Graft Survival Rates Following Follicular Unit Extraction at 12 and 24 Months: A Retrospective Cohort Study at Vera Clinic, Istanbul, Turkey

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Abstract

Background. Follicular unit extraction (FUE) is the dominant minimally invasive technique in contemporary hair restoration surgery. Long-term graft survival data from high-volume specialist centres remain limited, constraining evidence-based patient counselling.

Methods. A retrospective cohort of 309 consecutive patients who underwent FUE at Vera Clinic, Istanbul, between January 2022 and December 2024 was analysed. Graft survival was assessed by standardised trichoscopic photography and hair-count mapping at 12 months (n = 309) and 24 months (n = 249; 80.6% follow-up rate). Multivariable linear regression identified independent predictors of 24-month survival.

Results. Mean graft survival was 91.4% (SD = 4.1%) at 12 months and 89.8% (SD = 5.0%) at 24 months. Higher Norwood–Hamilton (NH) grade, lower donor density, and older patient age were each independently associated with reduced survival (all $p < 0.05$). At 24 months, 90.4% of patients reported being satisfied or very satisfied with their outcome.

Conclusions. FUE in a standardised high-volume setting achieves durable graft survival exceeding 89% at two years. NH grade, donor density, and patient age are key predictors and should guide pre-operative planning and counselling.

Keywords: follicular unit extraction; FUE; graft survival; hair transplantation; retrospective cohort; trichoscopy; Norwood–Hamilton classification

1. Introduction

Androgenetic alopecia (AGA) affects approximately 50% of men by the age of 50 and up to 25% of women over a lifetime, making it one of the most prevalent dermatological conditions worldwide [1,2]. Hair transplantation, and specifically follicular unit extraction (FUE), has emerged as the preferred surgical solution for medically stable hair loss, owing to its minimally invasive nature, absence of a linear donor scar, and rapid patient recovery [3,4]. Unlike follicular unit transplantation (FUT), in which a strip of scalp is excised and dissected ex vivo, FUE harvests individual follicular units directly from the donor zone using a motorised or manual punch of 0.7–1.0 mm in diameter [5]. While cosmetic and functional outcomes are broadly comparable between methods, FUE imposes unique mechanical stresses on follicular units during extraction, channelling, and implantation, each of which may influence long-term graft viability [6,7].

Reported graft survival rates vary considerably in the literature, ranging from 75% to over 95%, depending on surgeon experience, graft handling protocols, recipient-site density, and patient characteristics [8,9,10]. Large single-centre series with standardised outcomes methodology are essential

to benchmark clinical practice, yet data from high-volume specialist centres operating under consistent protocols remain sparse [11].

The present study, conducted at Vera Clinic in Istanbul, Turkey, in the framework of a research collaboration between the University of Economics and Human Sciences (Warsaw, Poland) and Vera Academy and Vera Clinic (Istanbul, Turkey), aimed to: (a) report graft survival rates at 12 and 24 months post-FUE in a cohort of 309 consecutive patients; (b) identify independent predictors of survival using multivariable regression; and (c) describe the complication profile and patient-reported outcomes.

2. Methods

2.1 Study Design and Data Source

A retrospective cohort design was employed. Clinical data were obtained from the prospectively maintained records of Vera Clinic (Istanbul, Turkey) under a formal data sharing agreement between Vera Clinic and the research team at the University of Economics and Human Sciences, Warsaw. All consecutive patients who underwent FUE at Vera Clinic between January 1, 2022, and December 31, 2024, and attended at least one post-operative follow-up visit were considered for inclusion.

2.2 Participants

Inclusion criteria were: age 18–70 years; confirmed diagnosis of AGA (NH grade II–VI for men, Ludwig grade I–III for women); documented hair loss stability of at least one year; and minimum donor density of 50 follicular units (FU)/cm² at baseline trichoscopy. Exclusion criteria were: active scalp disease or infection; systemic immunosuppressive therapy within six months prior to surgery; prior scalp irradiation; concurrent conditions expected to affect hair growth (e.g., uncontrolled thyroid disease, iron deficiency anaemia); and unwillingness to discontinue minoxidil or finasteride for at least four weeks before and six months after surgery.

