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Research Article

The Radial Forearm Free Flap: A Versatile Method for Head and Neck Reconstruction; Our Experience

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Abstract

Background: The radial free forearm flap (RFFF) was one of the first free tissue transfer flaps to be described. It has since become a work-horse for soft tissue replacement in head and neck cancer surgery, being commonly used to replace external skin and internal mucosal linings.

Materials and Methods: This was a retrospective study on the reconstructions with microvascular radial forearm free flap in the head and neck area performed by physicians in the Head and Neck Service at our Hospital between June 2018 and January 2020. The aim of this study is to report our experience with radial forearm flap.

Results: A total of 14 reconstructions with microvascularized free forearm free flap were carried out.

Discussion: RFFF offers ease of harvesting and reliability due to its constant, reproducible vascular anatomy. It is also versatile owing to the relatively long pedicle and thin, pliable, hairless skin paddle. A two-team approach is possible in head and neck surgery, various forms being applicable, for example, free or pedicled, proximally or distally.

Conclusion: The key points are careful flap and template design, flap design on the forearm to include the lateral intermuscular septum as well as a superficial vein (usually cephalic), elevate medial and lateral fasciocutaneous parts of the flap and dissect to-wards the lateral intermuscular septum and Brachioradialis muscle is most critical element of elevating the flap.

Keywords: *Radial Free Forearm Flap (RFFF); Head and Neck Reconstruction*

Background

The radial free forearm flap (RFFF) was one of the first free tissue transfer flaps to be described. It has since become a work-horse for soft tissue replacement in head and neck cancer surgery, being commonly used to replace external skin and internal mucosal linings [1]. It is an extremely versatile flap allowing intricate folding of the skin, using two or more skin paddles/islands, and incorporating vascularized tendon and/or bone [2].

The radial forearm flap, sometimes called "the Chinese flap", is a free flap technique that was developed by Yang, Chen, Gao of the Shenyang Military Hospital in 1978 [3]. Yang., *et al*. (1981) reported the transfer of 60 forearm flaps with the loss of only one. Since the original description of radial forearm flap, this versatile flap has found numerous applications in plastic and reconstructive surgery [4,5].

Its value in head-and-neck reconstruction and upper and lower extremity reconstruction is well documented. Nevertheless, its application as both retrograde flow-pedicled island flap and free flap has resulted in two major drawbacks: donor site morbidity and sacrifice of the radial artery.

The forearm flap is a fasciocutaneous flap based on the radial artery. Venous drainage is provided by two venae comitantes which accompany the artery and the subcutaneous forearm veins which drain into the cephalic, basilic and median cubital veins. The two venous systems communicate via a branch which drains into the median cubital vein. Any part of the volar forearm skin can be used but in practice the presence of hair may dictate the site of the flap. Distally designed flaps have the advantage of being thinner than proximal flaps, a feature which is particularly noticeable in female patients [6,7].

