

Versatility of Radial Forearm Free Flap in Reconstruction of Different Defects: A Cross-sectional Study

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ABSTRACT

Introduction: The Radial Forearm Free Flap (RFFF) is a commonly used flap for soft tissue reconstruction, offering several advantages despite sacrificing the radial artery in the forearm. Understanding the anatomy of radial artery perforators, including their distribution, territory, and flow is crucial for reliable and safe flap harvest and design.

Aim: To describe the versatility and applications of RFFF in reconstructing defects in various body parts.

Materials and Methods: This cross-sectional study was conducted in the Department of Plastic and Reconstructive Surgery at SCB Medical College and Hospital, Cuttack, between January 2019 and January 2021, on 39 cases (age group: 20-70 years) who underwent RFFF. RFFF was utilised for reconstruction of the lip, palate, buccal mucosa, tongue, foot, nose, and phallus. Preoperative evaluation included assessing the vascular status of the non dominant hand using the Allen's test.

Results: RFFF was used for postcancer resection reconstruction in 11 cases of buccal mucosa (28.2%), 7 cases of the lip (17.9%), 6 cases of the tongue (15.3%), 2 cases of the palate (5.1%), 2 cases of phallus reconstruction (5.1%), 1 case of post-traumatic nose defect, and 1 case of 1st web space of the hand (2.5%). In 26 cases of postcarcinoma resection reconstruction, RFFF was used for buccal mucosa, lip, tongue, and palate. The patients were followed-up for 2-8 months.

Conclusion: RFFF fulfills most of the anatomical prerequisites for an ideal flap, providing a microvascular reconstructive option for patients with large defects in the head and neck, foot and ankle, and phallus. It exhibits a high success rate, good aesthetic and functional outcomes, allowing for the reconstruction of various defects. This study confirms the reliability of the radial free flap as a method for reconstructive surgery.

Keywords: Buccal mucosa, Phallus, Resection, Vascular

INTRODUCTION

The Radial Forearm Free Flap (RFFF), often referred to as the Chinese flap, was initially introduced as a free flap by Yang and Gao in 1981 [1]. Lu and Biemer later reintroduced it as a pedicle flap based on retrograde flow [2]. Refinements in the vascular anatomy have increased the reliability and applicability of this flap for reconstructing defects in various parts of the body. The forearm flap, known for its thin, pliable, and hairless skin, consistent vascular anatomy, and acceptable donor site morbidity, is frequently used for free tissue transfers [1,2]. It is commonly employed as a fasciocutaneous flap for reconstructing defects in the head, neck, and limbs. RFFF is considered a primary reconstructive strategy in challenging defects involving the lip, buccal mucosa, cheek, extremities, and phallus. Microvascular free flaps have evolved significantly since the reconstruction of a dorsal ankle defect using a groin flap in 1973 [3].

RFFF is applied for oral cavity reconstruction (tongue, lip, palate) as well as foot, ankle, and phallus reconstruction. An osteocutaneous flap can be raised by including the bony segment of the radius. Before harvesting the RFFF, confirmation of the patency of the palmar arch through Allen tests or angiography is crucial [4], as the radial side fingers rely on blood supply from the ulnar artery through the palmar arch after the flap is harvested. In head and neck reconstruction, the RFFF offers various options due to its low flap loss and complication rates, making it an excellent choice for oral lining restoration when bulk is not required [5].

Phallic reconstruction is a complex procedure requiring a multidisciplinary approach, and the RFFF is considered the gold standard for phallus reconstruction. The flap is versatile, reliable, and offers large vessels suitable for anastomosis, while also being

relatively hairless [6]. For foot reconstruction, the RFFF meets most of the anatomical prerequisites for an ideal foot flap, providing a normal foot contour, durable weight-bearing surface, and excellent aesthetic results. The radial artery, with a typical pedicle length of about 18 cm and lumen width of approximately 3 mm, is suitable for microanastomosis in the head and neck region with facial, superior thyroidal, and superficial temporal arteries [7]. The cephalic vein is commonly used for venous drainage of the RFFF.

