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A 31-year review of composite radial forearm free flaps for head and neck reconstruction

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Abstract

The aim of this study was to report the patient characteristics and radial fracture rates in a consecutive series of composite radial forearm free flap (CRFFF) for head and neck reconstruction over a 31-year period. The patients were identified from between 1990 to 2020 inclusive from theatre records and records from previous analyses at the Unit on free flap outcomes. Electronic case notes were accessed where available, to gather information on the operation, histopathology, and radiographs. Patients were categorised into three groups for analysis: (1) new oral cancers with a composite radial being the first choice of flap, (2) new oral cancers with a composite radial being the choice of flap following compromise of another bony flap, (3) osteoradionecrosis (ORN) cases. There were 103 CRFFF cases, median (IQR) age 69 (59-80) years, comprising 78 (Group 1), 5 (Group 2) and 20 (Group 3). The CRFFF failure rate was 6% (6/103) and the radius fracture rate was also 6% (6/103), both with 95% confidence interval 2.2-12.2%. Of the 6 radius fractures, 1 underwent surgical management (rush nailing), 1 died in hospital and the others managed with cast immobilisation. Two-year overall survival after surgery for the103 patients was 54% (SE 5%), while 5-year survival was 40% (SE 5%). In conclusion, in spite of the familiarity with other bone flaps such as fibular free flap, DCIA, scapula, and the limited bone stock and potential fracture related morbidity associated with the CRFFF, this flap still has a place in the surgical reconstructive armamentarium.

Keywords: head and neck cancer; free tissue transfer; composite radial free flap; osteoradionecrosis; radial fracture; reconstruction

Introduction

In a systematic review reporting a total of 9499 cases of mandibular reconstruction with vascularised bone flaps over a 25-year period, 12% were composite radial forearm free flaps (CRFFF).[1] The potential disadvantages of the CRFFF relate mainly to donor site morbidity, especially radius fracture, and the limited bone stock available. Radial fracture rates have been reported in the regions of 0% and 18%.[2-4] Fracture confers considerable morbidity in respect to delayed healing, joint stiffness, and osteoporosis owing to prolonged immobilisation.[5] In cases where fracture does not occur the morbidity of harvest is similar to the soft tissue radial.[4,6] Modifications on the earliest harvesting techniques such as limiting the harvest to 40% of the radial radius [2,7-11] use of a keel shaped osteotomy to reduce points of stress, and prophylactic plating along with arm casting have led to a reported reduction in the incidence of fracture rates.

The CRFFF has limited bone stock compared to the fibula, DCIA, and scapula, however despite this, the flap

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has been described in management of mandibular ORN,[13] and reconstruction of small volume maxillary,[14,15] lateral mandibular segmental defects,[16] and to augment the zygomatic implants perforator flap (ZIP flap).[17]

Although there are previous articles reporting series of CRFFF,[2,4,5 16-19] the majority report relatively small numbers, typical between 4 and 86, with two studies reporting 155[16] and 167[10] cases, respectively. The previous literature has tended to lack long-term follow up or in the information provided for the plating and casting management. Very few studies report on recipient vessels used in the neck.

The aim of this present study was to report the patient characteristics and outcomes, including radius fracture rates, use of recipient vessels, flap utilisation, and survival in a consecutive series of CRFFF used in the reconstruction of head and neck defects over a 31-year period. These data serve to put into current context the place of the CRFFF as a reconstructive option following head and neck cancer.

Methods

This was a consecutive series of all oral HNC patients having composite radial forearm free-flap (CRFFF) resections undertaken at the Head and Neck Cancer Centre, Liverpool, UK over a 31-year period from 1990. Cases were identified by theatre logs and previous analyses on free flap outcomes. Electronic case notes were accessed where available to gather information on the operation, histopathology, and radiographs.

Data included patient demographics, TNM staging,[20] HNC site, diagnosis, Oral cancer-histology type or ORN, date of operation, use of radiotherapy, composite radial free flap as first or second reconstruction choice, length of radial bone harvest, donor site hand side, recipient vessels of anastomosis on the neck, overall free-flap success, radius fracture, treatment of radial fracture, length of hospital stay, and date of death.

