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ORIGINAL ARTICLE
Reconstructive

Aesthetic and Functional Reconstruction of Periorbital Region Using Radial Forearm Free Flap

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Background: This study describes the utilization of the radial forearm free flap (RFFF) for the restoration of severe soft tissue deficiency involving the upper and lower eyelids in three patients.
Methods: This study is a retrospective review of the senior authors' clinical records for patients who presented with periorbital defect and underwent reconstruction with RFFF between 2018 and 2022.
Results: As a part of a comprehensive reconstructive surgery, we used the RFFF to deliver an ample amount of well-vascularized soft tissue. The flap's vessels were anastomosed to the ipsilateral facial vessels in all cases. Patients showed significant functional improvement, with complete eyelid closure achieved. No immediate postoperative complications were noted.
Conclusions: RFFF demonstrated optimal outcomes in upper eyelid reconstruction.
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INTRODUCTION

Eyelid reconstruction presents a notable challenge within reconstructive surgery, demanding a thorough understanding of the anatomical complexity of the eyelids to ensure both functional and aesthetic success. The upper eyelid comprises three layers: the anterior lamella, which includes the skin and orbicularis oculi muscle; the middle lamella, consisting of the orbital septum and preseptal/postseptal fat; and the posterior lamella, composed of the tarsus and conjunctiva. Above the tarsus, we have the lid retractors (levator palpebrae superioris and Müller muscle) posterior to the postseptal fat, then the conjunctiva.

The layers of the lower lid are similar to those of the upper except that the lid retractors consist of the capsulopalpebral fascia and the inferior tarsus muscle (instead of the levator muscle, and Müller muscle respectively).[1,2]

Eyelid defects can arise from an array of causes, such as congenital abnormalities, traumatic injuries, or as sequelae of oncologic excisions.[3] The loss of tissue in these areas poses significant concerns due to the eyelid's necessity to retain mobility, flexibility, and a suitable mucosal surface for corneal contact. The reconstructive approach is determined by the defect's extent, with local flaps serving well in limited defects[4–6]; however, extensive, full-thickness deficiencies often necessitate more intricate procedures, such as free tissue transfer.[7–13] The radial forearm free flap (RFFF) is a well-established method for reconstructing considerable defects in the head and neck region, particularly when thin and pliable tissue is required. The flap's pedicle length is pivotal, with the radial forearm offering the necessary length for microvascular anastomosis.

This study showcases the application of the RFFF in the reconstruction of large eyelid defects. Previous literature has documented its use in both isolated eyelid reconstruction and as a component of total eyelid restoration.[7–10,14,15] We detail the procedures within the context of a comprehensive surgical treatment plan.

PATIENTS AND METHODS

Following the guidelines set by the Declaration of Helsinki, we received institutional review board approval (protocol no.: 2020-011). We then retrospectively assessed the senior authors' clinical records for patients presented with periorbital defects between 2018 and 2022. All patients were consented for utilizing the photographs in this study. The patients who underwent RFFF for reconstruction, either with or without other reconstructive procedures, were reviewed. The study involved defect analysis, operative detail, and outcomes during the follow-up.

Disclosure statements are at the end of this article, following the correspondence information.

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RESULTS

Over the study period, there were three patients who underwent RFFF for periorbital reconstruction. The defects of the patients were different and required customization of the RFFF. The patient history and operative details are explained case by case below. The follow-up period ranged from 1 to 3 years.

Surgical Technique for Flap Harvest

The flap is harvested under tourniquet control after exsanguination. The elevation usually starts in the

Takeaways

Question: Can a radial forearm free flap (RFFF) be customized to fit in different defects in the periorbital region?

Findings: We present the results of the senior surgeon using the RFFF to reconstruct the different types of defect in the periorbital region.

Meaning: The RFFF is a feasible option that can be customized to execute various kinds of defects in the periorbital region.

Fig. 1. Preoperative photographs of the patient in case 1. A, Eyes open. B, Eyes closed.

