

Single Versus Simultaneous Double Free Flaps for Head and Neck Reconstruction

Comparison of Flap Outcomes and Donor-Site Morbidity

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Introduction: Ablative procedures of the head and neck often result in substantial defects that require large-volume tissue transfer for restoration of form and function. Multiple simultaneous free flaps may be required for complex defects, but these procedures are often avoided because of the perception of an increase in associated surgical complications and morbidity. We present our experience with the use of simultaneous multiple free flaps as compared with single free flaps (SFFs) for head and neck reconstruction.

Methods: Thirty-seven patients with a history of head and neck malignancy underwent SFF reconstruction, and 21 patients underwent double free flap (DFF) reconstruction. Statistical analysis was conducted comparing demographics, comorbidities, etiology of disease, and surgical outcomes between the 2 patient groups.

Results: Operative time and length of hospital stay were both significantly longer in the DFF group versus the SFF group. Despite significantly higher rates of preoperative radiation, osteoradionecrosis, and operation for secondary malignancy in DFF group, no significant differences in flap survival, partial flap loss, recipient site complications, or donor site complications were found. Overall flap-related reoperation rates were low, as were total flap losses. There were 10 complications (24%) that required reoperation in the DFF group, and 1 total flap loss (2.4%), on per-flap basis. There were 10 complications (27%) that required reoperation in the SFF group and 3 total flap losses (8.1%). Per-flap incidence of donor site morbidity in the DFF group was significantly lower than that in the SFF group (23.8% vs 56.8%, respectively, $P = 0.011$).

Conclusions: The use of multiple free flaps for reconstruction of major head and neck tissue defects is sometimes necessary to achieve adequate reconstructive results. These procedures have no significant associated increase in overall flap-related complications. Our findings suggest that donor site morbidity can be minimized in double-flap reconstructions by thoughtful flap selection.

Key Words: donor site, double flap, free flap, head and neck reconstruction, multiple free flaps

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Ablative procedures of the head and neck often result in substantial defects requiring complex multidimensional reconstruction for rehabilitation of both function and cosmesis. Free tissue transfer has become an accepted contemporary standard of practice for reconstruction

of major defects of the head and neck.^{1–12} In cases of advanced disease, these patients may require large volumes of tissue transfer to achieve adequate reconstruction and restoration of function. Composite defects are common, necessitating multiple tissue types, and in these cases, a single free flap (SFF) may be inadequate to the task.^{2–4,6,8–10,12–15}

Technical proficiency in microsurgical reconstruction has improved over the last 2 decades to the point where there is an expectation of flap survival in excess of 95% at centers that perform a significant volume of these cases.^{2–9,11–16} As these procedures have become safer, more successful, and routine, there has been a greater focus on improving the functional and aesthetic results, which in some cases are accomplished with the use of multiple free flaps.^{4,6,7,9,13,15} The available literature describing these procedures has increased significantly in recent years, demonstrating a reasonable degree of safety and success and generally supports the notion of improved outcomes with regard to both function and cosmesis relative to single-flap procedures.^{2–4}

However, these are complicated procedures with many variables that can affect the success of the reconstructive effort and associated surgical morbidity. The seemingly logical perception is that a multiple free flap procedure would impose an increase in risk of patient morbidity, as well as risk to the technical success of the flaps used during the reconstruction relative to a simpler single-flap procedure. However, there are very few studies that directly compare the outcomes of single-flap versus multiple-flap procedures in this complex patient population, and those that do propose varied conclusions.^{5,6,11,15} In addition, while the available data generally support multiple-flap procedures as safe and effective, there remains significant room for improvement in outcomes. For example, overall surgical morbidity, although unfortunately inherent in this patient population, is frequently overlooked in favor of other technical considerations, but can and should be minimized when practical.

In this article, we present our experience with the use of simultaneous multiple free flaps for head and neck reconstruction of major tissue defects in patients with a history of head and neck cancer, a critical analysis of the associated surgical morbidity, and proposed improvements in surgical strategy that may diminish the overall burden of postoperative surgical stigmata in these complicated patients.

