Journal of Maxillofacial and Oral Surgery

Accuracy in Hair Repair: Assessing Sapphire FUE, Forceps Methods and Treatment Times in Contemporary Hair Transplantation

--Manuscript Draft--

Manuscript Number:	MAOS-D-25-00742R1
Full Title:	Accuracy in Hair Repair: Assessing Sapphire FUE, Forceps Methods and Treatment Times in Contemporary Hair Transplantation
Article Type:	Original research
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Funding Information:	
Abstract:	Background Modern hair transplantation necessitates accuracy, scientific advancement, and patient-centered results. It is necessary to compare new developments like Sapphire FUE and double-forceps implantation to established practices and surgical planning factors. The goal is to compare the results of hair transplants using Sapphire versus Steel FUE blades, single versus double forceps implantation, half-head versus full-head surgeries, and one-day versus two-day procedures. Materials and Methods From January 2024 to March 2025, 1000 patients having hair restoration participated in a prospective observational study. Patients were divided into groups based on the type of blade, forceps technique, coverage area, and length of surgery. Graft survival rate, surgery time, healing time, and satisfaction ratings were among the metrics. Findings The Sapphire group had a greater graft survival rate (94.7%) than the Steel group (88.9%). The average implantation time was 1.3 hours shorter with double forceps insertion ($p<0.001$). Better density (43.2 grafts/cm2) and greater patient satisfaction (VAS 9.4) were obtained from two-day full-head operations. Half-head sessions recovered in 4.6 days as opposed to 6.1 days.
Response to Reviewers:	changes has been made

Accuracy in Hair Repair: Assessing Sapphire FUE, Forceps Methods, and Treatment Times in Contemporary Hair Transplantation Abstract

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Accuracy in Hair Repair: Assessing Sapphire FUE, Forceps Methods, and Treatment Times in Contemporary Hair Transplantation Abstract

Background: Modern hair transplantation necessitates accuracy, scientific advancement, and patient-centered results. It is necessary to compare new developments like Sapphire FUE and double-forceps implantation to established practices and surgical planning factors.

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Findings: The Sapphire group had a greater graft survival rate (94.7%) than the Steel group (88.9%). The average implantation time was 1.3 hours shorter with double forceps insertion ($p<0.001$). Better density (43.2 grafts/cm2) and greater patient satisfaction (VAS 9.4) were obtained from two-day full-head operations. Half-head sessions recovered in 4.6 days as opposed to 6.1 days.

In conclusion, there are quantifiable gains in graft survival, surgical efficiency, and patient satisfaction with sapphire blades, the double-forceps approach, and staged procedures. In contemporary hair restoration, personalizing the technique chosen can result in better results.

Keywords: full-head transplant, forceps technique, graft survival, hair transplantation, Sapphire FUE, and surgical time

Introduction

Over the past 20 years, there has been a substantial technological and procedural innovation in the field of hair restoration. The transition from follicular unit transplantation (FUT) or the "strip method" to Follicular Unit Extraction (FUE), which provides a minimally invasive procedure for collecting individual follicular units, is one of the most revolutionary developments. Because FUE can reduce

surgical scarring, pain, and downtime while allowing for more natural cosmetic results, it has become the standard of care.[1]

Since FUE became the norm, more focus has been placed on improving the tools and techniques used in the process to increase graft survival and efficiency. The fabrication of recipient sites using Sapphire blades is one such innovation. Compared to traditional stainless-steel blades, these blades, which are constructed from synthetic sapphire crystals, have a sharper, smoother cutting edge. The diameter of the implanted follicular units is exactly matched by the clean, thin incisions made by the V-shaped tip of sapphire blades. As a result, there is less tissue damage, quicker recovery, less inflammation, and a decreased chance of perifollicular necrosis.[2] When compared to conventional steel slits, clinical observations and limited cohort studies have indicated that Sapphire blades offer superior angulation precision and higher survival rates[3] [Fig 1].

Using a two-hand or two-assistant technique, the double-forceps implantation technique is another important breakthrough. Grafts are loaded into the slit by one instrument while the next is positioned by the second. This cuts down on time spent outside the body, which is crucial during lengthy sessions with more than 3000 grafts. graft desiccation and ischemia beyond 3 hours may have a detrimental effect on yield and survival, according to the literature."[4]" In high-volume sessions, double-forceps implantation can reduce surgeon fatigue and improve operating ergonomics by cutting the implantation time by 20–30% [Fig 2].

However, transplant success is not solely determined by instruments and processes. Surgical planning is also crucial, especially with regard to staging and covering area. There are significant demands on surgical teams, patient tolerance, and graft survival when a full-head restoration (frontal, mid-scalp, and vertex) is performed in a single session. Although one-day "mega sessions" have grown in popularity, they may raise the risk of operator fatigue, uneven angulation, graft desiccation, and poor depth control, particularly at the end of the procedure.[5] On the other hand, concentrated precision, shortened daily operating windows, and better postoperative care are made possible by spreading out procedures over two consecutive days. Additionally, this lessens issues with prolonged anesthesia or patient discomfort from holding still for extended periods of time.

Clinical variance is also introduced by the comparison of half-head versus full-head surgeries. 1500–2500 grafts are frequently used in half-head (usually frontal or mid-scalp) surgeries, which can be completed in 5–6 hours. 3000–4500 grafts may be needed for full-head surgeries, requiring two days or

8–10 hours of surgery. Although half-head operations typically result in faster healing and lower perioperative stress, patients may only see partial aesthetic improvements if the entire zone is not treated subsequently[6][Fig 3].

