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Outcomes following head neck free flap reconstruction requiring interposition vein graft or vascular bridge flap

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Abstract

Background: Interposition vein grafts (IVG) and vascular bridge flaps (VBF) have been exploited as vascular conduit in challenging head and neck reconstructions.

Methods: A retrospective review was conducted on 6025 flaps. The effect of patients' characteristics and length of IVG on flap compromise and loss were analyzed. Comparison between IVG and VBF was performed.

Results: The flap compromise and loss rates for the overall group were 8.2% and 3.2%, respectively. An IVG was used in 309 free flaps. The average length of the vein grafts was 6.9 ± 4.2 cm. An unplanned return to the operation room occurred in 32 cases (10.4%) and failure of the flap in 12 patients (3.9%). Binary logistic regression found a significant association between flap compromise and loss rates and length of IVG, hypertension, prior radiation, and neck dissection. In the multiple regression model, length of IVG and prior radiation significantly influenced the outcomes. Thirty-nine patients underwent reconstruction with a long IVG (>10 cm). Twenty-six patients underwent surgical reconstruction with radial forearm flap as a VBF. The rate of flap compromise was higher in the group with a long IVG ($P = .01$).

Conclusions: In head and neck free flap reconstruction, the length of IVGs and history of radiotherapy are associated with flap compromise and loss. In case of long distance between the pedicle and the recipient site, the use of a VBF bridge should be considered as a safe alternative.

KEYWORDS

bridge flap, flow-through vascular flap, head and neck reconstruction, microvascular free flap, vein graft

1 | INTRODUCTION

Head and neck reconstruction can be challenging in patients with extensive tumor, prior surgery, recurrences, or history of radiotherapy.[1–4] The choice of recipient vessels can directly affect the outcomes and different strategies are considered when the distance from the free flap to healthy recipient vessels is greater than the pedicle length.[5] Although the use of flaps with long pedicle and the choice of recipient neck vessels outside the zone of injury can be effective in overcoming this problem, in some cases extension to the flap pedicle length is required.[1,6,7] In these situations, interposition vein grafts (IVGs) or vascular bridge flow-through flaps have been exploited.[3,5,8]

Although interposition vein grafting has been used for many years, reluctance to employ this technique remains,

owing to concerns about a purported increased risk of free flap loss.[9] Indeed in head and neck free flap reconstruction, few studies in literature accounts for the use of vein graft, leading to controversial outcomes.[2]

As evidence suggests that long vein grafts (LVGs) are associated with a higher risk of thrombosis and complications, in complex head and neck defects; the inclusion of a vascular carrier, a flow-through or vascular bridge flap is an important alternative to consider in these challenging reconstructions.[3,10,11]

The aim of this study is to retrospectively evaluate the outcomes of the patients who underwent head and neck free flap reconstruction with vein grafts and vascular bridge flaps (VBF) at China Medical University Hospital. We examined how the length of a vein graft can influence free flap success, and compared complication rates between free flaps with vein grafts or VBF, in patients with inadequate flap pedicle length to reach the recipient vessels.

2 | METHODS

2.1 | Patients

A retrospective chart review was conducted to identify patients who underwent head and neck free flap reconstruction performed between January 1983 and December 2017 at our institution. Patients' demographics, medical history, family history, flap characteristics, and surgical outcomes were collected from our prospectively designed databases. Among them, we selected reconstructions with the use of IVG or VBF. The length of the vein grafts was analyzed in the chart. First, we evaluated if the length of a vein graft influenced flap compromise and flap loss. Flap compromise was defined as the presence of compromised free flap vascular perfusion resulting in an unplanned return to the operating room for attempted flap salvage.[5]

Furthermore, among patients with vein grafts we selected a subgroup of patients with vein graft length of 10 cm or longer. This cutoff was empirically set, as in our experience we would usually perform a flow-through flap to bridge a distance of 10 cm or longer between the recipient and the flap vessels. We compared characteristics of patients and flap compromise and flap loss between the subgroup using LVGs, and the subgroup with free flaps using VBF. The study was approved by our Institutional review and ethical board.