METHODS

Under institutional board review approval, records of consecutive patients between 2009 and 2013 who underwent free-flap reconstruction of major head and neck tissue defects were reviewed. Patients were categorized into 2 groups: those undergoing reconstruction with an SFF and those undergoing simultaneous reconstruction with DFFs. Flap selection was determined by the senior author (H.S.H.). All patients included in the study had a history of head and neck malignancy. Patients who received more than 2 simultaneous free flaps or whose etiology was unrelated to malignancy were excluded from this study. Demographic and outcomes data were collected regarding patient comorbidities, flaps and recipient vessels used for reconstruction, procedural time, length of hospital stay, and postoperative

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TABLE 1. Demographic Data for Included Patients

	Single Flap	Double Flaps	<i>P</i>
Total patients, n	37	21	
Average age, y	55.24	54.19	0.713
Male, n (%)	28 (75.7)	16 (76.2)	0.965
Female, n (%)	9 (24.3)	5 (23.8)	
Comorbidities			
Tobacco use	31 (83.8)	20 (95.2)	0.205
Ethanol abuse	21 (56.8)	12 (57.1)	0.977
Hypertension	13 (35.1)	7 (33.3)	0.892
Hyperlipidemia	2 (5.4)	2 (9.5)	0.560
Diabetes	3 (8.1)	1 (4.8)	0.636
Hypothyroidism	2 (5.4)	3 (14.3)	0.254
Chronic obstructive pulmonary disease	1 (2.7)	1 (4.8)	0.686
Coronary artery disease	2 (5.4)	—	0.286
Preoperative chemotherapy	7 (18.9)	5 (23.8)	0.665
Preoperative radiation	15 (40.5)	15 (71.4)	0.024*
Etiology of defect			
Primary malignancy	35 (94.6)	9 (42.9)	<0.001*
Osteoradionecrosis	2 (5.4)	10 (47.6)	<0.001*
Recurrent malignancy	—	2 (9.5)	0.058

Statistical analysis was performed using Pearson χ^2 or Fisher exact test for categorical variables and Student *t* test for scale variables. *P* < 0.05 was considered statistically significant.

*Statistical significance.

complications. Donor site morbidity was defined as the need for additional procedures beyond primary incisional closure, for example, the use of a skin graft or skin substitute. Donor site complications were defined as postoperative events that required return to the operating room or dressing changes and included hematomas, dehiscence, and infection. Recipient site complications were defined as postoperative events that required return to the operating room and included partial flap loss and total flap loss.

Statistical analyses were performed on demographic and outcome variables comparing the 2 study groups using Pearson χ^2 or Fisher exact test for categorical variables where appropriate and Student *t* test for scale variables. Forward stepwise logistic regression analysis was performed on select variables to assess for independent risk factors associated with total flap loss, overall recipient site complications, and overall donor site complications. *P* < 0.05 was considered statistically significant.

RESULTS

Demographics

Fifty-eight patients underwent reconstruction of major head and neck defects: 21 with multiple flaps and 37 with single flaps (Table 1). All patients had either active primary malignancies or a history of previously treated malignancies. The SFF group included 28 males and 9 females, whereas the DFF group included 16 males and 5 females (*P* = 0.965). The average ages of the patients treated for each group were 55.24 (SFF) and 54.19 (DFF), respectively (*P* = 0.713). The most common comorbidities are listed in Table 1, none of which demonstrated a statistically significant difference between the 2 treatment groups (Table 1).

Of the SFF patients, 7 (18.9%) underwent previous chemotherapy versus 5 (23.8%) of the DFF patients (*P* = 0.665). Fifteen (40.5%) of the SFF patients had previous radiation therapy versus 15 (71.4%) of the DFF patients (*P* = 0.024), which was a statistically significant difference (Table 1).

Regarding etiology of disease and the subsequent need for surgery, 35 (94.6%) of the SFF patients versus 9 (42.9%) of the DFF patients were being treated for a primary malignancy (*P* < 0.001), and 2 SFF patients (5.4%) versus 10 DFF patients (47.6%) presented with osteoradionecrosis (*P* < 0.001) that required resection and reconstruction. There were no SFF patients and 2 DFF patients (9.5%) who presented with recurrent malignancies (*P* = 0.058) (Table 1).

Flaps and Vessels Used in Reconstruction

Within the SFF group, the most common single flap used was the anterolateral thigh (ALT) fasciocutaneous flap (18 patients [48.6%]), followed closely by the ulnar forearm fasciocutaneous flap (14 patients [37.8%]) (Table 2). Within the DFF group, the most common flap combination used was overwhelmingly the fibula osteocutaneous flap + ALT (14 patients [66.7%]), followed by the ALT + ALT (4 patients [19%]) (Table 2).