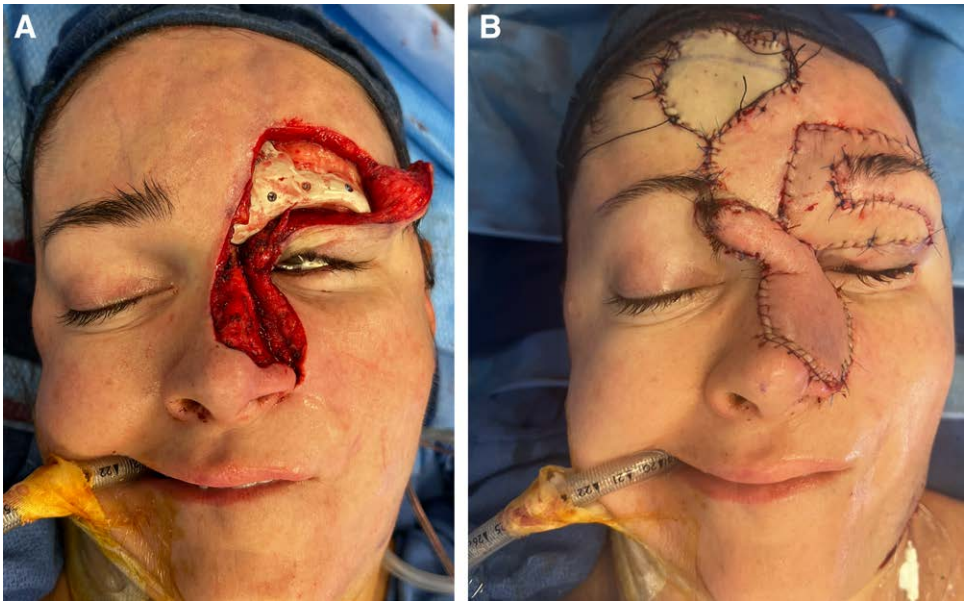

Fig. 2. Operative photographs. The created nasal and brow and eyelid defects with the custom PEEK implant inserted while the brow flap was flipped laterally (A). The forehead flap covered the nasal defect with split-thickness skin grafting to the donor site, and the RFFF covered the brow and eyelid defect with central de-epithelialization for insetting the brow flap (B).

subfascial plane at the ulnar border while preserving paratenon of the tendons. To additionally incorporate the palmaris longus (PL) tendon for reconstruction, elevation continues deep to the tendon instead of superficial to the tendon in the cases that the PL is preserved. The palmar cutaneous branch of the median nerve is preserved. Once the intermuscular septum containing the radial artery and venae comitantes is reached, radial incision is made to proceed flap elevation from the lateral side. Cephalic vein and superficial radial nerve are preserved in all cases. Brachioradialis tendon is then retracted to reveal the intermuscular septum. The septum is then divided deep to the vascular pedicle. At the proximal incision of the flap, triangular tapering fasciocutaneous tissue is designed. This tissue provides additional coverage to the pedicle and relieves tension over the pedicle. The vascular pedicle is then dissected up to its origin. No flap thinning is performed in this case series. For the donor site closure, skin pinch test is used to decide whether to close it with full-thickness skin graft from groin area (case 1) or primarily (case 2 and 3). The donor site healed uneventfully in every case without functional problems or cold intolerance.

Fig. 3. Illustrations of the case 1 operative details. Brow flap (black arrow), custom PEEK implant (white arrow), forehead flap (white arrowhead), skin grafting over the forehead donor site (double white arrowheads), RFFF (double black arrowheads) with central de-epithelialization for brow flap insetting.

Case 1: Advanced Reconstruction in Parry Romberg Syndrome

A 43-year-old woman with a protracted history of Parry-Romberg syndrome presented with multiple reconstructive procedures in her medical history, including cranioplasty, full-thickness skin grafts to the upper lid, orbital roof bone grafting, and midface reconstruction using a scapula free flap, with the most recent surgery occurring 20 years prior. The series of operations were performed by different surgeons, not including the author. She had developed significant soft tissue atrophy on the left nasal sidewall and upper lid, resulting in brow contractures, enophthalmos, lagophthalmos, glaucoma, and chronic dry eye due to the incomplete closure of the upper eyelid (Fig. 1). Pending hardware extrusion was also present.

