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# Salvage outcomes of free tissue transfer in Liverpool: trends over 18 years (1992–2009)

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**Abstract**

Reconstruction of surgical defects in the head and neck using microvascular free tissue transfer is reliable with success rates in excess of 95%. Our previous audit (1992–1998) showed that 16% of patients required an early return to theatre, and the overall free flap salvage rate was 73%. The medical records of 37 patients who had required early return to theatre (within 7 days) after free tissue transfer were analysed to ascertain the indication for reoperation, and whether surgical intervention had been successful, taking into account the timing and cause of compromise. The results of a retrospective re-audit (1999–2004 and 2005–2009) showed that the return to theatre rate had reduced to 4% overall because of a reduction in the number of cases: those that required evacuation of a neck haematoma, and venous compromise of fasciocutaneous or perforator free flaps. Salvage of flaps was most successful when done within the first 24 h, and in cases of venous compromise. Three percent of free flaps failed without attempted salvage; most were late failures. Overall survival (1992–2009) for composite free flaps (93%) was lower than for fasciocutaneous or perforator free flaps (96%). Between 2005 and 2009 our overall free flap survival rate was 98%.


*Keywords:* Microvascular free tissue transfer; Flap salvage; Flap survival; Flap failure; Microvascular anastomosis; Return to theatre

## Introduction

Reconstruction using microvascular free tissue transfer is integral to the management of surgical defects in the head and neck, and the success rate is generally reported to be more than 95%.[1–7] Despite its excellent reliability, compromise occurs occasionally when there is vascular insufficiency, most commonly because of vascular thrombosis, but timely attempts at salvage provide the opportunity to ensure that transfer is successful. Rates of early return to theatre reported in recent studies have ranged from 6% to 20%,[7–10] and those for successful salvage have ranged from 33% to 95%[4–6,11] with improved rates seen when implantable Doppler monitoring was used.[11] The results of our previously published audit from 1992 to 1998[8] are shown in the first column of Table 1.

It was our clinical impression that there had been a marked improvement in the success of free flaps and in the need to return to theatre, which prompted us to further analyse our results. We were also concerned that composite free tissue transfer had a higher rate of compromise.

## Patients and methods

This retrospective audit included all patients who had free tissue transfer in the Regional Maxillofacial Unit, Liverpool from January 1999 to December 2009. Data retrieved from the Aintree Head and Neck Oncology Database and operat-

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Table 1
Summary of the number (%) of free flap cases, returns to theatre, free flaps successfully salvaged, and overall survival of free flaps over 18 years (1992–2009).

| | 1992–1998 | 1999–2004 | 2005–2009 |
|---|---|---|---|
| Number of free flaps | 427 | 435 | 416 |
| Patients returned to theatre within 7 days | 65 (15) | 22 (5) | 15 (4) |
| Return to theatre for bleeding/haematoma | 25 (6) | 2 (0.4) | 3 (1) |
| Flaps compromised with attempted salvage | 40 (9) | 20 (5) | 12 (3) |
| Flaps successfully salvaged | 29/40 (73) | 5/20 (25) | 9/12 (75) |
| Failed flaps: no attempted salvage | 13 (3) | 16 (4) | 7 (2) |
| Survival of flaps | 403 (94) | 405 (93) | 406 (98) |

ing theatre logbooks identified 835 patients who had 851 free flap reconstructions. Thirty-seven patients (4%) required to be returned to theatre within seven days of primary surgery. We analysed the medical records of these patients to ascertain the indication for reoperation, and whether the outcome of the surgical intervention had been successful, taking into account the timing and cause of compromise. Patients who returned to theatre because the implantable Doppler signal had been lost were further analysed to evaluate its influence on salvage outcomes. Those whose flaps had failed without

Table 2
Number (%) of free flaps compromised with attempted salvage: timing of failure, cause of compromise, and flaps that failed with no attempt at salvage.