The most common recipient arteries used for microanastomosis in the SFF group were the superior thyroid artery (16 patients [43.2%]) and the facial artery (15 patients [40.5%]) (Table 3). The most common recipient artery combinations used for microanastomosis in the DFF group were the superior thyroid artery + facial artery (17 patients [81%]) and the superior thyroid artery + superior thyroid artery (2 patients [9.5%]) (Table 3).

The most common recipient vein used for microanastomosis in the SFF group was the external jugular vein (21 patients [56.8%]) (Table 4). The most common recipient vein combination used for microanastomosis in the DFF group was the external jugular vein + facial vein (9 patients [42.9%]) (Table 4).

Outcomes

There was a statistically significant difference in procedural time between the 2 groups, with the SFF group taking an average of 622 minutes versus 740 minutes for the DFF group (*P* < 0.001). The average hospital stay was also longer for patients in the DFF group at 28.1 days versus 13.1 days in the SFF group (*P* < 0.001) (Table 5), although there were 2 patients with lengths of stay of more than 50 days and 1 patient with length of stay of more than 100 days, which we

TABLE 2. Type of Individual Flaps and Multiple Flap Combinations Used for Reconstruction Study Patients Included in this Study

	n (%)
Single flaps	
ALT	18 (48.6)
Ulnar forearm	14 (37.8)
Fibula	3 (8.1)
TUG	2 (5.4)
Double-flap combinations	
Fibula + ALT	14 (66.7)
ALT + ALT	4 (19.0)
Fibula + fibula	1 (4.8)
Fibula + ulnar forearm	1 (4.8)
ALT + ulnar forearm	1 (4.8)
TUG indicates transverse upper gracilis flap.	

TABLE 3. Recipient Arteries Used for Microvascular Anastomosis in Both the Single Flap and Double Flap Groups

	No. of Patients (%)
Single flaps	
Superior thyroid	16 (43.2)
Facial	15 (40.5)
External carotid	5 (13.5)
Superficial temporal	1 (2.7)
Double flaps	
Superior thyroid + facial	17 (81.0)
Superior thyroid + superior thyroid	2 (9.5)
Superior thyroid + external carotid	1 (4.8)
Facial + ascending pharyngeal	1 (4.8)

thought might have contributed to this difference. However, when we identified outlier hospital stays with the interquartile range outlier detection method, there were 2 outliers in the DFF group and 1 in the SFF group. Excluding outliers, the difference in average hospital stay was still statistically significant, with the SFF group at 12.47 (SD, 5.84) days and DFF group at 21.47 (SD, 12.17) days ($P < 0.001$) (Table 5).

Data for flap loss and complications were statistically analyzed by patient and by flap. Because there were 37 SFF patients and 37 SFF flaps, relative to 21 DFF patients and 42 DFF flaps, the percentage of complications and statistical results varied somewhat between the 2 different analyses. On a per-patient basis, there were 3 total flap losses (8.1%) in the SFF and 1 total flap loss (4.8%) in the DFF group ($P = 0.636$). There were no partial flap losses in the SFF group and 2 partial flap losses (9.5%) in the DFF group ($P = 0.058$) (Table 5).

Total flap loss and partial flap loss did not statistically differ between groups (Table 5). In the DFF group, 1 ALT flap was lost because of venous outflow problems and was replaced with a vertical rectus myocutaneous flap. Skin paddle loss in 1 fibula flap due to late infection required replacement with an ALT flap. Three fibula flaps were revised in the operating room for late venous thrombosis. One ALT flap was revised because of arterial thrombosis. There were 3 instances of intraoral flap dehiscence that required operative revision and 1 hematoma that was evacuated.

Similarly, recipient site complications did not differ significantly between groups. Recipient site complications in the SFF group included 2 ALT flap losses, each of which was replaced with a pectoralis myocutaneous flap and loss of an ulnar forearm flap. There were 2 incidences of anastomotic revision for venous outflow issues. One incidence of flap dehiscence required revision with a pectoralis myocutaneous flap. Two hematomas required evacuation, and there were 2 recipient site infections that required incision and drainage. Overall, there were 10 recipient site complications (27%) in the SFF group and 9 recipient site complications (43%) in the DFF group on a per-patient basis ($P = 0.224$) (Table 5).