Materials and Methods

This was a retrospective study on the reconstructions with microvascular radial forearm free flap in the head and neck area performed by physicians in the Head and Neck Service at our Hospital between June 2018 and January 2020. The aim of this study is to report our experience with radial forearm flap. We revised our records and we analyzed demographic variables (age, sex and comorbidities), type of reconstruction, location, cancer stage and peri- and post-operative complications. All patients were staged by TNM system with physical examination and Computed Tomography scan, then discussed on multidisciplinary team. The timed Allen Test were performed to all patients (See figure 1). To choose the arm side we prefer left flaps in right-handed patients, but always we evaluate previous intravenous lines, surgery, injury, scars, skin deformities, fractures or vascular compromise. The patient's preference is also taken into account (See figure 2) Our surgical technique starts flap harvest at lateral edge over brachioradialis muscle, progress towards intermuscular septum and down to the lateral aspect of the artery, proceed to medial dissection and dissect vessels and elevate flap from distal-to-proximal. We prefer Subfascial RFFF elevation technique. We perform always the same protocolized surgical technique sequence: we Apply a tourniquet to the upper arm (maximum time of 90 minutes permitted) and adjust the operating table and/or the chairs so that the reconstructive surgeon and assistant are seated; Design the flap on the forearm to include the lateral intermuscular septum as well as a superficial vein, usually the cephalic vein; the preferred position of the proximal extension is laterally between the radial artery and cephalic vein; start the dissection laterally, with two skin hooks anchoring the skin lateral to the flap; Incise the circumference of the skin flap and the proximal curvilinear extension towards the cubital fossa with a No. 15 scalpel blade; Elevate the flap with a scalpel from laterally in a deep subcutaneous (not subdermal) plane until the cephalic vein which lies deep to the subcutaneous fat comes into view; Using a scalpel, elevate the cephalic vein from lateral-to-medial with the intervening subcutaneous tissue between vein and flap; Elevate and skeletonize the cephalic vein proximal to the flap; The lateral antebrachial cutaneous nerve accompanies the cephalic vein in the same subcutaneous plane. If an innervated flap is planned, this nerve is elevated with the cephalic vein; Separate the vein without its surrounding soft tissue from the main vascular pedicle using sharp scalpel dissection; Elevate the lateral aspect of the flap in a subfascial plane over the extensor and abductor tendons with a No.15 scalpel blade; Identify the superficial branch of the radial nerve lateral to the brachioradialis and medial to the extensor pollicis brevis and abductor pollicis longus; Scalpel points to superficial branch of radial nerve lateral to brachioradialis; Extend the dissection medially over the epitenon covering the latter two tendons and the radial nerve, until the flat tendon of brachioradialis is visualized; It is very important to maintain epitenon over these tendons to provide a "cover" for skin grafting, if required; Carefully continue with sharp dissection over the brachioradialis tendon up to its sharp medial edge; To retract the brachioradialis muscle and tendon, the assistant stands on the radial side of the arm and the surgeon sits next to the trunk of the patient where he/she is protected from physical interference by the resection team; While the assistant applies lateral traction to the muscle with skin hooks, release the medial edge of the brachioradialis muscle off the (poorly defined) underlying lateral intermuscular septum using sharp dissection; Sharply dissect and elevate the tendon superiorly up to its musculotendinous junction; the radial artery generally lies immediately below the tendon; therefore, the angle of the scalpel blade is changed to a horizontal plane to cut along the under surface of the brachioradialis tendon; Distally, the perforators commonly hook around the medial edge of the brachioradialis tendon where they are vulnerable to injury, especially when incising perpendicularly past the me-dial edge of the tendon; Incise the fascia overlying the muscle

lateral to the vascular pedicle; Once the brachioradialis muscle has been mobilized, the full length of the radial artery is visible and the likelihood of injuring the perforators is much less; Ligate and divide larger muscle perforators with Liga clips and coagulate small ones with bipolar forceps; Next elevate the medial side of the flap by cutting the epimysium covering the wrist flexor muscles with a scalpel; Elevate the deep fascia over the ten-dons, but preserve the epitenon covering the tendons, Elevate beyond the flexor carpi radialis and incise the deeper muscle fascia over the flexor digitorum superficialis muscle; Incise the fascia over the radial artery and isolate, ligate and transect the artery and venae comitantes; Dissection now proceeds from distal-to-proximal); Meticulously divide the side-branches along the artery until enough vessel length is achieved to reach the recipient vessels in the neck; this permits drainage of both the superficial and deep venous systems via a single venous anastomosis; we select a vein as drainage vessel; Deflate the tourniquet; While awaiting reperfusion of the flap vasculature, the surgeon prepares the recipient vessels in the neck (we prefer facial artery) and we control bleeding side-branches on the pedicle and on the flap with bipolar coagulation and/or Liga clips before disconnecting the flap from its blood supply. We prefer end-to-end microvascular anastomosis with 9/0 Ethylon®. We close primer donor site with full-thickness skin grafts. Always fix and immobilize skin graft with sutures and appropriate dressings. We use volar splint to restrict movement of flexor tendons beneath skin graft; Maintain epitenon over tendons and bury tendons by oversewing with deeper muscles.

