RESEARCH PAPER

Adrenaline Infiltration in The Recipient Area During Follicular Unit Extraction Using the Implanter Technique: A Prospective Observational Study

[1]*Dr. Shalini Muthuraj, [2]Dr. Rajprakash Bhaskaran, [3]Dr.Goutham Vijayakumar, [4]Professor Dr. Murugesan Krishnan and [5]Professor Dr. Parthiban Saketheraman

[1]Post Graduate student, Saveetha dental college and hospital Saveetha Institute of Medical and Technical Sciences (SIMATS) Saveetha University, Chennai, Tamil Nadu, India Shalinimuthuraj2017@gmail.com
[2]Professor, Saveetha dental college and hospital Saveetha Institute of Medical and Technical® sciences, Saveetha university, Chennai, Tamil Nadu, India" rajprakashomfs@gmail.com
[3]Senior Lecturer , Saveetha dental college and hospital Saveetha Institute of Medical and Technical Sciences (SIMATS) Saveetha University, Chennai, Tamil Nadu, India drgouthamvijayakumar@gmail.com
[4]Head of department, Saveetha dental college and hospital Saveetha Institute of Medical-and Technical sciences, Saveetha university, Chennai, Tamil Nadu, India dr.mkm70@gmail.com
[5]Professor, Department of Periodontics, Sri Venkateshwaraa Dental College and Hospital, Ariyur, Pondicherry – 605102 partthiban@gmail.com
*[1]*Shalinimuthuraj2017@gmail.com*

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ABSTRACT

Background:
Effective hemostasis in the recipient area is essential for precision and graft stability during follicular unit extraction (FUE) using the implanter technique. Adrenaline infiltration may reduce intraoperative bleeding and improve visualization; however, its clinical impact and safety in recipient site preparation remain underreported. The aim of the study is to evaluate the intraoperative efficacy and safety of dilute adrenaline infiltration in the recipient area during implanter-based FUE hair transplantation.

Materials and Methods:
This prospective observational study included 50 consecutive patients undergoing primary FUE hair transplantation using the implanter technique at a single tertiary hair restoration center. A diluted adrenaline solution (1:200,000) was infiltrated locally into the recipient area prior to graft implantation. Primary outcome measures included intraoperative bleeding and ease of graft implantation. Secondary outcomes included local and systemic complications as well as patient-reported postoperative symptoms. Data were analyzed using Microsoft Excel and IBM SPSS Statistics Version 19.0.

Results:
All cases demonstrated noticeable reduction in intraoperative bleeding following adrenaline infiltration, resulting in improved visualization of recipient sites. Enhanced tissue turgor facilitated better angulation control and depth precision during implantation. Surgeons reported smoother implanter handling and reduced graft popping. No major local or systemic complications were observed. Seven patients (14%) experienced transient head heaviness lasting less than six hours, which resolved spontaneously. No cases of tissue ischemia, necrosis, tachycardia, hypertension, or immediate graft loss were recorded.

Conclusion:
Recipient area infiltration with dilute adrenaline (1:200,000) appears to improve intraoperative conditions during implanter-based FUE without compromising safety. It may serve as a simple and effective adjunct to enhance procedural efficiency and graft stability. Further controlled studies with long-term follow-up are recommended.

Keyword: *Adrenaline infiltration; Epinephrine; Follicular unit extraction; Implanter technique; Recipient site hemostasis; Hair transplantation; Graft stability*
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**Author for Correspondence: Shalinimuthuraj2017@gmail.com*

INTRODUCTION

Hair restoration surgery has evolved into a refined microsurgical discipline focused on achieving natural density, minimal trauma, and rapid recovery. Over the past two decades, follicular unit transplantation has progressively shifted from strip harvesting to follicular unit extraction, reflecting patient demand for minimally invasive techniques and improved cosmetic outcomes(1). Follicular Unit Extraction is now widely adopted because it allows individual graft harvesting with reduced linear scarring, faster healing, and enhanced patient acceptance (2,3). As surgical instrumentation and implantation devices have advanced, the emphasis has moved beyond harvesting efficiency toward optimizing recipient site preparation and graft placement dynamics.

The implanter technique represents a further refinement in recipient area management. Unlike traditional slit-and-place methods, the implanter allows simultaneous creation of the recipient site and placement of the follicular graft. This approach reduces graft handling, shortens out-of-body time, and potentially minimizes mechanical trauma to delicate follicular structures. Precision in angulation, depth control, and distribution has become central to achieving natural hairline design and uniform density (4). However, these benefits also depend heavily on the physiological state of the recipient scalp at the time of implantation.