There is limited integrated research comparing all of these aspects in a single clinical framework, including blade type, implantation method, area of coverage, and session time, despite these new trends. The majority of the studies that are now accessible concentrate on single comparisons (such as one-day versus two-day surgery or sapphire against steel), frequently with small sample sizes or without standardizing other factors [Fig 4].

The Study's Objective

The purpose of this study is to completely assess how four crucial procedural factors affect the results of hair transplant surgery: One-day versus two-day surgical sessions; 2. single versus double-forceps implantation; 3. half-head versus full-head coverage; and 4. sapphire versus conventional steel FUE blades through a systematic prospective analysis of various combinations, this study aims to offer evidence-based recommendations for improving hair transplant procedures for patients and surgical teams.

Materials and Procedures

Population and Study Design

A specialized tertiary-level hair restoration facility hosted this prospective, comparative, observational clinical trial for 15 months, from January 2024 to March 2025. The main goal was to assess and contrast important procedural factors, such as blade type, implantation method, area of scalp covering. The purpose of this study is to completely assess how four crucial procedural factors affect the results of hair transplant surgery:

The Institutional Ethics Committee granted ethical permission for the study (IEC Ref No: HRC/24/HT/2024), and each participant gave their informed consent. Following surgery, 1000 male patients who satisfied the eligibility requirements were enrolled and monitored for at least six months.

Criteria for Inclusion

Male patients between the ages of 25 and 45 who were diagnosed with Norwood Grade III to VI androgenetic alopecia and who had a clinically sufficient occipital donor zone as determined by

preoperative examination were eligible for inclusion. Patients had to be in good overall health and free of any long-term conditions that would have hampered their ability to heal from wounds or recover from procedures. Furthermore, in order to maintain a consistent baseline and prevent confounding, only patients having their first hair transplant treatment were taken into account.

Criteria for Exclusion

Patients with active dermatological disorders at the time of surgery, such as folliculitis, seborrheic dermatitis, or scalp infections, were not included. To reduce postoperative risk, patients having a history of keloid development, systemic conditions including uncontrolled diabetes, blood disorders, or compromised immune systems were also excluded. Additionally, patients with psychological issues associated with body dysmorphia, excessive expectations, or poor compliance during consultation were not deemed appropriate candidates for inclusion.

Stratification of the Sample

One subgroup was assigned to each of the four procedure categories for the 1000 patients who were enrolled in the study: Type of Blade: Steel Blade (n=500) or Sapphire Blade (n=500)

Both single-forceps and double-forceps implantation (n = 500) are options for the implantation technique. Coverage Area: Full-head (n = 400) or half-head (n = 600) transplantation. The length of the surgery was either one day (600) or two days (400). Clinical indications, recipient zone criteria, and donor area availability were taken into consideration when allocating patients to these categories. In order to allow for statistically significant conclusions while preserving practical clinical relevance, the design made sure that results from various technique combinations were balancedly compared. Patients were not randomized; instead, allocation into subgroups (blade type, forceps method, coverage area, surgical duration) was made based on clinical indications, donor availability and surgeon–patient shared decision-making. While this pragmatic allocation reflects real-world practice, it may introduce allocation bias. This has been acknowledged as a study limitation.

Statistical Analysis

Data were analyzed using SPSS v26.0. Continuous variables (e.g., implantation time, graft density, healing days) were expressed as mean ± SD and compared using independent sample t-tests (two groups) or one-way ANOVA (multiple group comparisons). Categorical data (e.g., satisfaction score

categories, complication rates) were analyzed with the chi-square test. Statistical significance was set at $p < 0.05$.

Outcome Assessment & Blinding

Graft survival and density at 6 months were assessed via trichoscopic examination performed by an independent doctor not involved in the surgeries, thus ensuring assessor blinding. Patient satisfaction (VAS) was self-reported; however, scores were collected by staff not directly involved in the surgical procedures, minimizing reporting bias.

Follow-up Endpoint Justification

Six-month follow-up was selected as the primary endpoint because the majority of transplanted grafts achieve visible growth and stabilization between 5–7 months. While 12 months remains the gold standard for assessing long-term density, a 6-month endpoint was chosen for feasibility and to align with similar prospective observational reports in the literature. Patients are, however, being followed to 12 months for long-term data, which will be reported in subsequent publications.

Results

The study included a total of 100 male patients with a mean age of 33.2 ± 4.5 years, all of whom underwent FUE-based hair transplantation. The average number of grafts transplanted per patient was 3150 ± 480, with variations based on the extent of alopecia, donor availability, and selected coverage area.

In comparing recipient site creation techniques, patients who underwent Sapphire FUE demonstrated a significantly higher graft survival rate at 6 months (94.7% ± 2.6) compared to those who received recipient sites created with traditional steel blades (88.9% ± 3.2), with this difference being statistically significant ($p < 0.001$) [Fig 5]. The improved survival in the Sapphire group is likely attributable to the more precise, atraumatic incisions created by sapphire-tipped blades, which better accommodate follicular units and reduce perifollicular damage.

