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ARTICLE

Single versus dual venous anastomosis in radial forearm free flaps in head and neck reconstruction

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ABSTRACT

A retrospective cohort study of 253 radial forearm free flap (RFFF) procedures in head and neck reconstruction performed in our department between 2005 and 2018 was reviewed. In order to explore the effects between single and dual anastomoses, we applied Fisher's exact test for statistical analysis. Although no flap failure was identified, more venous compromises were observed in single anastomosis group (5/80 vs. 1/173). We conclude that dual venous anastomoses can reduce venous compromise resulted from unexpected causes in RFFF transfer. Therefore, we especially recommend dual venous anastomoses for those who cannot withstand a second surgery.

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Introduction

Since radial forearm free flaps (RFFFs) were proposed in 1994, they have become one of the most extensively used free flaps for head and neck defects [1,2]. The straightforwardness of vessel dissection and pliable nature of the flap contribute to easy and safe handling of this flap.

The radial artery sustains the blood flow of the RFFF, while two different drainage systems, including the superficial system and the deep system, return the blood. The superficial system is formed from the cephalic vein and subcutaneous veins, while the deep system includes the radial veins. These two systems connect to each other *via* the cubital perforating vein at the cubital fossa. The vessel caliber, thickness of the vessel wall and blood flow velocity differ between them [3,4].

A majority of cases of flap failure originate from failure of the vascular pedicle [5]. Thrombosis and compression lead to most pedicle failures other than those resulting from operative factors [6]. However, as the RFFF has two different drainage systems, the selection of the more suitable venous system remains controversial [2,7]. Dual anastomosis seems safer as two separate perfusion passages are created. However, this kind of bypass may reduce perfusion pressure, slow blood flow velocity and increase the risk of vein thrombosis [8].

This study aims to compare the incidence of venous complications in single and dual venous anastomosis in RFFFs with the aim of reducing flap failure and achieving higher success rates.

Material and method

We accomplished a retrospective cohort study of 253 patients who had undergone RFFF reconstruction between 2005 and 2018 at the Department of Oral and Maxillofacial Surgery of Beijing Stomatological Hospital, Capital Medical University. There were 139 males and 144 females. Patient age ranged from 22 to 83, with a mean age of 59.2.

Patients were then divided into a single venous anastomosis group (group 1) and a dual venous anastomosis group (group 2) according to the number of veins used. There were 80 flaps in group 1. Of these flaps, 46 were in males, and 34 were in females. Defect causes involved malignant tumors ($N = 76$), pseudoankylosis ($N = 2$), erythema ($N = 1$) and hemangioma ($N = 1$). Group 2 consisted of 173 flaps, with defects being caused by malignant tumors ($N = 171$), scar ($N = 1$) and palatal fistula ($N = 1$). Other records are listed in Table 1.

A single surgery unit was responsible for the operations, and all of the vessel anastomoses were performed by the same surgeon. In group 1, the cephalic vein was used as the drainage vein, while in group 2, the cephalic vein and radial vein were used. Flap size and recipient vessels were determined by the primary defects, which are listed in Tables 1 and 2. There was no significant difference in sex ($p = 0.578$), defect cause ($p = 0.082$), defect site ($p = 0.158$) or recipient artery ($p = 0.154$).

Regular observation was implemented after surgery. If any sign of flap compromise, such as color change and swelling, was observed, exploration was performed as quickly as possible. Fisher's exact test was applied for the statistical analysis. A p value <0.05 was deemed statistically significant.

Results

No flap failure was identified, although six incidences of venous compromise occurred after surgery (Table 3). Five of them were in group 1 (6.3%). Among them, two were caused by venous thrombosis, which occurred two and six days after surgery respectively. One occurred on the second day after surgery, and we found that the vessel pedicle was pressed by the sternocleidomastoid muscle. These three flaps survived after repeat anastomosis. Another case occurred one day after surgery because there was no blood flow in the cephalic vein. This crisis was resolved by anastomosing the radial vein. The last case occurred three

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Table 1. Variables grouped by type of venous anastomosis (single or dual).