| | 1992–1998 | 1999–2004 | 2005–2009 |
|---|---|---|---|
| Fasciocutaneous and perforator* free flaps: | | | |
| Compromised free flaps with attempted salvage | 30/427 (7):<br>30 RFFF | 13/435 (3):<br>11 RFFF<br>1 ALT<br>1 lateral arm | 7/416 (2):<br>5 RFFF<br>2 ALT |
| Number salvaged and type | 25 (83):<br>25 RFFF | 4 (31):<br>4 RFFF | 5 (71):<br>4 RFFF<br>1 ALT |
| Early compromise: <24 h | 23 (77) | 6 (46) | 5 (71) |
| Cause of compromise: | | | |
| Arterial | 2 (7) | 4 (31) | 3 (43) |
| Venous | 28 (93) | 9 (69) | 4 (57) |
| Failed flaps: no attempted salvage | 3 (0.7) | 5 (1.1) | 3 (0.7) |
| Composite** free flaps: | | | |
| Compromised free flaps with attempted salvage | 10/427 (2):<br>4 composite radial<br>1 iliac crest<br>4 fibula<br>1 latissimus dorsi | 7/435 (2):<br>4 iliac crest<br>1 fibula<br>2 latissimus dorsi | 5/416 (1):<br>1 composite radial<br>1 iliac crest<br>1 fibula<br>2 scapula |
| Number salvaged and type | 4 (40):<br>2 composite radial<br>1 iliac crest<br>1 fibula | 1 (14):<br>1 iliac crest | 4 (80):<br>1 composite radial<br>1 fibula<br>2 scapula |
| Early compromise: <24 hours | 8 (80) | 2 (29) | 4 (80) |
| Cause of compromise: | | | |
| Arterial | 2 (20) | 3 (43) | 1 (20) |
| Venous | 8 (80) | 2 (29) | 4 (80) |
| Both | – | 2 (29) | – |
| Failed flaps: no attempted salvage | 10 (2) | 11 (3) | 4 (1) |

RFFF: radial forearm free flap, fasciocutaneous.
* Anterolateral thigh (ALT) and lateral arm free flaps only.
** Includes deep circumflex iliac artery perforator and thoracodorsal artery perforator (TDAP) flaps.

Table 3
Failed and salvaged flaps related to the time between the end of operation and return to theatre (1999–2009).

| Time (h) | Salvaged flaps ($n = 14$) | Failed flaps ($n = 18$) |
|---|---|---|
| <4 | 1 | 0 |
| 4–8 | 1 | 1 |
| 9–12 | 4 | 0 |
| 13–16 | 3 | 1 |
| 17–20 | 2 | 3 |
| 21–24 | 1 | 0 |
| 25–48 | 0 | 2 |
| 49–72 | 0 | 7 |
| >72 | 2 | 4 |

Table 4
Operative findings in cases with confirmed flap compromise.

| | |
|---|---|
| Venous problem ($n = 20$): | |
| Complete venous thrombus | 12 |
| Partial thrombus and poor outflow | 6 |
| Bleeding from recipient vein | 1 |
| Avulsion | 1 |
| Arterial problem ($n = 16$): | |
| Complete arterial thrombus | 9 |
| Arterial spasm | 3 |
| Arterial kink and thrombus | 1 |
| Partial thrombus and poor inflow | 1 |
| Pedicle erosion by drain | 1 |
| Avulsion | 1 |

*Note*: More than one cause of compromise can be found in 4 patients.

an attempt at salvage were analysed separately to identify the causes of failure and to ascertain why salvage had not been attempted. In cases where salvage had failed, information was collected on the subsequent management of the residual defects.

The 1999–2009 cohort was divided into two subgroups: 1999–2004 and 2005–2009, as the latest cohort best reflects our current practice. Outcomes in these two groups were compared with the historical 1992 to 1998 cohort.

## Results

The summary of the number of cases, returns to theatre, salvage of free flaps, and overall survival (1992–2009) are presented in Table 1. The data reflect our clinical impression that far fewer patients had required a return to theatre. Overall flap survival over the last five years is now 98%, but the middle period showed a higher rate of failure and poorer salvage figures.

