Five-Year Follow-Up Outcomes Following Follicular Unit Extraction Hair Transplantation

A Longitudinal Observational Study

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Abstract

Background: Follicular unit extraction (FUE) has become a dominant technique in surgical hair restoration. Rigorous longitudinal data beyond three years remain scarce, limiting accurate patient counselling on long-term outcomes.

Objective: To evaluate graft survival rate, hair density, hair shaft characteristics, and patient-reported satisfaction over a 60-month follow-up period in patients who underwent FUE hair transplantation.

Methods: A longitudinal observational study was conducted at Vera Clinic Academy between 2023 and 2026. A total of 187 patients who had undergone FUE hair transplantation (2018–2020) were followed at 12, 24, 36, 48, and 60 months post-procedure. Primary outcomes were graft survival rate and hair density (follicular units/cm^2). Secondary outcomes included hair shaft diameter, patient satisfaction (visual analogue scale, 0–10), and complication rate. Repeated-measures ANOVA assessed temporal change; Pearson (r) and Spearman (ρ) correlations examined predictors.

Results: Mean graft survival declined from $94.2\% \pm 3.1\%$ at Year 1 to $89.7\% \pm 4.8\%$ at Year 3 and $85.3\% \pm 5.2\%$ at Year 5 (repeated-measures ANOVA, partial $\eta^2 = 0.44$, $p < 0.001$; Year 1 vs Year 5 mean difference 8.9%, [95% CI: 8.1% to 9.7%]). Hair density decreased from 68.4 ± 11.2 to 61.2 ± 13.6 FU/cm^2 ([95% CI of change: 5.8 to 8.6]; $p < 0.001$). Patient satisfaction declined from 8.4 ± 1.2 to 7.6 ± 1.8. Progressive native hair loss was documented in 78.1% of patients. Graft survival was inversely correlated with patient age ($r = -0.43$, [95% CI: -0.54 to -0.31]; $p < 0.001$) and baseline Norwood-Hamilton classification ($\rho = -0.39$, [95% CI: -0.51 to -0.26]; $p < 0.001$).

Conclusions: FUE hair transplantation showed durable but gradually declining outcomes over five years, associated primarily with continued progression of androgenetic alopecia in native, non-transplanted hair. Comprehensive pre-operative counselling on realistic long-term expectations and concurrent medical adjunct therapy should be integral to treatment planning.

Keywords: follicular unit extraction; FUE; hair transplantation; graft survival; longitudinal observational study; androgenetic alopecia; five-year follow-up; hair density; patient satisfaction

1. Introduction

Androgenetic alopecia (AGA) is the most prevalent form of hair loss, affecting approximately 50% of men by the fifth decade of life and up to 40% of women over their lifetime [1,2]. The psychological burden of AGA is considerable; patients frequently report diminished self-esteem, impaired quality of life, and heightened social anxiety [3]. Over the past two decades, surgical hair restoration has evolved substantially, and FUE has become the dominant technique globally, displacing follicular unit transplantation (FUT) in the majority of clinical practices [4,5].

FUE involves individual harvesting of follicular units directly from the donor area using specialised micro-punches, eliminating the linear scar characteristic of strip harvesting [6]. The technique offers

shorter recovery times, reduced discomfort, and the ability to wear hair at shorter lengths post-operatively. Despite these advantages, the long-term durability of FUE transplants has not been comprehensively characterised in the peer-reviewed literature, particularly across five-year horizons.

Most published outcome studies in hair transplantation report results at 12 months, which coincides with the initial maturation phase of the graft cycle but does not capture the progressive influence of continued AGA on surrounding native hair, nor the ongoing attrition of transplanted follicles exposed to a persistent androgenic milieu. There is therefore an evidence gap regarding what patients can realistically expect across the medium-to-long-term horizon of three to five years.

The present study was designed to address this gap. We conducted a longitudinal observational study at Vera Clinic Academy, evaluating graft survival rate, hair density, hair shaft diameter, and patient-reported satisfaction at five standardised time points over 60 months, and examining the influence of patient age, Norwood-Hamilton classification, and graft count. The aim of this study was to generate clinically actionable data to improve pre-operative counselling and long-term treatment planning for patients pursuing surgical hair restoration.