Patients were categorised into three groups for analysis: (1) new oral cancers with a composite radial being the first choice of flap, (2) new oral cancers with a composite radial being the choice of flap following compromise of another bony flap, (3) osteoradionecrosis (ORN) cases. Fishers exact test was used to compare patient groups in regard to categorical variables and the Mann-Whitney (2 groups) or Kruskal-Wallis (>2 groups) test for numerical variables. Kaplan-Meier methods were used to report overall survival, with follow-up of patients either to death, last clinic known to be alive or to 12-2-2021; the log rank test was used to compare survival curves. Statistical significance was regarded as $p<0.05$ and the analyses were performed using SPSS v25.

Audit approval was granted by the hospital Clinical and Audit Management System (CAMS No. 9727).

Results

There were 103 CRFFF cases from 1990 to 2020, median (IQR) age 69 (59-80) years and 58% (60) were male. The CRFFF failure rate was 6% (6/103) and the radius fracture rate was also 6% (6/103), both with 95% confidence interval 2.2-12.2%; one patient had both a radius fracture and a failure of the CRFFF. Of the 6 radius fractures, 1 underwent surgical management (rush nailing), 1 died in hospital and the others were managed with cast immobilisation. Two-year overall survival after surgery for these 103 patients was 54% (SE 5%), while 5-year survival was 40% (SE 5%); 6 patients died in hospital.

There were 78 patients with new oral cancers for whom the first choice of flap was a composite radial (Group 1), comprising 75 squamous cell carcinomas and 3 adenocarcinomas. In addition, there were 5 patients for whom the choice of flap was not a composite radial (1 DCIA, 4 fibula) and where there was flap compromise, and a composite radial was used as a second reconstructive option (Group 2). There were also 20 ORN patients (Group 3) who had a composite radial used to reconstruct the resection in the ORN; 2 of these patients previously had another bony flap (1 DCIA, 1 fibula) which failed, and the second reconstruction involved a composite radial. Comparison of these three groups by patient demographics, treatment details and outcomes is shown in Table 1. Group 2 (2^{nd} reconstruction) new patients stayed longer in hospital (median 71 days) compared with Group 1 (1^{st} reconstruction) new patients (median 19 days) or Group 3 ORN patients (median 12 days), $p=0.007$. Almost all (4 of 5) of Group 2 cases were before 2010, compared with 56% of Group 1 cases and 30% of ORN cases, $p=0.046$. Patients in Groups 2 and 3 were younger on average (median 67 and 61 years respectively) than for Group 1 patients (median 75 years), $p=0.005$. There was also a differing mix of recipient vessels of anastomosis in the neck, $p<0.001$. The facial artery was the recipient artery for 80% (4/5) of Group 2 second reconstructions and 91% of Group 1 first reconstructions but for only 30% for ORN patients, with the transverse cervical artery involved for 55% of the ORN group. The internal jugular vein was the recipient vein for 75% (3 of 4) of Group 2 second reconstructions, while the most common veins for Group 1 first reconstructions were either the internal jugular (50%) or common facial (29%) and for ORN cases it was either the transverse cervical venous system (45%) or common facial vein (25%). Further details of the 6 flap failures are summarised in Table 2.

For Group 1 new case first reconstruction patients involving a composite radial, flap failure was 5% (2/44) for operations during 1990-2009 and 9% (3/34) during 2010-2020, $p=0.65$; radius fracture rates were 9% (4/44) and 3% (1/34), $p=0.38$. Stays in hospital became shorter over time, $p=0.001$, median (IQR) of 24 (14-38) days for 1990-2009 and 14 (10-23) days for 2010-2020. Patients selected for CRFFF were younger during 1990-2009 at a median (IQR) 67 (55-78) years compared with 79 (70-84) years for 2010-2020, $p=0.001$. During 2010-2020 only 3 of 34 patients were aged under 65 compared to 22 of 44 during 1990-2009. Figure 1 shows Kaplan-Meier survival curves by time period for Group 1 patients aged 65 years and over. Overall, two and five-year survival during 1990-2009 (n=44) was 51% (SE

Table 1
Patient demographics, clinical status and outcome for the three groups.

