may facilitate topical application.

The most directly relevant evidence is the cohort study by Alghazzawi and Almodalal. Sixteen patients aged 16 to 30 years with visible cleft lip scars underwent four microneedling



sessions at three-week intervals with topical oil-based hyaluronic acid. Scar outcomes were assessed by the patients and an external observer using POSAS. The authors reported improvement in scar thickness of 67.28% according to patients and 61.55% according to the observer, while flexibility improved by 65.57% and 60.25%, respectively. (11)

This study provides direct cleft-specific evidence that the combined intervention can improve selected scar characteristics. Importantly, however, the study did not include a microneedling-only control group and did not evaluate subsequent hair transplantation or graft survival. Therefore, the independent contribution of hyaluronic acid cannot be determined, and the findings should not be interpreted as proof that the intervention improves follicular graft survival.

Comparative interpretation: Fat grafting offers an approach to volume deficiency and scar contour, but entails an additional harvesting procedure and the published combined-treatment series cannot isolate its contribution. Microneedling is less invasive and has cleft-specific evidence for improvement in measured scar characteristics when combined with topical HA, but there is no controlled evidence that it increases subsequent follicular survival. Neither intervention can currently be recommended as a proven graft-survival enhancement protocol. (9,11)

This distinction is central to the proposed role of microneedling with HA. The current evidence supports scar modification; the hypothesis that scar modification improves subsequent FUE survival remains to be tested.

Wound healing involves coordinated inflammatory, proliferative and remodelling phases regulated by growth factors and cytokines. (12) Controlled injury from microneedling provides a mechanistic hypothesis for remodelling an established scar; the specific effect on recipient-site vascularity and subsequent transplanted follicle survival remains unverified.

A follicular graft is temporarily dependent on the recipient bed during the period preceding revascularization. A scarred environment may therefore be less forgiving of mechanical trauma, excessive density or inaccurate placement. Recipient-site conditioning could theoretically address some of these limitations by improving tissue pliability and remodelling.

For future comparative research, a consistent definition of graft survival is needed, such as the proportion of implanted follicular units producing visible growing hairs at a prespecified late follow-up, assessed using standardized baseline graft counts and trichoscopy. Hair density, calibre, orientation, scar quality, satisfaction and adverse events should be reported separately.

The wound-healing literature demonstrates that tissue repair involves coordinated inflammatory, proliferative and remodelling phases, with growth factors and cytokines regulating fibroblast activity and extracellular-matrix deposition. (12) Microneedling deliberately creates a controlled injury and may therefore induce a new remodelling cycle within an established scar.

However, the biological rationale should not be confused with clinical proof. Improvement in scar flexibility does not necessarily translate into greater follicular survival. Hair follicles require a complex microenvironment involving dermal-epidermal interactions, vascular support and signaling pathways that are not fully captured by gross scar measurements.

Therefore, the appropriate scientific position is that recipient-site conditioning is plausible and promising, but its effect on graft survival remains an empirical question.

7. Scar Assessment and Outcome Measurement

A major limitation of the published moustache reconstruction literature is the inconsistent use of standardized outcome measures. Early reports commonly relied on clinical photographs or subjective assessments. These reports are useful for demonstrating feasibility but provide limited information about comparative efficacy.

The Patient and Observer Scar Assessment Scale was developed to provide separate patient and observer assessments of scar characteristics. Draaijers and colleagues demonstrated acceptable consistency and reliability and showed that observer assessment was influenced by vascularity, thickness, pigmentation and relief, whereas patient assessment was influenced particularly by itching and scar thickness. (18)

For future studies of recipient-site conditioning before moustache transplantation, POSAS should be supplemented rather than used alone. Recommended outcomes include standardized photographic assessment, trichoscopic measurement of hair density, graft survival, hair calibre and direction, patient satisfaction and adverse events.

Objective assessment should ideally be performed at predefined intervals extending beyond the early postoperative phase. Because transplanted follicles undergo a postoperative shedding phase followed by regrowth, early photographs alone may underestimate or overestimate final outcomes.

8. Proposed Clinical Framework

The evidence reviewed supports an individualized rather than universal approach to recipient-site conditioning.



First, the scar should be assessed for maturity, thickness, pliability, fibrosis, contour and visible hair deficit. A soft, relatively pliable scar may be suitable for direct FUE, whereas a rigid and markedly fibrotic scar may warrant consideration of staged conditioning.