Recipient area hemostasis plays a critical role in hair transplantation. During implantation, repeated penetration of the scalp can lead to persistent oozing, obscured visibility, graft popping, and suboptimal placement accuracy. Excessive bleeding not only prolongs operative time but may also compromise graft survival through displacement or increased manipulation. Therefore, strategies that enhance vasoconstriction and reduce intraoperative bleeding have become integral to procedural refinement (5).

Adrenaline, also known as epinephrine, is a potent sympathomimetic agent widely used in surgical practice for its vasoconstrictive properties. When infiltrated locally, it induces contraction of vascular smooth muscle through alpha-adrenergic receptor stimulation, thereby reducing capillary bleeding. In dermatologic and plastic surgical procedures, adrenaline is commonly combined with local anesthetics to prolong anesthetic duration and minimize intraoperative blood loss. Its application in hair transplantation has traditionally been associated with tumescence and donor area infiltration, yet its targeted use in the recipient area during implanter-based procedures warrants focused evaluation.

In follicular unit extraction using the implanter technique, the procedural sequence differs from conventional methods. Because the implanter both creates and fills the recipient site, any bleeding that occurs immediately after needle entry may interfere with accurate graft release(6). Micro-hemorrhage within dense recipient zones can increase tissue resistance, promote graft extrusion, and reduce placement precision(7). Consequently, controlled vasoconstriction within the recipient area may theoretically enhance implantation efficiency and reduce graft manipulation. Despite these theoretical advantages, concerns persist regarding the biological implications of adrenaline infiltration. Excessive vasoconstriction could potentially compromise microcirculatory perfusion and transiently reduce oxygen delivery to implanted follicles(8). Hair graft survival depends on rapid revascularization and diffusion of nutrients during the immediate postoperative phase. Therefore, balancing hemostasis with adequate tissue perfusion remains crucial. Understanding whether localized adrenaline infiltration alters graft survival, edema formation, operative field clarity, or postoperative recovery is essential for evidence-based protocol development.

The scalp is richly vascularized, supplied by multiple arterial branches that create a dense capillary network within the dermis and subcutaneous layers. This extensive vascularity explains the brisk bleeding often encountered during recipient site creation. While such vascularity supports robust healing, it can challenge surgical precision during dense packing. Implanter-based techniques, particularly in high-density sessions, may involve thousands of repetitive insertions(9). Even minimal bleeding per insertion can cumulatively affect visibility and efficiency.

Previous surgical disciplines have demonstrated that judicious use of adrenaline infiltration reduces operative time and improves field clarity without significantly compromising tissue viability when administered in appropriate concentrations. Diluted adrenaline solutions are considered safe and effective for cutaneous procedures(10).

However, hair transplantation presents unique variables, including graft density, follicular fragility, and the requirement for uniform angulation. These distinct factors necessitate procedure-specific evaluation rather than extrapolation from other surgical fields.

Another important consideration is tissue turgor and mechanical resistance. Tumescent infiltration alters scalp thickness and rigidity, influencing the ease of implanter penetration. Adrenaline-induced vasoconstriction may further modify tissue characteristics by reducing bleeding-related tissue expansion(11). The interplay between tumescence, vasoconstriction, and implantation mechanics may directly affect graft stability. Reduced bleeding could decrease graft popping, a common intraoperative challenge where previously placed follicles are displaced during adjacent insertions.

Patient comfort and postoperative sequelae also merit attention. Adrenaline infiltration may influence postoperative edema, ecchymosis, and inflammatory response. Vasoconstriction can theoretically reduce immediate swelling, yet rebound vasodilation might contribute to delayed edema(12). Additionally, systemic

absorption of adrenaline, though typically minimal with dilute solutions, may produce transient cardiovascular effects in susceptible individuals. Therefore, careful monitoring and standardized dosing protocols are essential.

The increasing popularity of high-density hair transplantation sessions underscores the need for procedural optimization. Surgeons strive to achieve maximal follicular survival while minimizing operative time and complications. Small technical modifications, such as refined infiltration techniques, can cumulatively influence outcomes. However, many intraoperative practices in hair restoration remain guided by empirical experience rather than structured prospective evaluation(13).