Donor site complications did not differ significantly between groups. There were 3 total donor site complications (8.1%) in the SFF group and 2 total donor site complications (9.5%) in the DFF group on a per-patient basis ($P = 0.857$) (Table 5). Conversely, donor site morbidity differed significantly between groups on a per-flap basis. There were 19 flaps (51.3%) in the SFF group and 10 flaps (23.8%) in the DFF group that required primary skin grafting or placement of a skin graft substitute ($P = 0.011$).

Logistic Regression Analysis

Forward stepwise logistic regression analysis was performed using selected demographic and outcome variables to identify independent

risk factors for flap loss (total or partial), recipient site complications, and donor site complications (Table 6). Variables analyzed included gender, age, length of hospital stay, procedural time, preoperative chemotherapy, preoperative radiation, presence of a primary malignancy, and a diagnosis of osteoradionecrosis. None of the selected independent variables demonstrated a statistically significant relationship. Multivariable analysis was not performed for donor site morbidity, as flap selection determined this outcome (Fig. 1).

DISCUSSION

The use of multiple free flaps for reconstruction of major head and neck tissue defects is sometimes necessary to achieve reconstructive goals. Complicated patients with significant tissue involvement due to active malignant disease or with extensive destruction or destabilization of healthy tissues due to previous radiation therapy are commonly in need of healthy bone and/or a significant amount of healthy soft tissue in order to reliably achieve a durable and functional outcome, and there is often an indication for multiple flaps in order to replace the tissues that are resected.

Multiple previous studies have explored the indications, technical, and functional outcomes for these procedures, with the general consensus being that multiple-flap reconstructions have merit. Despite the demonstration of acceptable complication rates and reasonable results, it remains apparent from some reports that double-flap procedures are frequently avoided because of the perception that they are associated with increased risk and complication rates.^{2,5} While there are a few studies that offer direct comparison of outcomes between single-flap and double-flap procedures, the majority of the available literature offers only descriptive data from a single group of patients with no statistical comparison or focuses on indications for these procedures.^{2-8,10,11,13,15} This study aimed to address these issues with an extensive statistical comparison of single-flap and double-flap reconstructions performed by a single surgeon.

Our data regarding procedural and inpatient recovery times were consistent with previously reported series—average operative times for double flap cases ranged from 9.8 to 14 hours and inpatient stays from 10 to 35 days—and confirmed that DFF procedures are associated with an increase in these times relative to single-flap procedures, as might be expected.^{2,5-8,12,14} Overall flap survival and complication rates were also congruous with previously reported studies for multiple-flap procedures.^{7,10-12,14} Of note, there was no statistical difference in flap

TABLE 4. Recipient Veins Used for Microvascular Anastomosis in Both the Single Flap and Double Flap Groups

	n (%)
Single flaps	
External jugular	21 (56.8)
Facial	5 (13.5)
Internal jugular	5 (13.5)
Superior thyroid	5 (13.5)
Superior temporal	1 (2.7)
Double flaps	
External jugular + facial	9 (42.9)
External jugular + internal jugular	3 (14.3)
Facial + superior thyroid	3 (14.3)
External jugular + superior thyroid	2 (9.5)
External jugular + external jugular	2 (9.5)
Internal jugular + internal jugular	1 (4.8)
Facial + internal jugular	1 (4.8)

TABLE 5. Outcomes

	Single Flaps	Double Flaps	P
Average procedural time, min	622.19	740.33	0.001*
Average hospital stay, d	13.14	28.14	0.001*
Average hospital stay excluding outliers	12.47	21.47	0.000*
Total flaps	37	42	
Total flap loss			
Per patient	3 (8.1%)	1 (4.8%)	0.636
Per flap	3 (8.1%)	1 (2.4%)	0.252
Partial flap loss			
Per patient	0 (0%)	2 (9.5%)	0.058
Per flap	0 (0%)	2 (4.8%)	0.183
Recipient site complications			
Per patient	10 (27%)	9 (43%)	0.224
Per flap	10 (27%)	10 (24%)	0.747
Donor site complications			
Per patient	3 (8.1%)	2 (9.5%)	0.857
Per flap	3 (8.1%)	2 (4.8%)	0.548
Donor site morbidity			
Per patient	19 (51.3%)	7 (33.3%)	0.191
Per flap	19 (51.3%)	10 (23.8%)	0.011*

survival, overall recipient site complications, or donor site complications relative to those patients who underwent SFF procedures.

