Original article

Enhancing density in hair transplant surgery: The role of tumescent injection in the recipient area in implanter technique – A randomized study

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Abstract. *Background:* Hair transplant surgery has undergone significant evolution - from FUT to FUE for follicular extraction, and from needles, slits, and implanter techniques to the sapphire technique for implantation. Despite these advances, achieving optimal density remains a challenge. In recent years, patients' expectations for higher density have increased substantially, prompting surgeons to adopt techniques that are more effective and consistently deliver superior results. *Objectives:* To achieve density in hair transplant surgery mainly in FUE (Follicular Unit Extraction) + Implanter technique using Tumescent which has a composition of 100ml NS plus one ampule of Adrenaline at the recipient area using a spinal needle to increase the surface area. The author's technique differs from the conventional needle-based approach and offers a distinct method for optimizing density. *Materials & method:* Patients willing to under Hair Transplant surgery by FUE + Implanter Technique where selected. The sample size was 100. Male patients with no associated medical co-morbidities where selected. A long 26-gauge spinal needle was used to inject the same tumescent solution in the recipient area. Implantation was performed using 1.2 or 1.0mm Inrut Implanters. A standard 1cm x 1cm box was placed over the image at the anterior region, where higher density is required, to assess density. *Results:* The hair density appreciated from 221 grafts per square inch in the non-tumescent group to 282 grafts per square inch in the tumescent group while the graft survival rate increased from 70.8% to 90.3%. Thus, increasing the patient satisfaction levels. *Conclusion:* Achieving optimal density in FUE combined with the implanter technique in hair transplant surgery remains a challenge. By increasing the surface area with tumescent solution, the popping effect during implantation is minimized. As the number of grafts per unit area increases, the resulting density also increases, serving as an indirect marker of success. This study presents a promising alternative for enhancing density; however, further comparative studies are needed to establish more precise treatment outcomes. The author has applied this method specifically to the implanter technique, rather than the conventional approach.

Key words: Density, FUE + Implanter technique, 1 inch square box

Introduction

Norwood Pattern hair loss is the most common type of hair loss in both men and women[1,2]. Over the years, hair transplantation has emerged as an effective solution for hair restoration. Early techniques often yielded suboptimal aesthetic results, but innovations in follicular unit extraction (FUE) and follicular unit transplantation (FUT) have significantly improved outcomes[3]. However, achieving a natural density in the transplanted area remains challenging due to limitations in the recipient site's vascularity and tissue characteristics[4].

Initially described in the field of liposuction, the technique has since found broad surgical applications, including vascular surgery, breast surgery, plastic surgery, and ENT procedures[5,6]. In hair transplantation, its use is primarily aimed at minimizing bleeding, thereby providing a clear operative field, and improving patient comfort by reducing pain[7,8]. Additionally, it expands the scalp tissue, creating a firmer and less vascularized recipient site[9]. The epinephrine component of the solution further induces vasoconstriction, reducing the risk of postoperative hematoma formation[10].

This study aims to critically assess the impact of tumescent injections on hair density outcomes in hair transplantation procedures. Evaluating improvements in hair density occurs through the hair count method in a standardized 1cm x 1cm area[11] and patient satisfaction.

Materials and Methods

This prospective observational study was conducted over a 1-year period[12] with a sample of 100 patients undergoing hair transplantation via FUE and FUT methods. Patients were equally divided into non tumescent and tumescent groups. The primary focus was to measure the improvement in hair density within a defined area post-procedure. Ethical approval was obtained in accordance IHEC/SDC/PhD/OMFS-2343/23/TH-092. Data collection was standardized, with assessments conducted preoperatively and at 1, 3, 6 months and 1 year postoperatively.

Participant selection

Patient consultation, examination, and selection are crucial for successful outcomes in hair restoration surgery. The hair restoration surgeon must take a holistic approach in identifying those patients who are, and who are not candidates for surgery[13,14].

Inclusion criteria

- Patients with androgenetic alopecia
- Patients with grade 3–6 (Hamilton–Norwood scale of male pattern baldness)[15]
- Individuals with adequate donor hair availability and healthy scalp skin[16]

Exclusion criteria

- Patients with autoimmune scalp disorders or chronic dermatologic conditions[17].
- Those currently on medications that affect hair growth (e.g., testosterone, anabolic steroids etc.)[18].
- Individuals with a history of previous unsuccessful hair transplant procedures.

