Bipaddle Radial Forearm Flap for Head and Neck Reconstruction

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Background: Although the radial forearm free flap has become a workhorse flap in head and neck reconstruction, the skin grafting of the donor is the main drawback resulting in an unacceptable contour deformity and an unsightly appearance. Several technical modifications have been therefore applied to the radial forearm (RF) flap marking, elevation, and inset to overcome this major shortcoming. In this article, we report our clinical series with the bipaddle RF flap.

Methods: The authors described their 11 cases of head and neck oncologic reconstruction with the bipaddle RF flap. The skin island is designed longer and narrower and split into 2 separate skin paddles each nourished by a proximal and a distal independent perforators raising from the radial artery so that the donor site could be closed directly. The narrow design of the skin paddle and the subsequent splitting in its 2 components applying the "perforator-pedicle propeller flap method" allow for the changing of the flap shape according to the shape of the recipient site defect.

Results: From 2007 to 2013, the bipaddle RF flap method was used in 11 patients to restore head and neck defects following cancer ablation. The mean age of the patients was 43 years, ranging from 31 to 50 years. The location of the defects was the tongue (n = 7) and the intraoral region (n = 4). The defect sizes varied from 4 × 5 cm to 5 × 6 cm, and the flap maximum width was 3 cm with mean area of 26.4 cm^2. The healing was uneventful in all patients with excellent cosmetic and functional results of both donor site and recipient site after 20 months of mean follow-up.

Conclusions: The bipaddle RF free flap is a reliable and versatile option for the reconstruction of a wide range of soft tissue defects of head and neck region. This method allows for a customized resurfacing of the defect because of its large variability in shape and size. The harvesting site is closed primarily, and a second donor site for skin graft is avoided.

Clinical Question, Level of Evidence: Therapeutic, IV

Key Words: Bipaddle, radial forearm flap, kiss flap, head and neck, donor site

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Since Yang and colleagues[1] first introduced the radial forearm (RF) flap in the clinical practice in 1978, it has become a versatile and reliable method for reconstructive microsurgery. Flap characteristics include thin, pliable fasciocutaneous tissue, a long vascular pedicle with vessels of large caliber, reliable anatomy, relative hairlessness, good sensation, and relative ease and simplicity of flap elevation, making this flap suitable for various kinds of high-risk reconstructions and cases where only a thin coverage is needed.

Despite all these advantages, the main drawback of the RF flap is the unacceptably high donor-site morbidity due to the sacrifice of 1 of the major artery of the upper limb, the possible numbness of the dorsal aspect of the hand, and the aesthetically unfavorable scar because of the requirement of skin graft coverage of the harvesting site that can often not be closed primarily with a certain risk of complications such as tendon exposure and infection.[2] Several technical modifications have been therefore applied to the RF flap marking, elevation, and inset to overcome these major shortcomings and include the extended RF flap,[3] the distally based RF flap,[4,5] the transverse RF flap,[6] the perforator-based flap,[7–9] and the shape-modified radial artery perforator flap.[10–12]

To capitalize all the advantages of the traditional RF flap minimizing donor-site morbidity, we describe in this article a variation of the RF flap applying the "perforator-pedicle propeller flap method." A longer and narrower RF flap was designed and divided in its 2 components, each nourished by a proximal and a distal independent perforator arising from the radial artery as 2 small perforator flaps that can be rotated as a propeller flap with the small perforator as axis. In this way, the paddles can be tailored and altered to exactly match the shape of the recipient site defect to resurface a single large defect. The use of this flap design provided a tension primary closure of the donor site without any further morbidity.