Characteristic	Variables	Single anastomosis (%)	Dual anastomosis (%)	*p* Value
Defect site	Buccal	23 (31.1)	51 (68.9)	0.158
	Tongue	23 (24.2)	72 (75.8)	
	Gingiva	11 (50.0)	11 (50.0)	
	Palate	4 (26.7)	11 (73.3)	
	Mouth floor	4 (40.0)	6 (60.0)	
	Oropharynx	6 (54.5)	5 (45.5)	
	Other	9 (34.6)	17 (65.4)	
Recipient artery	Facial	31 (25.8)	89 (74.2)	0.154
	Superior thyroid	46 (37.1)	78 (62.9)	
	Other	3 (33.3)	6 (66.7)	

Table 2. Recipient site veins.

Single anastomosis		Dual anastomosis	
External jugular	26	External jugular + Common facial	61
Common facial	25	External jugular + Concomitant venae of facial artery	38
Internal jugular	16	External jugular + Superior thyroid	26
Concomitant venae of facial artery	8	External jugular + Internal jugular	21
Anterior facial	2	External jugular + Tongue	6
Superior thyroid	1	Common facial + Concomitant venae of facial artery	4
Anterior jugular	1	Common facial + Anterior jugular	4
Tongue	1	Common facial + Superior thyroid	4
		External jugular + Posterior facial	3
		External jugular + Anterior jugular	2
		Internal jugular + Anterior jugular	1
		Internal jugular + Common facial	1
		Anterior facial + Superior thyroid	1
		External jugular + Anterior facial	1

Table 3. Venous compromise in single and dual anastomosis.

Variable	*N*	Venous compromise (%)	*p* Value
Single anastomosis	80	5 (6.3)	0.013
Dual anastomosis	173	1 (0.6)	

days after surgery for an unknown reason. Although we did not perform any other management except for exploration, the condition improved naturally. Only one case of venous compromise occurred in group 2. It was observed six hours after surgery. Once the sternocleidomastoid muscle that pressed the pedicle was removed, the flap survived. There was a significant difference in the incidence of venous compromise between single and dual anastomosis ($p = 0.013$).

We also analyzed the relationship between venous compromise and recipient venous systems. The external jugular vein (EJV) system of the head and neck includes the anterior jugular vein and the EJV, while the internal jugular vein (IJV) system includes the tongue vein, the superior thyroid vein, the IJV, the anterior facial vein, the common facial vein and the concomitant venae of facial artery. When applying one vein anastomosis, the IJV system ($N = 53$) was more commonly used than the EJV system ($N = 27$). When two veins were used during the operation, attaching both the EJV and IJV systems was the most favored option ($N = 161$), followed by two IJV system veins ($N = 10$) and two EJV system veins ($N = 2$) (Figure 1). Venous compromise occurred the most when using one IJV system vein ($N = 4$, 7.5%), followed by one EJV system ($N = 1$, 3.7%), and both the EJV and IJV systems ($N = 1$, 0.6%). No venous compromise was observed when two IJV or EJV system veins were used. There was not a significant difference in the incidence of venous compromise between recipient venous systems ($p = 0.051$).