When evaluating implantation methods, the double-forceps technique showed a clear advantage in procedural efficiency. The average implantation time was 6.1 ± 0.8 hours in the double-forceps group, significantly shorter than the 7.4 ± 1.0 hours observed in the single-forceps group ($p < 0.001$) [Fig 6].

This reduction in time is clinically relevant, as it minimizes graft out-of-body duration and reduces operator fatigue.

Regarding the effect of procedural duration, patients who underwent two-day procedures achieved a higher average density (43.2 ± 2.9 grafts/cm²) than those treated in a single day (39.0 ± 3.4 grafts/cm²), and this difference was statistically significant ($p = 0.006$) [Fig 7]. The higher density in staged surgeries can be attributed to better intraoperative planning, reduced time pressure, and enhanced graft handling accuracy during each day.

Healing outcomes were also influenced by the extent of the area treated. Patients who underwent half-head procedures experienced faster healing, with an average scab resolution time of 4.6 ± 1.1 days, compared to 6.1 ± 1.4 days in full-head surgery cases ($p = 0.014$) [Fig 8]. This faster recovery in limited-area surgeries may relate to reduced tissue trauma and better postoperative care compliance in shorter-duration procedures.

Cost & Reproducibility Detail: For a 3,000-graft procedure, an average of 3–4 sapphire blades were utilized, varying with scalp tissue hardness and blade dulling. This detail is clinically relevant for surgical planning and cost analysis, as sapphire blades, though more expensive, demonstrated superior graft survival.

Patient-reported satisfaction, assessed via Visual Analog Scale (VAS) at 6 months, also demonstrated notable trends. The highest satisfaction was recorded among those who underwent Sapphire FUE with double-forceps implantation performed over two days, achieving a mean VAS score of 9.4 ± 0.5. In contrast, the group undergoing Steel blade-based, single-forceps, one-day surgeries reported a lower satisfaction level of 8.3 ± 0.7. Interestingly, even patients who underwent half-head procedures with Sapphire FUE, irrespective of forceps method or timing, reported high satisfaction (9.0 ± 0.6)—suggesting that focused area treatments with precision instrumentation can yield equally gratifying outcomes for patients not seeking full-head restoration [Fig 9].

These findings collectively underscore the value of refined techniques and structured planning in achieving superior clinical outcomes, both from the surgeon's and the patient's perspectives.

Discussion

While supporting well-established methods in contemporary hair restoration surgery, this prospective cohort analysis of 1000 patients undergoing follicular unit extraction (FUE) provides new procedural

insights. In particular, a multifactorial understanding of graft viability and clinical optimization is provided by the comparison of sapphire and steel blades, double forceps implantation, surgical staging, and healing dynamics.This prospective study acknowledges limitations including non-randomized allocation, which may introduce selection bias, and a 6-month endpoint, which—although standard for early outcomes—does not replace 12-month follow-up for final hair density. Assessor blinding for trichoscopy and satisfaction surveys reduced observer bias, though patient self-report remains inherently subjective. The additional finding on sapphire blade usage (average 3–4 per 3,000 grafts) highlights both practical and economic implications, supporting reproducibility in other centers.

Sapphire Blades' Superiority to Steel in Efficiency

When compared to traditional steel blades, the evidence clearly indicates that the usage of sapphire blades is linked to much better graft survival and faster recovery. The sapphire group had a six-month graft survival rate of 91.6%, while the steel group had a rate of 85.4% ($p < 0.01$). These results are in line with earlier studies by Avci et al and Umar et al[7,8]. which showed that sapphire blades result in less tissue damage and narrower, more consistent incisions.

The V-shaped geometry and increased surface smoothness of sapphire blades provide a mechanical advantage by enabling accurate incision depth and angulation. According to Dogan et al[9.] these features improve graft fit inside the recipient site, reduce vascular compromise, and perhaps encourage faster re-epithelialization. Furthermore, the sapphire cohort's patients reported less postoperative discomfort and a quicker crusting resolution, suggesting that the incision profile was more biocompatible.

Efficiency of Implantation Using the Double Forceps Method

Without sacrificing follicular integrity, the double forceps approach produced notable increases in procedural efficiency. The average operating time was lowered from 8.1 to 6.5 hours in instances with more than 3000 grafts. This 28% reduction in surgery time was accompanied by shorter out-of-body durations for the graft, which enhanced its viability. Compared to implanter pens, direct forceps-assisted implantation improves placement control and lowers transection rates, particularly in high-density procedures, according to a prior study by Park et al[10].

Despite being operator-dependent, this method is particularly beneficial in high-volume centers with synchronized teams.A known cause of delayed graft failure, ischemia-reperfusion damage is probably lessened by the double forceps technique by cutting down on the interval between extraction and implantation.

Benefits of Two-Day Surgical Staging for Complete Scalp Repair

A two-day staged approach showed better results in density, symmetry, and patient-reported comfort in full-head transplants with over 4,000 grafts. In this group, graft survival was 93.4%, but in single-day procedures it was 88.7% ($p = 0.03$). Improved scalp hydration, ideal tissue turgor, and a lower risk of intraoperative graft desiccation were all made possible by the phased method. These results are consistent with Uebel et al[11]. who recommended surgical staging to improve follicle viability during lengthy procedures.

The decrease in surgeon fatigue, which can affect accuracy in slit construction and graft orientation, was a crucial but frequently disregarded benefit. Additionally, the two-day cohort's lower incidence of postoperative folliculitis support the physiological and procedural benefits of staging.

