


Outcomes of Single Anastomoses for Superficial and Deep-System Venous Drainage of Radial Forearm Free Flaps

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Abstract

Objective. Venous insufficiency occurs in radial forearm free flaps (RFFFs) when either the deep venous system (DVS) or superficial venous system (SVS) is used as the venous outlet. We report our experience using the antecubital perforating vein (APV) in a single-vessel anastomosis to the median-cubital or cephalic vein to drain both systems.

Study Design. Retrospective review.

Setting. Single, academic, tertiary care center.

Methods. Data were collected from 72 patients who underwent RFFF from October 2009 to January 2017. In all cases, DVS and SVS were dissected, and an APV single-vessel anastomosis was attempted.

Results. Anatomical variations precluded single-vessel anastomosis in 11 (15.3%) cases. In 61 (84.7%) cases, single-vessel anastomosis produced unobstructed drainage for DVS and SVS without intrinsic venous insufficiency. Venous thrombosis and total loss occurred in 2 (3.3%) and 1 (1.6%) patients, respectively. Proximal dissection of the cephalic vein addressed a vessel-depleted neck in 3 cases.

Conclusion. The antecubital perforating vein is present and functional in most patients, allowing for single anastomosis techniques for RFFF. Antecubital perforators capture DVS and SVS outflow through a single, extended venous pedicle, eliminating the risk of venous insufficiency and need for vein grafts.

Keywords

radial forearm free flap, free tissue transfer, head and neck reconstruction, single-vessel anastomosis, venous drainage

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The radial forearm free flap (RFFF) is one of the most widely performed procedures in head and neck reconstruction. It is considered a workhorse flap due to its

pliability, long vascular pedicle with adequate vessel caliber, consistent anatomy, ease of harvest, osteofasciocutaneous capability, and relatively low rate of donor site morbidity.^{1–6} Success rates approaching 95% with the RFFF are common,^{7–13} with most flap failures stemming from inadequate venous drainage.^{5,14,15} The RFFF has 2 major venous systems: the superficial venous system (SVS) consists of the cephalic vein, and the deep venous system (DVS) consists of paired radial venae comitantes that course along the radial artery.

There is no formally established consensus in the literature as to whether the SVS or DVS is more advantageous for anastomosis with RFFF transfer. Some authors favor the SVS due to larger-caliber veins that allow for a more technically straightforward anastomosis.^{16,17} Other authors prefer the DVS, arguing that it may provide the majority of the venous outflow from the flap.^{14,15,18} Prior publications have demonstrated that both the SVS and DVS are equally effective in draining the RFFF and support that one system does not significantly improve flap survival over the other.^{19,20} However, several authors have suggested using both systems simultaneously to drain the flap may be more reliable and advantageous to flap survival than using one system alone.^{3,7,21–23} In 2003, Ichinose et al¹⁰ proposed that using both venous systems with a multiple-vein anastomosis provided an ideal system that preserves partial outflow if the other pedicle were to develop a thrombus. There is evidence in the literature to further

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support the value of preserving drainage from both venous systems; however, a multiple-vein anastomosis has been argued to significantly increase the risk of postoperative complications while extending operative time. A study by Futran and Stack²⁴ argued that an additional endothelial defect at the site of the second anastomosis, combined with a parallel drainage pathway that reduces pressure in each vein, could increase the risk of thrombus formation.²⁵ In addition, a second anastomosis can add up to 38 minutes of operative time,²⁴ which may lead to increased perioperative complications, morbidity, and cost.

With increasing importance being placed on minimization of operative time and reduction of health care costs, utilization of a technique to streamline the venous anastomosis portion of the RFFF procedure can be of significant clinical value. Efforts to use both venous drainage systems with only a single anastomosis have been explored with the antecubital perforating vein (APV). There is some variability in the nomenclature, as this vessel has been named the communicating vein,^{3,22} cubital perforating vein,²⁶ and profundus cubitalis²⁷ in prior publications. The APV is a convergence of the SVS and DVS within the antecubital fossa of the forearm (**Figure 1**). Harvesting the APV allows drainage from both venous systems in the RFFF through a single anastomosis to the median-cubital or cephalic veins. Another benefit to harvesting the RFFF with the APV is a longer vascular pedicle by using the proximal cephalic vein, which may obviate the need for venous grafting if the surgeon encounters difficulty at the planned recipient site vessels and must choose a contralateral or more distant site for anastomosis.^{21,27}