Surgical procedure

Before the procedure, the recipient area was cleansed and marked following a pre-designed hairline[18-21]. Hair in the target area was trimmed to facilitate uniform implantation, and local anesthesia was administered. A tumescent solution was prepared using normal saline, epinephrine (1:100,000), and lidocaine (0.05%)[22]. This solution was injected subdermally across the patients' recipient area using a fine 26 gauge needle[23]. The injection aimed to expand the scalp tissue, enhancing the stability and precision of the graft placement. Special care was taken to avoid over-tumescent injections, which could distort natural hair angles[24]. Follicular units were harvested from the donor area using either FUE or FUT techniques, as appropriate[25-27]. Grafts were meticulously implanted at a density of 50–60 grafts per cm², using a 1 cm² box placed uniformly for graphic representation (Figure 1), with a mean density of 54.72 grafts/cm² (Figure 2), equivalent to 260–320 grafts per square inch.

Post-surgery, patients received a regimen of antibiotics and anti-inflammatory medications to minimize the risk of infection and control swelling[28]. A headband worn immediately after the operation is useful in preventing the swelling from expanding down on to the face and creating a puffy appearance[29]. Detailed postoperative instructions were provided, emphasizing gentle scalp care[30,31].

Follow-Up protocol

Patients were scheduled for follow-up assessments at 1, 3, 6 months, and 1-year post-transplantation[32].

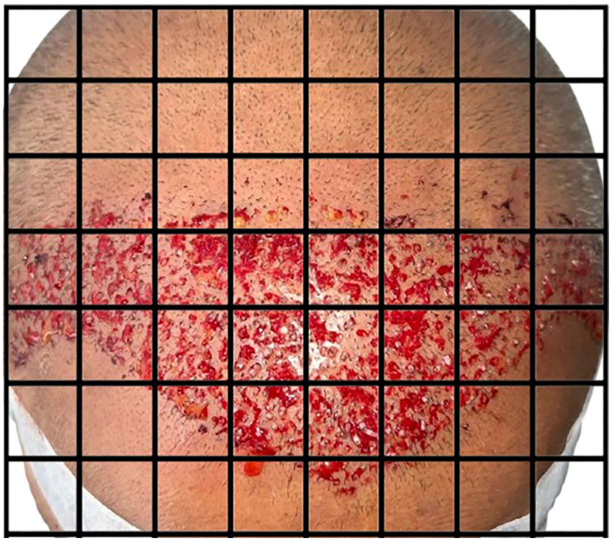

Figure 1. 1 square centimeter by 1 square centimeter box over the scalp at the implanted area.

During these visits, clinical evaluations were performed to assess graft survival and overall hair density improvement[33].

Hair count method

The primary quantitative measure of hair density was determined using the hair count method:

1. A standardized **1-cm by 1-cm area** was marked within the transplanted region.
2. Using magnification, the number of grafts within this defined area was manually counted[34].
3. Baseline measurements were recorded preoperatively and compared with subsequent counts at 1, 3, 6 months and 1year post-surgery.