Results

A total of 14 reconstructions with microvascularized free forearm free flap were carried out; A total of 14 operations were performed; all were men, with a mean age of 58 years. Tobacco use was present in all of the patients except for 2 patients, and 57% presented moderate-severe alcohol use. Of the total of patients had had prior treatment. The locations were tongue tumors (9), buccal mucosa tumor (1),

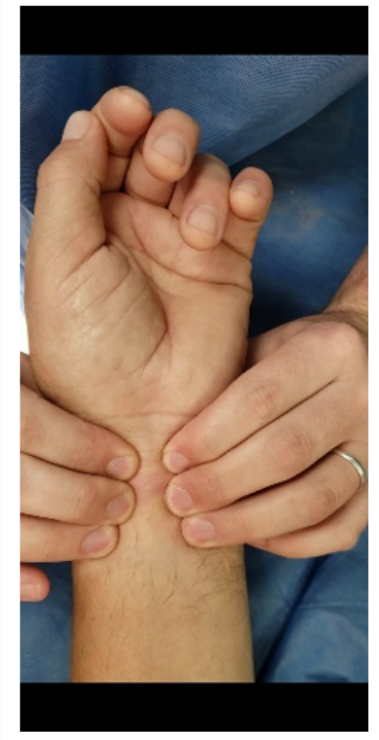

Figure 1: *Allen test.*

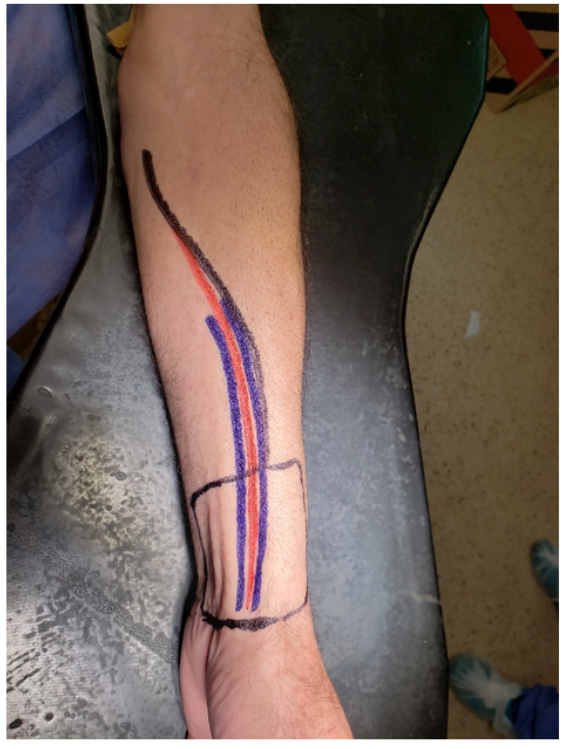

Figure 2: *Left-handed skin paddle flap. Red: Radial artery; purple Radial veins.*

maxillary sinus (2), hard palate tumor (1), and flour of the mouth (1). For palate defects we prefer double skin island like a "sandwich". For rest of patients we perform one skin paddle flap (See figure 3).

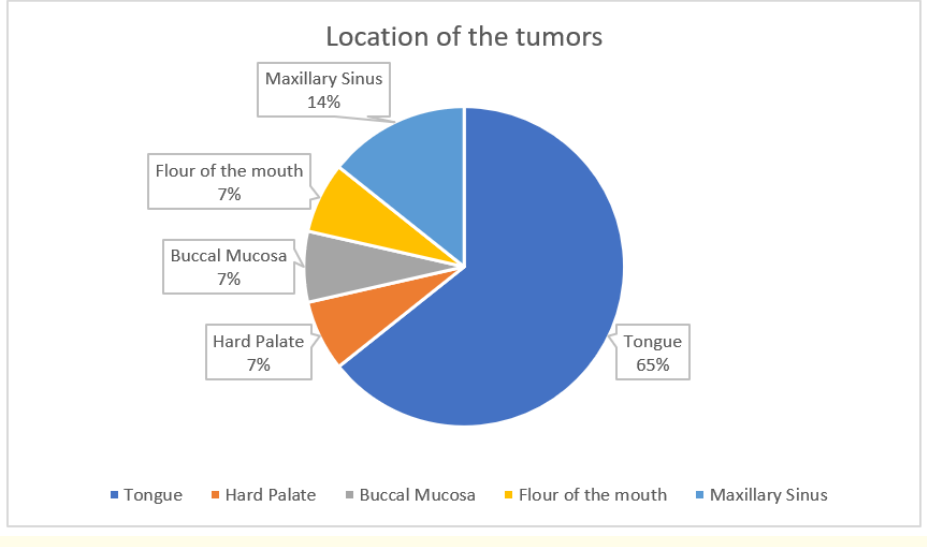

Figure 3: *Locations of the tumors.*

The postoperative care of all the patients included stay in ICU, absolute bed rest for 3 days, low-molecular-weight heparin for 7 days, antibiotic treatment (amoxicillin-clavulanic acid) for a week, and immobilization of the donor zone with a dorsal plaster splint for a week. Flaps were controlled visually and by puncture

