



Strategic Zone-Based Follicular Unit Management in Male Pattern Alopecia

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KEYWORDS

Androgenetic alopecia, Male pattern hair loss, Follicular unit extraction, Hair transplantation, Graft survival, Patient satisfaction, Hair density, Zone-based allocation.

ABSTRACT:

Background: Male pattern (androgenetic) alopecia is a common condition causing patterned hair loss and significant psychological impact. Hair transplantation is the definitive treatment, and strategic zone-based follicular unit allocation may optimize aesthetic outcomes. **Objective:** To evaluate the effectiveness, safety, and patient satisfaction of strategic zone-based follicular unit management in men with androgenetic alopecia. **Methods:** This prospective observational study included 110 male patients (age 19–55 years; Norwood-Hamilton grade II–VI) undergoing follicular unit extraction at Spring Hill Hospital Ltd, Faridpur. Pre-surgical optimization and strategic graft allocation to frontal and vertex zones were performed. Primary outcomes were post-surgical hair density and graft survival; secondary outcomes included patient satisfaction and complications. Data were analyzed using descriptive statistics and paired t-tests. **Results:** The mean number of follicular units transplanted per patient was $2,837 \pm 422$, with $1,178 \pm 215$ units allocated to the frontal zone and 948 ± 185 to the vertex. Overall hair density improved from 22.7 ± 5.0 FU/cm² pre-surgery to 38.3 ± 4.5 FU/cm² post-surgery (68.7% increase; $p < 0.001$). Frontal and vertex zones showed 74.8% and 66.1% density improvement, respectively. Graft survival rate was $91.8\% \pm 4.0\%$. Minor complications occurred in 11.8% of patients; no major complications were reported. Patient satisfaction was high, with 87.3% reporting satisfaction or very high satisfaction. **Conclusion:** Strategic zone-based follicular unit management is safe and effective for male pattern alopecia, achieving substantial improvements in hair density, high graft survival, and excellent patient satisfaction. Pre-surgical planning and targeted graft distribution are key to optimizing both objective and subjective outcomes.

INTRODUCTION

Androgenetic alopecia (AGA) is the most common cause of progressive, patterned scalp hair loss in men and represents a significant dermatological and psychosocial concern. Advances in understanding its genetic basis, androgen-dependent pathophysiology, and clinical progression have improved diagnostic and therapeutic approaches [1]. Although AGA is a benign condition, its principal morbidity is psychological. Men with male pattern hair loss (MPHL) frequently experience reduced self-esteem, perceived loss of attractiveness, and a sense of premature aging. Social perception studies demonstrate that bald or balding men are often viewed less favorably, reflecting the negative self-image reported by affected individuals [2].

Hair transplantation is an established and definitive treatment option for hair loss due to androgenetic alopecia, as well as alopecia resulting from trauma and selected inflammatory disorders [3]. The origins of modern hair transplantation date back to 1931, when

Okuda described autologous hair grafting using circular punch techniques, although his work initially received limited international recognition [4]. Currently, follicular unit transplantation (FUT) and follicular unit extraction (FUE) are the two primary surgical techniques in use. FUE has gained increasing popularity because of its minimally invasive nature, reduced scarring, and faster recovery. Contemporary studies report graft survival rates exceeding 90–95% and high patient satisfaction when procedures are performed by experienced surgeons [5,6].

Successful hair transplantation depends on accurate identification and optimal utilization of the safe donor zone. The occipital and adjacent parietal scalp regions are known for their high follicular unit density and resistance to androgen-mediated miniaturization, making them reliable sources of durable grafts [7]. To avoid overharvesting and preserve long-term donor potential, the donor scalp is often divided into defined



subzones, and extractable follicular units are carefully estimated [8].

Evidence from multicenter and observational studies confirms that FUE significantly improves scalp coverage, with recipient-site density increasing substantially following transplantation [9]. In Bangladesh, available studies on scalp reconstruction, robotic hair transplantation, and platelet-rich plasma therapy have reported generally favorable outcomes; however, these studies are limited by small sample sizes, short follow-up periods, and lack of standardized outcome measures [10–12]. Therefore, this study aims to evaluate the outcomes of strategic zone-based follicular unit management in men with male pattern (androgenetic) alopecia, focusing on graft survival, postoperative hair density, and patient satisfaction.

