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ORIGINAL ARTICLE

Comparative Analysis of Low and High Rotation Arc Single-Stage Tunnelled Forehead Flap for Medial Canthal Reconstruction

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What is already known on this topic?

- *The medial canthal region is a challenging area for reconstruction due to its complex anatomy and proximity to critical functional structures.*
- *Traditional forehead flaps, particularly 2-stage procedures, are commonly used for large or complex defects in this area.*
- *Flap reconstruction (e.g., glabellar, cheek advancement, nasolabial, Rintala) is generally favored over grafts in this region to avoid complications like ectropion, necrosis, or aesthetic deformity.*
- *Two-stage procedures, while effective, increase surgical burden, cost, and hospital visits—especially problematic in elderly patients.*
- *Single-stage forehead flaps have been explored, but literature lacks focus on optimizing flap design parameters such as rotation arc in tunneled techniques.*

What this study adds to the existing knowledge ?

- *Introduces and evaluates the low rotation arc (≤100°) single-stage tunnelled forehead flap as a simplified, efficient technique for medial canthal reconstruction.*
- *Demonstrates that low rotation arc flaps result in fewer complications (e.g., no necrosis or desepithelialization) and significantly reduced hospital*

Abstract

Objective: The study aimed to promote a simpler and more efficient surgical approach for reconstructing critical areas like the medial canthal region, addressing full-thickness defects. The use of the low rotation arc single-stage forehead flap was showcased, and its outcomes were compared with other flap techniques, including the high arc single-staged forehead flap.

Methods: Twenty patients with cutaneous tumors underwent single-stage tunnelled forehead flap reconstruction following excision. Ten patients received low rotation arc (≤100°) single-stage tunnelled forehead flap reconstruction, while the remaining 10 received high rotation arc (>100°) single-stage tunnelled forehead flap reconstruction. Demographic characteristics, defect dimensions, postoperative complications, and hospital visit frequencies were retrospectively assessed. Surgical methods were described for the low rotation arc single-stage tunneled flap, and outcomes were statistically compared.

Results: Ten patients underwent high rotation arc reconstruction (mean age: 69.1 years, defect size: 4.54 cm^2). Complications included desepithelialization (4 patients), partial flap necrosis (2 patients), and total flap necrosis (1 patient), with an average hospital visit frequency of 5.0. Patients with low rotation arc had significantly fewer hospital visits ($P < .005$).

Conclusion: Utilizing a single-stage forehead flap with low rotation arc in medial region reconstruction results in superior outcomes with fewer complications compared to high rotation arc flaps. This optimized method provides successful single-stage repair in this area.

Keywords: Medial canthus, reconstruction, single stage

Introduction

The medial canthal region is highly susceptible to exposure to sunlight.[1] Tumors in this area can exhibit local aggressive progression, invading nearby muscles and nasal bones, leading to aesthetic concerns. Furthermore, invasion into functional structures such as the canthal tendon and lacrimal duct can result in serious complications, including blindness.[2] Hence, in the reconstruction of this area, it is crucial to ensure that the tumor is excised completely with negative margins to avoid leaving any residual disease.[3]

In defects involving multiple structures within the orbit region, simple reconstruction options such as grafts often prove unsuccessful or fail to achieve the desired outcomes.[4] Graft applications in this area not only raise esthetic concerns but also contribute to functional worries such as contracture-induced ectropion.[5] Consequently, flap reconstruction emerges as a robust option for repairing defects in this region.

In their 2022 study, Bhandari and colleagues categorized defects in the medial canthal region into 2 regions: upper and lower. They noted that defects in the upper region predominantly featured glabellar and forehead flaps, whereas defects in the lower region were primarily addressed with cheek advancement, nasolabial, and forehead flaps.[6]

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visits compared to high rotation arc flaps.

- *Confirms that even moderately large defects can be successfully reconstructed with low-arc flaps in a single stage, avoiding the need for multiple surgeries.*
- *Highlights the potential of this optimized flap design to improve quality of life, reduce healthcare costs, and serve as a reliable alternative to more invasive or staged options.*

While Chao et al[8] popularized the use of glabellar flap in the medial canthal region, Ogino and colleagues employed multiple flaps such as glabellar flap, cheek advancement, and Rintala flaps for large defects.[7]

In particular, for extensive medial canthal region defects extending up to the middle third of the nasal sidewall, previous studies in the literature have highlighted the prominence of multiple flap options or 2-stage forehead flap procedures.[9]

Given the high incidence of skin cancers in the elderly, single-stage repairs are crucial. Single-stage repairs help reduce the number of hospital visits for elderly individuals, leading to lower costs for both patients and healthcare facilities.[10]

This study aimed to popularize a less complicated and more effective surgical method for single-stage reconstruction of critical regions such as the medial canthal area, where full-thickness defects require significant attention. To achieve this goal, the application of the low rotation arc single-stage forehead flap was demonstrated, with the aim of comparing the outcomes with other flaps described in the literature, including high arc single-staged forehead flap.