2.3 Surgical Protocol

All procedures were performed under tumescent local anaesthesia. Grafts were extracted using a motorised rotary punch (0.8 mm; Devroye PCID, Belgium) at an extraction density not exceeding 30% of available donor area per session. Follicular units were maintained in chilled HypoThermosol preservation solution (BioLife Solutions, USA) at 4°C, with a target maximum out-of-body time of six hours. Recipient channels were created with sapphire blades matched to individual graft dimensions, and implantation was performed using the Choi implanter pen technique.

2.4 Measures

The primary outcome was graft survival rate at 12 and 24 months, defined as the proportion of transplanted grafts producing a terminal hair shaft of at least 1 cm at follow-up. Survival was quantified using standardised trichoscopic photography (Fotofinder Medicam 1000, FotoFinder Systems, Germany) and hair-count mapping of four standardised 1-cm² zones within the transplanted area; the mean count across zones provided each patient's estimate. Secondary outcomes included complication rates, patient satisfaction (five-point Likert scale), and change in Hair Restoration Index (HRI) score (validated 0–100 scale).

2.5 Statistical Analysis

Continuous variables are reported as mean and standard deviation (SD); categorical variables as frequency and percentage. Differences in 12-month survival across NH strata were assessed by one-way ANOVA with Tukey post-hoc comparisons. Paired t-tests compared 12- and 24-month survival within each grade stratum. Multivariable linear regression with backward elimination (removal criterion: $p > 0.10$) identified independent predictors of 24-month graft survival; NH grade was entered as an ordinal variable coded II = 1, III = 2, III vertex = 3, IV = 4, V = 5, VI = 6. All analyses were performed in SPSS (Version 28.0; IBM Corp.). Statistical significance was set at $p < 0.05$.

3. Results

3.1 Sample Characteristics

A total of 309 patients met eligibility criteria (274 male [88.7%], 35 female [11.3%]). Mean age was 35.2 years (SD = 8.6; range: 22–65). The most prevalent NH grade was IV (n = 84; 27.2%), followed by grade III (n = 65; 21.0%). Mean grafts transplanted per session was 3,124 (SD = 712; range: 1,500–5,200). Baseline donor density averaged 79.1 FU/cm² (SD = 11.8). Complete baseline and procedural characteristics are presented in Table 1.

Table 1. *Baseline patient and procedural characteristics (N = 309).*

Characteristic	n or M (SD)	% or Range
Total enrolled	309	—
Sex — male	274	88.7
Sex — female	35	11.3
Age (years)	35.2 (8.6)	22–65
NH grade		
II	39	12.6
III	65	21.0
III vertex	35	11.3
IV	84	27.2
V	55	17.8
VI	31	10.0
Grafts transplanted	3,124 (712)	1,500–5,200
Donor density (FU/cm²)	79.1 (11.8)	51–112
Out-of-body time (min)	221 (46)	115–348
Single-hair grafts (%)	22.8 (5.9)	11–37
Two-hair grafts (%)	53.3 (7.5)	37–68
Three+-hair grafts (%)	23.9 (5.1)	10–38

Note. M = mean; SD = standard deviation; NH = Norwood–Hamilton; FU = follicular unit. Graft composition percentages (single/two/three+) sum to 100%.

3.2 Graft Survival at 12 Months

All 309 participants attended the 12-month assessment. Mean graft survival was 91.4% (SD = 4.1%; median = 92.2%; range: 78.6%–97.7%). Survival was highest in NH grade II (M = 93.9%, SD = 2.8%) and declined progressively, reaching 86.5% (SD = 5.6%) in grade VI, $F(5, 303) = 12.1$, $p < 0.001$. Grade-stratified results are presented in Table 2.

Table 2. *Graft survival rates at 12 and 24 months by Norwood–Hamilton grade.*

NH Grade	n	12-Mo M% (SD)	24-Mo M% (SD)	Δ (%)	p
II	39	93.9 (2.8)	92.5 (3.1)	−1.4	0.064
III	65	92.7 (3.3)	91.4 (3.7)	−1.3	0.078
III vertex	35	92.2 (3.7)	91.1 (4.0)	−1.1	0.096
IV	84	91.5 (3.9)	89.9 (4.5)	−1.6	0.029*
V	55	89.3 (4.7)	87.4 (5.3)	−1.9	0.016*
VI	31	86.5 (5.6)	84.7 (6.2)	−1.8	0.021*
Overall	309	91.4 (4.1)	89.8 (5.0)	−1.6	—

Note. M = mean; SD = standard deviation; Δ = 24-month minus 12-month survival. p-values from paired t-test within each grade stratum (24-month completers only). Overall 24-month assessment based on n = 249 (80.6% follow-up). Non-significant declines (grades II–III vertex) are not starred. * $p < 0.05$.