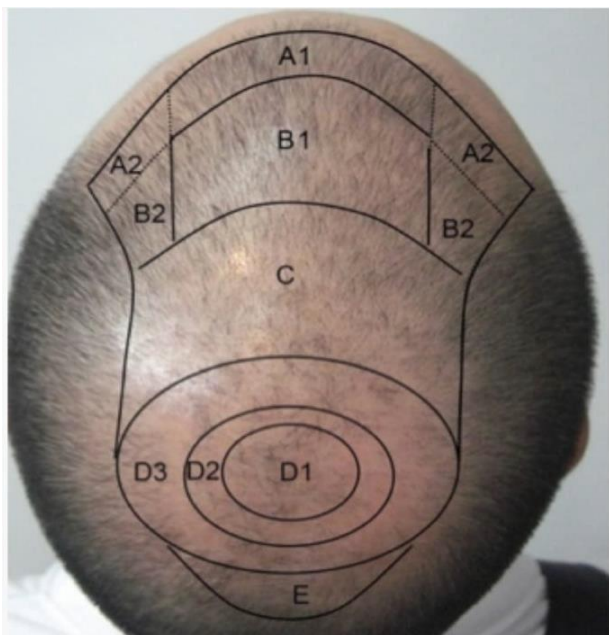


Figure 1: Zone 1: A1+A2; Zone 2: B1 +B2; Zone 3: C and Zone 4: D1, D2, D3 and E

METHODOLOGY

Study Design and Setting: This prospective observational study was conducted at Spring Hill Hospital Ltd, Faridpur, from January 2024 to December 2024, to evaluate the effectiveness of zone-based follicular unit allocation with pre-surgical optimization in patients with male pattern alopecia. **Study Population and Sample Size:** A total of 110 male patients aged 18–55 years with androgenetic alopecia (Norwood-Hamilton grade II–VI) scheduled for hair transplantation were enrolled using purposive sampling. Patients with scalp infections, previous hair transplant surgery, or systemic conditions contraindicating surgery were excluded. All participants provided written

informed consent. **Pre-Surgical Optimization:** All patients underwent thorough pre-surgical evaluation, including scalp assessment, donor and recipient area mapping, hair density measurement, and counseling on realistic outcomes and post-operative care. **Zone-Based Follicular Unit Allocation:** Recipient scalp areas were divided into strategic zones according to the hair loss pattern and aesthetic priority. Follicular units were allocated to achieve optimal density, particularly in the frontal and vertex regions, while preserving donor sites for potential future procedures. **Data Collection:** Baseline data included age, duration of hair loss, family history, Norwood-Hamilton grade, and scalp characteristics. Intraoperative data recorded the number of follicular units transplanted per zone, surgery duration, and any complications. Final outcomes were assessed in terms of hair density, graft survival, and patient satisfaction.

Outcome Measures:

- Primary: Improvement in hair density and coverage in recipient zones.
- Secondary: Patient satisfaction, graft survival rate, and post-surgical complications.

Ethical Considerations: The study adhered to the Declaration of Helsinki and received approval from the institutional ethics committee of Spring Hill Hospital Ltd. Patient confidentiality and data privacy were strictly maintained. **Data Analysis:** Data were analyzed using SPSS version 26. Descriptive statistics (mean, SD, frequency, percentage) summarized demographics and surgical outcomes. Paired t-tests or Wilcoxon signed-rank tests compared pre- and post-surgical hair density. Some outcomes, such as graft survival and patient satisfaction, were reported descriptively without statistical comparison. A p-value <0.05 was considered statistically significant.

RESULTS

Participant Characteristics: A total of 110 male patients underwent hair transplantation during the study period. Table 1 presents the baseline characteristics of the participants. The mean age was 33.1 ± 7.6 years (range 19–55). Distribution according to Norwood-Hamilton grade was as follows: Grade II – 17 (15.5%), Grade III – 31 (28.2%), Grade IV – 28 (25.5%), Grade V – 22 (20.0%), Grade VI – 12 (10.9%). Positive family history of androgenetic alopecia was reported in 71 patients (64.5%).

Table 1: Baseline Characteristics (N = 110)

Characteristic	Frequency (%) / Mean \pm SD
Age (years)	33.1 ± 7.6
Norwood-Hamilton Grade	



- II	17 (15.5%)
- III	31 (28.2%)
- IV	28 (25.5%)
- V	22 (20.0%)
- VI	12 (10.9%)
Positive family history	71 (64.5%)

Surgical Data: The mean number of follicular units transplanted per patient was $2,837 \pm 422$ (range 1,900–3,600). The frontal zone received a mean of $1,178 \pm 215$ units, while the vertex zone received 948 ± 185 units. The average surgery duration was 5.3 ± 0.9 hours. Minor post-operative complications occurred in 13 patients (11.8%), and no major complications were reported. (Table 2)

Table 2: Intraoperative and Surgical Data (N = 110)