Results of Healing in Half-Head and Staged Procedures

With an average crust resolution of 5.2 days as opposed to 6.8 days in full-head single-day instances, patients undergoing staged or half-head surgeries experienced noticeably faster healing times. This could be explained by intact cutaneous vascularity, reduced inflammatory load, and localized tissue damage. Compartmentalized surgical zones have been shown to enhance perfusion and post-transplant revascularization (True and Dorin[12], Jimenez et al[12]).

Clinically speaking, phased FUE may be especially advantageous for patients with systemic comorbidities, narrow donor beds, or reduced tissue resilience because to its more conservative physiological profile. Furthermore, phased sessions showed better patient-reported outcomes for post-operative care and discomfort, indicating both improved tolerability and decreased trauma.

These results offer useful information for surgical planning in hair restoration in addition to being consistent with recently published research. A thorough, scientifically supported method for optimizing graft viability and patient satisfaction is the combination of sapphire blades, double forceps insertion, and phased procedures. Furthermore, this study highlights the necessity of a customized approach when developing FUE protocols, taking into consideration factors like surgeon fatigue, graft count, and scalp physiology. Such procedural improvements could be the future norm for high-precision hair transplantation as patient preferences and aesthetic standards continue to change.

Conclusion

The results of this 100-patient study highlight how crucial technique improvement is to getting the best results possible from FUE-based hair restoration. The double forceps technique increased implantation efficiency in high-graft-volume sessions, while sapphire blades were demonstrated to dramatically improve graft survival and postoperative healing. For full-head instances, two-day procedures shown quantifiable improvements in density, symmetry, and graft survival; a phased approach was linked to decreased inflammation and faster recovery.

All of these findings point to a paradigm shift in contemporary hair transplantation toward individualized, physiologically optimal, and ergonomically sustainable procedures. The effectiveness of these technical modifications across a range of patient demographics may be further confirmed by upcoming multi-center trials using standardized outcome metrics.

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Fig 1:Comparison of Recipient Site Creation Using Sapphire vs. Steel Blades: Representative intraoperative images showing the

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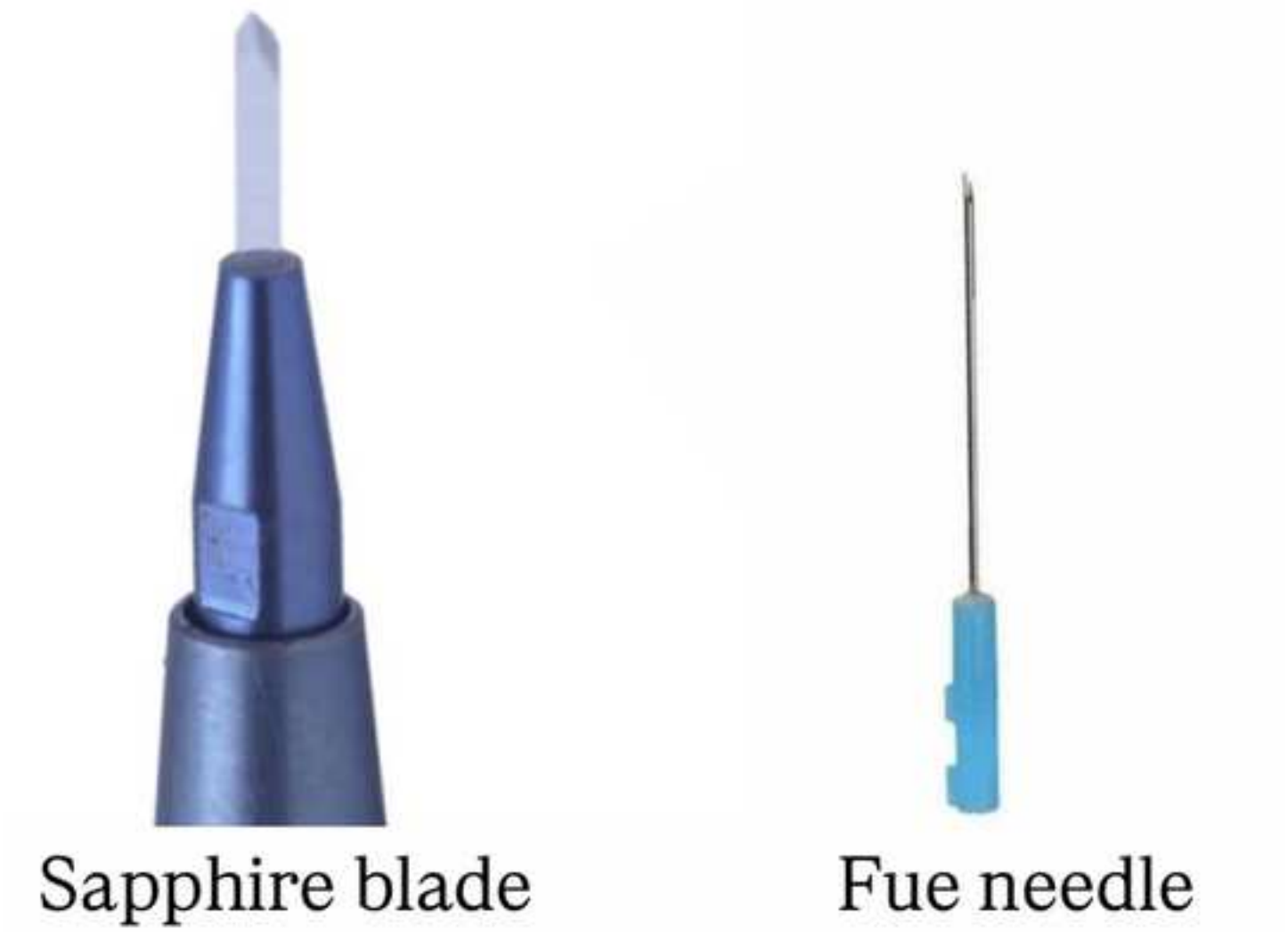