TABLE 1. Our Series of 11 Bipaddle Radial Forearm Flaps

Patients	Sex and Age, y	Defect Location	Etiology	Radiation Therapy	Defect Size, cm	Flap Size, cm	Donor Site	Complications and Follow-up
1	M, 43	Tongue	SCC	No	6 × 5	6 × 3 and 6 × 2, 30 cm^2	Primary closure	None, 37 mo
2	M, 45	Tongue	SCC	No	6 × 4.5	5.5 × 2.5 and 5.5 × 2.5, 27.5 cm^2	Primary closure	None,37 mo
3	M, 38	Oral cavity	SCC	No	5 × 4	5 × 2 and 5 × 2, 20 cm^2	Primary closure	None, 33 mo
4	F, 42	Oral cavity	SCC	No	5 × 5	5 × 2.5 and 5 × 2.5, 25 cm^2	Primary closure	None, 28 mo
5	M, 50	Tongue	SCC	No	6 × 5	6 × 3.5 and 6 × 2.5, 36 cm^2	Primary closure	None, 25 mo
6	M, 47	Oral cavity	SCC	Postoperative 60 Gy	5.5 × 5.5	5.5 × 3 and 5.5 × 2.5, 30.25 cm^2	Primary closure	None, 20 mo
7	F, 31	Tongue	SCC	No	5 × 4.5	5 × 2.5 and 5 × 2, 22.5 cm^2	Primary closure	None, 16 mo
8	F, 38	Tongue	SCC	No	5 × 4.5	5 × 2.5 and 5 × 2, 22.5 cm^2	Primary closure	None, 14 mo
9	M, 44	Tongue	SCC	No	5.5 × 5	5.5 × 2.5 and 5.5 × 2.5, 25 cm^2	Primary closure	None, 11 mo
10	M, 50	Tongue	SCC	Postoperative 56 Gy	5 × 4.5	5 × 2.5 and 5 × 2, 22.5 cm^2	Primary closure	None, 5 mo
11	M, 49	Oral cavity	SCC	No	6 × 5	6 × 2.5 and 6 × 2.5, 30 cm^2	Primary closure	None, 3 mo

M indicates male; F, female; SCC, squamous cell carcinoma.

In the present investigation, we retrospectively reviewed our series of 11 cases in which such variation of the original flap was applied and the vascular basis of our method and the advantages in terms of morbidity over other previous modifications in RF flap methods are described.

PATIENTS AND METHODS

Patients

From 2007 to 2013, the bipaddle RF flap method was used in 11 patients to restore head and neck defects following cancer ablation. Eight were male, and 3 were female. The mean age of the patients was 43 years, ranging from 31 to 50 years. The location of the defects was the tongue (n = 7) and the intraoral region (n = 4). The defect sizes varied from 4 × 5 cm to 5 × 6 cm with a mean size of 5.5 × 4.7 cm. None of the patients had previous irradiation or surgery. The patients and their flap characteristics are summarized in Table 1.

Methods

Before surgery, the radial and ulnar artery competencies of each patient were examined with Allen test and with a handheld Doppler device. In all cases, the first step of the operation provided for complete resection of tumor at the recipient site. Depending on the precise size and shape of the defect, a long and narrow longitudinal-shaped RF flap was marked along the vascular territory of the radial artery on the RF so that the donor site could be closed primarily. According to the principle of converting flap breadth to flap length, the size of the defect was measured by approximating the wound shape as a circle or an ellipse, and then, with the help of a paper template with the same dimensions, the total area of the 2 skin paddles of the flap was calculated to be adequate to resurface the single defect. The size of the skin paddle varied depending on the skin laxity of the forearm; the pinch test defined the maximum width of the ellipse of the forearm skin that could be recruited and harvested while maintaining the donor-site direct suture.

Elevation of the flap was similar to conventional RF flap under general anesthesia and tourniquet control. The dissection proceeded in a subfascial plan, from both the radial and ulnar sides to identify the perforators until the flap was completely islanded. Attention was paid to preserve the superficial radial nerve and the deep fascia. The radial artery and its venae comitantes were identified and dissected proximally up to the necessary length. After the removal of the tourniquet, the perfusion was checked. The longitudinal skin paddle was then divided in its 2 proximal and distal components reproducing the required shape to resurface the defect, taking care to not damage the perforators. Applying the "perforator-pedicle propeller flap method," the skin paddles were rotated on their own perforator, stacked side by side, and sutured together avoiding, the kinking of the pedicle. The proximal origin of the pedicle was then ligated and anastomosed to the recipient vessels. The donor site was finally closed primarily.