Variable	Mean \pm SD / Frequency (%)
Follicular units transplanted	$2,837 \pm 422$
Frontal zone allocation	$1,178 \pm 215$
Vertex zone allocation	948 ± 185
Surgery duration (hours)	5.3 ± 0.9
Minor post-op complications	13 (11.8%)
Major complications	0 (0%)

Post-Surgical Hair Density: Table 3 shows a significant increase in hair density post-surgery in all zones. The overall hair density increased from 22.7 ± 5.0 FU/cm² pre-surgery to 38.3 ± 4.5 FU/cm² post-surgery, corresponding to a 68.7% improvement. Zone-specific analysis showed that the frontal zone, which is typically prioritized for aesthetic outcome, exhibited the highest improvement (74.8%), increasing from 23.5 ± 4.8 to 41.0 ± 4.3 FU/cm². The vertex zone also demonstrated substantial improvement (66.1%), increasing from 21.0 ± 5.2 to 34.8 ± 4.7 FU/cm². These results indicate that strategic allocation of follicular units to specific zones effectively enhances hair density, particularly in the frontal region.

Table 3: Hair Density Improvement After Surgery (N = 110)

Parameter	Pre-Surgery (Mean \pm SD)	Post-Surgery (Mean \pm SD)	% Improvement	Statistical Test	p-value
Overall, Hair Density (FU/cm ²)	22.7 ± 5.0	38.3 ± 4.5	68.7%	Paired t-test	<0.001
Frontal Zone	23.5 ± 4.8	41.0 ± 4.3	74.8%	Paired t-test	<0.001

Density (FU/cm ²)					
Vertex Zone Density (FU/cm ²)	21.0 ± 5.2	34.8 ± 4.7	66.1%	Paired t-test	<0.001

Notes: FU/cm² = Follicular Units per cm² and % Improvement = $[(\text{Post} - \text{Pre}) / \text{Pre}] \times 100$. A p-value <0.05 was considered statistically significant.

Graft Survival and Patient Satisfaction: Table 4 shows that the overall graft survival rate was high at 91.8%, indicating that most transplanted follicles successfully survived after surgery. The frontal zone, which is typically prioritized for aesthetic impact, demonstrated the highest improvement in hair density (74.8%), while the vertex zone also showed substantial improvement (66.1%). Patients who received strategically higher allocation in the frontal zone reported better satisfaction with the surgical outcome.

Table 4: Graft Survival and Zone-Based Hair Density Improvement (N = 110)

Parameter	Value (Mean \pm SD / %)
Graft Survival Rate	$91.8 \pm 4.0\%$
Frontal Zone Hair Density Improvement	$74.8 \pm 6.4\%$
Vertex Zone Hair Density Improvement	$66.1 \pm 6.0\%$
Effect of Frontal Zone Allocation on Satisfaction	Improved satisfaction observed

Postoperative Complications

Postoperative complications following strategic zone-based follicular unit management were predominantly mild and self-limiting (Table 5). Overall, 63 patients (57.3%) experienced at least one complication, while 47 patients (42.7%) had an uneventful postoperative course, indicating a favorable safety profile for the procedure. The most frequently observed complications were donor-site pain or discomfort (16.4%) and postoperative edema involving the forehead or periorbital region (12.7%).

Table: Postoperative Complications Following Hair Transplantation (n = 110)

Complication	Number of Patients (n)	Percentage (%)



Postoperative edema (forehead/periorbital)	14	12.7
Pain or donor-site discomfort	18	16.4
Folliculitis (donor or recipient area)	7	6.4
Shock loss (temporary shedding)	9	8.2
Donor-site hypopigmentation	5	4.5
Recipient-site infection	2	1.8
Hypertrophic scarring/keeloid	1	0.9
Poor graft growth/patchy density	4	3.6
Persistent numbness/paresthesia	3	2.7
No complications	47	42.7

of participants was 33.1 ± 7.6 years, with most patients presenting in Norwood–Hamilton grades III to V. This age distribution and severity pattern are comparable to the population-based findings reported by Shankar *et al.*, who observed increasing prevalence and severity of male pattern hair loss with advancing age in a large cohort of Indian men [13]. Furthermore, a positive family history of androgenetic alopecia was observed in nearly two-thirds of patients in this study, supporting earlier findings by Chumlea *et al.*, who identified genetic predisposition as a major risk factor for the development and progression of male pattern hair loss [14]. Consistently, Rahaman *et al.* reported a strong association between alopecia patterns and socio-demographic factors, including age, family history, and occupational stress, which aligns with the present findings and reinforces the role of genetic susceptibility in androgenetic alopecia within the Bangladeshi population [15].