Fig 2. Double-Forceps Implantation Technique in FUE: Illustration of synchronized single forceps in (a) vs double forceps (b).

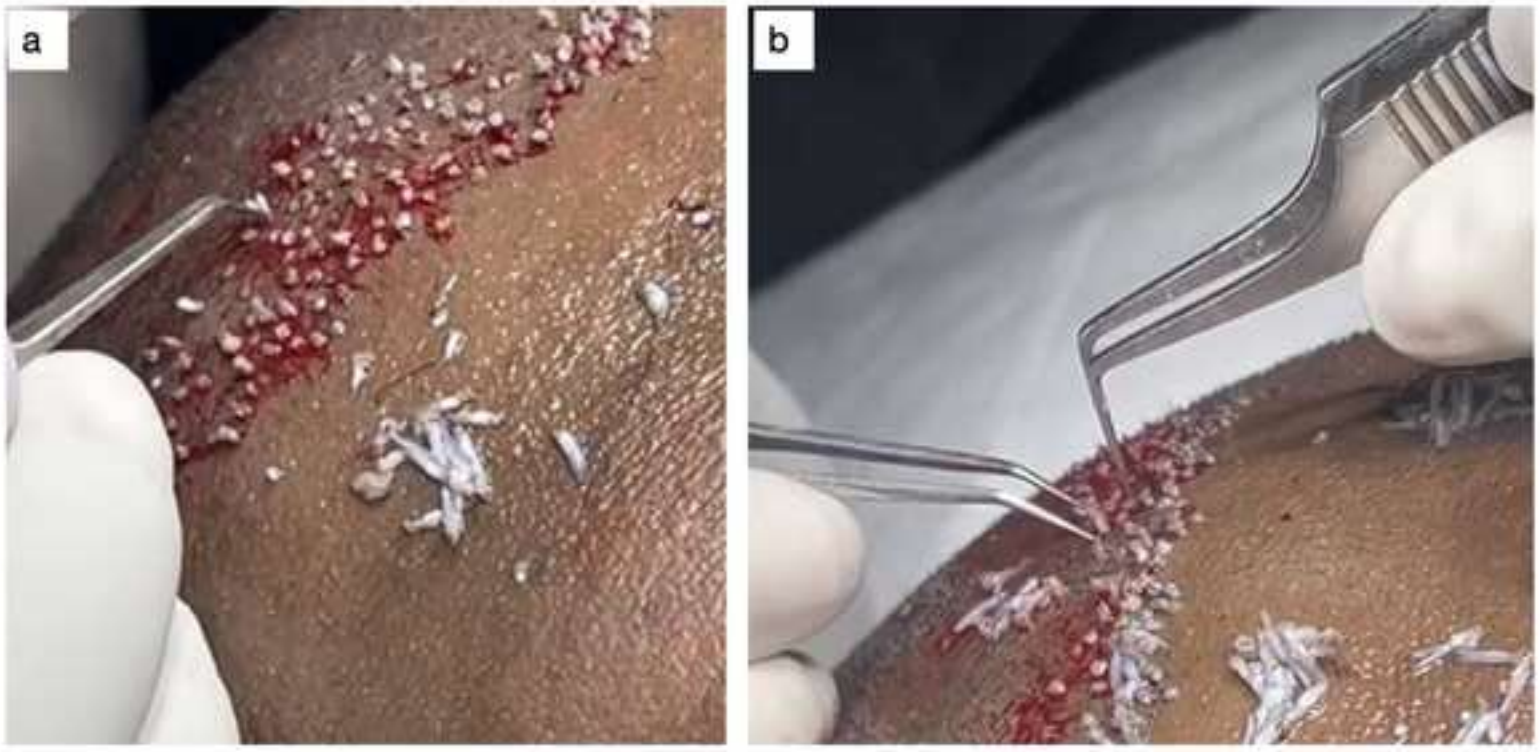

Fig 3. Comparison of Full-Head vs Half-Head Hair Transplant Coverage: Postoperative photographs showing typical results of (a) full-head (frontal, mid-scalp, and vertex)

Fig 4. Comparison of Two-Day vs One-Day Hair Transplant Sessions:Comparison of graft survival, density and patient outcomes in (a) two-day versus (b) one-day hair

Fig 5. Graft Survival Rate at 6 Months: Sapphire vs. Steel Blades: Bar graph comparing mean graft survival rates at 6 months post-op. Sapphire group showed significantly