2.2 | Statistical analysis

SPSS software (IBM Corp., Armonk, NY) was used for the statistical analysis. Descriptive statistic was used to summarize the clinical data and outcomes. Overall, for the cohort with vein grafts, a univariate binary logistic regression was performed to investigate the association between flap compromise and flap loss and the length of vein graft. Several variables including age, sex, hypertension, smoking, diabetes, diagnosis, type of flap, vessel/s grafted, prior radiation, prior chemotherapy, prior neck surgery, and vein graft donor site were also evaluated. In case of significant association of two or more variables a multiple regression was performed.

For comparison of LVGs and VBF, the Shapiro-Wilk test was used to verify for normal distribution of continuous variables. Then, unpaired *t* test was conducted. The chi-square test was used to compare categorical variables. Statistical significance was defined as $P < .05$.

3 | RESULTS

A total of 6025 free flaps performed between January 1983 and December 2017 for head and neck reconstruction were included in the study. Flap compromise and loss rates for the overall group were 8.2% and 3.2%, respectively. The compromise and loss rates for nonvein grafted cases (5716) were 8.1% and 3.2%, respectively.

Interposition vein grafting was used in 309 free flaps. The average age of the patients was 53.7 (±13.2) years. Indications for free flap reconstruction included mandibular, oral cavity, skull, and pharyngoesophageal defects. If the design of the flap considered a skin paddle, the dissection was conducted in the subfascial plane. All the fibula flaps were harvested as osteocutaneous flaps and the latissimus dorsi (LD) flaps as musculocutaneous flap. In case of need of a bulky flap, a muscle (gracilis or vastus laterali [VL] flap) or musculocutaneous (LD or anterolateral thigh [ALT] + VL + tensor fascia lata [TFL]) flap was performed. In 22 cases of hypopharyngeal reconstruction, a segment of jejunum based on the second jejunal artery and vein was harvested.

TABLE 1 Characteristic of patients

Characteristics	*n*	%
Sex		
Male	246	79.6
Female	63	20.4
Prior radiation	125	40.5
Prior chemotherapy	165	53.4
Prior surgery	38	12.3
Hypertension	51	16.5
Smoking	53	17.2
Diabetes	18	5.8
Flap compromise	32	10.4
Flap loss	12	3.9

TABLE 2 Diagnosis of the patients

Diagnosis	*n*	%
Buccal cancer	214	69.26
Hypopharyngeal reconstruction	31	10.03
Osteoradionecrosis	30	9.7
Skull exposure	27	8.7
Hypopharyngeal cancer	7	2.3

The average length of the vein grafts was 6.9 ± 4.2 cm. Table 1 summarizes the characteristic of the patients. An unplanned return to the operation room occurred in 32 cases (10.4%) and failure of the flap in 12 patients (3.9%) in patients with IVGs. The types of flaps used in our series, the diagnosis and the nature of the vessels needing a vein graft varied widely in our population (Tables 2–4).

Vein graft donor sites included the greater saphenous, anterior jugular, lesser saphenous, and distal pedicle veins. Vein grafts were utilized for the arterial anastomosis (A) alone in 50 flaps (16.2%), the venous anastomoses (V) alone in 73 flaps (23.6%), and for both venous and arterial anastomosis (AV) in 186 flaps (60.2%). The rate of flap compromise was 4%, 12.9%, and 8.2% in the group A, AV, and V, respectively. The rate of flap loss was 0%, 5.9%, and 1.4% in the group A, AV, and V respectively.

Binary logistic regression found a significant association between the rate of flap compromise and the length of the vein graft, hypertension, prior radiation, and prior neck dissection.