in area where such monitoring was possible. Early nutrition was started with a nasogastric tube first day after surgery. Oral nutrition was started on an intrahospital basis once the absence fistulas had been confirmed, with the average being about 14 days. The exception consisted of 4 patients in which there was no early closure of the flap, these patients were consequently discharged with a nasogastric tube and oral feeding was initiated later on an ambulatory basis once the defect had closed. Mean hospital stay was 22 days (See figure 4).

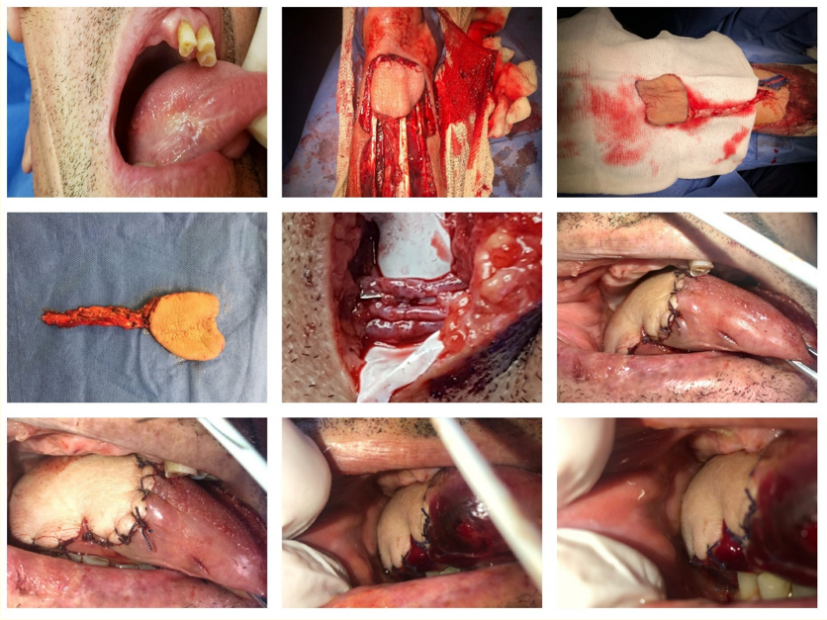

Figure 4: *Patient with tongue cancer. Harvest of radial forearm free flap and inset with reconstruction and microvascular anastomosis. 5-day post-surgery no necrosis.*

The motive for the operations was cancer. The most prevalent histology was squamous cell cancer, found in 13/14 and 1 adenoid cystic carcinoma of the palate. Staging according to the most predominant T was T3, with a total of 10 patients. Insofar as the surgical technique, there were no intraoperative complications and all the microvascular anastomoses were carried out. No mortality associated with the procedure was reported. No necrosis was presented on flaps. 4 oral fistulas were reported. Within the revision of the factors associated with flap failure closure it was found that all patients "mandibular swing" surgical technique was carried out. In these 3 cases of suture dehiscence was necessary reconstruction with local flap. The other case was performed closure by secondary intention. The median follow up was 15 months with a multidisciplinary team

Discussion

RFFF offers ease of harvesting and reliability due to its constant, reproducible vascular anatomy. It is also versatile owing to the relatively long pedicle and thin, pliable, hairless skin paddle. A two-team approach is possible in head and neck surgery, various forms being

applicable, for example, free or pedicled, proximally or distally. However, functional, esthetic issues and donor site morbidity are inevitable complications necessitating local rotation and advancement flap or skin grafting, while primary closure is only possible with a cutaneous flap less than 2 ~ 3 cm [8]. Both split and full-thickness skin grafts are possible, but the latter ensure the better cosmetic appearance [9].

Although RFFF yields a dependable success rate, the most common reason for failure is inadequate venous drainage [10]. RFFF has two major venous drainage systems, superficial and deep vein, the former utilizing the cephalic vein and the latter the venae comitantes [11]. The superficial veins are marked with the tourniquet tightened.

The skin incision should begin distally, usually from the ulnar aspect, and dissection proceeds subfascially taking care to preserve paratenon. Some surgeons dissect suprafascially first, changing to a deeper level in the proximity of the vessel (over the bellies of brachioradialis).