The presence of the APV has been noted in 62% to 95% of cases in numerous studies,^{3,21,22,26} but the outcomes from using this vein to combine both systems via a single venous anastomosis remain underreported compared to either single anastomosis of one system or dual anastomoses of both systems. The aim of this study is to analyze our experience with routine microdissection of the APV, which allows drainage of both the SVS and DVS in the RFFF through a single anastomosis to the median-cubital or cephalic vein.

Methods and Materials

Patient Selection

Institutional review board (IRB) approval was obtained from the University of Arkansas for Medical Sciences IRB (IRB# 132834). A retrospective review of electronic medical records was performed to identify patients who received RFFF for reconstruction of head and neck defects from October 2009 to January 2017. All patients who received an RFFF with the intention to perform a dual-system, single-venous anastomosis were included in the study. All of the reconstructions were performed by a single surgeon at a single, academic tertiary care center. Data were collected from 72 patients in total, with 32 (44.4%) being male and a mean age of 60 years. The surgical indication was malignancy in 66 (91.6%) patients, soft tissue or bony necrosis in 3 (4.2%) patients, arteriovenous malformation in 2 (2.8%) patients, and esophageal stricture in

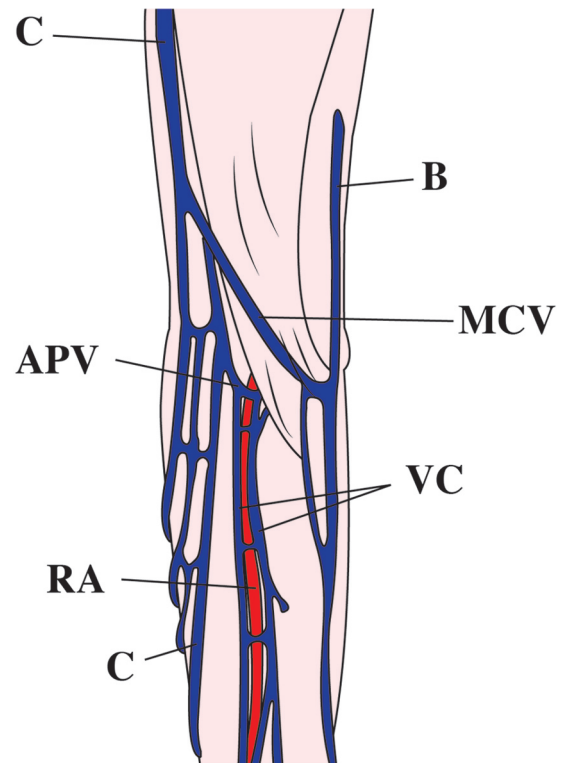


Figure 1. Anatomical representation of paired venae comitantes (VCs) with radial artery (RA). VC drain to the cephalic vein (C) via the anterior perforating vein (APV) and median cubital vein (MCV). Basilic vein (B) noted medially.



Figure 2. Radial forearm free flap with pedicle containing the deep venous system (DVS) and superficial venous system (SVS).

1 (1.4%) patient. No patients who underwent exploration of the antecubital fossa for identification of the APV in preparation of a dual-system, single-venous anastomosis were excluded from the study.

In all cases, the antecubital fossa was explored to identify the antecubital perforating vein to allow for a single-vessel anastomosis to capture both the superficial and deep venous systems. A GEM (Synovis Life Technologies, Inc.) venous coupler device was used for all anastomoses. **Figure 2**