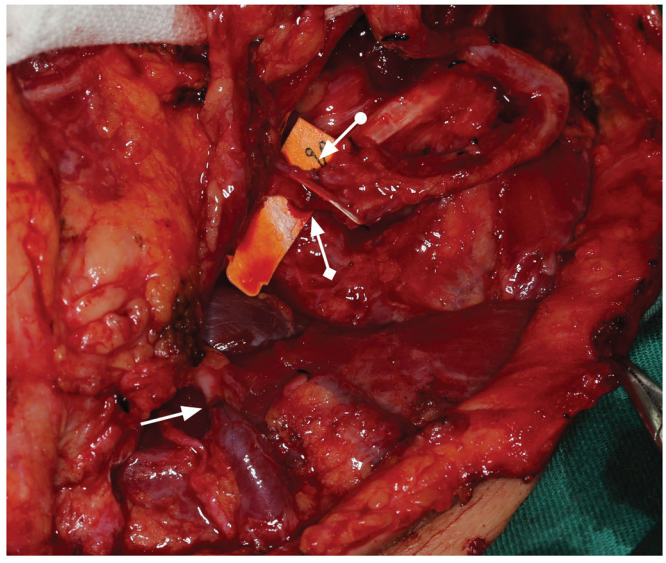

Figure 1. Attaching both the EJV and IJV systems was the most favored option when two veins were used. Here, we attached the facial artery to the radial artery (the white arrow with a square end), the radial vein to the concomitant venae of facial artery (the white arrow with a circular end), the cephalic vein to the EJV (the white arrow).

Discussion

Venous thrombosis is one of the leading causes of flap failure [9,10]. With the development of microsurgery technology, the incidence of primary thrombosis caused by anastomosis itself has decreased. However, secondary thrombosis resulting from postoperative immobilization and slow velocities in the veins still occurs frequently [4,5,11]. Therefore, the selection of veins for anastomosis has been a hot topic in recent years.

There are two aspects relating to vein anastomosis that must be considered. One focuses on the donor site. In our previous study, there was no difference between single and dual venous anastomosis in fibula osteocutaneous flap [12]. However, the RFFF is different because it is served by two different vein systems (Table 4). The cephalic vein has a shallow anatomic position and

Table 4. Venous compromise in different recipient venous systems.

Variables	*N* (%)	Venous compromise	*p* Value
EJV system	27 (10.9)	1 (16.7)	0.051
IJV system	53 (20.8)	4 (66.7)	
EJV + EJV system	2 (0.8)	0 (0)	
IJV + IJV system	10 (4.0)	0 (0)	
EJV + IJV system	161 (63.6)	1 (16.7)	

large diameter, which allows surgeons to dissect it easily, while the radial vein is covered by muscles and can only be accessed at the wrist initially [4,8]. On the other hand, the drainage of the radial veins was twice that of the cephalic vein in a hemodynamic study [13]. In addition, inadequate cephalic outflow can be easily adjusted by adding radial veins, while sluggish radial outflow is difficult to salvage by adding cephalic vein. This may imply an underlying weakness of superficial vein outflow. Previous intravenous cannulation may also lead to potential damage in the vein [4]. Selber et al. suggested that if the radial vein is more than 1 mm in diameter at the wrist, it may be chosen as the primary option for anastomosis. However, surgeons must make careful decisions because excluding the cephalic vein from the start might influence vein augmentation in later salvage surgery [8]. In order to ensure flap success, Roit et al. recommended attaching both cephalic and radial veins [7]. However, Futran et al. found that single vein anastomosis shortened the operation time and offered adequate outflow without increasing flap failure. Therefore, they recommended dual anastomoses can be regarded as a salvage method when venous compromise has occurred [6]. Such a second drainage system may also be beneficial in other flaps. Lack of intramuscular venous network, deep inferior epigastric perforator flap (DIEP flap) venous drainage depends only on a few venous collaterals, which increases the risk of venous congestion. In some cases, the superficial system even dominates the drainage [14]. Previous studies indicated that using both deep and superior inferior epigastric perforator veins not only salvaged flaps, but also reduced operative explorations and fat necrosis in breast reconstruction [15,16]. Derived from DIEP flaps, superficial inferior epigastric artery flap (SIEA flap) can minimize donor site morbidity without invading abdominal fascia. Kita et al. indicated the potential of dual venous anastomoses by adding superficial circumflex iliac vein in order to avoid venous insufficiency [17].