The main feeding vessel of RFFF, the radial artery, originates from the brachial artery at around 2 cm distal of the elbow, where the ulnar artery is also divided. The radial artery runs between the brachioradialis and pronator teres muscles at the proximal third and follows the lateral intermuscular septum between the brachioradialis and flexor carpi radialis at the distal. The wrist area becomes a surgical landmark offering palpable pulsation of the radial artery as there is no muscle coverage [12]. Crucially, the radial artery in the fasciocutaneous flap provides numerous branches to overlying subcutaneous tissue, skin, flexor muscles, and underlying periosteum of distal radius through deep fascia. The approximately five to seven perforating arteries arising from the radial artery at the lower arm constitute the arterial inflow of the radial forearm fasciocutaneous paddle. It is thus critical to closely attach the skin and the subcutaneous fascial layer during flap harvesting. Also, a strip of skin at least 3 cm width overlying the posterior extensor compartment of the forearm and the ulnar subcutaneous border should be kept intact due to poor vascularity of the radial artery in this region. The usual pedicle length of the radial artery is about 18 cm and the width of lumen is around 3 mm, which offers the proper length and size to perform microanastomosis in the head and neck region with facial, superior thyroidal, and superficial temporal arteries [13]. The radial artery always accompanies two venae comitantes which communicate with each other in a ladder shape. Deep venae comitantes drain into the median cubital vein, communicating with superficial veins at the elbow area. The cephalic vein is the most commonly used single vein for venous drainage of RFFF [14]. It is a large, fairly thick-walled vein found in a relatively constant location deep beneath the subcutaneous fat. Due to its size and superficial position, it is also very often used for intravenous lines, which may cause fibrosis and/or thrombosis of the vessel. It drains the anterolateral forearm and is formed mainly by the confluence of superficial veins on the dorsal aspect of the hand [15]. From there, the vein, or its tributaries, traverses the lateral snuffbox area to lie over the lateral side of the distal forearm. It gradually courses more medially towards the midlateral cubital fossa. The lumen width of the venae comitantes is around 1.5 mm, while the cephalic vein shows 3 mm or more [16]. Extremely narrowed lumens are observed with notable frequency in venae comitantes contrary to the cephalic vein. The difficulties of anastomosing venae comitantes mainly determine the survival of RFFF although the process is becoming easier. Valves manifest more frequently on deep, veins than on superficial veins [17], but the frequent interconnection permits bypassing and retrograde flow, which support the distally pedicled flap [18,19].

The fundamental vascular network of fasciocutaneous flap is made up of numerous invisible arterial/venous communications within the fascial layer, the so-called septocutaneous vascular network, which arises from arterial perforators and accompanies venae comitantes [20] (Figure 1).

Septocutaneous perforators from the radial artery approach the skin between the flexor carpi radialis (FCR) and brachioradialis (BR), with drainage through venae comitantes (VC) and/or cephalic vein. Over its length there are an average of 9 - 17 skin perforators that tend to be found in proximal and distal clusters. Most perforators were located in the proximal half of the distal one third, making this part probably the safest location for flap harvest. However, many studies detailing the location and vascular territory of the radial artery perforators, therefore, becomes necessary to facilitate operative planning in perforator-based flap harvest. The diameter of the artery is around 2.5 mm [21].

Conclusion

The patient should be placed in a supine position with the arm on a board positioned almost perpendicular to the body. The operation is often performed under tourniquet control and a preoperative Allen's test should be performed.

The axis of the flap lies just medial to the course of the radial artery at the wrist, approximately along a line connecting the center of the antecubital fossa to the radial border of the wrist where the radial pulse is palpable, approximating to the course of the artery. The key points are careful flap and template design, flap design on the forearm to include the lateral intermuscular septum as well as a superficial vein (usually cephalic), elevate medial and lateral fasciocutaneous parts of the flap and dissect to-wards the lateral intermuscular septum and Brachioradialis muscle is most critical element of elevating the flap, start flap elevation at lateral edge over brachioradialis muscle, progress towards intermuscular septum and down to the lateral aspect of the artery, proceed to medial dissection and dissect vessels and elevate flap from distal-to-proximal

Conflict of Interests

The authors do not present/display conflicts of Interests.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

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