In the multiple regression model, length of the vein graft had a regression coefficient of 0.31 (SE: 0.06; $P < .001$) while radiotherapy had a regression coefficient of 1.81 (SE: 0.53; $P < .01$).

Similarly, the binary logistic regression found a significant association between the rate of flap loss and the length of the vein graft, hypertension, prior radiation, and prior neck dissection.

TABLE 3 Free flaps performed in the study

Flap	N	%
ALT	218	70.6
Fibula	43	13.9
Jejunum	22	7.1
Gracilis	4	1.3
LD	6	2
ALT + VL + TFL	8	2.6
RFF	6	1.94
VL	2	0.65

Abbreviations: Type of free flap: ALT, anterior lateral thigh; ALT + VL + TFL, anterior lateral thigh + vastus lateralis + tensor fascia lata; LD, latissimus dorsi; RFF, radial forearm flap; VL, vastus lateralis.

TABLE 4 Nature of the vessel/s needing a vein graft in the surgeries

	N	%
AV	186	60.2
A	50	16.2
V	73	23.6

Abbreviations: A, artery; AV, artery and vein; V, vein.

In the multiple regression model, length of the vein graft had a regression coefficient of 0.27(SE: 0.07; $P < .001$) while radiotherapy had a regression coefficient of 2.25 (SE: 0.93; $P = .016$).

Among the group of patients with a vein graft, 39 patients (12.6%) underwent reconstruction with free flap assisted by a LVG (>10 cm). All the patients in this subgroup required a graft for both artery and vein. The average length of the grafts performed was of 16.4 ± 4.3 cm.

Twenty-six patients underwent surgical reconstruction with radial forearm flap as a VBF to bridge the blood flow from/to the recipient vessels to/from the free flap. Each patient had two free flaps: the main flap for the defect and the radial forearm flap as VBF. In all the patients, arterial and venous anastomoses were performed at both ends of VBF. The average length of the VBF was of 14.9 ± 2.4 cm.

Characteristics of these two groups of patients and of the surgeries performed are reported in Tables 5–8. Most characteristics of patients in the LVG and VBF graft groups were similar. The only statistically significant difference was found in the number of flap compromises between the two groups: 16 cases in LVG group and 3 cases in VBF group ($P = .01$).

TABLE 5 Characteristic of patients

	LVG		VBF	
Characteristics	***n***	**%**	***n***	**%**
Sex				
Male	30	76.9	19	73.1
Female	9	23.1	7	28.9
Prior radiation	22	56.4	19	73,1
Prior chemotherapy	23	59	16	61.5
Prior surgery	28	71.8	18	69.2
Hypertension	14	35.9	6	23.1
Smoking	14	35.9	14	53.8
Diabetes	2	5.1	2	7.7
Flap compromise	16	41	3*	11.5
Flap loss	6	15.4	2	7.7

Abbreviations: LVG, long vein graft; VBF, vascular bridge flap.
*$P = .01$.

TABLE 6 Diagnosis of the patients

	LVG		VBF	
Diagnosis	***n***	**%**	***n***	**%**
Buccal cancer	27	69.2	16	61.5
Hypopharyngeal reconstruction	4	10.3	2	7.7
Osteoradionecrosis	5	12.8	3	11.5
Skull exposure	3	7.7	4	15.4
Hypopharyngeal cancer	0	0	1	3.8

Abbreviations: LVG, long vein graft; VBF, vascular bridge flap.