Prospective observational studies provide valuable insight into real-world surgical outcomes without altering routine practice patterns. By systematically assessing parameters such as intraoperative bleeding, graft stability, implantation speed, postoperative edema, and early growth indicators, researchers can clarify the practical impact of recipient area adrenaline infiltration. Objective documentation allows differentiation between perceived benefit and measurable improvement. Standardizing infiltration concentration, volume, and timing is critical. Variations in dilution ratios or injection depth may significantly influence both efficacy and safety. Clear reporting of technique details enhances reproducibility and facilitates comparison across centers. In an era of evidence-based aesthetic surgery, protocol transparency strengthens clinical credibility and supports cumulative scientific progress(14).

The biological basis of graft survival involves ischemic tolerance, plasmatic imbibition, and revascularization. Follicular units can withstand a limited ischemic interval before neovascular connections are established. Moderate vasoconstriction confined to superficial dermal vessels is unlikely to induce sustained ischemia if systemic perfusion remains intact. Nevertheless, empirical confirmation through structured observation reassures clinicians regarding safety margins. Technological innovation in hair restoration has advanced rapidly, yet microenvironmental optimization of the recipient area remains comparatively underexplored. While donor harvesting techniques have been extensively studied, recipient site physiology during implanter-based insertion deserves equal attention(15). Because the recipient bed ultimately determines graft anchorage and survival, even subtle hemodynamic modifications may have meaningful consequences.

Adrenaline infiltration may also contribute to improved surgeon ergonomics. Clear visualization reduces fatigue and cognitive load during prolonged sessions. Enhanced precision in angulation and depth can improve aesthetic outcomes, particularly in cosmetically sensitive regions where directional accuracy is paramount. Reduced intraoperative interruptions for hemostasis may further streamline workflow efficiency. Ethical surgical practice demands rigorous evaluation of any adjunctive pharmacologic intervention. Even widely accepted agents require contextual validation when applied to new procedural frameworks. Prospective observational assessment ensures that potential benefits outweigh theoretical risks, thereby guiding rational integration into standard practice(16).

In this context, the present prospective observational study aims to evaluate the clinical impact of adrenaline infiltration in the recipient area during follicular unit extraction performed using the implanter technique.

The study seeks to systematically examine whether recipient area vasoconstriction influences intraoperative bleeding, graft stability, implantation efficiency, and overall procedural flow. Additionally, it intends to observe postoperative outcomes including edema, ecchymosis, early healing patterns, and short-term graft survival, while simultaneously monitoring for any local or systemic adverse effects associated with adrenaline use. Through structured and methodical observation, this research aspires to generate evidence-based clarity regarding the safety and practical benefits of adrenaline infiltration in optimizing recipient site conditions during implanter-based hair transplantation.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted to evaluate the clinical impact of adrenaline infiltration in the recipient area during follicular unit extraction performed using the implanter technique. A total of 50 consecutive patients undergoing primary FUE hair transplantation were included in the study. Consecutive recruitment was adopted to minimize selection bias and to reflect real-world clinical practice. As an observational design, no alteration was made to the routine surgical protocol apart from systematic documentation of predefined outcome parameters. All participants were followed through the intraoperative and immediate postoperative periods for structured assessment of safety and procedural efficiency.

Study Setting

The study was carried out at a single tertiary-level hair restoration center equipped with standardized surgical infrastructure for advanced FUE procedures. All surgeries were performed by the same experienced surgical team to ensure uniformity in operative technique, graft handling, infiltration protocol, and implantation methodology. Maintaining a consistent team minimized operator-dependent variability and enhanced procedural reproducibility. Standard aseptic precautions and institutional surgical protocols were followed throughout the study duration.

Patient Selection

Patients presenting to the center for surgical management of androgenetic alopecia were screened for eligibility. Those fulfilling the inclusion criteria and consenting to participate were enrolled consecutively until the required sample size of 50 patients was achieved.

Inclusion Criteria
Eligible participants included male and female patients between 20 and 50 years of age with a clinical diagnosis of androgenetic alopecia who were scheduled to undergo primary follicular unit extraction. Only patients undergoing their first hair transplantation procedure were considered, in order to eliminate confounding variables related to scar tissue, altered vascularity, or previous surgical modification of the recipient area.