Second, the conditioning modality should be selected according to tissue characteristics. Autologous fat grafting may be considered where substantial tissue deficiency or severe fibrosis is present. Microneedling is attractive when a minimally invasive remodelling approach is preferred and is supported by cleft-specific evidence for improvement in scar thickness and flexibility. (9,11)

Third, the response to conditioning should be assessed before transplantation. Clinical improvement in pliability is useful, but it should not be considered a surrogate for proven graft survival.

Fourth, FUE should be planned conservatively with careful donor selection, recipient-area mapping, single-hair graft selection where appropriate, and precise replication of native moustache direction. The aim is integration with surrounding facial hair rather than maximal graft density.

Finally, outcomes should be documented using standardized photographs, trichoscopy where available, POSAS and patient-reported satisfaction. This framework is an evidence-informed proposal and should not be regarded as a validated clinical guideline.

9. Limitations of The Current Evidence

The evidence base is limited by small sample sizes, predominance of case reports and case series, inconsistent outcome measures and lack of control groups. The direct cleft lip moustache reconstruction literature is particularly sparse.

An additional limitation of this review is the absence of a fully documented, reproducible database search and formal study-level quality assessment. Selection and citation bias cannot be excluded. The evidence table is descriptive and should not be interpreted as a quantitative comparison of treatments.

Evidence from scarring alopecia and other scar types is useful for biological context but cannot be assumed to provide equivalent effects in cleft lip scars. Similarly, evidence that microneedling improves acne or surgical scars cannot be interpreted as direct evidence that it improves follicular graft survival.

The strongest cleft-specific evidence for microneedling with HA evaluates scar thickness and flexibility rather than hair transplantation. (11) The contribution of HA itself remains

uncertain because the study did not include a microneedling-only comparator.

Publication bias is also likely. Successful reconstructive cases are more likely to be reported than unsuccessful or technically difficult cases. This is particularly relevant to hair transplantation, where outcomes can vary according to scar quality and operator experience.

10. Future Research Directions

Future research should move beyond descriptive case reports toward prospective comparative studies. The key question is whether recipient-site conditioning improves the outcome of subsequent follicular transplantation.

A future factorial or appropriately controlled study could compare direct FUE, microneedling followed by FUE, and microneedling plus HA followed by FUE, with comparable scar characteristics and standardized transplantation technique across groups. This design would help distinguish the effect of microneedling from the additional contribution of HA.

Primary outcomes should include objective hair density and graft survival, while secondary outcomes should include POSAS, patient satisfaction, standardized photographic grading and adverse events. Trichoscopy should be considered for objective assessment of hair calibre and density.

Future studies should also standardize microneedling depth, number of sessions, treatment interval, HA formulation and the interval between conditioning and FUE. Objective assessment of recipient-site vascularity could further clarify whether vascular changes mediate any improvement in graft survival.

Until such studies are available, microneedling with HA should be presented as a promising recipient-site conditioning strategy rather than as an established evidence-based protocol for increasing graft survival.

11. Conclusion

Moustache alopecia associated with cleft lip scars represents a distinctive reconstructive problem in which aesthetic hair restoration is constrained by the biological and mechanical properties of the recipient bed. Microhair and single-follicular-unit transplantation established the feasibility of restoring hair within upper-lip scars, while FUE has provided a flexible contemporary approach to harvesting and implantation. (4–7)

The available evidence supports recipient-site quality as an important consideration but does not yet establish a standardized conditioning protocol. Autologous fat grafting



provides direct clinical experience with staged conditioning in cleft lip scars, whereas microneedling has direct evidence for improving scar thickness and flexibility. (9,11)

Microneedling combined with topical hyaluronic acid is therefore a promising concept for recipient-site optimization. However, the existing cleft-specific study demonstrates improvement in scar characteristics rather than improvement in subsequent follicular graft survival. The distinction should be maintained in clinical counseling and scientific reporting.

Future prospective controlled studies incorporating objective hair-survival, trichoscopic, vascular and scar-quality outcomes are needed to determine whether recipient-site conditioning can translate into more predictable and durable moustache reconstruction in patients with cleft lip scars.

Declarations

Ethics approval

Not applicable. This article is a narrative review of previously published literature and does not involve new human participant recruitment or intervention.

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Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Dr. Abirami Sampathkumar: Conceptualization, literature search and review, data curation, synthesis of the literature, and manuscript preparation.

Dr. Keerthana Ponvel: Conceptualization, literature review, critical analysis, manuscript preparation, and critical revision of the manuscript.

Dr. Manikandhan Ramanathan: Conceptualization, supervision, critical analysis and interpretation, and critical revision of the manuscript.

All authors: Contributed to the development of the manuscript, critically reviewed the final version, approved the manuscript for publication, and agree to be accountable for all aspects of the work.

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