4 | DISCUSSION

In head and neck reconstruction, patients with vessel-depleted neck are complicated by increased distance from the pedicle of free flap to reliable recipient vessels.[12] In an attempt to overcome this problem and achieve successful outcomes, several strategies have been suggested. These include flaps with long pedicles and recipient vessels at a distance from the injured zone.[6] In cases where the pedicle of the flap is too short, or the distance from the free flap to reliable recipient vessels is greater than the pedicle length, a vascular reconstruction is also required.[3] In these situations, autologous vein grafts and VBF have been exploited as possible vascular conduits to consider.[3] Furthermore, vein graft interposition is a common strategy when vessel caliber mismatch exists between the recipient vessels and the flap pedicle.[2]

However, in head and neck free flap reconstruction, vein grafting has rarely been addressed in the literature because of the relative infrequency of its use. Few studies reported the outcomes of free flap reconstruction with vein grafts. Recent retrospective analysis showed that the free flap compromise and flap loss rates are significantly increased by the use of an IVG.[2,5] There is evidence to suggest that when vein grafts are used, reverse flow and lengthening of the vascular conduits can cause turbulent flow, stasis, and thrombosis.[3] However, so far, no study has clearly linked the length of the vein graft to a significantly increased risk of complications.

TABLE 7 Free flaps performed in the study

	LVG		VBF	
Flap	***n***	**%**	***n***	**%**
ALT	28	71.8	13	50.0
Fibula	5	12.8	6	23.1
Jejunum	3	7.69	3	11.5
Gracilis	0	0	1	3.8
LD	1	2.56	2	7.7
ALT + VL + TFL	1	2.56	1	3.8
RFF	1	2.56	0	0
VL	28	71.8	0	0

Abbreviations: LVG, long vein graft; VBF, vascular bridge flap. Type of free flap: ALT, anterior lateral thigh; ALT + VL + TFL, anterior lateral thigh + vastus lateralis + tensor fascia lata; LD, latissimus dorsi; RFF, radial forearm flap; VL, vastus lateralis.

TABLE 8 Recipient vessels of the flap

	LVG		VBF	
	n	**%**	***n***	**%**
IMA/V	9	23.1	6	23.1
TA/V	11	28.2	9	34.6
TCA + EJV	17	43.6	8	30.8
ST + EJV	2	5.1	3	11.5

Abbreviations: IMA/V, internal mammary artery and vein; LVG, long vein graft; ST + EJV, superior thyroid artery and external jugular vein; TA/V thoracoacromial artery and vein; TCA + ECJ, transvers cervical artery and external jugular vein; VBF, vascular bridge flap.

Out of 6025 head and neck free flap reconstructions, 309 cases required an IVG. Our rate of flap compromise requiring an unplanned return to the operation room was 10.4% and our flap loss rate was 3.9% in the cohort with IVG. These rates are lower than those previously reported in the literature. In a recent study, Maricevich et al showed that the free flap compromise rate was significantly higher in a group of vein grafted free flaps (14.5%) and reported a flap loss rate of 6.6%.[5] A review by Cheng et al on 4 retrospective studies and on 2102 flaps, reported that a total of 65 flaps used an IVG and 2037 did not. They found that the overall flap failure rate was 5.2%. The flap failure rates were 23.1% in the vein graft group and 4.6% in the group without vein graft.[2,8,12–15]

In our study, the flap compromise and loss rates for the overall group were 8.2% and 3.2%, respectively. The compromise and loss rates for nonvein grafted cases were 8.1% and 3.2%, respectively. Similarly, these data were slightly lower than those reported in the literature. The patients with VBF reported a significantly lower rate of flap compromise (11.5%) in comparison to long vein graft group (41%). The flap loss rate was 15.4% in the IVG group and 7.7% in the VBF group, but no statistical significance was found. Similarly, no statistically significant difference was found in the flap compromise and loss rates between vein-grafted, nonvein grafted, and vascular bridge flap groups. To date, no other studies reported the length of IVG and the outcomes of long IVG and VBF in head and neck reconstructions. To the best of our knowledge, our series accounts for the largest populations of flaps with IVGs and VBF reported in the literature.

In a binary logistic regression model, we found a significant association between the rate of flap compromise and flap loss and the length of the vein graft, hypertension, prior radiation, and prior neck dissection. The design of a multiple regression model confirmed a significance only for the

length of the vein graft and prior radiation. Patients with a history of radiotherapy and with a longer vein-grafted free flap were prone to develop an unfavorable outcome.