Although less commonly used than the RFFF, the Ulnar Forearm Free Flap (UFFF) has seen an increase in usage in recent years. However, limitations such as operator-dependent factors, limited knowledge of deep forearm muscle anatomy, and the risk of ulnar nerve damage in close proximity to the ulnar vessels contribute to its lesser utilisation [8,9]. Previous literature has focused on the use of RFFF for specific regions of the body, such as the head and neck, tongue, or limbs individually. This study was conducted with the aim to demonstrate the versatility of RFFF in reconstructing defects in nearly all regions of the body, including buccal mucosa, lip, tongue, palate, phallus, and foot defects. The study highlights the potential of RFFF as a solution for defects arising from different regions of the body.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Plastic and Reconstructive Surgery at SCB Medical College and Hospital, Cuttack, between January 2019 and January 2021, and included 39 cases of RFFF, following clearance from the Institutional Ethical Committee (IEC number 137/7.2.2020). The surgeries were performed from January 2019 to 2020, and the follow-up period was from February 2020 to January 2021. Informed consent was

obtained from all patients. As this was a time-bound study, all patients who visited the hospital for reconstructive surgery during the study duration were included, resulting in a total of 39 cases of RFFF included in the study.

Inclusion criteria:

- Patients aged between 20 and 70 years.
- Patients with stage I-III buccal mucosa, lip, and tongue carcinoma.
- Patients with traumatic amputation of the phallus.
- Patients with post-traumatic nose defects.

Exclusion criteria:

- Patients aged below 20 years or above 70 years.
- Patients with co-morbidities such as uncontrolled diabetes mellitus, chronic end-stage renal disease, or sepsis.

Study Procedure

RFFF was utilised for the reconstruction of various areas including the lip, palate, buccal mucosa, tongue, foot, nose, and phallus. Preoperative evaluation involved assessing the vascular status of the non dominant hand using the Allen's test. The patient was instructed to tightly clench their fist for one minute, and pressure was applied to occlude the radial and ulnar arteries. The patient was then asked to open their fingers, and the radial artery was released to observe the vascularity of the fingers. The same procedure was repeated for the ulnar artery. This test helped to determine the patency of the palmar arch and the dominant vessel of the hand [7].

The RFFF was harvested by elevating the flap towards the flexor carpi radialis in an ulnar to radial direction, superficial to the muscular fascia. The flap was elevated until the brachioradialis tendon was encountered, while preserving the cephalic vein and the superficial branch of the radial nerve. Distally, the radial artery was ligated and divided along with the venae comitantes. The proximal aspect of the skin paddle was focused on, and the skin overlying the cephalic vein was incised proximally to the antecubital fossa. The skin flap was then elevated off the flexor carpi radialis and brachioradialis, while preserving the cutaneous perforator to the flap. Finally, the flap was raised with its vascular pedicle from distal to proximal by elevating the radial artery and venae comitantes. The tourniquet was released, haemostasis was achieved, and the pedicle was divided. After the flap harvest, the donor site was closed with a split-thickness skin graft from the thigh [1].

STATISTICAL ANALYSIS

Descriptive statistics was used for the analysis of data.

RESULTS

A total of 39 patients underwent RFFF, with age group ranging from 20 to 70 years. Of these, 23 (58.9%) were males and 16 (41.1%) were females. The minimum duration of surgery was 170 minutes, while the maximum duration was 380 minutes [Table/Fig-1].