Refer to Figure 2 for a visual representation of the surgical technique. The procedure initiated with a release of scar contractures affecting the left upper eyelid and brow, extending to the lower forehead, leading to an 8×6cm soft tissue defect. Preservation of the left eyebrow structures and position was achieved by harvesting a laterally based cutaneous flap that was flipped laterally for RFFF inset in the later process. Concurrently, problematic supraorbital rim hardware was removed, and excess bone grafts were reshaped to align with the orbital roof. A custom PEEK implant was then used to reconstruct the superior and lateral orbital rims.[16] To address the upper eyelid deficit, a left RFFF was harvested and inset, and microvascular anastomosis was conducted using the left facial vessels. The central portion of the flap was de-epithelialized to accommodate the eyebrow flap over

Fig. 4. Six months postoperative follow-up.

the exposed forearm flap dermis. Finally, a forehead flap was utilized to repair the defect on the left nasal sidewall following contracted skin excision and split-thickness skin grafting to the donor site. An illustration demonstrating the procedure details is depicted in Figure 3. Postoperative course was uneventful until the recent follow-up at 1 year, and postoperative result is shown in Figure 4.

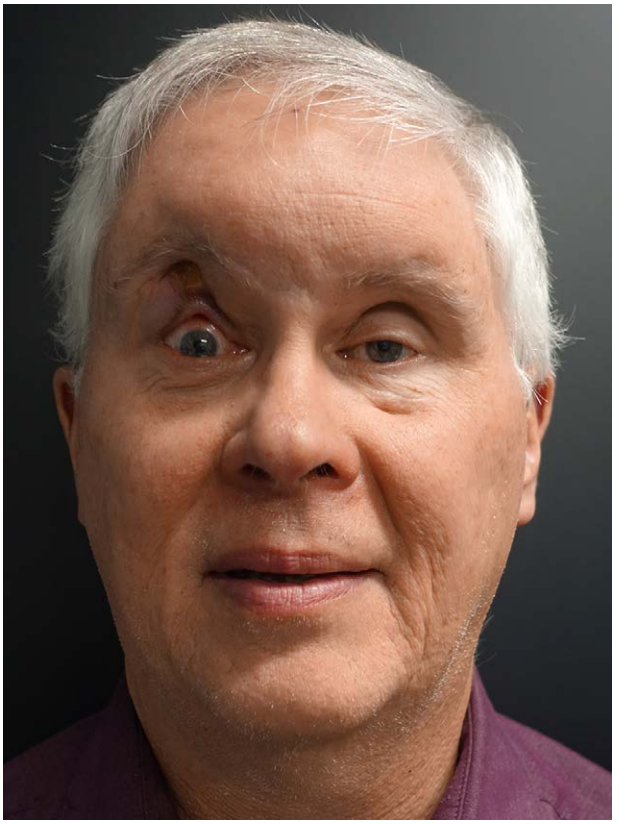

Fig. 5. Preoperative photograph showing right upper eyelid contracture of the patient in case 2.

Case 2: Right Upper Eyelid Reconstruction Posttrauma

A 64-year-old man with a history of severe head trauma and associated facial fractures had undergone multiple reconstructive procedures. Despite these interventions, he presented with a right upper eyelid scar contracture and retraction, impairing eyelid closure (Fig. 5).

The operative process began with the release of the right upper eyelid scar contracture. The upper skin flap was undermined towards the supraorbital rim, and the scar was excised down to the lash line, measuring 3×2 cm. The levator muscle was meticulously dissected off the scar tissue. As the patient refused to have an additional scar over his facial area that may concern his job, we elected to forego this option. A right RFFF was harvested and connected through microvascular anastomosis between the radial and superficial temporal arteries, using a coupler device for venous anastomosis. The flap filled the defect over the right supraorbital region and upper eyelid. The operative pictures are shown in Figure 6. Postoperative course was unremarkable up until the last follow-up at 3 years, and postoperative result at 18 months is shown in Figure 7.