In some patients, there is also legitimate concern over the availability of adequate recipient vessels to accommodate multiple free flaps.^{1,12} However, this was not an issue in our series, as careful coordination with the ablative surgeon generally allowed for preservation and/or identification and preparation of adequate vessels permissive of the planned tissue transfers. Our observations here were similar to those reported in previous studies.^{12,14}

Within our study group, we found significant differences between the SFF and DFF patient populations regarding indicatory diagnoses, history of radiation therapy, and the presence of osteoradionecrosis. These demographic differences have been previously documented, and it is intuitive that more involved disease would necessitate more extensive reconstruction.² It would be reasonable to assume that these factors might influence the outcomes and incidence of complications.¹⁷ However, our analysis indicated that these variables were not predictive of increased complications or flap loss. This suggests that double-flap reconstructions can be performed with an expected complication profile equivalent to that of single-flap reconstructions despite an overall higher incidence of comorbidities and more complicated disease history in patients requiring double-flap reconstruction.

In addition, we found that donor site morbidity in the DFF group was roughly half that of the SFF group on a per-flap basis, with more flaps in the SFF group requiring additional procedures for donor site closure. Flap selection obviously plays a major role in donor morbidity, and there were a much larger number of ulnar forearm flaps ($n = 14$) used in the SFF group relative to the DFF group ($n = 2$), and these flaps will almost always require a skin graft for closure, leaving what is frequently an unsightly and obvious donor site. While the ulnar (or radial) forearm free flap has been a workhorse for reconstruction of head and neck defects due to its lengthy pedicle and thin tissue, other options could potentially be considered that may result in a less morbid and less visible donor site, an idea that has been put forth previously.^{8–11} Other flaps that could be considered in these cases include thinned ALT flaps, superficial circumflex iliac artery perforator flaps, or medial sural artery perforator flaps. These have been used in recent years as alternatives to

the forearm flap for just this reason, and the donor sites can typically be closed into a simple linear incision and are in more easily concealable locations.^{3,18,19} If feasible, making use of these alternate flaps may be preferable to subjecting these patients to an even greater burden of morbid surgical stigmata.

In our series, 100% (3 of 3) of free fibula flap donor sites in the SFF group experienced donor site morbidity relative to only 29.4% (5 of 17) of free fibula donor sites in the DFF group. One possible explanation is that the use of a second fasciocutaneous free flap from a separate donor site may allow for the harvest of smaller fibula skin paddles, facilitating primary closure of the donor site and avoiding some of the morbid stigmata of these procedures. Again, this is a concept that has been previously discussed in the literature, with at least 1 study suggesting that there may be defined critical dimensions of the fibula skin paddle beyond which are associated with increased incidence of complications.²⁰

Although it may seem counterintuitive that an additional flap could result in less morbidity, there is also recent precedent for this concept in microvascular breast reconstruction, and the data in this study further support to this concept. In addition, as microvascular techniques, efficiency, and outcomes continue to improve, there has been a greater focus on donor site aesthetics in all arenas of reconstruction.^{8–11,20,21} If it can reasonably be accomplished given the clinical scenario, then ideally all efforts should be made to diminish secondary surgical disfigurement associated with these reconstructive procedures. “Microsurgical engineering,” the blending of flap choices, aesthetic sensibility, technical microsurgical creativity, and core reconstructive principles, can achieve this goal of durable reconstruction with minimization of donor site morbidity in simultaneous double-flap reconstructions.²²

Our study carries a few limitations. Given the relatively small number of included patients, the sample size may have been too small to identify statistical differences between groups; for example, the incidence of recipient site complications per patient was relatively higher in the DFF group but was not statistically significant. However, other studies have also suggested that overall complication and flap survival rates are similar between these 2 treatment groups and that it is actually the number of consecutive rather than synchronous flaps that may affect outcomes in these cases.^{6,11,15} We did not calculate flap areas or volumes and were thus unable to comment on flap harvest dimensions predictive of donor site morbidity. In addition, these procedures were performed by a single experienced microsurgeon, and these results may not be generalizable to more novice surgeons or those not routinely performing microsurgical head and neck reconstruction. Despite these

TABLE 6. Stepwise Logistic Regression of Flap Loss, Recipient Site Complications, and Donor Site Complications by Independent Demographic and Risk Factors

	Flap Loss	Recipient Site Complications	Donor Site Complications
	P	P	P
Gender	0.411	0.892	0.228
Age	0.590	0.211	0.303
Length of stay	0.739	0.777	0.758
Procedural time	0.790	0.813	0.096
Chemotherapy	0.439	0.773	0.502
Radiation	0.820	0.734	0.872
Primary malignancy	0.651	0.182	0.889
Osteoradionecrosis	0.755	0.356	0.334

$P < 0.05$ was considered statistically significant.