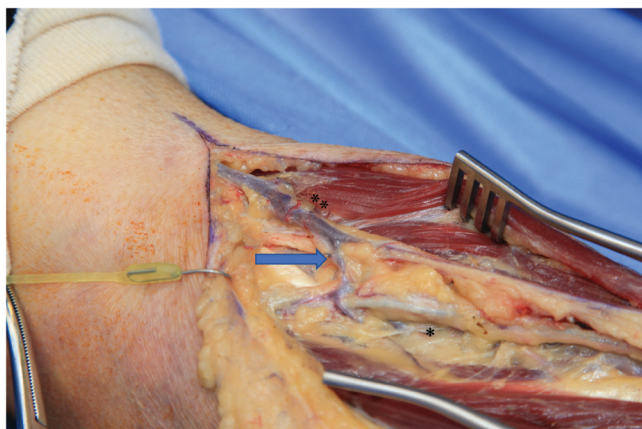


Figure 3. Subfascial dissection of venous pedicle with cephalic vein indicated by **, antecubital vein indicated by arrow, and the venae comitantes indicated by *.

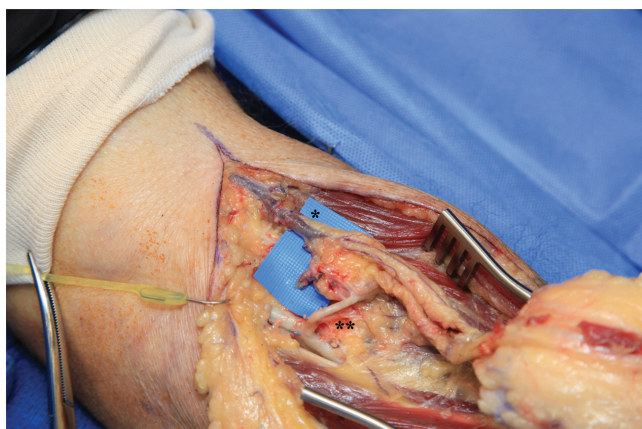


Figure 4. Radial forearm free flap with vascular pedicle prepared for ligation. The cephalic vein and radial artery are indicated by * and ** respectively.

demonstrates the anatomy of the forearm with the superficial and deep venous systems seen to converge into the APV.

Technique Description

The arm is positioned on an armrest at a 90° angle from the bed. The flap is harvested under a tourniquet, noting that the device should be placed more proximally in the arm if an extended venous pedicle is to be harvested. Surface anatomy of the course of the radial vessels and cephalic vein is marked, and the skin paddle is designed encompassing the drainage area of these 2 vessels. These vessels are ligated distally, and the skin paddle is raised in the suprafascial plane with identification and preservation of the radial nerve and its branches. The cephalic is dissected through the subcutaneous tissue in a distal to proximal fashion, its tributaries are ligated, and the same process is repeated for the radial vessels. As the plane of the dissection approaches the antecubital fossa, meticulous dissection is carried to identify the antecubital perforating vein that communicates to the deep and superficial venous systems

(**Figure 3**). The venae comitantes and their tributaries are transected proximally to the emergence of antecubital perforating vein, releasing them from the deep system (**Figure 4**). At this point, if needed, proximal dissection is performed on the cephalic vein into the arm for additional length. The artery is dissected in the standard fashion. Upon release of the tourniquet, the venous flow is closely observed to assess the drainage of both the superficial and deep systems. In the event that there is inadequate drainage of the deep system through the antecubital perforating vein, the largest radial venae comitantes is prepared for a second microanastomosis.

When single-vessel anastomosis to the cephalic vein, capturing both the SVS and DVS, was not feasible, limitations to the technique were noted. Surgical findings and outcomes were retrieved. Data collected included incidents of venous thrombosis, venous insufficiency, donor site morbidity, and partial and total flap failure. Events were collected within a 30-day postoperative period.

Results

Of the 72 RFFFs identified in the study, 61 (84.7%) cases were performed using the antecubital perforating vein with single-vessel anastomosis, with unobstructed drainage confirmed for the superficial and deep venous systems. All patients underwent long-term follow-up with no incidents of significant donor site morbidity, specifically chronic lymphedema, noted in the study. Within this group of 61 RFFFs, 3 (4.92%) experienced venous thrombosis, 2 of which were salvaged. There was 1 (1.63%) total flap loss, giving a flap survival rate of 98.37%. There were no incidences of intrinsic venous insufficiency identified in the study when using the single-vessel technique. In 3 (4.92%) cases, the cephalic vein was dissected further proximally to address a vessel-depleted neck, obviating the need for an additional vein graft.

