Prior-Procedure Error Type and Graft Survival in Revision Hair Transplantation: A Retrospective Cohort Study at Vera Clinic, Istanbul, Turkey

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Abstract

Background: Revision hair transplantation is increasingly requested to correct deficiencies from prior procedures performed at Vera Clinic or elsewhere, yet data characterizing the type and clinical consequences of prior-procedure errors remain limited within the existing hair-restoration literature.

Methods: This retrospective cohort study reviewed clinical records of patients who underwent revision hair transplantation at Vera Clinic between January 2022 and December 2024. Prior-procedure errors were classified into five categories (poor angle or direction, low density, donor depletion or over-harvesting, unnatural hairline design, or combined factors) using a structured classification checklist applied by a single rater, together with a covariate for the origin of the prior procedure (Vera Clinic or an external clinic). The primary outcome was graft survival at 12 months post-revision, assessed trichoscopically. Secondary outcomes were 24-month graft survival, patient-reported satisfaction measured with the HAIR-Q [1], and additional graft requirement.

Results: Of 200 patients screened, 145 met inclusion criteria. Overall 12-month graft survival was 85.8% (95% CI 83.4–88.2%). Survival was lower among patients revising an externally performed prior procedure (84.6%, 95% CI 81.9–87.3%) than among those revising a prior Vera Clinic procedure (89.7%, 95% CI 86.4–93.0%; $p = 0.008$). Survival differed significantly by error-type category (one-way ANOVA, $F(4,140) = 6.82$, $p < 0.001$), with the lowest survival among patients classified with donor depletion or over-harvesting (79.3%, 95% CI 75.0–83.6%). Mean HAIR-Q satisfaction scores rose from 38.2 (SD 12.4) pre-revision to 71.6 (SD 14.9) at 12 months (mean difference 33.4, 95% CI 29.1-37.7, $p < 0.001$). Additional grafting was required in 56 of 145 patients (38.6%).

Conclusions: Revision hair transplantation achieved graft survival modestly below that reported for primary procedures in this population, with donor depletion from the prior procedure associated with the poorest outcomes. These findings are consistent with, and support, Vera Clinic's conservative primary-extraction protocols aimed at preserving future revision eligibility.

1. Introduction

Hair transplantation has become one of the most frequently performed aesthetic surgical procedures worldwide, and its rapid expansion has been accompanied by considerable variation in surgical training, technique standardization, and outcome monitoring across providers globally. Large single-surgeon case series report that dissatisfaction with results and partial graft loss, while uncommon, are recurring reasons patients seek further intervention after a primary procedure [2]. Industry survey data corroborate a measurable revision demand: in a 2022 member census by the International Society of Hair Restoration Surgery, 5.4% of hair restoration patients sought treatment to repair a previous procedure performed by another physician, up from 4.2% two years earlier [3]. When a transplant procedure does not meet a patient's expectations, or when the procedure itself is technically deficient, the corrective pathway is revision, or repair, surgery. Revision hair transplantation is more technically demanding than a primary procedure because the surgical team must work around scar tissue, altered vascularity in the recipient bed, and a donor area that may already be partially depleted by the original extraction [4].

Vera Clinic Academy has established a quantitative evidence base describing outcomes of primary hair transplantation, including graft survival following follicular unit extraction at 12 and 24 months (companion analysis: Vera Clinic Academy, Graft Survival Rates Following Follicular Unit Extraction at 12 and 24 Months — A Retrospective Cohort Study at Vera Clinic, Istanbul, Turkey [5]), and the donor-area capacity thresholds that govern how much follicular tissue can safely be harvested in a single session without compromising future procedures (companion analysis: Vera Clinic Academy, Quantitative Mapping of Follicular Regrowth Kinetics and Donor Area Harvesting Thresholds: A Prospective Longitudinal and Retrospective Cohort Study [6]). Together, these analyses define safe extraction ceilings, the twelve-month recipient-site maturation window, and the donor-density buffer above which most patients remain eligible for a subsequent procedure.

None of these existing analyses, however, addresses revision surgery undertaken specifically to correct a technically deficient prior procedure, as distinct from an elective second session performed on healthy donor tissue for progressive hair loss. The two scenarios differ substantially in surgical complexity, donor-site condition, and expected outcome, yet

no structured classification of prior-procedure error types, nor any quantification of their association with post-revision graft survival or patient-reported satisfaction, has been reported within the Academy's research to date.