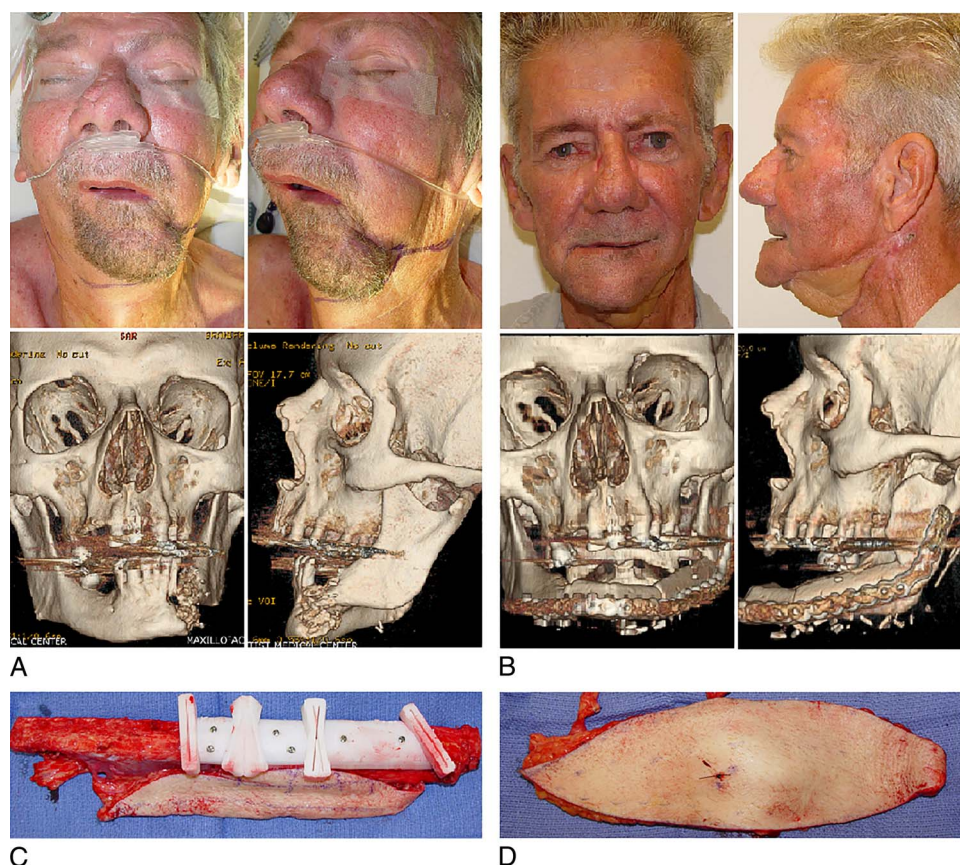


FIGURE 1. A 68-year old man with extensive mandibular osteoradionecrosis secondary to radiation therapy for oral squamous cell carcinoma. A, Preoperative pictures and CT scan images. B, Postoperative pictures and CT images. A free fibula (FFF) osteocutaneous flap (C) was used for reconstruction of the mandible, and an ALT fasciocutaneous free flap (D) was used for soft tissue coverage. The FFF was anastomosed to the right facial artery and right facial vein, whereas the ALT was anastomosed to the right superior thyroid artery and a branch of the right internal jugular vein. Preoperative virtual surgical planning was used to facilitate intraoperative efficiency and accuracy of the reconstruction.

limitations, our data suggest that there may be no additional risk to the technical success of simultaneous DFFs or increased recipient site morbidity associated with these procedures.

CONCLUSIONS

Patients suffering from head and neck malignancies and the deleterious effects of treatments associated with their pathologic processes pose reconstructive challenges often requiring microsurgical expertise. Our results indicate that simultaneous double-flap reconstructions of head and neck defects can be performed with a complication profile equivalent to single-flap reconstructions. Thoughtful flap selection, including the confidence to use a second free flap in the initial reconstruction, plays a crucial role in minimizing donor site morbidity.

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