Case 3: Right Lower Eyelid and Midface Reconstruction

A 64-year-old woman, with a history of facial trauma and multiple subsequent procedures, including forehead flap, presented with dry eye, right lower eyelid scar contracture, and sclera show (Fig. 8).

Regarding the operative detail (Fig. 9), scar release began along the right lower eyelid, extending to the inferior orbital rim while preserving the inferior orbital nerve. The local flap options, such as the Fricke flap, were opted

Fig. 6. Intraoperative photographs showing contracture release and re-creation of the soft tissue defect at the right upper eyelid (A) and at completion of the procedure showing final closure after inset of the RFFF (B).

out because they may result in aggravating the difference in brow position and superior sulcus deformity.[17] Also, the lower eyelid malpositioning may not be corrected without a sling support. A left RFFF was harvested, incorporating a 10-cm PL tendon graft. Microvascular anastomosis between the radial artery and superficial temporal artery was achieved, with venous anastomosis facilitated by a coupler device. The tendon graft was anchored medially to the periosteal layer of the nasal bone and laterally to the orbital rim, forming a sling to prevent flap migration. The RFFF skin paddle was inset, completing the lower eyelid and midface reconstruction. Postoperative course was uneventful until the recent follow-up at 3 years, and postoperative result at 18 months is shown in Figure 10.

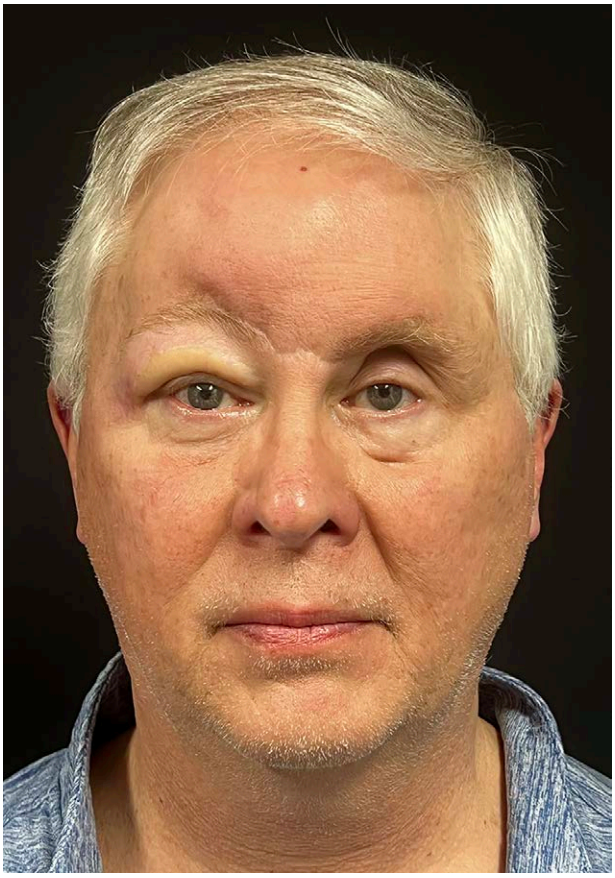

Fig. 7. Eighteen months postoperative follow-up.

DISCUSSION

Eyelid reconstruction stands as a testament to the complexity of blending reconstructive precision with aesthetic subtlety. The eyelid's role in facial expression, ocular health, and visual function cannot be overstated. For the

Fig. 8. Preoperative photograph showing right lower eyelid contracture of the patient in case 3.