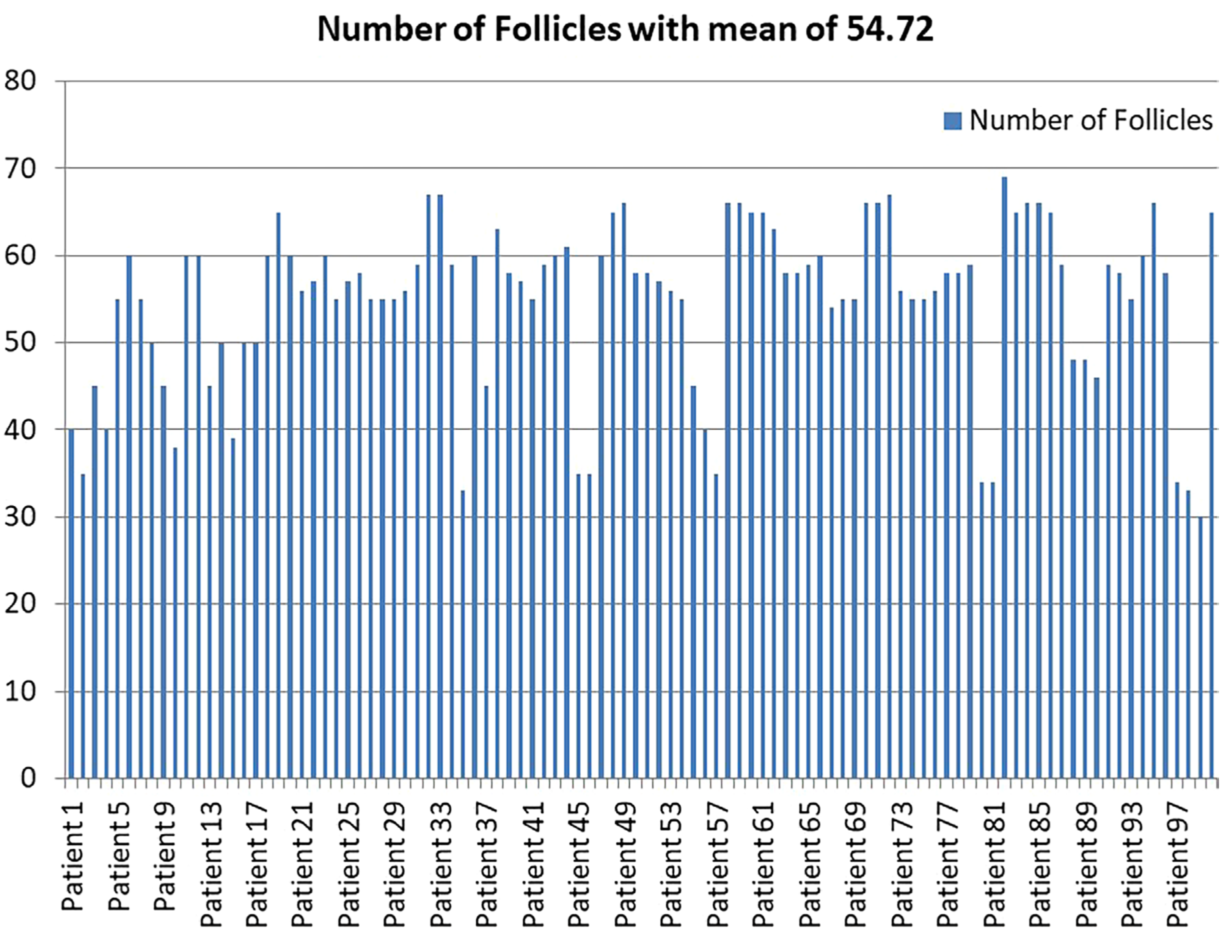

Figure 2. Number of grafts placed per patient with the mean being 54.72 follicles.

Statistical analysis

Statistical analyses were performed to evaluate the significance of hair density improvement. Data was processed using a standard statistical software. A paired t-test was applied to compare preoperative and postoperative hair densities. A p-value of less than 0.05 was considered statistically significant. A regression analysis was additionally employed to explore correlations between graft density and patient satisfaction scores[35,36].

Results

Hair density improvements

The study found that the average hair density within the recipient area was approximately 221 hairs per square inch in the non-tumescent group. With the use of tumescent injection during hair transplantation, the postoperative hair density measured at 1 year increased to approximately 282 hairs per square inch. The increase was statistically significant ($p < 0.001$), underscoring the effectiveness of tumescent injections in enhancing graft placement and overall density.

Graft survival and aesthetic outcomes

After 1 year, the graft survival rate of over 70.8% was noted in areas where the tumescent injection was applied, compared to 90.3% in the non-tumescent group[37]. This high survival rate contributed to a fuller appearance and improved aesthetic outcomes, as confirmed by both clinical assessments and patient feedback. The natural hairline and density were successfully replicated in most patients, resulting in high levels of patient satisfaction.

Patient satisfaction

Patient satisfaction was evaluated using standardized questionnaires and a Visual analog scale[34,35]. Most of the participants in the tumescent group reported high satisfaction with the results, while those in the non-tumescent group reported average to low satisfaction, citing improvements in hair density and overall appearance.

Comparative analysis

Compared to patients who underwent hair transplantation without tumescent injection, the tumescent group demonstrated lower intraoperative bleeding and pain[38], as well as improved overall hair density, as measured by hair counts, which corresponded with higher patient satisfaction. These comparative outcomes further support the efficacy of tumescent injection as an adjunct in hair transplantation, benefiting both the donor and recipient sites.

Discussion

This study demonstrates that tumescent injection in the recipient area significantly improves postoperative hair density and graft survival, supporting its role as an important adjunct in modern hair transplantation. Continuous refinements in FUE and FUT techniques aim to enhance natural outcomes. Nonetheless, optimizing the recipient bed remains a major challenge[39-43]. Our findings show that tumescence effectively addresses this by providing tissue expansion, homeostasis, and improved surgical visibility.