Methods

A total of 20 patients, who underwent excision due to cutaneous tumors and were deemed unsuitable for graft repair, received single-stage tunnelled forehead flap reconstruction. Between December 2022 and January 2024, patients underwent surgical procedures and were followed up for a minimum of 3 months and a maximum of 2 years. Early cases had follow-up extending to 24 months. Ten patients underwent low rotation arc (≤100°) single-stage tunnelled forehead flap reconstruction, while the remaining 10 received high rotation arc (>100°) single-stage tunnelled forehead flap reconstruction. The demographic characteristics of the patients, dimensions of the surgical defects, postoperative complications, and hospital visit frequencies were retrospectively evaluated. Reconstruction was planned simultaneously with tumor excision, and given the fixation of the tumors to the bone and periosteum, surgical margins were determined accordingly, including excision of the periosteum.

All procedures conducted in studies involving human participants were in compliance with the ethical standards set forth by the Institutional Review Board (IRB) and adhered to the principles outlined in the 1964 Helsinki Declaration and its subsequent amendments or comparable ethical standards. Ethical approval for this study was obtained from the Sağlık Bilimleri Üniversitesi Institutional Review Board (ApprovalNo.: KAEK 2024 143 Date: June 21, 2024) Written informed consent was obtained from all participants prior to their inclusion in the study. Statistical analysis was performed using SPSS version 19.0 (IBM Corp., Armonk, NY, USA). Continuous variables were analyzed using the independent samples *t*-test depending on data distribution. A *P*-value < .05 was considered statistically significant.

Surgical Technique

The angle between the vertical line passing through the most medial aspect of the defect in the medial canthal region and the horizontal line passing through the most inferior aspect of the planned flap in the forehead region on the same side was measured using a protractor. After determining the flap to be harvested from the forehead region according to the size and shape of the defect, the flap was designed with the supratrochlear artery of the contralateral side as the base. The proximal portion of the designed flap was de-epithelialized from its base. Maximum care was taken to preserve the dermal plexus (Figure 1). While elevating the flap above the periosteum (in a thin layer), dissection was performed under the periosteum as the dissection proceeded from the proximal to the base of the flap (Figure 2). After preparing the flap, subperiosteal dissection was performed in the glabellar region, followed by the creation of a supraperiosteal tunnel over the nasal bone to allow flap passage while preserving periosteal attachments. The flap was then passed through this tunnel and adapted to its new position. For smaller defects, the donor site was closed primarily with wide undermining to avoid eyebrow displacement. For larger defects, a full-thickness skin graft harvested from the supraclavicular area was utilized to prevent tension. Secondary intention healing was not employed in any case.

Results

The mean age of the 10 patients who underwent low rotation arc reconstruction was 76 years (± 11.4 SD), with an average defect size of 4.47 cm^2 (± 0.50 SD). These patients had an average hospital visit frequency of 2.33 (± 0.58). No complications were observed in this group (Table 1).

The mean age of the 10 patients who underwent high rotation arc reconstruction was 69.1 years (± 3.9 SD), with an average defect size of 4.54 cm^2 (± 0.86 SD). These patients had an average hospital visit frequency of 50 (± 1.15). In this group, desepithelialization was observed in the flaps of 4 patients, while partial flap necrosis occurred in 2 patients, and total flap necrosis was noted in 1 patient (Table 1).

Figure 1. Illustrates the design of the flap (F) to appropriate dimensions for the defect area and the preparation of its proximal portion by de-epithelialization while preserving the dermal plexus (D).

Figure 2. Demonstrates the elevation of the flap after its design. The flap is meticulously raised over the periosteum in the area indicated by the black arrow. Subsequently, in the region indicated by the red arrow, the flap is prepared beneath the periosteum to preserve its pedicle.

Statistically, patients who underwent reconstruction with a low rotation arc had significantly fewer hospital visits (P = .002) and fewer complications (P = .008).

In the long term, no complications, including tumor recurrence, were observed. Pathology results revealed that 85% of the tumors were basal cell carcinoma, while 15% were squamous cell carcinoma.