		Group 1, New Ca, 1st reconstruction		Group 2, New Ca, 2nd reconstruction		Group 3, ORN		p Value*	All cases	
		%	n	%	n	%	n		%	n
	No. of patients	100	78	100	5	100	20		100	103
Gender	Male	55	43	40	2	75	15	0.20	58	60
Age at surgery	<65	32	25	20	1	65	13		38	39
	≥65	68	53	80	4	35	7		62	64
	Median (IQR)	75 (62-81)		67 (na)		61 (54-67)		0.005	70 (59-80)	
Year of surgery	1990-2009	56	44	80	4	30	6	0.046	52	54
	2010-2020	44	34	20	1	70	14		48	49
Dental status	Edentulous	39	27/70	50	1/2	17	2/12	0.30	36	30/84
Site	Anterior mandible	17	13	0	0	5	1	0.11	14	14
	Body of mandible	55	43	60	3	90	18		62	64
	Retromolar	21	16	40	2	5	1		18	19
	Maxilla	8	6	0	0	0	0		6	6
Overall stage	Early 1-2	14	11	0	0		-	>0.99	14	11
(Pathology)	Advanced 3-4	86	64	100	5		-		86	69
	Not known		3		0		20			23
Radiotherapy	Yes	58	40/69	40	2	100	20	<0.001	66	62/94
Forearm used	Left	94	73	100	5	85	17	0.46	92	95
	Right	6	5	0	0	15	3		8	8
Length of radial	<60	26	18	40	2	29	5		27	25
Flap taken (mm)	60-69	14	10	20	1	6	1		13	12
	70-79	23	16	20	1	53	9		29	26
	≥80	36	25	20	1	12	2		31	28
	Not known		9		0		3			12
	Median (IQR)	70 (57-80)		60 (na)		70 (57-71)		0.60	70 (57-80)	
Recipient artery	External carotid (ECA)	3	2	0	0	15	3	<0.001	6	5
	Facial (FA)	91	60	75	3	30	6		77	69
	Transverse cervical (STA/TCA)	6	4	25	1	55	11		18	16
	Not known		12		1		0			13
Recipient vein	Transverse cervical venous system (SCV/TCV)	2	1	25	1	45	9	<0.001	12	11
	Facial (CF/FV/RMV)	29	19	0	0	25	5		27	24
	Ant/ Ext jugular (AJV/EJV)	15	10	0	0	15	3		14	13
	Internal jugular (IJV)	50	33	75	3	15	3		43	39
	EJV+IJV	5	3	0	0	0	0		3	3
	Not known		12		1		0			13
Flap outcome	Success	94	73	100	5	95	19	>0.99	94	97
	Failure	6	5	0	0	5	1		6	6
Radius fracture	Fracture	6	5	0	0	5	1	>0.99	6	6
Died in hospital	Yes	6	5/77	0	0	5	1	>0.99	6	6/102
LOS (discharged)	<14 days	31	22	20	1	63	12		36	35
	14-27 days	42	30	0	0	21	4		35	34
	≥28 days	28	20	80	4	16	3		28	27
	Median (IQR)	19 (12-30)		71 (na)		12 (9-18)		0.007	17 (11-30)	
Overall survival	One year	59% (SE 6%)		20% (SE 18%)		90% (SE 7%)		0.013		
	Two year	47% (SE 6%)		20% (SE 18%)		90% (SE 7%)				
	Five years	33% (SE 6%)		20% (SE 18%)		74% (SE 12%)				

*Fishers Exact test apart from Kruskal Wallis test for age, length of radial forearm and length of stay in hospital and log rank test to compare overall survival curves. P values computed after excluding any missing data. Any percentages stated in the table also omit missing data from the denominators. na: Interquartile range (IQR) not computed for denominators less than 10.