Another aspect focuses on the recipient site. It is more convenient to choose the IJV system because it is closer to the recipient artery [13]. In addition, the multiple branches of the IJV system provide a variety of options. On the other hand, the EJV system has a fairly long segment, which offers great freedom for anastomosis [9]. It can also be easily exposed due to its subcutaneous location, which shortens the operation time and reduces the need for invasive dissection [18]. However, the incidence of thrombosis was much higher in the EJV system than in the IJV system. The EJV system is associated with multiple risk factors for thrombosis. It has low blood flow and is easily compressed by external pressure. Therefore, it was suggested that an EJV system vein be chosen in the absence of other suitable veins [9,10,13]. If the IJV has to be resected, performing venous anastomosis with the contralateral IJV system would be wiser. Attaching both EJV and IJV system veins might prevent vein compromise [10,13,19,20].

This study concentrates on the recipient vein. We believe that double vein anastomoses can reduce vein compromise in the application of RFFFs. First, the relationship between the EJV and IJV systems resembles the relationship between the cephalic and radial veins. The diameter of the cephalic vein varies along the vein, with the largest diameter being ~3.5 mm at the cubital fossa. The radial vein has a smaller caliber and thicker wall. Meanwhile, the EJV and IJV systems have similar dissection characteristics. Therefore, cephalic-EJV system and radial-IJV system anastomosis might be more consistent with general physiological conditions. Second, the two separate vein systems can complement each other because regardless of which vein has inadequate outflow, the other system can still function. For example, we observed an abnormal color change in one of the flaps in group 2. Half of the flap, which was governed by the cephalic vein, had an unusual color, while the other half seemed normal. This phenomenon improved without any intervention the next day. We think there might have been compression of the cephalic vein, but the blood then flowed into the radial vein through the perforating vein, which rescued the flap. Although we have to make efforts to avoid any kind of technical error, accidents happen, which are beyond our control. Some factors might cause thrombosis in the IJV include pedicle positioning, traction of the IJV, thermal injury, hypercoagulation, etc [21]. Therefore, we recommend double vein anastomosis, especially in those who are too weak to withstand secondary salvage surgery, because it optimizes the consequences caused by unknown risks and undetached drawbacks. Using both the IJV and EJV system veins would be more favorable.

The disadvantages of this study should be considered. First, we did not use radial vein alone as an option because the radial vein is much smaller than the cephalic vein. According to measurements, the cephalic vein is almost twice the diameter of the radial vein at the junction of the exposed and covered part of the radial artery [1]. That means, when anastomosing small radial vein, surgery will be challenging and difficult. We only use radial vein under certain situations when, for example, congestion is found in the cephalic vein, or the only recipient vein that can be used is fairly small. But with accumulative experience in reconstructive surgeries, we will continue research in future studies. Besides, there may be selection bias due to the small amount of data. Although all of the surgeries were based on proven skills, there might still be a learning curve. Other factors, such as general condition, previous surgery, chemotherapy, operation time, and vessel caliber were not considered in this study. We also ignored anatomical variation and surgical pattern of the venous drainage of the RFFF, which may affect the accuracy.

Conclusion

During RFFF reconstruction, dual venous anastomosis offered a lower incidence of venous compromise than single venous anastomosis. Therefore, we recommend dual venous anastomosis during radial forearm reconstruction, especially in those who cannot withstand a second surgery, to avoid venous compromise and potential flap loss.