Exclusion Criteria
Patients with known hypersensitivity or documented allergic reactions to adrenaline were excluded. Individuals with a history of cardiovascular disease, including uncontrolled hypertension, arrhythmias, ischemic heart disease, or other significant cardiac conditions, were not considered eligible due to the potential systemic effects of adrenaline. Patients who had undergone previous hair transplantation procedures were excluded to avoid variability in scalp vascularity and tissue characteristics. Additionally, individuals with severe systemic illness or medically unstable conditions were excluded to ensure patient safety and homogeneity of the study population.

All participants provided informed consent prior to inclusion in the study. A detailed preoperative evaluation was performed, including medical history, physical examination, and baseline vital parameters.

Anesthesia and Surgical Technique
All procedures were performed under regional scalp anesthesia as per institutional protocol. Standard nerve blocks and field infiltration were administered to achieve adequate analgesia. Continuous monitoring of vital signs, including heart rate and blood pressure, was maintained throughout the procedure.

Follicular unit extraction was performed using motorized punches of appropriate diameter depending on hair shaft thickness and graft characteristics. Harvested grafts were preserved in chilled isotonic solution until implantation. Care was taken to minimize out-of-body time and mechanical trauma during graft handling.

Recipient site implantation was carried out using implanter pens. The implanter technique allowed simultaneous creation of the recipient site and direct placement of the follicular unit, thereby reducing graft manipulation. Particular attention was given to angulation, direction, and depth of insertion to achieve natural hairline aesthetics and uniform density.

Prior to initiation of graft implantation, a diluted adrenaline solution (1:200,000) prepared by mixing adrenaline with normal saline was infiltrated locally into the designated recipient area. The infiltration was performed in a controlled manner using fine-gauge needles to ensure uniform distribution within the dermal and subdermal planes. Adequate time was allowed for vasoconstrictive effect prior to commencement of implantation. The volume of infiltration was tailored according to the size of the recipient area while maintaining standardized dilution concentration across all cases.

Outcome assessment was structured into primary and secondary parameters. Observations were documented intraoperatively and during the immediate postoperative period. The primary outcome measure was intraoperative bleeding within the recipient area. Bleeding was assessed subjectively by the operating surgeon based on clarity of the surgical field, need for gauze compression, and frequency of suction or wiping required during implantation. The assessment was recorded using a predefined grading scale to maintain consistency. Ease of graft implantation was also evaluated as a primary parameter. This included subjective assessment of tissue resistance during implanter penetration, stability of placed grafts, and occurrence of graft popping. Procedural flow and uninterrupted implantation were considered indicators of improved operative efficiency.

Secondary outcome measures included local and systemic complications associated with adrenaline infiltration. Local complications assessed intraoperatively and postoperatively included evidence of tissue blanching beyond expected vasoconstriction, signs of ischemia, necrosis, excessive graft displacement, or delayed wound healing. The recipient area was evaluated clinically during follow-up visits for any adverse local tissue response. Systemic complications were monitored through continuous intraoperative observation of vital signs. Episodes of tachycardia, transient hypertension, palpitations, or other cardiovascular symptoms were recorded and managed as per standard clinical protocols. Patient-reported postoperative symptoms were also documented. These included pain, swelling, discomfort, tightness, headache, or any unusual sensations experienced within the early postoperative period. Feedback was obtained using a structured questionnaire to ensure uniform data collection.

All collected data were entered into Microsoft Excel for initial coding and organization and subsequently analyzed using IBM SPSS Statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation or median with interquartile range depending on distribution, while categorical variables were presented as frequencies and percentages. Normality of data was assessed using the Shapiro–Wilk test. Preoperative and intraoperative hemodynamic parameters were compared using paired t-test or Wilcoxon signed-rank test as appropriate. Associations between categorical variables were analyzed using Chi-square test or Fisher's exact test. Correlation analysis was performed using Pearson or Spearman correlation methods. A p-value < 0.05 was considered statistically significant, and all tests were two-tailed.

RESULTS

Intraoperative Findings
During the implantation phase, reduced bleeding in the recipient area was observed in all 50 patients (100%; 95%

CI: 92.9–100%) following infiltration with adrenaline. The vasoconstrictive effect of adrenaline contributed to effective hemostasis throughout the implantation procedure. The reduction in bleeding significantly improved the clarity of the operative field and facilitated smooth and precise placement of follicular grafts using the implanter technique.

In addition, increased recipient site surface area due to tissue turgor following adrenaline infiltration was noted in all 50 patients (100%; 95% CI: 92.9–100%).