Discussion

Reconstruction of the medial canthal region can be achieved through various methods ranging from grafting to flaps. However, due to the complex anatomical structure of this region and the potential complications such as ectropion resulting from graft contraction, surgeons have increasingly turned to flaps.[11] Several flap designs have been proposed for reconstruction in this area.[12] Pierrazi et al[13] utilized the orbicularis oculi myocutaneous flap, whereas Kashimura et al[14] employed the Hug flap to address defects in this region. Despite the availability of numerous flaps such as the glabellar flap and cheek advancement flap, the forehead flap emerges as a significant reconstruction option in this area.[15]

Forehead flaps offer a reliable and effective solution for reconstructing various facial defects and deformities. In reconstructive surgery, forehead flaps are commonly used for nasal, cheek, periocular, ear, and lip reconstructions.[16] Their ability to match surrounding tissue texture and contour makes them effective for restoring form and function in facial defects caused by trauma, cancer, or congenital conditions.Their versatility, combined with advancements in surgical techniques and technology, continues to expand their applications and improve outcomes for patients requiring facial reconstruction.[17] Advanced medial canthal malignancies may invade the orbit and, in some cases, require orbital exenteration, so it is crucial for that area needs to be reconstructed effectively.[18]

However, when referring to the forehead flap, the classical 2-staged forehead flap is commonly associated in the literature. Two-staged forehead flaps involve raising the flap in 2 steps: first,

Table 1. Supplemental

Parameter	High Rotation	Low Rotation	*P*
Sex (M/F)	5/2	3/0	
Age (mean ± SD)	69.1 ± 3.9	76.0 ± 11.4	
Complications (n, %)	7 (100.0)	0 (0.0)	.008
Defect size (mean ± SD)	4.54 ± 0.86	4.47 ± 0.50	.873
Hospital visits (mean ± SD)	5.00 ± 1.15	2.33 ± 0.58	.002

Shows the demographic characteristics of the patients, defect size in square centimeters, flap rotation angle, hospital visits, and complications.

transferring it to the recipient site without complete closure, allowing vascularization; second, completing the transfer and closing the donor site. This staged approach aims to reduce the risk of flap necrosis, particularly useful for complex defects with poor vascularity or requiring significant tissue transfer.[19]

However, given the 2-staged nature of the classical forehead flap, a minimum of 2 surgical procedures is required, thus increasing the surgical and hospital visit burden, particularly affecting elderly individuals and those with limited access to healthcare facilities. Consequently, this escalates the overall treatment costs significantly. Additionally, patients undergoing this procedure may experience an interim period with unfavorable aesthetic outcomes prior to the completion of the second stage, further contributing to their discomfort and psychological distress.[20]

This study aimed to highlight the use of single-stage forehead flap reconstruction for patients not eligible for skin grafting. This approach is expected to not only reduce hospital costs but also enhance the quality of life by decreasing dependency on hospital visits, particularly among the elderly population. The reason for the unsuitability of the skin graft was the tumor invasion extending into the periosteum. To cover the deperiosted area, a flap was chosen as the reconstructive option. One of the objectives of this study is to popularize a method that minimizes complications associated with the single-stage use of the forehead flap, which has received limited attention in the literature thus far.

In this study, it was observed that when the flap design was made with a low rotation angle, it exhibited significantly fewer complications compared to those with a high rotation angle. Additionally, as a natural consequence of the lower complication rate, patients had significantly fewer hospital visits. Therefore, the low rotation angle tunneled forehead flap yielded more optimal outcomes.

Upon examining the defect sizes, it was found that in patients undergoing repair with low rotation angle flaps, an average of 4.47 cm^2 wide defects were successfully closed without complications. However, in cases where flaps were designed with a high rotation angle, closing an average of 4.54 cm^2 wide defects, issues such as desepithelialization, partial necrosis, and even total necrosis were encountered. Mild asymmetric brow elevation was observed in 2 patients (both in the high-rotation group). In both cases, the asymmetry was minimal, did not interfere with eyelid function or vision, and was well tolerated by the patients. No surgical revision was deemed necessary, and the asymmetry gradually improved within 6 months postoperatively but not completely resolved.