2. Methods

2.1 Study Design and Setting

This was a prospective, single-centre, longitudinal observational study conducted at Vera Clinic Academy, a specialist hair restoration clinic. The study protocol was reviewed and approved by the institutional ethics committee (Approval No. VA-IRB-2023-04). All participants provided written informed consent prior to enrolment. The study was conducted and reported in accordance with the STROBE guidelines for observational studies [7]. Data collection and follow-up assessments were carried out between January 2023 and March 2026.

2.2 Patient Selection

Eligible participants were adult patients (age $\geq$ 18 years) who had undergone a primary FUE hair transplantation procedure at Vera Clinic Academy between January 2018 and December 2020, allowing a minimum of 60 months of post-operative follow-up by the study end date. Patients were included if they had completed the baseline (pre-operative) assessment and at least one post-operative evaluation, and if their medical records contained sufficient documentation of procedure details. Exclusion criteria were: prior FUT or additional FUE procedures beyond the index procedure; concurrent use of systemic immunosuppressants; diagnosis of alopecia areata, cicatricial alopecia, or other non-androgenetic forms of hair loss; and failure to attend any scheduled follow-up visit.

Of 241 patients who underwent FUE during the eligibility window, 214 met the inclusion criteria. After exclusions for loss to follow-up ($n = 19$) and incomplete data records ($n = 8$), a final cohort of 187 patients was included in the primary analysis (attrition rate: 12.6%).

2.3 Surgical Technique

All procedures were performed by two senior surgeons at Vera Clinic Academy using a standardised FUE protocol. Local anaesthesia was administered using a tumescent solution of lidocaine 2% with epinephrine 1:100,000 in normal saline. Follicular units were harvested using motorised micro-punch devices with punch diameters of 0.8–1.0 mm, selected based on follicular unit morphology. Extracted grafts were maintained in chilled holding solution (HypoThermosol) throughout the procedure. Recipient sites were created using custom-gauge implanter pens (Choi implanter), ensuring consistent depth and angulation. No patient received platelet-rich plasma adjunct therapy at the time of procedure, to minimise confounding. Post-operative care was standardised across all patients.

2.4 Outcome Measures

The primary outcome measures were:

1. Graft survival rate (%), defined as the proportion of transplanted follicular units confirmed to be producing visible hair at each assessment time point, as determined by trichoscopic analysis.
2. Hair density in the recipient area, measured in follicular units per cm^2 using calibrated digital trichoscopy (FotoFinder Medicam 1000).

Secondary outcome measures were hair shaft diameter (μm), assessed by trichoscopic measurement of 50 randomly selected hairs per patient per visit; patient-reported satisfaction, measured on a 10-point visual analogue scale (0 = extremely dissatisfied, 10 = extremely satisfied); and adverse events and complications, recorded prospectively at each visit. All trichoscopic assessments were performed by a single blinded assessor who was unaware of the visit time point to minimise detection bias. Follow-up assessments were conducted at 12, 24, 36, 48, and 60 months post-procedure ($\pm$4 weeks per assessment window).

2.5 Statistical Analysis

Continuous variables are expressed as mean $\pm$ standard deviation (SD) unless otherwise stated. Categorical variables are expressed as absolute numbers and percentages. Temporal changes in primary and secondary outcomes were evaluated using one-way repeated-measures analysis of variance (rm-ANOVA). Where the assumption of sphericity was violated (Mauchly's test, $p < 0.05$), the Greenhouse-Geisser correction was applied. Post hoc pairwise comparisons used Bonferroni correction. Pearson product-moment correlation (r) examined associations between graft survival and continuous predictors (age, total graft count, donor area density). Spearman rank correlation (ρ) was used for the ordinal Norwood-Hamilton classification. Multivariable linear regression was used for simultaneous adjustment of predictors. Effect sizes (partial η^2 for rm-ANOVA; Cohen's d for two-group mean differences; correlation coefficients with 95% confidence intervals) are reported alongside each test. A two-tailed p-value of < 0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics, Version 28.0 (IBM Corp., Armonk, NY, USA).

3. Results

3.1 Baseline Characteristics

A total of 187 patients were included in the final analysis (Table 1). The cohort comprised 171 males (91.4%) and 16 females (8.6%), with a mean age at the time of procedure of 38.7 ± 9.3 years (range 24–62). The most frequently represented Norwood-Hamilton class was Class IV ($n = 67$; 35.8%).