8%) and 36% (SE 8%) respectively, and for 2010-2020 (n=34) was 41% (SE 9%) and 26% (SE 9%), log rank test of survival curves p=0.15. Kaplan-Meier survival curves for patient groups 1 and 3 by time period are shown in Figure 2. There was a significant difference (log rank test chi-squared = 6.4, p=0.01) between group 1 (n=78) and group 3 (n=20) with ORN patients having the better survival.

Discussion

The composite radial forearm free flap remains an important reconstructive option following head and neck cancer surgery. Although our Unit has previously published its experience on free flaps,[12, 21,22] we have never previously focused on the CRFFF specifically. Previous papers on free tissue

Table 2
Further details concerning the 6 flap failures.

Year	Group	Age	Diagnosis	Location	Fracture	LOS	Recipient artery	Recipient vein	Comment
1993	1	80	SCC	Body of mandible		46	FA	IJV	Venous failure day 1. Second surgery: Pec Major with 6th rib. Persistent fistula in the neck. Died in hospital day 46.
2008	1	83	SCC	Anterior mandible		35	ECA	EJV	Arterial failure day 3. Second surgery: local tissue used with previous Pec Major, mandibular swing and no fistula.
2010	1	80	SCC	Body of mandible		11	FA	EJV	Venous failure day **3.** Secondary surgery: Buccal fat pad and local tissue advancement, mandibular swing and no fistula. patient unwilling for another free flap
2010	1	86	SCC	Retromolar		30	FA	IJV	Venous failure day 6. Secondary surgery: Local advancement including tongue flap to close the oro-cutaneous fistula, mandibular swing and no fistula
2019	3	67	ORN	Anterior mandible		12	ECA	EJV	Venous failure day 1. Secondary surgery: Local advancement including tongue flap to close the oro-cutaneous fistula, mandibular swing and no fistula
2019	1	79	SCC	Body of mandible	Radius fracture	Died in hospital	ECA	RMV	Arterial failure day 7 as anastomosis breakdown due to neck infection.. Secondary surgery: Local advancement including tongue flap to close the oro-cutaneous fistula, mandibular swing and no fistula

RT: radiotherapy.
LOS: length of stay in hospital.
NK: Not known.

transfer have allowed accurate historical records which for this consecutive series has been updated by more recent electronic patient case notes. Although this study has a considerable number of patients collated over a 31-year period, it has certain limitations. It has not been possible from this historical series to report osteotomy rate, non-union, fistula rates, oral rehabilitation details or health-related quality of life. The findings of this study compare similarly with other large series,[9, 23] and this current paper details the recipient neck vessels, something which is lacking in other previous similar studies.

In this series six patients (6%) suffered a radius fracture, most of whom were managed with cast immobilisation. This rate compares favourably with the literature. [2,4,5,24-26] Given the predominance of elderly patients in our cohort, likely with osteoporosis, it is perhaps surprising that fracture rates were not higher. In our two cohorts, namely 1990-2009 and 2010-2019, there was a reduction in fracture rates in the later period. It is difficult to be certain about the reason for this reduction, and the low number of fractures means that statistical significance cannot be inferred. Nevertheless, it is important to point out that we have changed our practice between the two time periods. Since 2010, we routinely prophylactically plate the radius with a 2.4mm volar reconstruction plate, together with a two-week above elbow, followed by a two-week below elbow cast immobilisation protocol. The use of prophylactic plating to prevent radius fracture has previously been well described in the literature.[27]

This current paper highlights the utility of the CRFFF for primary reconstruction of composite oral defects (Group-1), particularly in elderly edentulous patients. The median age of these patients was 75 years. Interestingly, there is a significant shift in the median age of patients in this group between our two time periods, with half of the 1990-2009 cohort under 65 years compared with 9% of the 2010-2020 cohort. This reflects the change in choice of composite flaps in our Unit over the last 30 years. However, it also serves to highlight the continued utilisation and usefulness of the CRFFF in the elderly population. The CRFFF has a role in providing additional support in selected cases of maxillectomy where reconstruction is by zygomatic implants (ZIP flap).[16] With this technique there is very early rehabilitation prior to commencement of adjuvant therapy should it be required.