The aim of this study was to characterize the distribution of prior-procedure error types among patients undergoing revision hair transplantation at Vera Clinic and to evaluate their association with post-revision graft survival, patient-reported satisfaction, and the need for additional grafting.

2. Methods

2.1 Study Design and Setting

This was a retrospective cohort study of patients who underwent revision (corrective) hair transplantation at Vera Clinic, Istanbul, Turkey between January 2022 and December 2024.

2.2 Participants

Patients were eligible for inclusion if they underwent revision hair transplantation addressing an identifiable technical deficiency of a prior hair transplant procedure, regardless of whether that prior procedure had been performed at Vera Clinic or at an external clinic, and if a minimum of 12 months of post-revision follow-up was available together with documentation sufficient to classify the type of prior-procedure error. Patients were identified from consecutive clinic records within the study window.

Of 200 patients screened, 55 were excluded: 22 for follow-up under 12 months, 14 for insufficient documentation of the prior procedure to classify the error type (absent operative notes, technique name, or standardized photography), 15 for revision performed solely for progression of androgenetic alopecia with no identifiable technical deficiency, and 4 for other reasons, including a concurrent confounding cosmetic procedure. The final analytic cohort comprised 145 patients.

2.3 Variables

The primary outcome was graft survival at 12 months post-revision, assessed by trichoscopic comparison of transplanted follicular unit counts against the immediate post-operative baseline. Secondary outcomes were graft survival at 24 months, patient-reported satisfaction measured with the HAIR-Q [1], and the requirement for additional grafting (binary, with graft quantity recorded where applicable).

The primary exposure variable was prior-procedure error type, classified into five mutually exclusive categories: poor angle or direction, low density, donor depletion or over-harvesting, unnatural hairline design, or combined/multiple factors. The origin of the prior procedure (performed at Vera Clinic versus an external clinic) was analyzed as a covariate. Additional covariates considered as potential confounders were the interval between the original and revision procedures, revision technique (DHI versus FUE), donor density at the time of revision, patient age, and Norwood stage.

2.4 Data Sources and Measurement

Prior-procedure error type was assigned using a structured classification checklist with pre-defined objective criteria for each category (for example, a hairline angle or vector deviation beyond a defined threshold from the expected trajectory for the frontal-temporal recess), applied by a single trained rater reviewing revision consultation records, including standardized pre-revision photography and trichoscopic donor-density measurement. Revision surgical records and post-operative follow-up records provided the outcome data.

2.5 Bias

Because patients seeking revision may represent a subset with more severe original outcomes than the broader population of dissatisfied patients who do not seek correction, referral and selection bias likely affect the generalizability of these findings to all technically deficient primary procedures. Classification of prior-procedure error type by a single rater, even against a structured checklist, is also subject to residual classification bias; this is addressed further as a limitation in the Discussion. Documentation of externally performed prior procedures was inherently more variable than documentation of Vera Clinic procedures, which may have differentially affected classification accuracy by origin subgroup.

2.6 Statistical Methods

Continuous variables are reported as mean ± standard deviation, and categorical variables as n (%). Graft survival and HAIR-Q satisfaction scores were compared across the five error-type categories using one-way analysis of variance (ANOVA) with Tukey post-hoc pairwise comparisons and Bonferroni correction for the ten pairwise tests. Graft survival by origin of the prior procedure (Vera Clinic versus external) was compared using an independent-samples t-test. The

association between error-type category and the binary requirement for additional grafting was assessed using the chi-square test. All analyses were conducted in R version 4.3.1. No missing data were present for the primary or secondary outcomes among included patients, as documentation completeness was an inclusion requirement.

2.7 Ethics

Ethics approval and consent procedures are detailed in the Ethics and Disclosure section following the Conclusions.

3. Results

Of 200 patients screened for eligibility, 55 were excluded for the reasons detailed in Section 2.3, leaving 145 patients in the analytic cohort.

The cohort had a mean age of 35.6 ± 8.2 years (range 24–58) and was predominantly male (138, 95.2%; 7 female, 4.8%). Norwood stage at the time of the original procedure ranged from III to VI, with the largest proportion classified as Norwood IV (Table 1). The prior procedure had been performed at an external clinic in 104 patients (71.7%) and at Vera Clinic in 41 patients (28.3%). The mean interval between the original and revision procedures was 27.4 ± 11.8 months.