These advantages align with previous studies showing that recipient-site firmness, reduced bleeding, and controlled tissue hydration, are critical for follicular viability[26,27,44,45]. The significant increase in hair density in the tumescent group (282 vs. 221 hairs/in^2) reflects improved implantation stability and reduced graft trauma, consistent with previous reports that controlled tissue resistance enhances graft placement accuracy[42]. The higher graft survival observed in the tumescent group further aligns with earlier evidence suggesting that small technical modifications can markedly influence outcomes in hair transplantation[46].

Patient satisfaction in this study was higher in the tumescent group, which is consistent with evidence that density and natural hairline appearance are the strongest predictors of positive patient perception[23,47,48].

Improvements in hair density have also been associated with better psychological well-being in androgenetic alopecia patients[49,50].

However, tumescence must be applied carefully. Excessive infiltration may distort implantation angles and increase tissue tension, as noted in studies describing donor and recipient-site challenges[51,52]. Variations in scalp thickness and follicular density—especially in specific populations such as Asian males - may also affect outcomes and require individualized injection volumes[53]. Additionally, adherence to safe anesthetic dosing remains important to prevent systemic toxicity[25].

When compared with other adjunctive approaches, such as PRP-assisted FUE[54-56], tumescence alone still provides substantial improvement in graft survival and placement efficiency, supporting its foundational role in both FUE and FUT procedures. As future practice trends shift toward personalized surgical planning and advanced biological support techniques[46,57], optimizing the recipient bed with tumescent injection will continue to play a central role in achieving superior hair transplantation outcomes.

Conclusion

The incorporation of tumescent injection in the recipient area during hair transplantation represents a significant advancement in the field of hair restoration. By expanding the scalp tissue, reducing intraoperative bleeding, and allowing for the precise placement of follicular units, tumescent injection markedly improves post-transplant hair density. Our study, which employed the hair count method in a standardized 1cm x 1cm section, revealed a statistically significant increase in hair density 1 year post-surgery.

In addition to the quantitative improvements, the technique also demonstrated high graft survival rates and elevated patient satisfaction scores. These outcomes underscore the benefits of tumescent injection as an adjunct to conventional hair transplantation methods. However, challenges such as over-expansion, patient variability, and technical expertise remain areas for improvement.

Future directions include optimizing injection protocols, integrating advanced imaging and AI for precise assessments, and conducting large multicenter trials to standardize and refine the technique. With further research and innovation, tumescent injection has the potential to evolutionize hair restoration, providing patients with natural, dense, and aesthetically pleasing results.

Overall, the ability of tumescent injection to enhance hair density, improve graft survival, and ensure natural hairline aesthetics represents a significant step forward in the ongoing evolution of hair restoration techniques. Continued research and collaboration among experts in the field will undoubtedly refine these techniques further, leading to more effective and personalized hair transplantation strategies in the future.

Limitations and Future Scopes

Limitations: One of the main challenges is avoiding over-expansion of the scalp. Excessive tumescent injection may lead to increased tissue tension, which can potentially distort the natural angles of hair implantation.

Patient-to-patient variability in scalp thickness, tissue elasticity, and absorption rates may affect the uniformity of results. Excessive adrenaline in the recipient area should be avoided because it increases telogen effluvium in the immediate postoperative period, and it also may diminish the uptake of the grafts[29]. Although generally safe, the use of tumescent anesthesia carries a risk of local anesthetic systemic toxicity (LAST)[58,59].

Future scope: Future research should focus on refining the tumescent injection technique to optimize both the volume and concentration of the solution. Studies exploring different formulations could provide insights into achieving the ideal balance between tissue expansion and graft stability. The integration of real-time imaging techniques during the injection process may also enhance precision. While this study provides valuable insights, larger randomized controlled trials involving multiple centers are necessary to further validate the findings. Such studies would help standardize the use of tumescent injections across different patient populations and clinical settings. Comparative studies between tumescent and non-tumescent techniques could also shed light on the cost-effectiveness and long-term benefits of the method.

Future protocols may also benefit from personalized treatment plans based on individual scalp characteristics, such as tissue elasticity and vascular density. By tailoring the tumescent injection parameters to each patient, clinicians could maximize graft survival and aesthetic outcomes.

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Abbreviations: FUE: Follicular Unit Extraction; FUT: Follicular Unit Transplant.

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