3.3 Graft Survival at 24 Months

At 24 months, 249 participants (80.6%) completed follow-up. Of the 60 non-attendees, 38 (63.3%) were contacted by telephone and reported no adverse events; 22 (36.7%) were lost to follow-up. Mean 24-month graft survival was 89.8% (SD = 5.0%; median = 90.9%; range: 74.5%–97.2%). The absolute decline from 12 to 24 months was −1.6 percentage points, 95% CI −2.0 to −1.2, $p < 0.001$, with the greatest attrition in NH grade IV–VI patients (Table 2). The 12-to-24-month decline was statistically significant only in grades IV, V, and VI ($p < 0.05$); grades II, III, and III vertex showed numerically smaller declines that did not reach significance at the stratum level.

3.4 Predictors of 24-Month Graft Survival

Results of the multivariable linear regression (n = 249; $R^2 = 0.39$) are presented in Table 3. Three variables independently predicted graft survival: higher NH grade (b = −1.84, 95% CI −2.39 to −1.29, $p < 0.001$); lower donor density (b = +0.13, 95% CI +0.04 to +0.22, $p = 0.004$); and older patient age (b = −0.09, 95% CI −0.17 to −0.01, $p = 0.028$). Out-of-body time, total grafts transplanted, and sex were non-significant after adjustment.

Table 3. *Multivariable linear regression predicting 24-month graft survival (n = 249).*

Variable	b	95% CI	p
NH grade (ordinal: II = 1 to VI = 6)	−1.84	−2.39 to −1.29	< 0.001
Donor density (per 1 FU/cm² increase)	+0.13	+0.04 to +0.22	0.004
Patient age (per 1 year increase)	−0.09	−0.17 to −0.01	0.028
Out-of-body time (per 10 min increase)	−0.05	−0.13 to +0.03	0.211
Grafts transplanted (per 100 grafts)	−0.02	−0.10 to +0.06	0.618
Sex (male vs. female)	−0.38	−1.81 to +1.05	0.601

Note. Dependent variable: graft survival (%). $R^2 = 0.39$. Variables removed by backward elimination are excluded. NH grade coded ordinally: II = 1, III = 2, III vertex = 3, IV = 4, V = 5, VI = 6. b = unstandardised regression coefficient.

3.5 Complications

A total of 86 participants (27.8%) experienced at least one complication within 24 months; all resolved without surgical re-intervention (Table 4). Temporary shock loss was the most frequent event (n = 51; 16.5%), resolving spontaneously within 12 weeks in every case. Bacterial infection occurred in four participants (1.3%) and was managed successfully with oral antibiotics.

Table 4. *Complications within 24 months (N = 309).*

Complication	n	% (N=309)	Management / Resolution
Temporary shock loss	51	16.5	Spontaneous; all cases, ≤12 weeks
Folliculitis	23	7.4	Topical antibiotic / antiseptic wash
Transient forehead oedema	14	4.5	Spontaneous resolution ≤10 days
Ingrown hairs	11	3.6	Needle incision + topical treatment
Persistent numbness (>3 months)	9	2.9	Resolved spontaneously by 12 months
Cyst formation	5	1.6	Incision and drainage
Bacterial infection	4	1.3	Oral antibiotic course (7 days)
Hypertrophic scar (donor site)	3	1.0	Intralesional triamcinolone injection
Any complication	86	27.8	All resolved; no reoperation required

Note. Total events = 120 across 86 patients (some patients experienced >1 complication). Percentages calculated from total enrolled cohort (N = 309).

3.6 Patient Satisfaction and HRI Score

At 24-month follow-up (n = 249), 90.4% of participants reported being satisfied or very satisfied: very satisfied, 63.1% (n = 157); satisfied, 27.3% (n = 68); neutral, 7.2% (n = 18); dissatisfied, 2.4% (n = 6). Mean HRI score improved from 37.8 (SD = 11.2) at baseline to 73.1 (SD = 14.5) at 24 months, a mean increase of 35.3 points, 95% CI 32.4 to 38.2, $p < 0.001$.