The mean number of follicular units transplanted per patient was $2,837 \pm 422$, with higher allocation to the frontal zone ($1,178 \pm 215$) compared to the vertex (948 ± 185). This reflects a strategic approach prioritizing cosmetically critical areas, consistent with evidence that careful distribution of grafts improves visual density and patient satisfaction [16]. Higher graft numbers in the frontal region contributed to the significant hair density improvement (74.8%) and likely influenced the high overall graft survival rate (91.8%).

A key finding of this study was the significant improvement in hair density across all scalp zones, with the greatest improvement observed in the frontal region (74.8%). This aligns with the principles outlined by Anastassakis, who emphasized that strategic density planning in cosmetically critical areas such as the frontal scalp yields superior visual coverage, even when donor resources are limited [17]. The vertex zone also demonstrated substantial improvement, though to a slightly lesser extent, consistent with known vascular and cosmetic differences between scalp regions.

The postoperative complication profile in this study was favorable, with most adverse events being minor and self-limiting. Donor-site pain and postoperative edema were the most common complications, consistent with findings reported by Kerure and Patwardhan, who identified pain, edema, folliculitis, and transient shock loss as the most frequent early postoperative issues following hair transplantation [18]. Similarly, Nadimi reported that serious complications such as infection, scarring, or permanent sensory loss are rare when proper surgical technique and postoperative care are employed [19]. The low incidence of major complications in this study is comparable to large surgical series reported in the literature. Salantri *et al.*, in a series of 533 hair transplantation procedures, reported low rates of

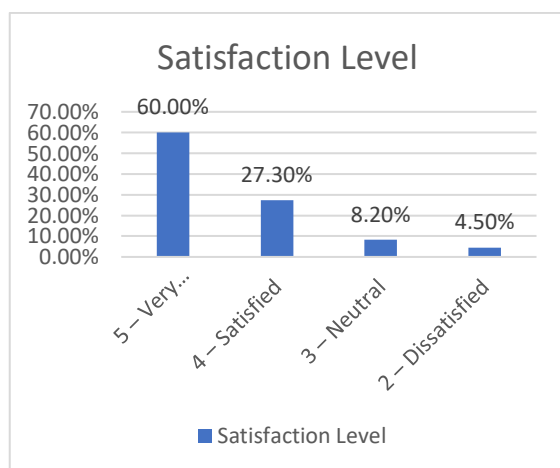


Figure I: Patient Satisfaction (N = 110)

Figure I illustrates the patient-reported satisfaction following zone-based follicular unit allocation and pre-surgical optimization. The majority of patients, 66 (60.0%), reported being very satisfied (score 5) with their post-surgical outcomes, while 30 patients (27.3%) were satisfied (score 4). A small proportion of patients, 9 (8.2%), reported a neutral experience, and 5 patients (4.5%) were dissatisfied. Importantly, no patients reported being very dissatisfied (score 1).

These findings suggest that the surgical approach and strategic zone-based allocation were highly effective in achieving favorable cosmetic outcomes, with most patients expressing high levels of satisfaction.

DISCUSSION:

Male androgenetic alopecia is a highly prevalent condition with a well-established genetic and age-related predisposition. In the present study, the mean age



infection and scarring, reinforcing the overall safety of modern hair transplantation techniques [20]. The absence of major complications in the present study further supports the safety of strategic zone-based follicular unit management when performed by experienced surgical teams.

Patient satisfaction was notably high in this study, with over 87% of participants reporting being satisfied or very satisfied with their outcomes. This aligns with Chouhan *et al.*, [21] who found that strategic graft distribution improves cosmetic results, and with Liu *et al.*, [22] who reported that patient satisfaction is closely linked to frontal density and natural hairline design. This high satisfaction rate appears closely linked to effective frontal zone allocation, improved hair density, and minimal complication rates.

Despite these encouraging findings, this study has limitations. The single-center design and relatively short follow-up period may limit the generalizability of results and the assessment of long-term graft survival and late complications. Future multicenter, prospective studies with extended follow-up and standardized patient-reported outcome measures are recommended to further validate the benefits of strategic zone-based follicular unit management.

CONCLUSION:

This study demonstrates that zone-based follicular unit management in male pattern alopecia is safe, effective, and yields high patient satisfaction. Strategic allocation of grafts, particularly to the frontal and mid-scalp regions, significantly improves hair density (74.8% frontal, 66.1% vertex) and achieves a high overall graft survival rate (91.8%). Minor complications were infrequent, and no major adverse events occurred. Patient-reported satisfaction was high, with 87.3% of participants expressing satisfaction or very high satisfaction. These findings are consistent with global literature and underscore the importance of pre-surgical planning, zone-specific graft distribution, and meticulous surgical technique in optimizing both objective and subjective outcomes in hair restoration.

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