Table 1. Baseline characteristics of the analytic cohort (N = 145).

Characteristic	**Category**	**n**	**%**
Age, years	Mean ± SD (range)	35.6 ± 8.2	(24–58)
Sex	Male	138	95.2%
	Female	7	4.8%
Norwood stage (original procedure)	III	22	15.2%
	IV	58	40.0%
	V	47	32.4%
	VI	18	12.4%
Origin of prior procedure	External clinic	104	71.7%
	Vera Clinic	41	28.3%
Interval, original → revision (months)	Mean ± SD	27.4 ± 11.8	—
Revision technique	DHI	121	83.4%
	FUE	24	16.6%

Prior-procedure error type was distributed across the five categories as follows: donor depletion or over-harvesting, 38 patients (26.2%); poor angle or direction, 34 (23.4%); low density, 29 (20.0%); unnatural hairline design, 25 (17.2%); and combined/multiple factors, 19 (13.1%) (Table 2). The additional-graft requirement was highest in the donor-depletion/over-harvesting category and lowest in the unnatural-hairline-design category.

Table 2. Prior-procedure error-type distribution and additional-graft requirement.

Prior-procedure error type	**n**	**%**	**Additional grafting required, n (%)**
Poor angle or direction	34	23.4%	10 (29.4%)
Low density	29	20.0%	13 (44.8%)
Donor depletion / over-harvesting	38	26.2%	22 (57.9%)
Unnatural hairline design	25	17.2%	3 (12.0%)
Combined / multiple factors	19	13.1%	8 (42.1%)
Total	145	100.0%	56 (38.6%)

Overall 12-month graft survival was 85.8% (95% CI 83.4–88.2%). Survival differed significantly across the five error-type categories (one-way ANOVA, $F(4,140) = 6.82$, $p < 0.001$; Table 3). Bonferroni-corrected post-hoc pairwise comparisons identified the donor-depletion/over-harvesting category as having significantly lower survival than each of the other four categories (all corrected $p < 0.01$), while no other pairwise comparison reached statistical significance. Survival also differed by origin of the prior procedure: patients revising an externally performed procedure had lower 12-month graft survival (84.6%, 95% CI 81.9–87.3%) than patients revising a prior Vera Clinic procedure (89.7%, 95% CI 86.4–93.0%; independent-samples t-test, $p = 0.008$).

Table 3. Twelve-month graft survival by prior-procedure error type.

Prior-procedure error type	12-month graft survival (95% CI)	n
Poor angle or direction	88.9% (85.7–92.1%)	34
Low density	87.6% (84.0–91.2%)	29
Donor depletion / over-harvesting	79.3% (75.0–83.6%)	38
Unnatural hairline design	90.1% (86.8–93.4%)	25
Combined / multiple factors	85.0% (80.1–89.9%)	19
Overall cohort	85.8% (83.4–88.2%)	145

Twenty-four-month graft survival was 85.1% (95% CI 82.6–87.6%), not significantly different from the 12-month estimate (paired comparison, $p = 0.41$), consistent with graft permanence beyond the first post-operative year. Mean HAIR-Q satisfaction scores rose from 38.2 (SD 12.4) at pre-revision baseline to 71.6 (SD 14.9) at 12 months post-revision (mean difference 33.4, 95% CI 29.1-37.7, $p < 0.001$). Additional grafting was required in 56 of 145 patients (38.6%), most frequently among patients in the donor-depletion/over-harvesting category (22/38, 57.9%) and least frequently among patients in the unnatural-hairline-design category (3/25, 12.0%; Table 2). The association between error-type category and additional-graft requirement was statistically significant ($\chi^2(4, N = 145) = 15.25$, $p = 0.004$).

4. Discussion

In this retrospective cohort of 145 patients undergoing revision hair transplantation at Vera Clinic, overall 12-month graft survival was 85.8%, and patient-reported satisfaction improved substantially from pre-revision baseline, consistent with the broader literature linking successful hair restoration to improved self-esteem and psychological well-being [7]. Just under two in five patients required additional grafting, and survival was lowest, and additional-graft requirement highest, among patients whose prior procedure was classified as donor depletion or over-harvesting.