4. Discussion

The principal finding of this study is that FUE performed at a dedicated high-volume hair restoration centre achieves graft survival rates of 91.4% at 12 months and 89.8% at 24 months across a cohort of 309 consecutive patients — figures consistent with, and in several NH strata superior to, rates reported in the broader surgical literature [8,12,13]. The modest absolute decline of 1.6 percentage points between assessments indicates that most graft attrition occurs within the first year, consistent with established follicular engraftment biology [14].

The inverse relationship between NH grade and graft survival is biologically plausible. Patients with advanced AGA exhibit a more hostile recipient-zone microenvironment, characterised by progressive follicular miniaturisation, reduced dermal papilla vascularity, and elevated local dihydrotestosterone concentrations [14,15]. After adjustment for donor density and patient age, the regression model estimated a model-adjusted survival loss of 1.84 percentage points per ordinal NH grade increment, equivalent to a 9.2-percentage-point difference in predicted survival between grade II and grade VI. This exceeds the unadjusted observed difference of 7.8 percentage points (92.5% vs. 84.7% at 24 months),

reflecting partial confounding by covariates correlated with NH grade. The model-adjusted gap is clinically meaningful and warrants systematic discussion during pre-operative counselling.

Donor density emerged as an independent positive predictor of survival. Higher density likely reflects a more vigorous scalp vasculature and permits intraoperative selection of grafts with superior follicular architecture, consistent with recommendations for quantitative trichoscopic donor-area mapping [16].

The modest but significant age effect ($b = -0.09$ per year, $p = 0.028$) aligns with evidence of age-related declines in follicular stem cell activity and scalp microvascular density [17]. The 16.5% rate of temporary shock loss falls within the 10%–22% range reported in the hair transplantation literature [18] and resolved spontaneously in all cases.

Strengths and limitations. The principal strength of this study is its large consecutive single-protocol cohort with standardised trichoscopic outcome assessment. Several limitations qualify the findings. First, the retrospective single-centre design precludes randomised comparison and may introduce selection bias, as patients were not consecutively enrolled under a prospective protocol and eligibility was applied at chart review. Second, outcome measurement relied on trichoscopic hair-count mapping of four standardised zones rather than whole-scalp graft-by-graft counting; while standardised, this sampling approach may not capture regional variation in survival. Third, the 19.4% loss to 24-month follow-up may disproportionately exclude patients with poorer outcomes, potentially overestimating mean survival; baseline characteristics of completers versus those lost to follow-up were not formally compared, and survivor bias cannot be excluded. Fourth, residual confounding by unmeasured factors (e.g., smoking, perioperative care adherence, surgeon-level variation) may persist despite multivariable adjustment, and the single-centre setting limits external validity to comparable high-volume specialist practices.

Future prospective multicentre trials with blinded outcome assessors and formal comparison of completers versus non-completers are warranted to confirm and extend these findings.

5. Conclusions

FUE conducted within a standardised, high-volume clinical setting achieves durable graft survival exceeding 89% at 24 months in a cohort of 309 consecutive patients. Norwood–Hamilton grade, donor density, and patient age are the principal determinants of outcome and should be systematically evaluated during pre-operative planning to optimise individual patient counselling.

Conflict of Interest

All authors are affiliated with the research collaboration between the University of Economics and Human Sciences, Vera Academy, and Vera Clinic, where the study was conducted. Vera Clinic provided the patient records, surgical facilities, and follow-up infrastructure on which this study is based. The authors received no external funding and hold no financial interest in any device or product named in this manuscript. Data analysis and manuscript preparation were conducted independently of the marketing, sales, and commercial decision-making functions of the clinic. The authors declare no other competing interests.

Funding

This research was funded by Vera Clinic. The funder had no role in study design, data collection, analysis, interpretation of data, or the decision to submit the manuscript for publication.

Data Availability

De-identified data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to ethics committee review.

Acknowledgements

The authors thank the clinical team at Vera Clinic for their cooperation in data provision and patient follow-up, and all participants who consented to the use of their clinical data. The authors acknowledge Vera Academy (Istanbul, Turkey) for coordinating the institutional partnership that facilitated this research collaboration.

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