RESULTS

The results from the retrospective review of our series are summarized in Table 1. We used the bipaddle RF flap to successfully treat 11 patients. The flap sizes ranged from 20 to 36 cm^2 with a mean area

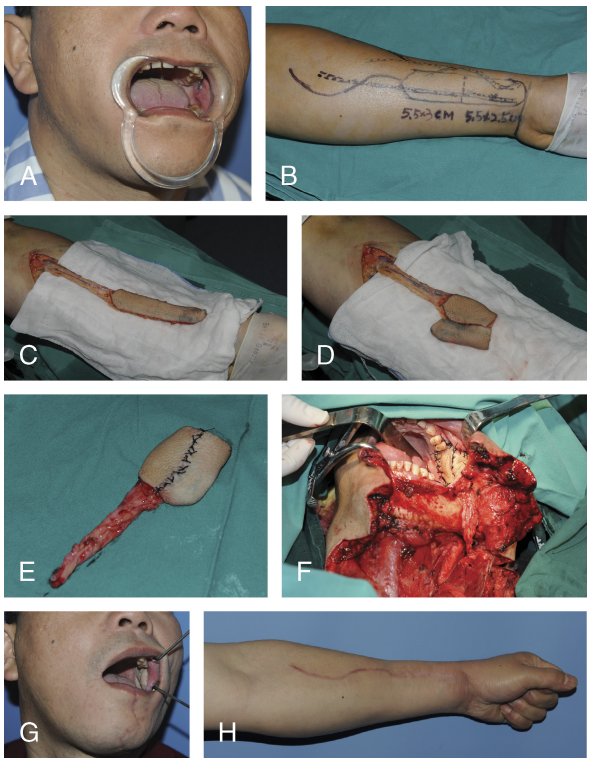

FIGURE 1. A, A 47-year-old man presented with a squamous carcinoma of the left retromolar trigone. B, A left RF flap (5.5 × 3 cm and 5.5 × 2.5 cm) was designed and (C) harvested to reconstruct the defect. D, The original skin island was divided in 2 paddles, each one nourished by an independent perforator of the radial artery. E, They were placed side by side "kissing" together and sutured obtaining a single skin paddle having the size of 30.25 cm^2. F, The flap was inset and anastomosed to the facial vessels. G and H, Postoperative view at 20 months of follow-up with an optimal result.

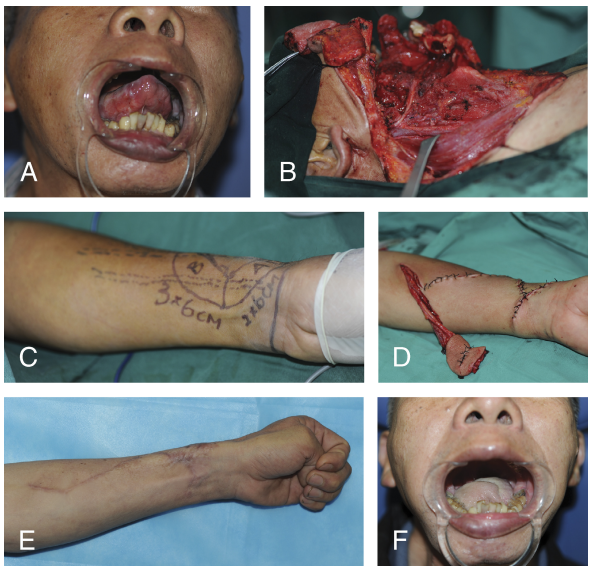

FIGURE 2. A, A 43-year-old man was diagnosed with squamous cell carcinoma involving the right half of the tongue. B, The defect after the excision of the tumor and neck dissection. C, A left horseshoe-shaped free bipaddle RF flap was designed and (D) harvested and divided into 2 parts (6 × 3 cm and 6 × 2 cm), each based on a radial artery perforator. Primary closure of the donor site was achieved. E and F, No complications occurred, and 37 months after the operation, results at the donor and the recipient sites were excellent.

of 26.4 cm^2. The maximum width of the original RF flap skin paddle was 3 cm to allow the primary closure of the donor site in all cases. The healing was uneventful in all patients with excellent cosmetic and functional results of both donor site and recipient site after a mean of 20 months of follow-up.