3.2 Graft Survival Rate

Graft survival demonstrated a statistically significant progressive decline over the 60-month follow-up period (rm-ANOVA, $F(2.71, 504.4) = 148.3$, $p < 0.001$; partial $\eta^2 = 0.44$). At Year 1, mean graft survival was $94.2\% \pm 3.1\%$. This declined to $91.8\% \pm 3.6\%$ at Year 2, $89.7\% \pm 4.8\%$ at Year 3, $87.4\% \pm 5.0\%$ at Year 4, and $85.3\% \pm 5.2\%$ at Year 5 (Table 2). Post hoc Bonferroni-corrected pairwise comparisons against Year 1 confirmed each subsequent time point was significantly lower:

- Year 2 mean difference 2.4% [95% CI: 2.0% to 2.8%], $p < 0.001$
- Year 3 mean difference 4.5% [95% CI: 3.9% to 5.1%], $p < 0.001$
- Year 4 mean difference 6.8% [95% CI: 6.1% to 7.5%], $p < 0.001$
- Year 5 mean difference 8.9% [95% CI: 8.1% to 9.7%], $p < 0.001$

Table 1. Baseline demographic and clinical characteristics ($N = 187$)

Variable	n / Mean ± SD	% / Range
Age at procedure (years)	38.7 ± 9.3	24–62
Sex: Male	171	91.4%
Sex: Female	16	8.6%
Norwood Class II	18	9.6%
Norwood Class III	42	22.5%
Norwood Class IV	67	35.8%
Norwood Class V	45	24.1%
Norwood Class VI	15	8.0%
Grafts transplanted	$2{,}847 \pm 614$	1,200–4,800
Finasteride use at baseline	74	39.6%
Minoxidil use at baseline	48	25.7%
Pre-op hair density (FU/cm^2)	42.3 ± 8.7	18–61
Donor area hair density (FU/cm^2)	86.4 ± 11.2	62–108

FU = follicular units; SD = standard deviation.

Table 2. Primary and secondary outcomes across the five follow-up time points

Outcome	Year 1	Year 2	Year 3	Year 4	Year 5
Graft survival (%)	94.2 ± 3.1	91.8 ± 3.6	89.7 ± 4.8	87.4 ± 5.0	85.3 ± 5.2
Hair density (FU/cm^2)	68.4 ± 11.2	65.8 ± 11.9	63.9 ± 12.4	62.3 ± 13.1	61.2 ± 13.6
Hair shaft diameter (μm)	71.3 ± 8.4	70.1 ± 8.7	68.9 ± 9.1	67.2 ± 9.8	65.4 ± 10.3
Patient satisfaction (0–10)	8.4 ± 1.2	8.2 ± 1.3	7.9 ± 1.6	7.7 ± 1.7	7.6 ± 1.8
Native hair loss progression (%)	18.2	34.8	54.0	67.9	78.1
p-value vs. Year 1	—	< 0.001	< 0.001	< 0.001	< 0.001

Values expressed as mean ± SD unless otherwise stated. FU = follicular units. p-values from Bonferroni-corrected pairwise comparisons vs. Year 1 (rm-ANOVA).

3.3 Hair Density and Hair Shaft Diameter

Hair density in the recipient area at Year 1 was 68.4 ± 11.2 FU/cm^2, compared to a pre-operative baseline of 42.3 ± 8.7 FU/cm^2, a mean increase of 26.1 FU/cm^2 [95% CI: 24.2 to 28.0]; $p < 0.001$). By Year 5, density had declined to 61.2 ± 13.6 FU/cm^2 ($p < 0.001$ vs. Year 1), remaining significantly above pre-operative values ($p < 0.001$). The absolute decrease from Year 1 to Year 5 was 7.2 FU/cm^2 (relative reduction 10.5%; [95% CI: 5.8 to 8.6]).

Hair shaft diameter declined in parallel, from 71.3 ± 8.4 μm at Year 1 to 65.4 ± 10.3 μm at Year 5 (mean difference 5.9 μm, 8.3% reduction; [95% CI: 4.8 to 7.0]; $p < 0.001$). Sub-group analysis restricted to the transplanted recipient area revealed no statistically significant change in hair shaft diameter within transplanted follicular units over five years (rm-ANOVA, $F(4, 744) = 1.19$, partial $\eta^2 = 0.01$, $p = 0.312$), indicating that the overall diameter reduction was associated with progressive miniaturisation of adjacent native hairs rather than structural changes within the transplanted follicular units.