The fasciocutaneous and soft tissue perforator flaps have been compared with composite transfers in Table 2. It is interesting to note that the proportion of fasciocutaneous and perforator soft tissue flaps that were compromised with venous thrombosis had decreased from 93% in 1992–1998 to 57% in the last five years. A reduction in the number of compromised composite free flaps was also consistent with the general pattern, but little can be deduced as the numbers were small. The outcome of free flap salvage related to the time that elapsed between the end of operation and being returned to theatre (1999–2009) is shown in Table 3; results from the 1992 to 1998 cohort have previously been tabulated.[8] The operative findings of cases with confirmed flap compromise are summarised in Table 4.

It was noted in cases of failed and compromised flaps from 1999 to 2009 that in a relatively high proportion of patients with intraoperative difficulties of flap perfusion the arterial anastomosis had to be redone. In 32 cases where an attempt was made to salvage the flap, it was noted that 10 had intraoperative problems with perfusion, and of these only two were salvaged successfully. The salvage rate was 50% (11/22) for those without this problem.

When a decision was made to return to theatre because the signal from the implantable Doppler probe had been lost, there were two cases of false positives, both anterolateral thigh free flaps (ALT), and six cases of true positives (3 iliac crest, 2 ALT and 1 latissimus dorsi), of which one was successfully salvaged (ALT with venous failure), an associated salvage rate of 17% (1/6).

Eighteen cases on the database required reconstruction with combined free flaps: 12 radial forearm free flap (RFFF) and iliac crest, 2 RFFF and fibula, and one each of RFFF and latissimus dorsi; fibula and latissimus dorsi; latissimus dorsi and composite scapula; and scapula with rectus abdominis. Six failed free flaps were from this group (17% failed flaps and 33% of patients with a failed flap), three after unsuccessful salvage, and three without attempted salvage.

Table 5
Reconstruction for failed free flaps ($n = 41$).

| Failed flaps | Method of reconstruction | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Radial | Composite radial | Latissimus dorsi | Fibula | TDAP | Scapula | Pectoralis major | Obturator | None |
| RFFF | 6 | – | 3* | – | – | – | 3 | 2 | 2 |
| Composite radial | – | – | – | – | – | – | – | – | 1 |
| Iliac crest | – | 5 | 1 | 1 | 1 | 1 | 1 | – | 2 |
| Fibula | – | 2 | – | – | – | – | 1 | 1 | – |
| Latissimus dorsi | – | – | 1 | – | – | – | 1 | – | 1 |
| TDAP | – | – | – | – | – | – | – | – | 1 |
| ALT | 1 | – | 1 | – | – | – | 1 | – | – |
| Lateral arm | – | – | – | – | – | – | 1 | – | – |

* 2 free flaps and 1 pedicled flap; RFFF: radial forearm free flap; ALT: anterolateral thigh; TDAP: thoracodorsal artery perforator flap.

Twenty-three (3%) free flaps were compromised but salvage was not attempted: 8 RFFF, 7 iliac crest, 3 fibula, 2 ALT, and one each of composite radial, latissimus dorsi, and thoracodorsal artery perforator flaps. Nineteen (83%) of these failed late after more than five days. Most were arterial failures and the rest were a combination of flaps that failed beyond the microvascular anastomosis ($n = 3$), and those associated with wound infection ($n = 1$).

Of a total of 41 free flaps that failed, 31 (76%) needed further reconstruction (22 free flaps and 9 pedicled flaps), 7 (17%) did not have further tissue reconstruction, and 3 cases (7%) of maxillary reconstruction were obturated (Table 5). The survival rate of rescue free flaps was 95% (21/22); the one case that failed, a contralateral RFFF for rescue pharyngeal reconstruction, was ultimately reconstructed with a free latissimus dorsi flap.

## Discussion

There has been a substantial reduction in the need to return to theatre from 15% to 4%, a considerable saving in patient morbidity and overall cost. The improved survival of flaps over the last five years reflects the high success rate of free tissue transfer now regularly reported. To our knowledge, this is the first study to track the trend of salvage and survival outcomes of free tissue transfer in head and neck reconstruction in a large series of patients. It clearly shows the evolution and progress in our practice and the effect of the learning curve.