The infiltration produced adequate tissue expansion and firmness in the recipient region, which enhanced surgical visibility and improved the surgeon's ability to control the depth and angle of graft implantation. The increased turgidity of the recipient site also helped maintain the stability of the created implantation sites during graft insertion.

Overall, both intraoperative parameters evaluated in the study—reduced bleeding and increased recipient site turgor—were consistently observed across the entire study population, suggesting a uniform intraoperative benefit associated with adrenaline infiltration during the implantation phase.

Postoperative Complications:

Postoperative monitoring revealed minimal complications among the study participants. The most commonly reported postoperative symptom was head heaviness, which occurred in 7 patients (14%; 95% CI: 6.9–26.2%). This symptom was mild and transient in nature and resolved within less than 6 hours in all affected individuals without the need for additional medical intervention.

Importantly, no cases of ischemia were observed among the study participants (0%; 95% CI: 0–7.1%). Similarly, tissue necrosis was not reported in any patient (0%; 95% CI: 0–7.1%), indicating that adrenaline infiltration did not compromise tissue viability in the recipient area.

Furthermore, no systemic adverse effects related to adrenaline infiltration, such as tachycardia or hypertension, were recorded during the postoperative observation period (0%; 95% CI: 0–7.1%). This finding suggests that the use of adrenaline in the recipient area was well tolerated by the study population.

Overall, the postoperative outcomes demonstrated a low incidence of complications, with the majority of patients experiencing an uneventful recovery following the procedure.

DISCUSSION

The present prospective observational study evaluated the intraoperative benefits and postoperative safety of adrenaline infiltration in the recipient area during follicular unit extraction (FUE) using the implanter technique. The findings demonstrated that adrenaline infiltration resulted in consistent intraoperative advantages, particularly reduced bleeding and increased tissue turgor, while being associated with minimal postoperative complications. These results suggest that the use of adrenaline in the recipient area may improve surgical conditions during hair transplantation procedures without compromising patient safety.

One of the most notable findings of the present study was that reduced bleeding during implantation was observed in all patients (100%). The vasoconstrictive property of adrenaline is well known and has been widely utilized in various surgical procedures to achieve local hemostasis(17). Adrenaline acts primarily on α-adrenergic receptors in the vascular smooth muscle, leading to vasoconstriction and reduced local blood flow. In the context of hair transplantation, excessive bleeding can obscure the operative field and interfere with precise graft placement. Therefore, achieving effective hemostasis is crucial for maintaining a clear surgical field during implantation(18).

Similar findings have been reported in previous studies evaluating the role of adrenaline in dermatologic and hair transplantation procedures. For instance, Rassman and Bernstein (2002) reported that the addition of epinephrine in local anesthetic solutions significantly reduces bleeding during hair transplantation surgeries, thereby improving surgical visibility and facilitating graft placement(3). Reduced bleeding not only improves visualization but also minimizes graft manipulation time, which may contribute to better graft survival. Likewise, Mysore (2010) highlighted that epinephrine-induced vasoconstriction plays a key role in maintaining a dry surgical field during follicular unit transplantation procedures(19).

Another important intraoperative observation in the present study was the increase in recipient site surface area due to tissue turgor following adrenaline infiltration, which was observed in all participants(20). Tissue turgidity in the recipient area is a desirable characteristic during graft implantation because it stabilizes the scalp tissue and facilitates controlled insertion of follicular grafts. The increased firmness of the recipient area allows the surgeon to maintain the correct depth and angulation of implantation, which is essential for achieving natural hair growth patterns.

This observation is consistent with the concept of tumescence, which is commonly used in dermatologic and hair transplantation surgery. Tumescence refers to the infiltration of fluid into tissue planes to create expansion and firmness of the operative field(21). According to Klein JA, tumescence enhances scalp rigidity, making it easier to create and maintain recipient sites during hair transplantation procedures. In addition, the increased tissue tension helps in reducing graft popping and improving implantation efficiency (22)

Furthermore, improved visibility and control over implantation angles observed in the present study align with the findings of Avram and Rogers (2009), who emphasized that adequate tissue turgor and hemostasis are essential factors for precise follicular graft placement. Proper angulation and orientation of grafts are critical determinants of the aesthetic outcome of hair transplantation procedures. Therefore, techniques that

enhance surgical visibility and tissue stability can significantly contribute to improved procedural outcomes(12).