It has been reported that a possible inherent thrombogenicity of vein grafts may increase the risk of complications.[3,5,7,16] However, it should be also considered that usually vein grafts are exploited in more complicated cases with hostile recipient bed, more prone to develop unexpected outcomes. In these cases, prolonged operative times come along with a greater likelihood of anastomotic errors due to the requirement of additional anastomoses and consequent surgeons fatigue.[5] In our series, all the anastomoses were performed by the senior author HCC and no anastomotic errors were found at the re-exploration of the flap. Apart from some cases of kinking, twisting, and pressure on the pedicle, no likely explanation was found for the vascular compromise of the flaps. Indeed vein grafting add to the complexity of the surgery and introduces another opportunity for events that lead to flap thrombosis.[1]

Furthermore, according to our experience, when the distance between the pedicle of the flap and the recipient vessels is more than 10 cm we prefer to reconstruct the vascular defect by means of a vascular bridge flap.[1] Covering a long gap with a vein graft can come with an increased likelihood of kinking and twisting of the vessels. A VBF is more reliable, as the vascular pedicle is well protected with a considerable amount of soft tissue-skin envelope, and could be a consistent lifeboat option when the options for recipient vessels are limited. Moreover, VBF serve a dual purpose: They work as axis supplies to the main flap, while catering the need of extra-tissue for the reconstruction of extensive and complicated defects.

In our series, we compared the group of patients with a very long vein graft to a group of patients undergoing head and neck reconstruction with free flap using radial forearm flap bridge flap as a vascular carrier. The patients with VBF reported a significantly lower rate of flap compromise (11.5%) in comparison to long vein graft group (41%). Despite these interesting data, surgeons should also consider the drawback of harvesting a second flap only to reach distant or healthy recipient sites, which may appear burdensome and unnecessary for patients.[1] However, when exploiting IVGs in a hostile recipient bed, where the risk of a flap compromise is estimated to be notable, the VBF emerges as a more dependable alternative. In our experience, by using a reliable VBF, we were able to achieve great survival rate of the reconstructions, sensibly reducing the number of re-explorations. Nevertheless, these results are limited by the small size of our clinical series.

One of the downsides of a VBF is an increased hazard for the pedicle, which is related to the performance of several anastomoses for connecting both the ends of VBFs, to the recipient site and to the main flap. Performing this surgery can be demanding, owing to the number of the anastomoses involved, the caliber of the vessels and the potential complicated inset, which can introduce kinks and twists. Nevertheless, in our series, the senior author (HCC) performed all the anastomoses and we reported a lower rate of complications, in comparison to long IVG. Furthermore, in microsurgical procedures, Godina stated that arterial interposition grafts are superior to vein graft for arterial reconstruction because there is less turbulent flow through an arterial interposition graft than a reverse venous graft.[17] This is likely due to the thicker walls, limited distention, and lack of valves in the artery, which equate to decrease turbulence and more natural blood flow to the flap. This reduction in flow disturbance leads to better anastomosis patency rates. Thus, we believe that, in the setting of VBF, concerns about a reduction of flow to the main flap, due to blood shunting in the VBF, can be negligible.

Interestingly, there was no statistically significant association between vein graft donor site and the rates of flap compromise or flap loss. The choice of donor site should be carefully decided on the surgical and clinical characteristic of each patient. In the decision-making process, adequate length, caliber, and reliability of the donor vessels should be primarily taken into account, along with the expected morbidity of the donor site. According to these principles, the first choice leans on the distal flap pedicle veins. Nevertheless, they rarely provide a sufficient length and caliber and the dissection itself could potentially impair the venous outflow of the main flap in some cases. Anterior jugular vein offer a consistent alternative with low donor site morbidity, as it is usually already exposed in neck surgery, although it is not always reliable, especially in radiated and previously operated neck. The greater and lesser saphenous veins are usually the most common donor site chosen as IVGs, owing to their consistency, reliability, and suitable length.[18] In our experience, we found that in bedridden patients the great saphenous vein is often compromised by the number of procedures these patients had undergone, thus we usually prefer to harvest the lesser saphenous vein in these cases. Potential disadvantage of lesser saphenous vein graft is the less convenient location for dissection with the patient in the supine position. However, the lesser saphenous vein is usually a better match for microanastomosis to the recipient vessels and flap pedicle when compared to the thick-walled greater saphenous vein with much larger caliber.[19,20]