Disclosure statement

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References

[1] Yang GF, Chen PJ, Gao YZ, et al. Forearm free skin flap transplantation: a report of 56 cases. 1981. Br J Plast Surg. 1997;50(3):162–165.
[2] Xie Y, Feng T, Ou Y, et al. Superficial versus deep system single venous anastomosis in the radial forearm free flap: a meta-analysis. Int J Oral Maxillofac Surg. 2021;50(7): 873–878.
[3] Zhai QK, Dai W, Tan XX, et al. Proper choice of donor site veins for patients undergoing free radial forearm flap reconstruction for the defects of head and neck. J Oral Maxillofac Surg. 2018;76(3):664–669.
[4] Cha YH, Nam W, Cha I, et al. Revisiting radial forearm free flap for successful venous drainage. Maxillofac Plast Reconstr Surg. 2017;39(1):14.
[5] Mao C, Yu G, Peng X, et al. 168 Cases of free flap transplantation with double vein anastomoses for reconstruction of head and neck defects. Hua Xi Kou Qiang Yi Xue Za Zhi. 2006;24(6):530–532.
[6] Futran ND, Stack BC. Single versus dual venous drainage of the radial forearm free flap. Am J Otolaryngol. 1996;17(2): 112–117.
[7] Riot S, Herlin C, Mojallal A, et al. A systematic review and meta-analysis of double venous anastomosis in free flaps. Plast Reconstr Surg. 1963;136(6):1299–1311.
[8] Selber JC, Sanders E, Lin H, et al. Venous drainage of the radial forearm flap: comparison of the deep and superficial systems. Ann Plast Surg. 2011;66(4):347–350.
[9] Reiter M, Baumeister P. Venous anastomosis in free flap reconstruction after radical neck dissection: is the external jugular vein a feasible option?. Eur Arch Otorhinolaryngol. 2017;274(5):2239–2244.
[10] Yin SC, Su XZ, So HI, et al. Comparison of internal jugular vein system anastomosis and external jugular vein system anastomosis in free flaps for head and neck reconstruction: a Meta-Analysis. J Oral Maxillofac Surg. 2020;78(1):142–152.
[11] Chen K, Mardini S, Chuang DC, et al. Timing of presentation of the first signs of vascular compromise dictates the salvage outcome of free flap transfers. Plast Reconstr Surg. 2007;120(1):187–195.
[12] Han Z, Li J, Li H, et al. Single versus dual venous anastomoses of the free fibula osteocutaneous flap in mandibular reconstruction: a retrospective study. Microsurgery. 2013; 33(8):652–655.
[13] Kim YC, Kim MJ, Kim HB, et al. Impact of venous outflow pattern on flap compromise in head and neck reconstruction: review of 309 radial forearm free flaps. J Craniofac Surg. 2019;30(4):1194–1197.
[14] Tran NV, Buchel EW, Convery PA. Microvascular complications of DIEP flaps. Plast Reconstr Surg. 2007;119(5): 1397–1405.
[15] La Padula S, Hersant B, Noel W, et al. Use of the retrograde limb of the internal mammary vein to avoid venous congestion in DIEP flap breast reconstruction: further evidences of a reliable and time-sparing procedure. Microsurgery 2016;36(6):447–452.
[16] Vijayasekaran A, Mohan AT, Zhu L, et al. Anastomosis of the superficial inferior epigastric vein to the internal mammary vein to augment deep inferior artery perforator flaps. Clin Plast Surg. 2017;44(2):361–369.
[17] Kita Y, Fukunaga Y, Arikawa M, et al. Anatomy of the arterial and venous systems of the superficial inferior epigastric artery flap: a retrospective study based on computed tomographic angiography. J Plast Reconstr Aesthet Surg. 2020;73(5):870–875.
[18] Ibrahim AE, Adelman DM, Parham C, et al. The external jugular vein used as recipient vessel in head and neck free flap reconstruction: outcomes compared to the internal jugular vein. J Craniofac Surg. 2019;30(1):178–183.
[19] Brown DH, Mulholland S, Yoo JHJ, et al. Internal jugular vein thrombosis following modified neck dissection: implications for head and neck flap reconstruction. Head Neck. 1998;20(2):169–174.
[20] Ross GL, Ang ESW, Lannon D, et al. Ten-year experience of free flaps in head and neck surgery. How necessary is a second venous anastomosis?. Head Neck. 2008;30(8): 1086–1089.
[21] Yang B, Qu Y, Su M, et al. Characteristics and surgical management of flap compromise caused by thrombosis of the internal jugular vein. J Craniomaxillofac Surg. 2017;45(2): 347–351.