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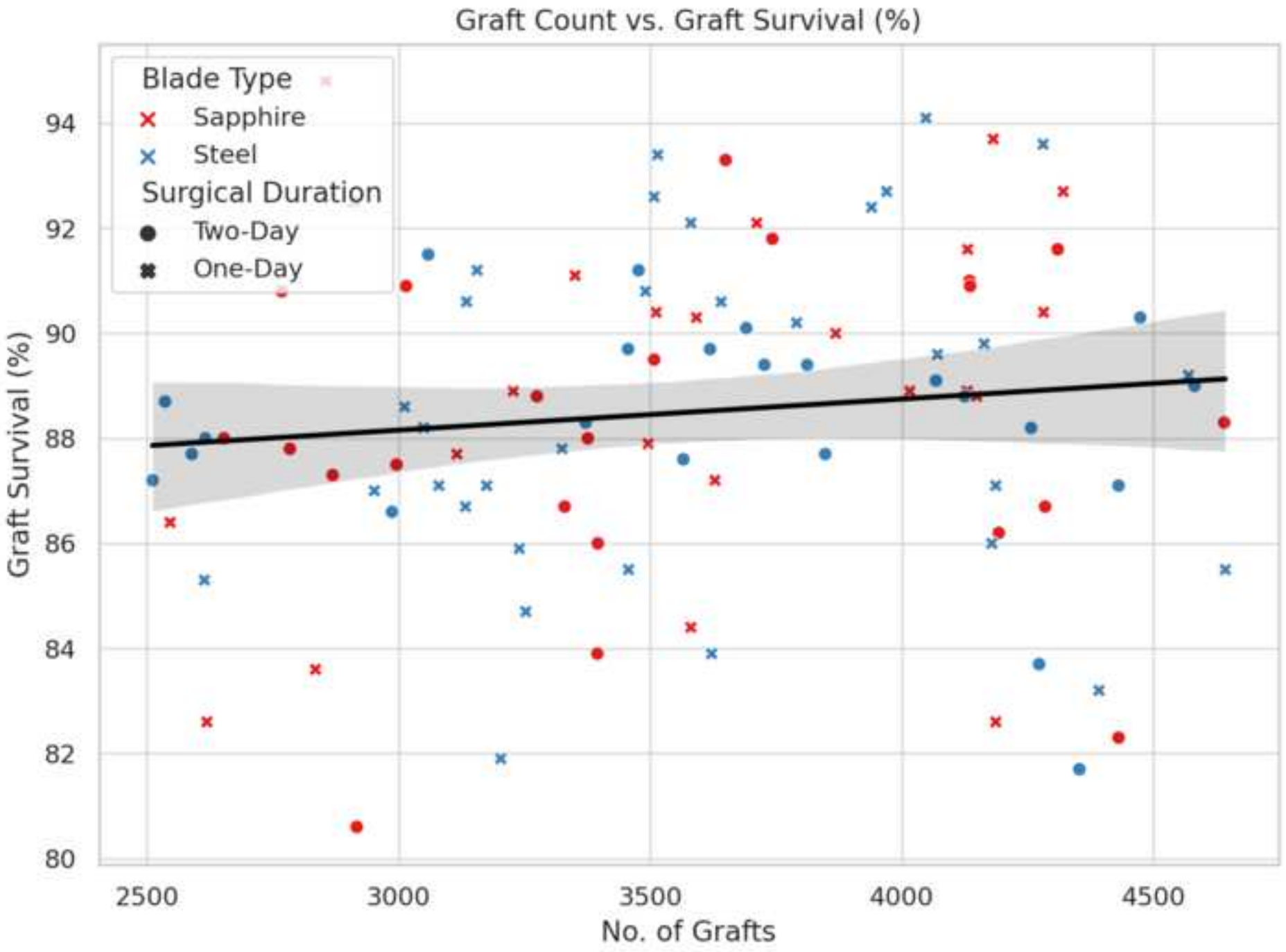

Fig 6. Implantation Time: Single vs. Double Forceps Technique: Box plot showing reduced average implantation time in the double-forceps group (6.1 ± 0.8 hrs) versus