In 11 (15.3%) cases, an APV was absent or had a valve impeding drainage of the DVS, in which case, 2 venous anastomoses were performed to drain the DVS and SVS separately. Absence of APV communication between the superficial and deep systems was identified in 8 (11.1%) patients, and the remaining 3 (4.2%) patients were noted to have a present APV but had functional anatomic abnormalities that limited venous outflow from the deep system, presumed to be secondary to valves within the veins. There were no incidences of flap failure, venous thrombosis, or venous insufficiency within this group of 11 patients.

Discussion

The APV was first described by Soutar et al¹ in 1983, and several studies have analyzed the anatomical consistency and availability of the vein for harvest. In our study of 72 RFFF procedures, 84.7% were performed using the APV to capture both the SVS and DVS with a single anastomosis with no incidence of intrinsic venous insufficiency. We found venous thrombosis and flap failure rates to be consistent with accepted outcomes.

Previous studies have identified the APV anatomically, although its use in anastomoses is described variably. The

APV was found to be available for use in only 62% of 40 cases for Thoma et al²¹ in 1994 but was noted to be present in 99.4% of 188 cases for Tahara et al²⁶ in 1995. For Valentino et al³ in 1996, it was present in 95% of their 54 cases and available in 78%. In another study performed in 2010 by Sader et al²² with 158 RFFF transfers, the APV was used in 98.1%. Our study corroborates that the APV is present in most patients and unimpeded by functional valves for its use in anastomoses that seek to capture both venous systems.

The RFFF yields a dependable success rate, with most flap failures stemming from inadequate venous drainage. The thin-walled veins are at increased risk for kinking and obstruction from exogenous compression, and the low-velocity, low-pressure venous system is more prone to stasis and thrombus formation at sites of intimal damage when compared to the arterial system.⁵ Most reported failure rates for RFFF transfer to the head and neck range from 0% to 10%,²⁴ with earlier studies reporting failure rates up to 17%.² A study by Moscoso and Urken²⁸ in 1994 reported a failure rate of 4% in a series of 318 RFFFs, while a meta-analysis by Futran and Stack²⁴ in 1996 gave an overall failure rate of 3.2%. A retrospective review of 140 RFFFs by Eckardt and Fokas¹² in 2003 showed a failure rate of 6.6%. In 2011, a retrospective review by Kruse et al¹³ showed a failure rate of 4.9% on 81 RFFFs. A recent meta-analysis comparing SVS vs DVS indicated no difference in failure rate when using either the SVS or DVS, although dual systems were not included in this meta-analysis.²⁹ In our study of 61 RFFFs, there was 1 total flap loss resulting in a failure rate of 1.6%. When considering flap survival, we conclude that harvesting the APV to provide dual venous drainage through a single anastomosis is a successful alternative to other methods of using both venous systems described in prior publications.

Although flap survival rates are comparable, we believe there are several benefits to harvesting the APV. First, both the SVS and DVS are preserved to allow dual venous outflow from the RFFF. Many authors have supported the use of dual venous systems, reporting more reliable drainage when compared to a single system.^{3,7,21-23} Authors who favor the sole use of either the SVS or the DVS have stated that preservation of the other venous system for additional anastomosis can serve as a lifeboat if their selected system were to fail postoperatively.^{4,10,15,16} In 2004, Ichinose et al¹⁰ concluded that dual venous anastomosis resulted in a lower rate of thrombosis if both the SVS and DVS were used. They proposed that using both systems with a multiple-vein anastomosis provided a fail-safe mechanism that preserves partial outflow if the one pedicle were to develop a thrombus.¹⁰ The utilization of the APV takes advantage of this concept by employing both venous systems simultaneously, which many studies propose may be more reliable and advantageous to long-term flap survival.