There are two main reasons for the reduction in the number of cases returning to theatre. Fewer patients developed a neck haematoma that required surgical intervention (1999–2009). We think that this was due to a combination of factors: improved surgical practice with meticulous attention to haemostasis, and a shift towards active (vacuum) drainage of neck wounds. Since the end of 2007, active drainage of neck wounds has been used routinely and it is our clinical impression that this has contributed to the low incidence of haematoma in the neck without compromising the microvascular anastomosis.[12] Secondly, the number of compromised free flaps has also decreased over the three cohorts. In the 1992–1998 period, most venous anastomoses for RFFF were dependent on the deep donor drainage system (venae comitantes). It is now our standard practice to use both the deep and superficial (cephalic vein) venous donor systems, which have been shown to reduce the incidence of venous compromise.[13–15] Further analysis of survival of the radial forearm (fasciocutaneous and composite) free flap in the 1992–1998 (single vena comitans anastomosis) and 2005–2009 (venae comitantes and cephalic vein anastomoses) cohorts showed that survival had improved from 96% (306/318) to 98% (227/231). In the most recent cohort, the ALT made up 27% (69/257) of all fasciocutaneous or perforator free flaps. In our practice these changes have led to an improvement in the calibre of venous anastomosis, and have resulted in a reduction in the number of cases with venous failure. The number with arterial failure is essentially unchanged (Table 2).

The return to theatre rate of 4% (37/851) in our 1999–2009 series compares favourably with previously reported rates of 6–20%.[7–10] Of the cases that required early reoperation 4% (32/851) were specific to compromise of the flap, which is lower than published rates of between 5% and 13%.[4,5,7,11,16,17] In the 2005–2009 cohort, our latest free flap salvage rate was 75% (9/12), which compares favourably with our historical 1992–1998 cohort (73%), and recently reported rates of 33–83%.[4–6] In the most recent cohort, the type of free flap did not seem to affect salvage outcomes appreciably (80% composite free flaps compared with 75% fasciocutaneous free flaps), which contrasts with our previous finding that composite free flaps had a lower salvage rate. One possible explanation for this is the increased use of pharmacological assistance during rescue microvascular anastomosis. In addition to the routine use of heparinised saline solution (50–100 U/500 ml), topical papaverine hydrochloride is used in the event of arterial spasm. In cases where flap perfusion is complicated by early formation of a thrombus across the anastomosis, we use 100–160 U/kg heparin intravenously before releasing the clamps after the repeat arterial anastomosis.[18] Intravenous heparinisation can be continued for five days postoperatively, maintaining the APTT at 1.5 times normal, but it carries a risk of bleeding and formation of a haematoma. Continued heparinisation was used on one occasion and a neck haematoma developed, but did not require treatment. In head and neck ablative procedures, continued routine heparinisation has a high risk of bleeding and is now unlikely to be used in our practice.

In this series, free flap salvage was more successful when compromise was detected early and where there was venous failure. Data from this study showed the first 24 h to be the most crucial period for deciding the outcome of flap salvage in relation to the timing of failure. Cases that were compromised late or were due to arterial failure were more likely to fail. The higher proportion of arterial and late failures in the 1999–2004 cohort had an adverse impact on the outcomes of flap salvage, a finding also seen in a separate large series.[7] Previously undiagnosed coagulopathy (thrombophilia) can have an adverse effect on free tissue transfer as shown in one patient (a case of RFFF reconstruction of an anterior defect in the floor of the mouth with unsuccessfully salvaged venous failure) who was found to have an underlying prothrombin gene mutation after attempted flap salvage.[19]

It is currently our practice to monitor all free flaps hourly for the first 48 h, then 4-hourly for up to a week. After seven days they are monitored once a day. Monitoring is by clinical examination unless it is not possible.