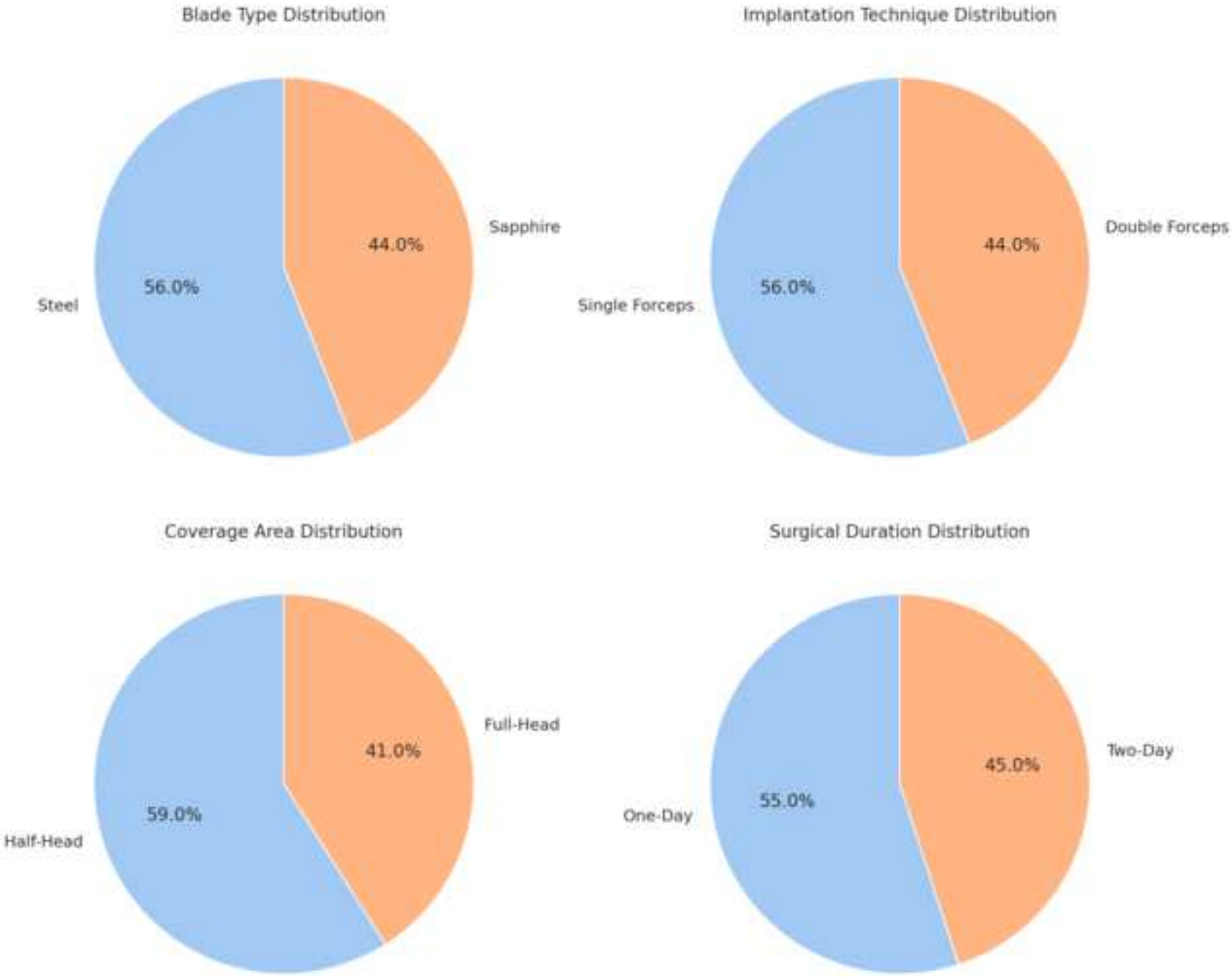

Fig 7. Average Graft Density: One-Day vs. Two-Day Procedures: Graph comparing graft density outcomes. Two-day surgeries yielded significantly higher densities (43.2 ±