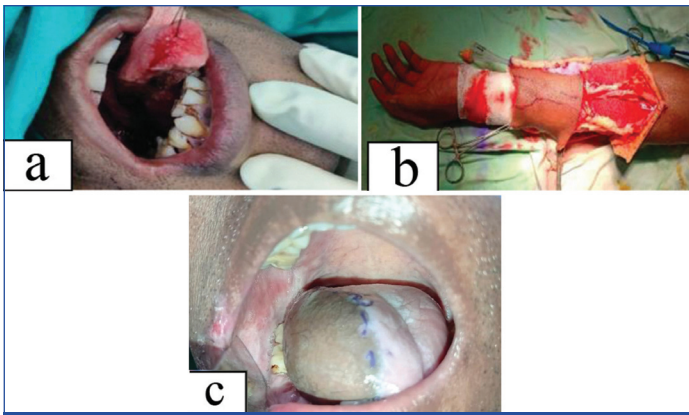
In cases of postcancer resection reconstruction, RFFF was used for buccal mucosa (11 cases, 28.2%), lip (7 cases, 17.9%), tongue (6 cases, 15.3%), and palate (2 cases, 5.1%) [Table/Fig-2a-c,3a-c].

In cases of post-traumatic reconstruction, RFFF was utilised for foot defects (9 cases, 23.1%), phallus reconstruction (2 cases, 5.1%), reconstruction of post-traumatic nose defects (1 case, 2.5%), and reconstruction of the 1st web space of the hand (1 case, 2.5%).

The patients were followed-up for a period of 6 months. Out of the 39 patients, 26 did not experience any complications, while five patients were lost to follow-up. Of which, three cases had complete

S. No.	Age	Sex	Location of defect	Cause	Duration of surgery (in mins)	Complications	Follow-up (in months)
1	38	M	Buccal mucosa	Carcinoma	180		2
2	56	F	Tongue	Carcinoma	210		3
3	63	M	Lip	Carcinoma	170	Partial graft loss	3
4	40	M	Buccal mucosa	Carcinoma	320		7
5	44	M	Buccal mucosa	Carcinoma	250		5
6	39	F	1 st web space	Trauma	195		4
7	55	M	Palate	Carcinoma	310		7
8	21	M	Tongue	Carcinoma	210		8
9	37	M	Tongue	Carcinoma	190		6
10	60	F	Buccal mucosa	Carcinoma	340	Venous congestion; flap loss	-
11	48	M	Tongue	Carcinoma	285		8
12	58	F	Palate	Carcinoma	265		6
13	37	M	Phallus	Trauma	380		
14	48	M	Nose	Trauma	220		2
15	61	F	Buccal mucosa	Carcinoma	325	Marginal necrosis	7
16	57	F	Foot	Trauma	185		3
17	43	M	Tongue	Carcinoma	320		4
18	39	M	Foot	Trauma	205	Arterial thrombosis; complete flap loss	
19	31	F	Buccal mucosa	Carcinoma	365		2
20	49	M	Tongue	Carcinoma	270		6
21	56	M	Foot	Trauma/Osteomyelitis	215		5
22	57	F	Buccal mucosa	Carcinoma	320		8
23	44	M	Foot	Trauma osteomyelitis	225		7
24	28	M	Lip	Carcinoma	180		3
25	36	M	Buccal mucosa	Carcinoma	355		4
26	31	F	Foot	Trauma	265	Arterial thrombosis; complete flap loss	
27	64	M	Lip	Carcinoma	205		6
28	32	F	Buccal mucosa	Carcinoma	320		
29	29	F	Foot	Trauma	250		6
30	41	M	Lip	Carcinoma	310		7
31	65	F	Buccal mucosa	Carcinoma	325		5
32	46	F	Lip	Carcinoma	265	Partial graft loss	6
33	34	M	Foot	Trauma	270		4
34	62	F	Buccal mucosa	Carcinoma	345		4
35	36	M	Foot	Trauma	190		5
36	69	F	Lip	Carcinoma	240		3
37	44	F	Foot	Trauma	215	Marginal skin necrosis	7
38	27	M	Phallus	Trauma	375		3
39	38	M	Lip	Carcinoma	230		6