Clinical Reports

Patient 1

A 47-year-old man presented with a squamous carcinoma of the left retromolar trigone (Fig. 1). After neck lymph node dissection and the tumor resection (clear margins were obtained with intraoperative histological examination), a left RF flap was harvested to reconstruct the defect. The original skin island was divided in 2 paddles (5.5 × 3 cm and 5.5 × 2.5 cm), each one nourished by an independent perforator of the radial artery. They were placed side by side "kissing" together and sutured, obtaining a single skin paddle having the size of 30.25 cm^2. The donor site was sutured directly. The flap was anastomosed to the facial vessels. The flap healed successfully at 20 months of follow-up with an optimal result at the donor site.

Patient 2

A 43-year-old man who was diagnosed with squamous cell carcinoma involving the right half of the tongue underwent neck dissection and hemiglossectomy (Fig. 2). A left horseshoe-shaped free bipaddle RF flap was harvested and divided into 2 parts (6 × 3 cm and 6 × 2 cm), each based on a radial artery perforator. The flap was fitted in the recipient site and anastomosed to the facial vessels, and primary closure of the donor site was achieved. No complications occurred, and 37 months after the operation, results at the donor and the recipient sites were excellent.

Patient 3

A 38-year-old man had squamous cell carcinoma of his right retromolar trigone (Fig. 3). After neck dissection, the cancer was resected with 1 cm of free margin. A bipaddle left RF flap was planned with the 2 segments (5 × 2 cm and 5 × 2 cm) located along the vascular territory of the radial artery that were harvested and sutured together to compose the appropriate shape to fit the defect. At the recipient site, the vessels were anastomosed to facial artery and comitant vein. The flap survived completely with no complication at the donor site or at the recipient site after 33 months with good outcomes.

DISCUSSION

In the last 30 years,[1] the RF flap has been demonstrated to be a reliable method becoming a workhorse flap for reconstructive microsurgery because of its versatility and reliability. The advantages of RF flap such as the relatively easy dissection, the consistency of the vasculature with a long and large-caliber pedicle, the abundance of draining veins (the cephalic vein can be included if necessary), the hairless nature, the availability of cutaneous nerves that can be coapted if required, and the thinness and the pliability of the skin paddle have made this flap an excellent indication for the free microvascular intraoral reconstruction. Although this variety of tools increases the armamentarium of the reconstructive surgeon according to the needs of the recipient site, the high donor-site morbidity of the RF flap still remain a major drawback. The most frequently described complications include delayed healing and unpleasant cosmetic result of the skin graft used to cover the donor site, possible sensory changes, forearm deformity, and seldom wrist ankylosis.[13–15]