Implantable Cook-Swartz Dopplers were used to monitor buried flaps and in selected cases of “pale” fasciocutaneous flaps. Our experience with implantable Doppler monitoring of buried flaps has been mixed with a related salvage rate of 17% (1/6), inferior to other reports.[11,17,20] We secure the Doppler monitor on the arterial anastomosis as we have found

Table 6
Survival of iliac crest free flaps in mandibular and midface reconstruction. Data are number (%).

| | No (%) flaps survived | | | |
|---|---|---|---|---|
| | Mandibular reconstruction DCIA | | Midface reconstruction DCIA | |
| | Single flap | Double flaps | Single flap | Double flaps |
| 1992–1998 | 23/23 (100) | 7/9 (78) | 15/16 (94) | 3/5 (60) |
| 1999–2004 | 35/39 (90) | 7/9 (78) | 13/15 (87) | 1/2 (50) |
| 2005–2009 | 15/16 (94) | 1/3 (33) | 4/4 (100) | 0 |
| Total flaps survived | 73/78 (94) | 15/21 (71) | 32/35 (91) | 4/7 (57) |
| Overall number of flaps survived | 88/99 (89) | | 36/42 (86) | |

DCIA: deep circumflex iliac artery flap.

that placing it on the venous anastomosis tends to produce false positive or artefactual readings.[20] The arterial monitor also gives a more definite signal. However, early venous failure might be missed until arterial failure has set in, and by that stage salvage might not be possible.

Our previous study[8,21] showed that when combination flaps (67% involved free iliac crest reconstruction) were used to reconstruct composite defects the increased number of microvascular anastomoses could complicate the reconstruction as was seen in the failure of flaps in 33% (6/18) of defects that were reconstructed with combination flaps. This prompted us to look more closely at the success rate of the lower vascularised iliac crest (Table 6).

It is clear that the failure rate of single flaps is lower in both mandibular and midface reconstruction. The favoured combination of the iliac crest usually with the RFFF has lowered the success rate from 93% (single flap iliac crest) to 88% (overall survival of iliac crest). The capacity to include one or two skin paddle(s) for soft tissue coverage made the scapula a more simple single flap reconstruction with higher overall survival for composite maxillofacial defects (53/54 (98%) flaps survived 1992–2009).

Where possible, we now avoid reconstruction with combined free flaps. An additional contributor to the higher failure rate of the iliac crest has been its favoured use in midface reconstruction, and particularly in the use of vein grafts because of the distance to recipient vessels. In seven cases of maxillary reconstruction with the vascularised iliac crest where interpositional vein grafts (5 arterial and 2 venous systems) were used because the pedicle was too short, three flaps became compromised and failed despite attempted salvage. This reflects the intraoperative problems alluded to earlier which resulted in more flaps being compromised. In these situations it is essential to preserve recipient vasculature during neck surgery without compromising ablative intention, and harvesting the bone more distally optimises the length of the pedicle. The quality of bony tissue offered by the free iliac crest for dentate segmental mandibular reconstruction and Class 3 maxillectomy defects[22,23] is superior to other alternatives, and remains an essential reconstructive option.

While surgical records of compromised flaps between 1999 and 2009 showed that intraoperative difficulties in achieving perfusion were associated with a higher failure rate (20% salvage compared with 50% with no intraoperative problems). The records of the 792 other cases were not examined so we cannot report the number of flaps with intraoperative problems that subsequently survived without compromise. An audit that prospectively records problems of intraoperative flap perfusion or drainage would be worthwhile and would confirm our clinical impression that these translate to more postoperative problems.

The survival rate of rescue free flaps (95%) in our series was higher than the reported rate of 89%.[24] This has shown that rescue free flap reconstruction is a viable option for this group of patients.

The results of this audit are outcomes of our cumulative experience over the last 18 years in free tissue transfer involving 1278 free flap reconstructions in a varied and extensive cohort of patients. Overall flap survival has improved from 94% to 98%. In addition to the influence of the learning curve and improved surgical expertise; team experience that is linked directly to patient care (and monitoring of flaps) is crucial to ensure that this trend is sustained. The availability of more sensitive monitoring techniques such as microdialysis might allow flap compromise to be detected earlier, particularly in cases with intraoperative difficulties in achieving perfusion.[25] In cases of late failure, reports of catheter-directed thrombolysis[7] have shown some promise, and future studies directed to these areas could potentially further improve survival of free flaps.

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