A two-team approach reduces operative time and in the older patient this can be an important consideration when balancing up fitness for major surgery, and complexity of other flaps such as a fibular, scapular or DCIA. The CRFFF can provide adequate restoration of mandible continuity with relatively low attendant morbidity.[28] With an ever-increasing elderly population with comorbidity, and increased risk for peripheral vascular disease in older patients, often precluding the use of a fibula as a donor site, the CRFFF continues to be a viable option. Notwithstanding this, the difficulty in placement of endosseous implants into a CRFFF remains.

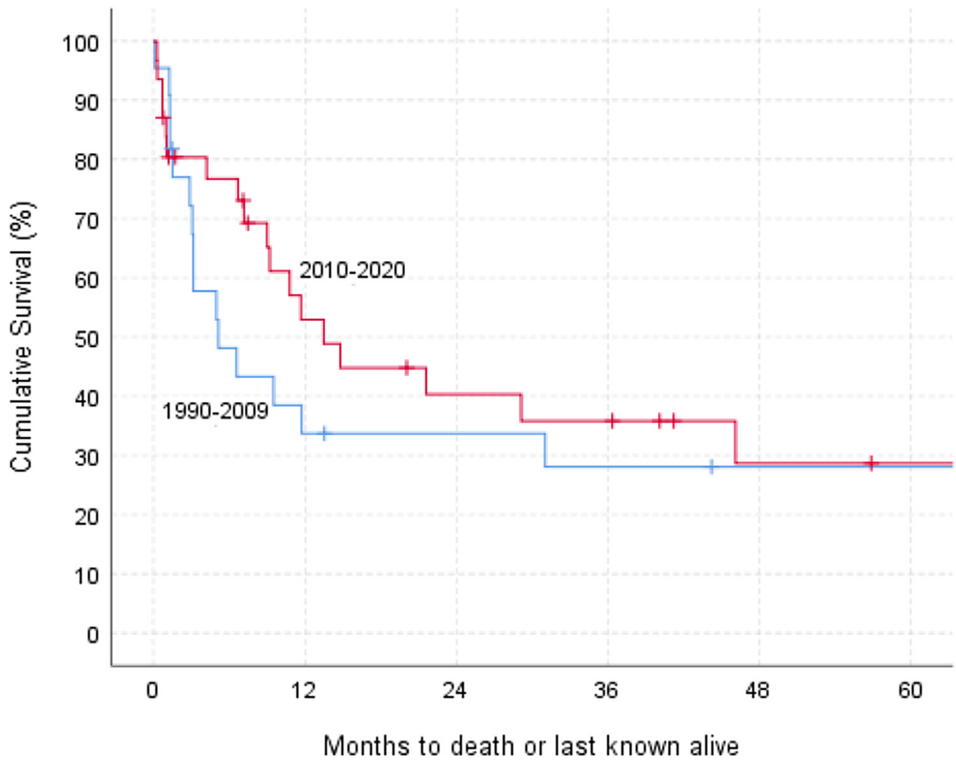

Figure 1. Kaplan-Meier survival by time period for group 1 patients aged 65 years and over Log-rank test chi-squared value =0.11 p=0.74 1990-2009 median (IQR) age 78 (77-83), n=22 2010-2020 median (IQR) age 80 (73-84), n=31.