In future studies, increasing the sample size and conducting more detailed examinations regarding etiology and accompanying diseases may lead to more comprehensive and reliable results. One significant limitation of this study is its focus on optimizing the forehead flap used in medial region reconstruction. Aesthetic outcomes and patient satisfaction were not systematically evaluated in this study, representing a limitation. The forehead and medial regions represent distinct aesthetic units with differences in skin thickness, texture, and color. Aesthetically, a mismatch on texture should be anticipated. Future research should incorporate validated outcome measures to allow for objective comparison. Statistical comparisons with other flaps in the literature were not conducted. However, in future research, comparing the forehead flap with alternative options for medial canthal region reconstruction can help determine the most ideal reconstruction method.

All in all, thetudy demonstrates that single-stage forehead flap designed with a low rotation arc is significantly more successful in reconstructing medial canthal region defects compared to those with a high rotation arc.

Conclusion

In conclusion, the utilization of single-stage forehead flap with a low rotation arc in medial region reconstruction yields superior outcomes with fewer complications compared to single-stage forehead flap with a high rotation arc. Therefore, it emerges as the optimized flap method for use in this area, providing successful results in single-stage repair.

Case: A 71-year-old female patient with a defect extending from the left medial canthal region to the nasal sidewall, due to previous excision followed by grafting, presented with positive surgical margins necessitating further intervention. A single-stage tunneled forehead flap with low rotation arc procedure was planned for repair following excision. Initial excision revealed a 5.4 cm^2 defect (Figure 3A). Subsequently, a pedicled flap was designed

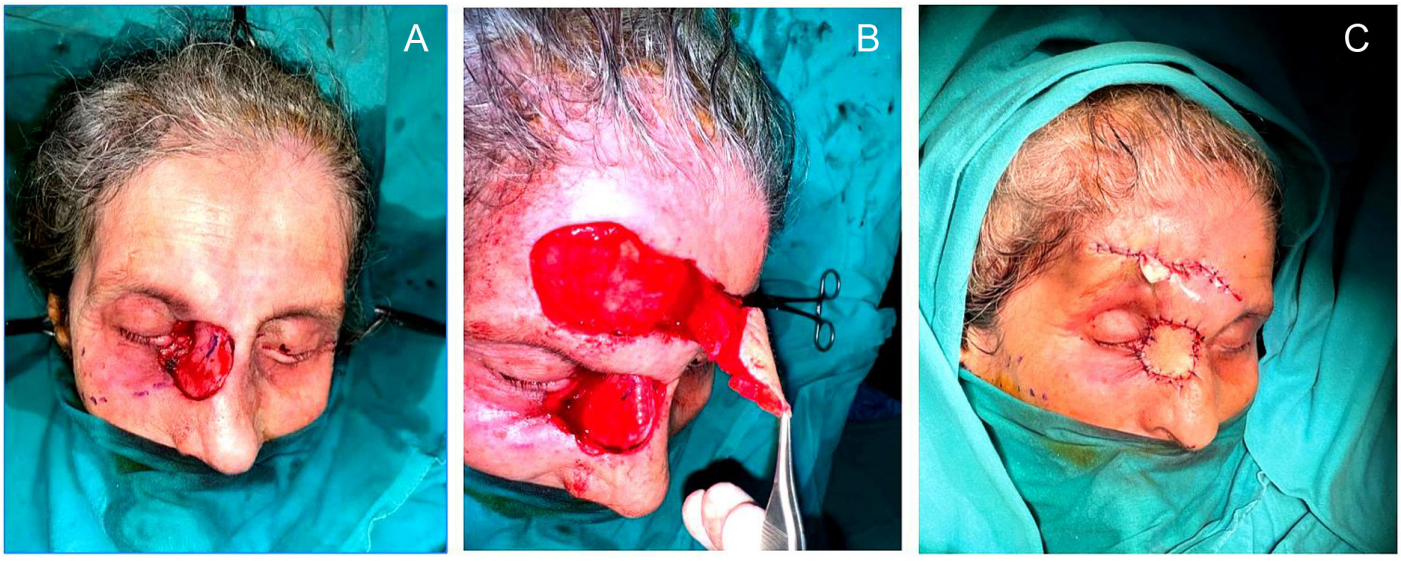

Figure 3. (A) The post-excision defect area is depicted. (B) The elevated state of the flap after preparation is shown. (C) Adaptation of the flap to the defect area and primary closure of the donor site are illustrated.

from the same side, based on the contralateral supratrochlear artery (Figure 3B). Following flap preparation, it was tunneled from the glabellar region and adapted to the defect site. The donor site was closed primarily (Figure 3C).

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Sağlık Bilimleri Üniversitesi (Approval no: KAEK 2024 143; Date: June 21, 2024).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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