Most surgeons who aim to drain the RFFF with both venous systems have used 2 anastomoses in the procedure.²⁷ This technique was challenged by Futran and Stack,²⁴ who favored a single anastomosis over a dual anastomosis. To reduce any confounding variables, most of their dual anastomoses were from the same drainage system; either both

anastomoses were from the SVS or both were from the DVS. They reported no difference in flap survival between single- and dual-vein anastomoses; however, they argued that an additional endothelial defect at the site of the second anastomosis, combined with a parallel drainage pathway that reduces pressure in each vein, would increase the risk of thrombus formation.^{24,25} In addition, they reported that a second anastomosis can add up to 38 minutes of operative time, which may lead to increased perioperative complications in patients who are usually at high risk due to their underlying state of health.²⁴

Many patients undergoing an RFFF have underlying hepatic, pulmonary, immunologic, and nutritional disorders and have increased risk for developing postoperative complications such as pneumonia, deep venous thrombosis, or anemia from surgical blood loss.^{7,24} Any effort to minimize operative time in these patients can potentially reduce morbidities and mortalities. The utilization of the APV takes advantage of this concept by using only a single anastomosis to minimize operative time.

Another benefit of harvesting the RFFF with the APV is the reliability of identifying a large-caliber vein for anastomosis. Both the SVS and DVS are drained through an anastomosis of either the median-cubital or cephalic vein in the antecubital fossa, which is generally larger than the venae comitantes.^{21,27} Not only does a larger vessel allow for a more straightforward anastomosis for the surgeon, but it also results in a more dependable flap, as a larger vessel caliber is less likely to become occluded when compared to a smaller caliber.^{3,21}

Harvesting the RFFF with the APV may result in a longer vascular pedicle, which can be beneficial if the surgeon encounters difficulty at the planned recipient site vessels and must choose a more distant site for anastomosis.^{21,27} For example, if suitable recipient veins are not identified in the ipsilateral neck, a longer pedicle can allow for anastomosis with vessels in the contralateral neck without additional venous grafting. One criticism of the longer pedicle is the risk of venous thrombosis due to longer veins being more prone to kinking or venous stasis. Thoma et al²¹ argue that this fear is unfounded and overcome by the avoidance of vein grafts. In addition, several studies have demonstrated successful RFFFs with long vascular pedicles.^{3,21,27} They concluded that the periadventitial fat attached to the pedicle was effective in preventing acute kinking and that no issues related to the redundancy of the vascular pedicle were encountered. Some authors suggest that this longer vascular pedicle using the cephalic vein in conjunction with the venae comitantes is a potential source of donor site morbidity such as lymphedema³⁰ and poor cosmesis due to the necessary extended proximal dissection to create a unified venous conduit.⁴ In our study, chronic lymphedema was not encountered in any patient, which suggests that this technique does not place patients at undue risk of increased morbidity.

Although previously described, the dearth of publications that address the use of a combined venous drainage via a single anastomosis, in light of the volume of literature pertaining to donor site vessel selection in RFFFs, highlights the

rarity of this technique compared to single- or dual-system anastomoses. This discrepancy is further emphasized in the otolaryngology–head and neck surgery literature. Most of the investigations into the venous drainage of the RFFFs are reported within plastic surgery publications, especially within the past 20 years, indicating a possible bias in regard to target audiences. As complex microvascular reconstructions of head and neck ablative defects are increasingly performed by otolaryngology-trained reconstructive surgeons, further discussions of a unified venous outflow tract through the use of a single anastomosis technique are warranted.

Conclusion

Contrary to prior reports of 2% to 3% intrinsic venous insufficiency when using single anastomosis of SVS or DVS, we found that most patients have free-flow antecubital perforators. This consistent anatomical pattern can be used to capture deep and superficial venous outflow through a single larger vein or to significantly extend the venous pedicle. We believe utilization of the APV for RFFF transfer is a successful alternative to methods described in prior publications; however, the additional benefits of maintaining dual-system venous outflow while streamlining the RFFF procedure with a single anastomosis may reduce postoperative complications and morbidities, improving long-term flap survival and patient outcomes.

Author Contributions

Mauricio Alejandro Moreno, design, conduct, participating surgeon, analysis, presentation, drafting; **Luke T. Small**, design, conduct, chart review, analysis, drafting; **James Reed Gardner**, design, conduct, analysis, drafting; **Alexandrea H. Kim**, design, conduct, chart review, analysis, drafting; **Emre Vural**, design, participating surgeon, drafting, analysis; **Jumin Sunde**, design, drafting, analysis.

Disclosures

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