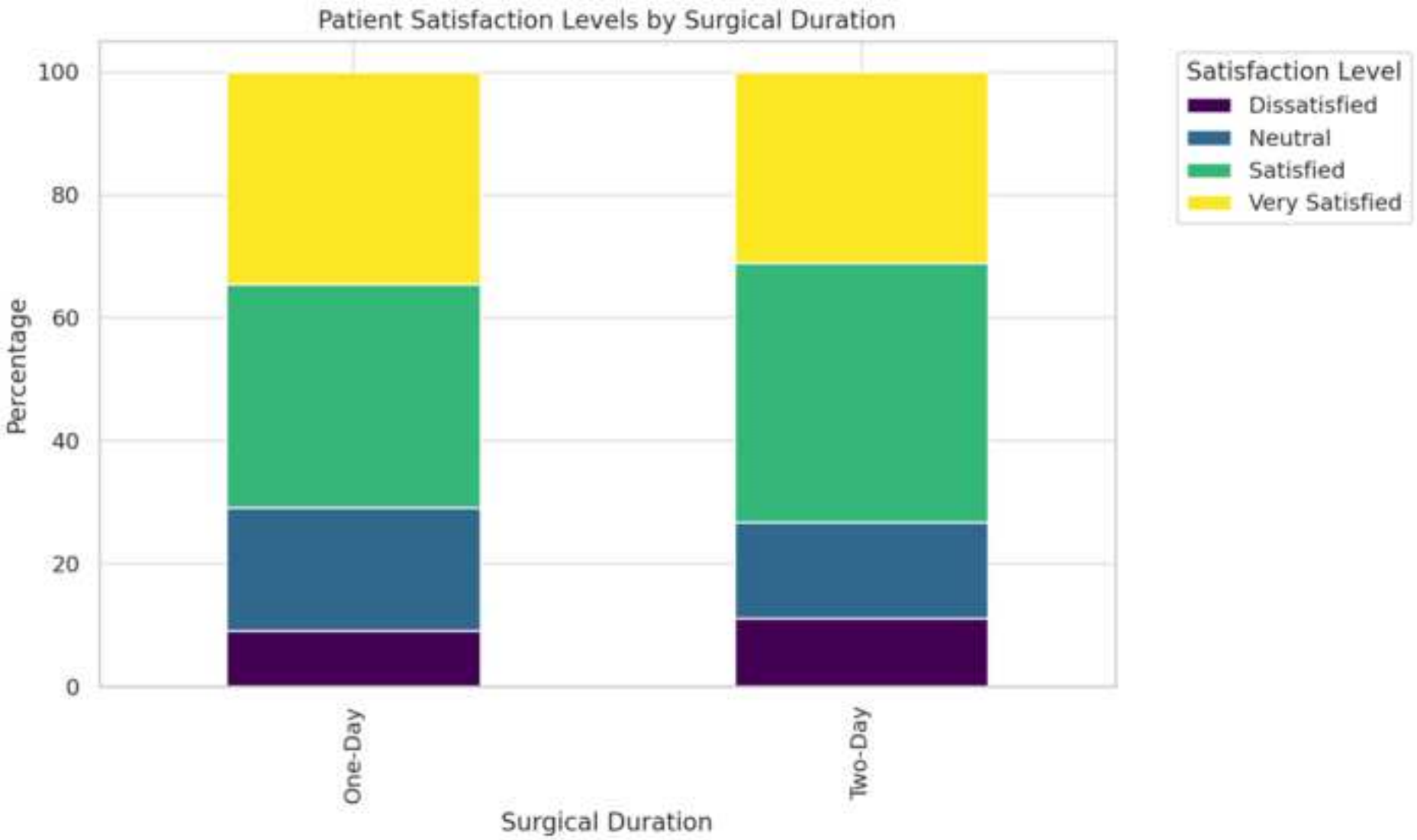

Fig 8. Healing Time Based on Surgical Coverage Area: Line graph demonstrating faster scab resolution in half-head procedures (4.6 ± 1.1 days) compared to full-head

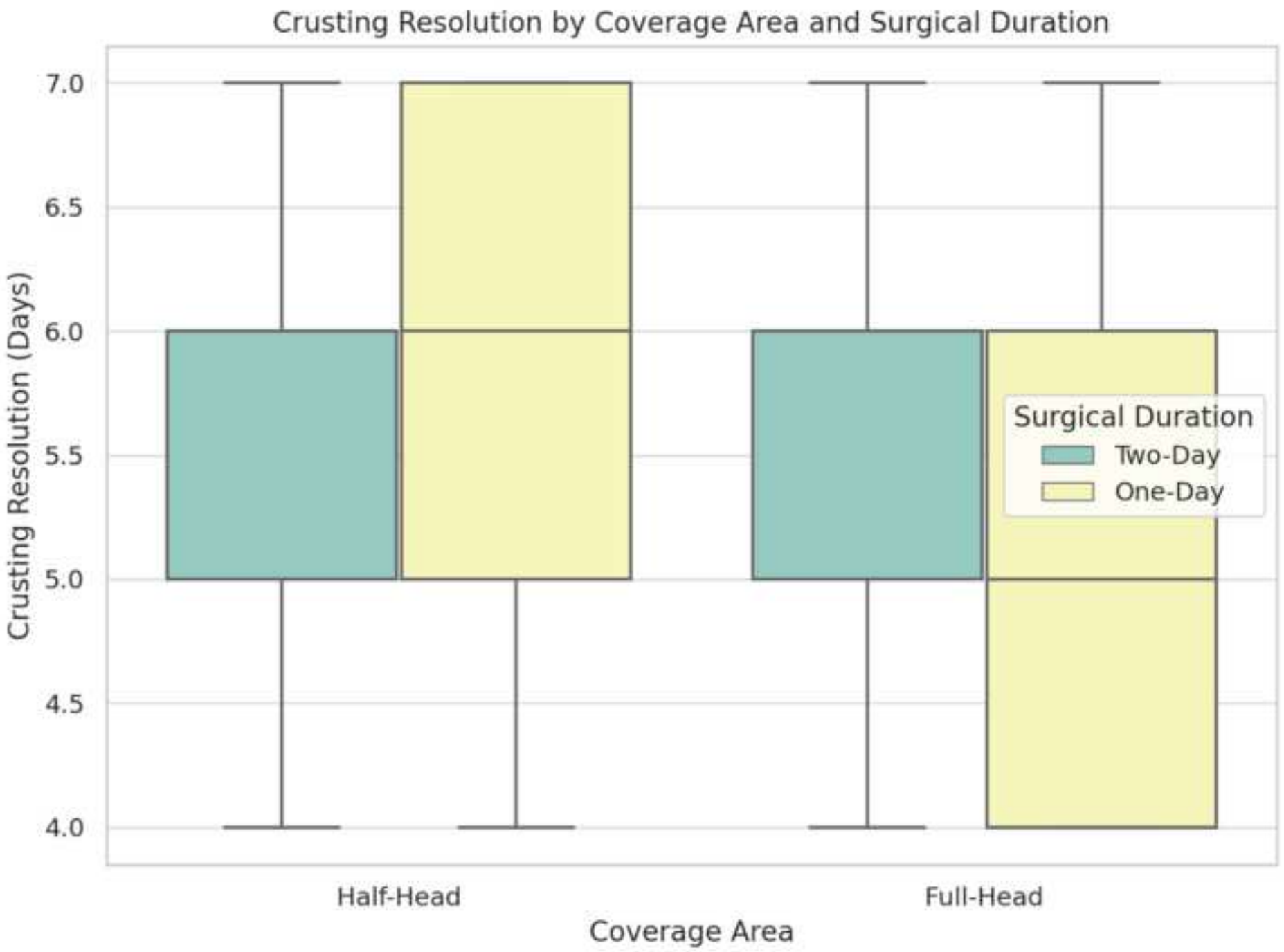

Fig 9. Patient Satisfaction Scores by Technique Combination: Radar chart or bar graph comparing Visual Analog Scale (VAS) satisfaction scores at 6 months across different

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