[Table/Fig-1]: Patient characteristics along with the duration and follow-up.
M: Male, F: Female



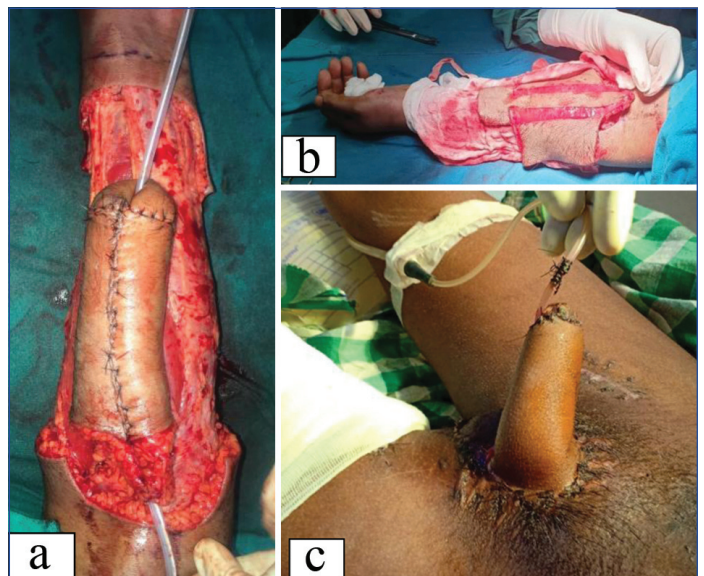
[Table/Fig-2]: a,b) Tongue reconstructed with RFFF after hemiglossectomy; c) Follow-up after one month.



[Table/Fig-5]: a,b) Postcarcinoma resection of foot tumour; c) Reconstructed with RFFF.



[Table/Fig-3]: a,b) Carcinoma lower lip, reconstructed with RFFF; c) Follow-up after 5 months.



[Table/Fig-6]: a,b) Phallus reconstruction with RFF; c) Postoperative image of the phallus reconstruction.

flap loss, with two cases due to radial artery thrombosis and one case due to venous thrombosis. The two cases of radial artery thrombosis were managed by re-exploration and reanastomosis, while the case of venous congestion was managed by re-exploration and venous anastomosis. One case with buccal mucosa defect underwent reconstruction using the Pectoralis Major Myocutaneous Flap (PMMC) due to flap loss [Table/Fig-4a-c,5a-c,6a-c].



[Table/Fig-4]: a,b) Post-traumatic lower one third leg defect reconstructed with RFFF; c) Follow-up after 6 months.

Among the nine cases of foot defects managed with RFFF, two cases had complications and were managed with negative pressure wound therapy followed by reverse sural flap and Split Thickness

Skin Grafting (SSG). Two cases experienced superficial marginal flap necrosis, which was debrided followed by SSG. Donor site complications included partial skin graft loss in two cases with tendon exposure, which was managed with SSG. Urethral complications occurred in two cases after three months, with one case developing a urethrocutaneous fistula repaired with excision and secondary suturing, and another case developing a urethral stricture managed by visual internal urethrotomy with the help of a urologist.

DISCUSSION

Each anatomic region of the body has distinguishing characteristics. The dorsum of the foot and ankle require thin, pliable soft tissue to cover exposed tendons without paratenon, bone, or joints. The Radial Forearm Free Flap (RFFF) is effective in restoring function and appearance for patients with soft tissue intraoral defects after tumour ablation surgery [10-14]. The RFFF offers advantages such as ease of flap elevation, large vessel diameter, longer pedicle, pliability, mobility, and thinness, making it ideal for buccal reconstruction. Additionally, the RFFF can be folded, further enhancing its versatility.