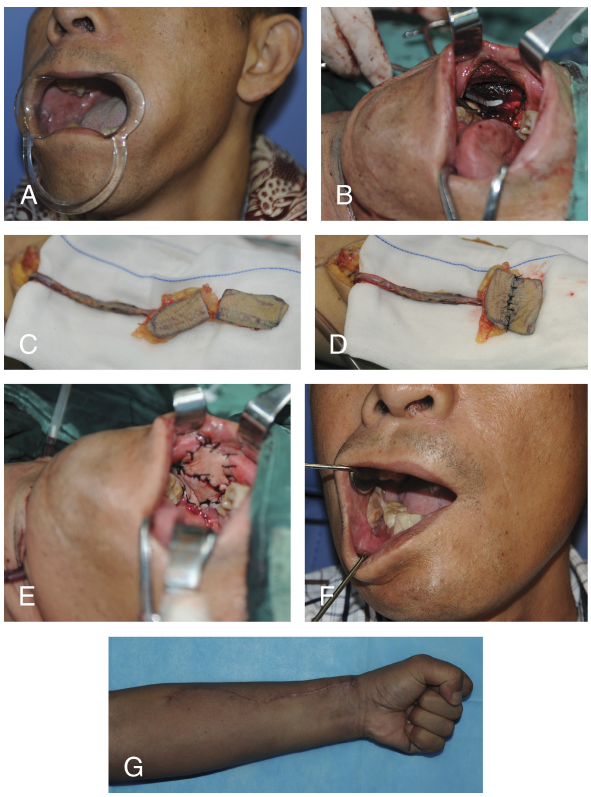

FIGURE 3. A, A 38-year-old man had squamous cell carcinoma of his right retromolar trigone. B, The defect after the cancer was resected with 1 cm of free margin. C and D, A bipaddle left RF flap was planned with the 2 segments (5 × 2 cm and 5 × 2 cm) located along the vascular territory of the radial artery that were harvested and (E) sutured together to compose the appropriate shape to fit the defect. F and G, The flap survived completely with no complication at the donor site or at the recipient site after 33 months with good outcomes.

The anatomical basis of the bipaddle RF flap has already been elucidated through several previous investigations on the vascular anatomy of the radial artery and its cutaneous perforator vessels.[15–17] Yang and Morris[18] found that the average number of radial artery perforators is approximately 12, the fascial branches being more numerous in the distal territory though smaller in caliber.[16,18–21] Furthermore, the safety of the splitting of the original skin paddle in 2 islands is due to the presence of at least 1 perforator nourishing the proximal and the distal parts and to the anastomoses of the cutaneous perforators that provide a rich vascular plexus running parallel to the main vessel (radial artery) and nourishing the overlying skin.[16,18–21] Perfusion investigations have already ascertained that a perforator entering the skin in the middle part of the forearm is able to supply the flap back to the proximal incision and up to four-fifths of the distal area, and a distal perforator can provide the supply proximally up to the elbow joint.[15,16] Although a venous congestion may be a consequence of the division of the paddle and on the stacking side by side of the 2 skin islands, we have never experienced that complication. The RF flap is claimed to require the sacrifice of a major vessels of the upper limb. Although someone reported a reduced blood pressure perfusion, ischemia, or motor dysfunction in the distal extremity after the RF flap harvesting compared with the contralateral healthy limb,[22] large sample size investigation showed no complications in the upper-limb circulation after the harvesting of the radial artery for a coronary graft.[23] Indeed, in our long experience of raising the RF flap including the bipaddle variant, we have never seen any serious short- or long-term vascular impairment of the harvesting site.

The use of the bipaddle technique has several advantages over the traditional method of harvesting the RF flap. The narrow design of the skin paddle and the subsequent splitting in its 2 components allow for the changing of the shape according to the shape of the recipient site defect (customized resurfacing). This can be achieved applying the concept of using simultaneously "perforator flaps" and "propeller flaps" called the "perforator-pedicled propeller flap method" originally described by Hyakusoku et al.[11,12,24,25] The 2 skin paddles as components of the original RF flap should be considered 2 small perforator flaps that can rotate around their axis (the perforator of the radial artery) as propeller flaps. The tension on the donor site is minimized, and it can be sutured directly minimizing the main drawback of the RF flap that is the high donor-site morbidity and the frequent postoperative local pain syndrome. All the advantages of the RF flap are preserved, and a second donor site for a skin graft is avoided.

With the bipaddle RF flap, it is possible to resurface a single large defect as described in the present investigation or to cover 2 separate small defects with a single flap and with only 1 set of microvascular anastomoses. In our series, some of the patients had small defects that could be covered with local flap (eg, facial artery musculomucosal flap).[26] We preferred the use of a free flap because in these patients local recipient vessels may be inadequate, and the neck may be vessel depleted because of neck dissection and radiation therapy; therefore, a long pedicle is often required. The thinness and the pliability of the RF flap made this flap more suitable for our cases than the anterolateral thigh flap that should have required immediate or secondary defatting and debulking. The RF flap was preferred over the lateral arm flap because of its strong vasculature and the length and caliber of the radial artery.

CONCLUSIONS

The bipaddle RF free flap harvested according to the perforator-pedicled propeller flap method is a reliable and versatile option for the reconstruction of a wide range of soft tissue defects of head and neck region. The modification allows for the primary closure of the donor site and for a customized resurfacing of the defect because of its large variability in shape and size, giving an excellent cosmetic result of both the harvesting and recipient sites.

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