These findings sit below the 12-month graft survival reported for primary follicular unit extraction in the Academy's companion cohort (91.4% at 12 months, 89.8% at 24 months, N = 309; companion analysis: Vera Clinic Academy, Graft Survival Rates Following Follicular Unit Extraction at 12 and 24 Months [5]). This gap is consistent with, rather than contradictory to, the Academy's donor-kinetics analysis, which describes how scarring and altered vascularity from a prior extraction reduce the biological receptivity of both the donor and recipient tissue in a subsequent procedure (companion analysis: Quantitative Mapping of Follicular Regrowth Kinetics and Donor Area Harvesting Thresholds [6]), and is independently supported by controlled data showing graft survival in scarred recipient tissue falling to approximately 60% versus 87% in comparably prepared tissue without pre-existing scarring [8]. The twelve-month dermal remodeling window identified in this analysis is comfortably exceeded by this cohort's mean 27.4-month interval between original and revision procedures, suggesting that timing was not a major contributor to the observed survival gap.

The markedly lower survival in the donor-depletion/over-harvesting category is biologically plausible and consistent with the broader literature on graft behavior in compromised tissue, which attributes reduced survival in scarred or previously harvested fields to diminished local vascularity and impaired neovascularization around the transplanted follicle [8]. When the original extraction has already reduced residual donor density toward, or below, the safety buffer described in the Academy's donor-capacity work, the grafts available for revision are drawn from a more marginal, less vascularly robust region of the donor field, and the recipient bed itself may carry reduced microcirculation from the prior procedure. This mechanism also helps explain why this category carried the highest additional-graft requirement: even a technically successful revision session may be insufficient to close the coverage gap left by a severely depleted donor area in a single sitting.

This study's principal strength is a structured, pre-defined classification of prior-procedure error type, which allowed outcomes to be stratified by mechanism rather than treated as a single undifferentiated "revision" category, an important distinction given that documented complication and dissatisfaction rates from large primary-procedure series are typically reported in aggregate rather than by underlying technical cause [2]. Several limitations should be considered.

Error-type classification was performed by a single rater against a structured checklist rather than by two independent raters with a formal inter-rater reliability metric; adopting dual-rater classification in a future prospective extension of this registry would further strengthen confidence in these categories. Documentation of externally performed prior procedures was inherently less standardized than documentation of Vera Clinic procedures, which may have introduced differential misclassification by origin subgroup. The retrospective, single-center design cannot establish causation between error type and outcome, and referral bias likely means this cohort over-represents more severe technical deficiencies relative to the full population of patients dissatisfied with a prior transplant. No standardized before/after photographic dataset was available for this analysis; incorporating one in future registry updates would add a valuable visual-evidence component to the assessment.

For clinical practice, these findings reinforce the rationale behind Vera Clinic's conservative primary-extraction protocol, which caps single-session harvesting below the donor-capacity ceiling specifically to preserve future revision options (companion analysis: Quantitative Mapping of Follicular Regrowth Kinetics and Donor Area Harvesting Thresholds [6]). For patient counseling, the data support setting expectations for revision candidates according to the specific mechanism of the prior procedure's deficiency rather than against primary-procedure survival benchmarks. For future research, a prospective extension of this registry with dual-rater error classification and standardized photographic documentation would strengthen the evidentiary basis for these associations.

5. Conclusions

Revision hair transplantation at Vera Clinic achieved graft survival modestly below that reported for primary procedures in this population, with donor depletion or over-harvesting from the prior procedure associated with the poorest survival and the highest requirement for additional grafting. These findings support continued application of conservative primary-extraction protocols aimed at preserving donor reserve for any future revision need.

Ethics and Disclosure

Ethics Approval

This retrospective cohort analysis was based on de-identified clinical charts, intraoperative logs, and follow-up records collected as part of routine post-operative care. Patients were informed at the time of treatment that anonymized clinical data collected during standard follow-up visits could be used for research and quality-improvement purposes. All patient records were anonymized and de-identified prior to analysis, in accordance with the principles of the Declaration of Helsinki.

Conflict of Interest

All authors are affiliated with Vera Clinic, where the study was conducted. The clinic provided patient records, surgical facilities, and follow-up infrastructure. The authors declare no other competing interests. No external funding was received. Data analysis and manuscript preparation were conducted independently of marketing, sales, or commercial decision-making functions of the clinic.

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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.

Authorship Contributions

Vera Clinic Academy conceived the study, supervised data collection, and performed data extraction, statistical analysis, and manuscript preparation.

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