Recent reports described the use of a composite artery and vein graft for additional pedicle length as an alternative to IVGs. The use of the descending branch of the lateral femoral circumflex artery and venae comitantes has been reported for head and neck and lower extremity reconstruction.[18–21] This innovative approach provides many benefits: The anatomy of the vessels is quite consistent; the structure of a composite

artery and vein graft, similarly to VBF, provides good support to the vessels, reducing the likelihood of unexpected twists or kinks; the multiple venae comitantes can provide additional chance for venous anastomosis and drainage. Nevertheless, in comparison to traditional vein grafts, the dissection of the descending branch of the lateral femoral circumflex can be tedious, hindering operative time, and cannot always ensure a sufficient length for bridging the gap.[6,22,23] Care should be taken to avoid injury to the motor nerve branches to the vastus lateralis muscle, which can be intimately related to the vascular bundle. In our experience, we did not apply the composite pedicle of a flap in lieu of a vein graft, either as some of patients already underwent ALT free flap or in order to spare a precious surgical alternative in case of second surgery. Although vein graft is the usual first choice for an interposition graft in microsurgical procedures, in a certain subset of the population, they may not be available or of adequate caliber, particularly in the elderly.[20] Should an adequate vein graft not be available, we believe that branch of the descending lateral femoral circumflex artery and venae comitantes should be considered.

Based on our findings, we first suggest to adequately design free flap reconstruction choosing long pedicles and adequate recipient vessels. In case of hostile situations or unplanned long gap between the flap and the recipient bed, we recommend avoiding long vein grafts over 10 cm and consider the use of a bridging free flap. The planning of the reconstruction and the decision to use or not use vein grafts or an additional bridge flap, should be judged on a case-by-case basis by carefully consider surgeons' experience, patients history and preferences, taking into account postoperative function, aesthetic appearance, and donor site morbidity.

Although this study found convincing evidence, there are some limitations: The study has a retrospective design and a larger prospective trial would provide better evidence to support our conclusions. Despite our data showing that the length of IVG and prior radiotherapy were associated with an increased incidence of free flap complication, it is impossible to determine an exact reason for every cases, as the complications are more likely to be multifactorial in these complex reconstructions.

5 | CONCLUSIONS

Vein grafting in free flap reconstruction is associated with an increased risk of thrombosis and complications in complex head and neck defects. Surgeons should be aware that the longer the vein graft the greater is the risk of flap compromise and flap loss. The use of a second free flap as a vascular bridge should be considered as a safer alternative when the distance between the flap pedicle and recipient vessels is substantial.

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AUTHOR CONTRIBUTIONS

G.Di T., E.R., S.H.C., S.N., J.C.Y.C., L.L., E.C., D.R., and H.-C. C. designed the study. G.Di T., E.R., N.S., J.C.Y.C., and H.-C.C. performed surgery. G.Di T., E.R., S.H.C., N.S., J.C.Y.C., L.L., E.C., D.R., and H.-C.C. collected data. G.Di T., E.R., S.H.C., N.S., J.C.Y.C., L.L., E.C., D.R., and H.-C.C. prepared the manuscript. G.Di T., E.R., S.H.C., N.S., J.C.Y.C., L.L., E.C., D.R., and H.-C.C. did the critical review.

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