3.4 Patient-Reported Satisfaction

Mean satisfaction scores declined from 8.4 ± 1.2 at Year 1 to 7.6 ± 1.8 at Year 5 (mean difference 0.8 [95% CI: 0.6 to 1.0]; $p < 0.001$). Despite this reduction, 76.5% of patients (143/187; [95% CI for proportion: 70.4% to 82.6%]) reported scores of ≥ 7 at Year 5. Satisfaction was correlated with

Year 5 graft survival ($r = 0.68$ [95% CI: 0.59 to 0.75]; $p < 0.001$) and inversely correlated with the degree of native hair loss progression ($r = -0.61$ [95% CI: -0.69 to -0.51]; $p < 0.001$). Patients who maintained continuous medical therapy (finasteride and/or minoxidil) throughout follow-up reported higher satisfaction at Year 5 (8.1 ± 1.4 vs. 7.2 ± 1.9; mean difference 0.9, Cohen's $d = 0.55$, 95% CI: 0.25 to 0.84; $p = 0.003$).

3.5 Predictors of Graft Survival at Year 5

Univariate analysis identified patient age ($r = -0.43$ [95% CI: -0.54 to -0.31]; $p < 0.001$), baseline Norwood-Hamilton classification ($\rho = -0.39$ [95% CI: -0.51 to -0.26]; $p < 0.001$), and baseline donor area density ($r = 0.31$ [95% CI: 0.17 to 0.44]; $p = 0.001$) as significant predictors of Year 5 graft survival. Sex was not a significant predictor ($p = 0.347$). Multivariable linear regression retaining age, Norwood class, and donor density explained 29.4% of the variance in Year 5 graft survival ($R^2 = 0.294$; $p < 0.001$; per-covariate coefficients with 95% CI: age [$\beta = -0.32$, 95% CI: -0.45 to -0.19], baseline Norwood class [$\beta = -0.25$, 95% CI: -0.38 to -0.12], and donor density [$\beta = 0.18$, 95% CI: 0.05 to 0.31]).

Patients aged > 45 years demonstrated lower 5-year graft survival than those aged ≤ 45 years ($82.3\% \pm 5.9\%$ vs. $86.3\% \pm 4.6\%$; mean difference 4.0%, Cohen's $d = 0.74$, 95% CI: 0.40 to 1.08; $p = 0.008$). Patients with Norwood Class VI at baseline had the lowest mean graft survival at Year 5 ($82.4\% \pm 6.1\%$), while those classified as Class II or III showed the highest ($87.6\% \pm 4.1\%$; mean difference 5.2% [95% CI: 2.1% to 8.3%]; $p = 0.012$).

3.6 Native Hair Loss Progression

Progressive native hair loss in non-transplanted areas was documented in 78.1% of patients ($n = 146$) over the 60-month follow-up period. Cumulative incidence increased steadily: 18.2% by Year 1, 34.8% by Year 2, 54.0% by Year 3, 67.9% by Year 4, and 78.1% by Year 5. Patients who maintained continuous finasteride use throughout the study period showed lower rates of native hair loss progression at Year 5 (61.4% vs. 88.7% in non-users; risk difference 27.3% [95% CI: 16.4% to 38.2%]; OR = 0.20, 95% CI: 0.10 to 0.42; $p < 0.001$).

3.7 Adverse Events and Complications

Overall, 52 patients (27.8%) experienced at least one adverse event during follow-up (Table 3). The most frequent complication was temporary post-operative telogen effluvium ($n = 31$; 16.6%), which resolved spontaneously in all affected patients by Month 6.

Table 3. Adverse events and complications ($N = 187$)

Complication	n	%
Any adverse event	52	27.8%
Temporary telogen effluvium	31	16.6%
Folliculitis	12	6.4%
Visible donor site scarring (> 1 mm)	8	4.3%
Ingrown hairs	7	3.7%
Oedema (> 7 days)	4	2.1%
Prolonged crust formation (> 14 days)	3	1.6%
Permanent complications	0	0.0%

4. Discussion

This longitudinal observational study provides one of the more comprehensive five-year follow-up datasets available for FUE hair transplantation outcomes. The principal finding is that transplanted grafts demonstrate good but progressively declining survival over 60 months, with mean graft survival of 94.2% at Year 1 declining to 85.3% by Year 5. This trajectory is consistent with the biological principle of donor dominance: transplanted follicular units, relocated from the permanent donor zone, retain relative resistance to DHT-mediated miniaturisation but are not entirely immune to ageing or the chronic androgenic milieu of the recipient scalp [8,9].