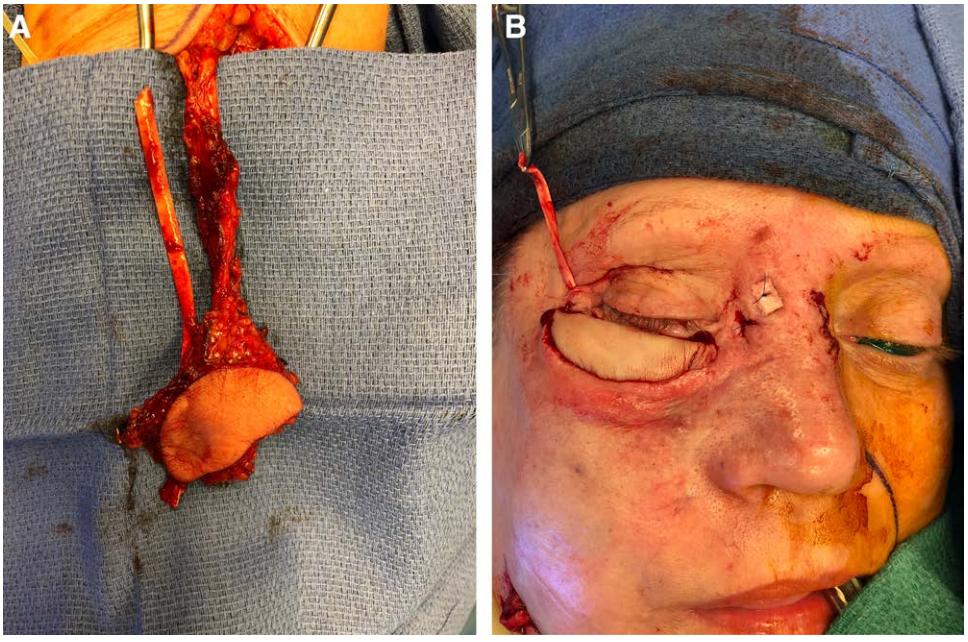

Fig. 9. Intraoperative photographs showing harvested RFFF with a sling of palmaris longus tendon (A) and inset of the RFFF and preparing PL graft to be anchored (B).

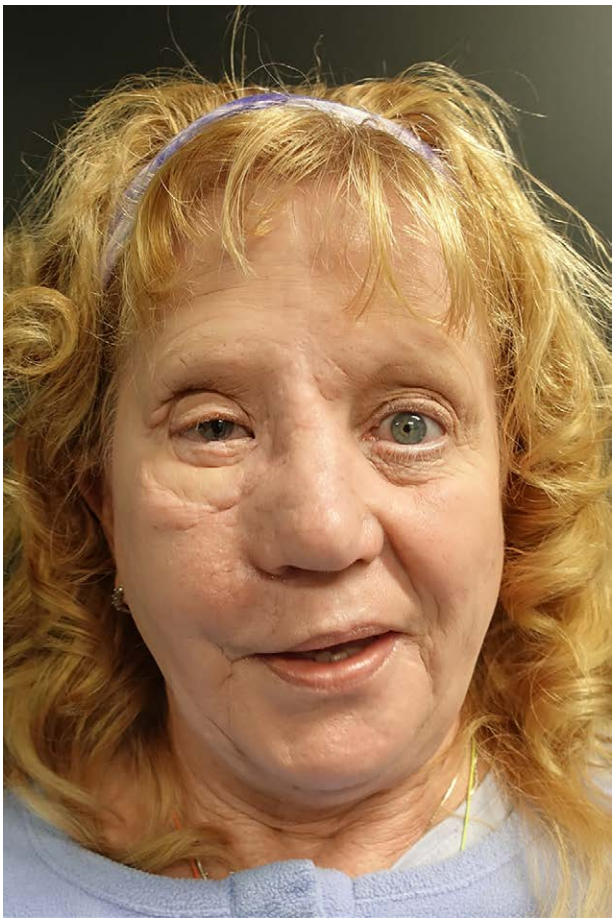

Fig. 10. Eighteen months postoperative follow-up.

periorbital reconstruction, there are various flap options with unique advantages and disadvantages (Table 1). The RFFF, with its pliable and thin characteristics, offers an exceptional solution for repairing defects while maintaining the delicate balance of eyelid function.