With regard to postoperative outcomes, the present study demonstrated minimal complications following adrenaline infiltration. The most common postoperative symptom observed was head heaviness, which occurred in 14% of patients and resolved within six hours without intervention. This transient symptom may be related to mild systemic absorption of adrenaline or the effects of local anesthetic infiltration. However, the self-limiting nature of this symptom suggests that it does not pose significant clinical concern.

Importantly, no cases of ischemia, tissue necrosis, or systemic adverse effects such as tachycardia or hypertension were observed in this study. These findings indicate that adrenaline infiltration in the recipient area, when used in appropriate concentrations, is generally safe and well tolerated. Concerns regarding tissue ischemia and necrosis have occasionally been raised in relation to vasoconstrictors. However, several studies have demonstrated that the scalp has a rich vascular supply, which reduces the risk of ischemic complications even in the presence of vasoconstrictors.

Supporting this observation, Mysore v et al. (2010) reported that the use of epinephrine in local anesthetic solutions during hair transplantation did not increase the risk of tissue necrosis or ischemic complications. Similarly, Jimenez and Ruifernández (2015) emphasized that adrenaline is widely considered safe in hair restoration surgery when used in controlled concentrations and proper infiltration techniques(16).

The absence of systemic adverse effects in the present study further supports the safety profile of adrenaline infiltration. Although adrenaline has the potential to produce systemic cardiovascular effects such as tachycardia and hypertension, these effects are usually associated with higher systemic absorption or inadvertent intravascular injection. Careful infiltration techniques and appropriate dosing can minimize these risks (23). Taken together, the findings of the present study suggest that adrenaline infiltration provides significant intraoperative advantages while maintaining a favorable safety profile. Reduced bleeding and increased tissue turgor can enhance surgical precision, facilitate graft placement, and potentially improve overall procedural efficiency. At the same time, the low incidence of postoperative complications indicates that the technique is well tolerated by patients.

From a clinical perspective, the findings of this study highlight the potential benefits of adrenaline infiltration in improving operative conditions during FUE using the implanter technique. By reducing intraoperative bleeding and enhancing tissue turgor, adrenaline infiltration may enable surgeons to perform graft implantation with greater accuracy and efficiency. These advantages could ultimately contribute to improved surgical workflow and better aesthetic outcomes in hair transplantation procedures(24).

The present study has several limitations that should be considered while interpreting the findings. First, the sample size was relatively small (n = 50), which may limit the generalizability of the results to a broader population undergoing hair transplantation procedures. Second, the study was designed as a prospective observational study without a control group, which makes it difficult to directly compare the outcomes with procedures performed without adrenaline infiltration. Third, the study primarily focused on immediate intraoperative observations and short-term postoperative outcomes, and long-term follow-up data regarding graft survival, hair density, and long-term complications were not evaluated. Additionally, the outcomes related to bleeding and tissue turgor were based on intraoperative clinical assessment rather than quantitative measurement, which may introduce a degree of subjective interpretation. Future studies involving larger sample sizes, randomized controlled designs, and objective measurement of intraoperative bleeding and graft survival would provide stronger evidence regarding the efficacy and safety of adrenaline infiltration in the recipient area during follicular unit extraction procedures.

Furthermore, the minimal postoperative complications observed in this study support the safety and feasibility of incorporating adrenaline infiltration into routine hair transplantation protocols, particularly when performed with appropriate technique and dosing.

Despite these promising findings, future studies with larger sample sizes and comparative study designs are necessary to further evaluate the long-term outcomes and optimize the use of adrenaline infiltration in hair transplantation procedures.

CONCLUSION

The findings of the present prospective observational study suggest that adrenaline infiltration in the recipient area during follicular unit extraction (FUE) using the implanter technique provides significant intraoperative advantages. The use of adrenaline was associated with effective reduction in intraoperative bleeding and increased tissue turgor, which improved surgical field visibility and facilitated precise graft implantation. These intraoperative benefits may contribute to enhanced procedural efficiency and improved surgical control during hair transplantation.

Importantly, the procedure demonstrated a favorable safety profile, with only minimal and transient postoperative symptoms such as head heaviness observed in a small proportion of patients. No serious complications, including ischemia, tissue necrosis, or systemic cardiovascular effects, were reported.

Overall, adrenaline infiltration in the recipient area appears to be a safe and useful adjunct during FUE procedures, improving operative conditions without increasing the risk of adverse outcomes. However, further large-scale studies with controlled comparative designs

and long-term follow-up are recommended to validate these findings and to better understand the long-term clinical outcomes associated with this technique.

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