In this study, two-folded free radial forearm flaps were used to repair full-thickness defects, resulting in satisfactory open-mouth width [15]. The success rate for buccal mucosa reconstruction with RFFF was 82%, with only 2 out of 11 cases experiencing complications. Previous studies have reported even higher success rates, emphasising the reliability of RFFF for treating buccal defects

[16-18]. RFFF is also suitable for intraoral reconstruction, such as defects following hemi-glossectomy. In this study, a 100% success rate was achieved with RFFF reconstruction in the tongue region, without any complications. Other studies have reported more than 90% flap survival rate for intraoral reconstruction with RFFF [19]. Its ability to offer less resistance to intraoral movements and avoid hindering muscular hypertrophy of the remnant tongue musculature makes it a preferred option [5].

The weight-bearing surface of the foot presents a challenging reconstructive scenario due to the high pressure it endures. In this study, RFFF was used in nine cases of foot reconstruction, seven of which were in the weight-bearing region. The success rate for these cases was 77%, with two flaps being completely lost. Similar success rates have been reported in previous studies [20,21]. RFFF has also shown positive outcomes in resurfacing the forefoot, weight-bearing surfaces, moderate-sized defects, and osteomyelitic wounds.

Phallic reconstruction is a complex procedure, and RFFF is considered the gold standard for modern phallic reconstruction. It offers versatility, dependability, and large vessels that are easy to anastomose. In this study, RFFF was used for two cases of phallus reconstruction, with one case presenting a urethral complication after three months, which was managed surgically [22]. Donor site morbidity can occur due to partial loss of the skin graft over the tendons, leading to tendon exposure, adhesions, and delayed healing.

The advantages of RFFF include adequate venous drainage, a long vascular pedicle, large luminal diameter at the elbow facilitating high volume blood flow, and relative ease of anastomosis. The thin, pliable, and malleable flap offers multiple options for covering three-dimensional defects easily, including the ability to rotate the flap on itself for inseting. These characteristics make RFFF a versatile flap [1].

[Table/Fig-7] provides a comparative analysis of the present study findings with past data from other studies [17,19,21,23].

Author's name and year	Place of study	No of subjects	Site of reconstruction	Complications	Success rate
Kruse AL et al., 2011[17]	Zurich	20 patients	Head and neck carcinoma reconstruction	4 flap failure (1 arterial; 3 venous)	95%
Song M et al., 2009 [19]	Sun Yat-Sen University Cancer Centre	26 patients	Buccal mucosa	Flap necrosis	96.2%
Elgohary H et al., 2019 [22]	Benha University Hospital	25 patients	Soft tissue defects of the heel	2 flaps-complete loss 2- partial loss (total 4 out of 25)	84%
Falcone M et al., 2016 [24]	London	25 patients	Phallus reconstruction	Vascular complication in 5 patients	80%
Present study	Cuttack	39 cases	Buccal mucosa Lip Tongue Palate Foot Phallus	3 complete flap loss (2 arterial and one venous thrombosis)	92.3%

[Table/Fig-7]: Summary of the comparison of previous literature and findings of the present study [17,19,22,24].

Limitation(s)

The present was a single centre study and five patients lost to follow-up. Also, the sample size was not statistically calculated due to the study time-bound nature, and all patients who visited during the study duration for reconstructive surgery were included.

CONCLUSION(S)

Radial forearm tissue transfer provides a rapid and versatile microvascular reconstructive option for patients with defects in the head and neck (lip, buccal mucosa, tongue, and palate), phallus, and foot. It is accessible, has reliable anatomy, and is easy to harvest, resulting in excellent aesthetic outcomes with minimal complications and donor site morbidity. These flap characteristics make radial forearm tissue transfer a pivotal flap in microvascular reconstruction.

This study revealed that the radial free flap is a reliable method for reconstructing defects in any anatomical region of the body. It is not restricted to any specific region and provides excellent outcomes with less technical demands compared to microsurgical tissue transfer. Therefore, radial forearm free flap surgery is an incredibly versatile option, especially when performed by an experienced microvascular surgeon.

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