The anatomy of the radial forearm flap, particularly its vascular composition, allows for a robust and reliable blood supply to the reconstructed area. The radial artery's caliber and the venae comitantes provide a circulatory redundancy that ensures the viability of the flap. When dealing with defects that include loss of both anterior and posterior lamellae, the RFFF can be tailored to include skin, subcutaneous tissue, and even a segment of the radial bone if structural support is required. A key advantage of the RFFF is its versatility. The flap's skin can be matched to the recipient site in terms of texture and color. Moreover, the flap's thinness is a crucial characteristic that enables it to conform to the complex contours of the eyelid, making it look more natural and less conspicuous. For dynamic reconstruction, particularly in patients with compromised levator function or when reconstructing the entire upper eyelid complex, the inclusion of the PL tendon within the flap allows the re-creation of a functional tarsal structure.[8,10] This tendon can be sutured to the remnant of the levator muscle or its aponeurosis, or alternatively to the periosteum of the orbital rim, to re-establish the mechanical action required for eyelid elevation. The microvascular anastomosis technique used in attaching the RFFF is pivotal. Given the small and fragile vessels involved in eyelid reconstruction, the choice of recipient vessels is critical. The facial vessels often provide a suitable match in terms of size and position. The venous anastomosis, facilitated by microvascular couplers, adds efficiency and reliability to the procedure, which is essential in preventing complications such as flap congestion or ischemia.

The literature on upper eyelid reconstruction documents an array of complex cases that highlight the ingenuity and adaptability required in oculoplastic surgery.[4–10,14,15] For instance, Iwanaga et al devised an innovative method using a composite radial forearm–PL tendon flap, adeptly addressing full-thickness defects by restoring both the anatomical integrity and the functional mechanics necessary for eyelid movement.[10] Meanwhile, Kushima et al introduced a groundbreaking technique to reconstruct the gliding surface of the extraocular muscles, ensuring that patients could achieve not only complete lid closure but also retain the full spectrum of eye movements—a critical aspect of ocular health and functionality.[14] Ueda et al further expanded the versatility of reconstructive methods by demonstrating how an RFFF can be effectively used in the nuanced and intricate reparative needs of both upper and lower eyelids, underscoring its utility in the delicate balance of cosmetic and reconstructive periorbital surgery.[8] These varied approaches represent the forefront of surgical innovation, offering significant hope and improved outcomes for individuals requiring complex eyelid reconstructions. These instances illuminate the RFFF's role in

Table 1. Flap Options for Extensive Periorbital Reconstruction

		Skin Island and Reconstruction Potential				
Flaps	**Characteristic**	**Anterior Lamella**	**Middle Lamella**	**Posterior Lamella**	**Sensory Restoration**	**Pedicle Length**
Free dorsalis pedis flap[18]	Thin and pliable	+	–	–	Superficial peroneal nerve	++
ALT free flap[11,12,19]	Thick and bulky (Possibly thinning)	+	+	–	Lateral cutaneous femoral nerve	+++
First web space of the foot[20]	Thin	+	–	+ (folded inset)	Deep peroneal nerve	+
SCIP[11]	Thin	+	–	–	Lateral cutaneous branch of intercostal nerves	+ (depends on anatomical variance)

not just providing tissue coverage but in restoring the complex anatomy and functionality of the eyelids, crucial for patients with significant tissue loss or deformation.

In the presented case of a patient with Parry-Romberg syndrome, the RFFF utility was further challenged by the progressive hemifacial atrophy characteristic of the syndrome. This required a highly individualized approach, considering not only the current defect but also anticipating the potential for future tissue changes. The successful outcome of this case reinforces the RFFF's status as a prime choice for surgeons when facing the most demanding reconstructive scenarios.

In sum, the RFFF embodies the principles of reconstructive surgery at their finest—respect for the aesthetic and functional anatomy, technical finesse in execution, and a profound understanding of the patient's clinical journey. This method continues to demonstrate outstanding outcomes in upper eyelid reconstruction, and its continued use and study further refine the art and science of reconstructive surgery.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Patients provided written consent for the use of their images.

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