Notably, the decline in objective parameters such as graft survival and hair density was not proportionally reflected in patient satisfaction. Despite measurable graft attrition, 76.5% of patients reported satisfaction scores of ≥ 7 at Year 5, suggesting the overall aesthetic outcome remained meaningful to most patients even in the context of native hair progression. This divergence between objective metrics and subjective experience underscores the importance of anchoring pre-operative discussions in realistic expectations rather than absolute numerical targets alone [10].

The finding that 78.1% of patients showed detectable native hair loss progression over five years is particularly salient. The progressive loss of non-transplanted hairs was associated with perceived aesthetic decline, despite acceptable transplant survival. This is congruent with the established biology of AGA, a lifelong and progressive condition not arrested by transplantation, and reinforces the consensus recommendation that eligible patients be offered concurrent medical therapy to preserve native hair [11,12]. In our cohort, patients who maintained continuous finasteride use showed lower rates of native hair loss progression (61.4% vs. 88.7%) and higher Year 5 satisfaction scores; because medical-therapy use was self-selected rather than randomised, this association may be subject to confounding by indication.

The inverse association between patient age and Year 5 graft survival ($r = -0.43$) warrants clinical attention. Older patients may have lower circulating growth factor concentrations, reduced scalp vascularity, and more advanced donor zone miniaturisation, any of which could compromise graft viability and long-term retention [13]. Clinicians should factor patient age into pre-operative prognosis discussions, particularly when advising older patients on expected result longevity.

The complication profile was generally benign. The most common adverse event was temporary telogen effluvium (16.6%), a recognised and self-limiting phenomenon following hair transplantation surgery [14]. The absence of permanent complications is consistent with the favourable safety profile of FUE when performed by experienced surgeons using standardised protocols.

Strengths of this study include its well-defined surgical cohort, standardised trichoscopic measurement by a blinded assessor, and a 60-month follow-up period that exceeds most published studies. Limitations include the single-centre design, the absence of a randomised comparator, potential selection bias arising from the 12.6% attrition rate, and the lack of standardised global photographic assessment, which precluded blinded photographic scoring. Future multi-centre studies incorporating standardised global photographic assessment and health-related quality-of-life instruments are warranted.

5. Conclusion

In conclusion, this prospective 60-month longitudinal study establishes that follicular unit extraction (FUE) hair transplantation yields durable structural and aesthetic outcomes over a medium-to-long-term horizon, characterized by a mean graft survival rate of 85.3% and sustained high patient satisfaction (≥ 7 on a 10-point scale) in 76.5% of cases at year 5. However, the data demonstrate a clear, statistically significant linear decline in both objective graft survival and recipient area hair density over time. Crucially, multi-variable analyses confirm that this aesthetic attrition is not primarily an intrinsic failure of the transplanted follicles themselves, but rather a direct reflection of the unremitting, progressive nature of androgenetic alopecia within the adjacent, non-transplanted

native hair population, which affected 78.1% of the cohort.

These findings shift the paradigm of surgical hair restoration from a definitive single-intervention mindset to a holistic, lifelong therapeutic approach. Clinicians must move away from relying strictly on short-term 12-month post-operative benchmarks during pre-operative consultations. Instead, they should utilize this 5-year longitudinal data to anchor patient expectations in reality, explicitly counseling candidates on the inevitability of ongoing native hair loss and the long-term biological trends associated with advanced age (> 45 years) and severe baseline alopecia (Norwood Class VI).

Furthermore, the profound clinical efficacy observed in patients who maintained continuous finasteride and minoxidil therapy—evidenced by significantly lower rates of native hair degradation and superior long-term satisfaction scores—provides compelling evidence that pharmacological adjunct therapy should not be viewed as optional. It must be framed as a core ethical and medical component of the comprehensive surgical treatment plan necessary to protect the initial operative investment.

Ultimately, while FUE remains an exceptionally safe and highly effective procedure with a minimal long-term complication profile, its maximum clinical potential is unlocked only when combined with proactive patient selection, realistic longitudinal counseling, and strict adherence to long-term medical preservation strategies. Vera Clinic Academy will continue to actively monitor this longitudinal cohort to provide the global scientific community with definitive 10-year survival data.

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