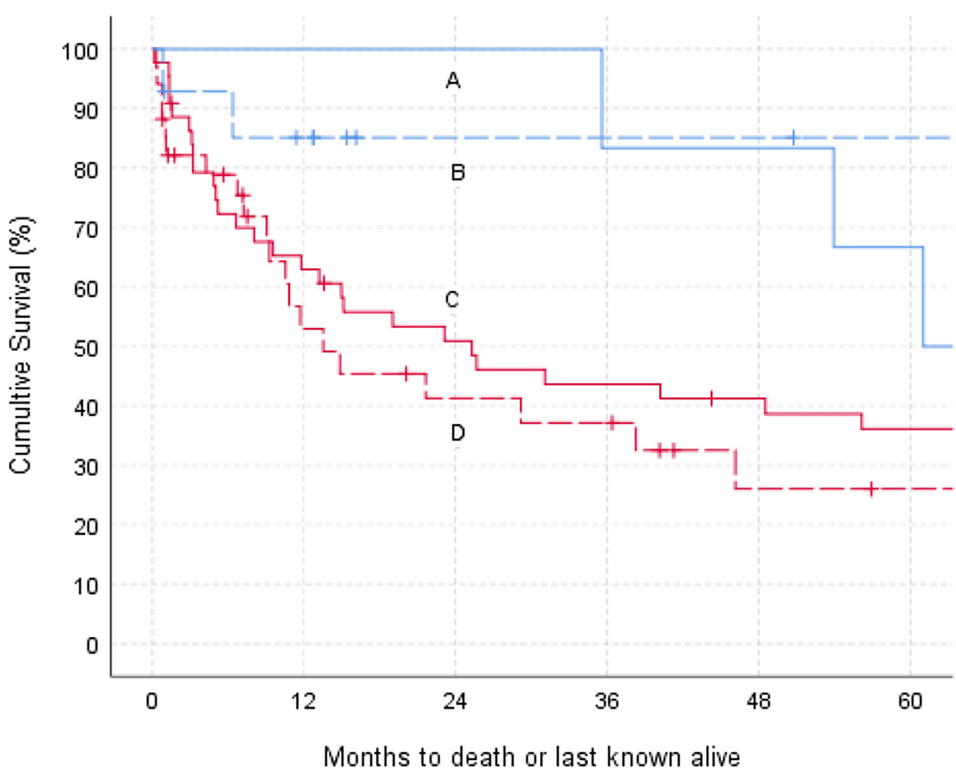

Figure 2. Kaplan-Meier survival by patient group and time period Footnote: A: ORN, 1990-2009, n=6 B: ORN, 2010-2020, n=14 C: Primary tumour without salvage, 1990-2009, n=44 D: Primary tumour without salvage, 2010-2020, n=34.

The second group in this series is where the CRFFF was used for flap salvage when the initial composite flap failed. In our unit the reported overall flap failure rate is 2%, with a rate of up to 7% when applied to composite flaps only.[12,22] Hence in this series the number of CRFFF (five patients) is small and difficult to draw any firm conclusions. Nonetheless, it should be pointed out that, all flap salvage cases utilising a CRFFF were successful and is demonstrates that this flap is a reliable salvage option.

The third studied group were patients with osteoradionecrosis (ORN). Radiotherapy is a commonly used modality both as primary treatment and following surgery. The number of patients with ORN are likely to increase as there is evidence of improved survival in HPV positive tumours. As a consequence, surgeons will be faced with the reconstructive challenges following ORN, hence the importance of the data concerning the CRFFF in this situation and its place in relation to other flaps.[12]

A notable outcome of this study was the recipient vessels in the neck particularly in ORN cases. As far as we are aware, there is only one other study [29] reporting recipient vessels in the neck for ORN, where the authors reported a series of 33 cases. The recipient vessels used were the facial artery (23 cases), superior thyroid artery (9 cases) and the lingual artery (1 case). In our present study 55% of the ORN cases had a successful arterial anastomosis at the transverse cervical artery (TCA) with 45 % at the transverse cervical venous (TCV) system. This is of significant relevance with regard to pre operative planning and choice of flap. We have demonstrated that the transverse cervical vessels can be reliably and safely used in selected cases of ORN requiring reconstruction. However, use of these vessels mandates the use of a flap with a reliably long pedicle, such that it can reach the infra clavicular area. The CRFFF with a pedicle length of up to 18 cm can predictably do this. Additionally, use of the CRFFF also facilitates utilisation of contra-lateral vessels should that be required.

In conclusion, the CRFFF remains an very useful flap for reconstructive head and neck surgeons to have in their armamentarium and in light of its potential limitations, particularly in terms of fracture rates and limited bone stock, appropriate training in both harvesting technique and case selection is important.

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Conflict of interest

We have no conflicts of interest.

Ethics Statement / Confirmation of Patients' Permission

Audit approval was granted by Liverpool University Foundation NHS Trust Audit Department (CAMS No. 9727). Patient permission N/A.

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