BASIC STUDY

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Anatomical evaluation of the superficial veins of the upper extremity as graft donor source in microvascular reconstructions: a cadaveric study

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Objective: The aim of study was to investigate the features and resources for vein grafts suitable for upper extremity arteries.

Methods: Sixteen upper extremities of 8 cadavers were investigated. Anatomic localizations, diameters, wall thickness and valve types of the superficial veins of the upper extremity were counted and evaluated.

Results: Average diameter of the brachial artery was 3.96 mm, the radial artery 2.54 mm, the ulnar artery 2.12 mm, the proper palmar digital artery 3 0.85 mm, the cephalic vein of the arm 1.81 mm, the basilic vein of the arm 3.20 mm, the cephalic vein of the forearm 2.04 mm, the basilic vein of the forearm 1.35 mm, and the dorsal venous network of the hand 1.27 mm. Three different types of valves were determined. The most frequent valve types were the Type 3 in the cephalic and basilica veins at 86.5% and 90.7%, respectively.

Conclusion: Data obtained on the superficial veins of the upper extremity may be helpful to surgeons in microsurgical reconstructions.

Key words: Cutaneous vein; graft source; upper limb; venous valve.

Vein grafts are used in many revascularization procedures, particularly reconstructive microsurgery and arterial bypass surgery. Superficial veins of the lower or upper extremities are vein graft sources.[1-10] Despite their anatomical variations, surgical dissections of the superficial veins are fast and easy to perform. Anatomical characteristics of the vein, such as diameter, wall thickness, valve types, number and structure of the perforating veins, and dissection convenience are important factors for patency performance of vein graft reconstructions.[1,7] Because of the known anatomical features, superficial veins of the lower extremity are more widely used in such surgical procedures.[10,11] However, in the arterial and venous reconstructions of the upper extremity, vein grafts of the same extremity are preferred instead of lower extremity grafts due to advantageous ease of surgical practice and anesthesia. It is noted that in many clinical studies, because of the various necessities, upper extremity vein grafts were preferred in such cases.[1-6,8]

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This study aimed to evaluate the relevant sources for the superficial vein grafts of the upper extremity and their anatomic features in upper extremity microvascular reconstruction procedures.

Materials and methods

This study included 16 (8 left, 8 right) upper extremities of 8 adult male formaldehyde-fixed cadavers aged between 46 and 68 years. Mean height was 1.65 (range: 1.60 to 1.72) m, mean weight was 52.37 (range: 42 to 65) kg and mean body mass index (BMI) was 19.02 (range: 16.22 to 22.49) kg/m^2. Skin dissection was carried out by carefully following hair follicles, keeping the superficial fascia intact. Starting from the deltopectoral triangle towards the metacarpophalangeal joints, each upper extremity was separated into 9 anatomic regions. The first 8 anatomic regions were determined based on a study by Iimura et al. (Fig. 1).[11] The dorsal venous network of the hand was determined as the 9th region in our study. In these anatomic regions, the cephalic vein was dissected starting from the deltopectoral triangle proximally until the wrist distally. The basilic vein was dissected from the proximal half of the biceps brachii as far as the flexor loop of the wrist distally, including all their perforating veins. Furthermore, in terms of ease of dissection and as a possible source of graft, the dorsal venous network of the hand was also dissected and included in the study.

Of these superficial veins, characteristics such as anatomical localizations, extensions, valve types, number and localization of their perforating veins, diameters and wall thickness were investigated. A Carl Zeiss stereoscopic dissection microscope was used to photograph the superficial veins and arteries of upper extremity cross-sections in order to measure their diameters and wall thicknesses (Fig. 2). Lumen diameter and wall thickness values of the arteries (brachial, radial, ulnar, proper palmar digital artery 3) and superficial veins of the upper extremity (cephalic and basilic veins of the arm and the forearm, medial vein of the dorsum of the hand) were measured using a software program (Image Tool for Windows v.3.00) developed by the University of Texas Health Science Center, San Antonio, TX, USA. Data were analyzed using SPSS v.11.0 (SPSS Inc., Chicago, IL, USA) with simple descriptive statistics.

The wall thicknesses and diameters of the brachial artery, cephalic and basilic veins of the arm (at the level of midpoint of the arm), radial and ulnar arteries, cephalic and basilic veins of the forearm (at the level of midpoint of the forearm), the middle longitudinal vein located at the dorsum of the hand (at the level of the carpometacarpal joint) and the proper palmar digital artery 3 (at the level of the proximal phalanx) were measured and compared using Spearman's correlation analysis SPSS v.11.0 (SPSS Inc., Chicago, IL, USA) program. P values of less than 0.05 were considered significant.

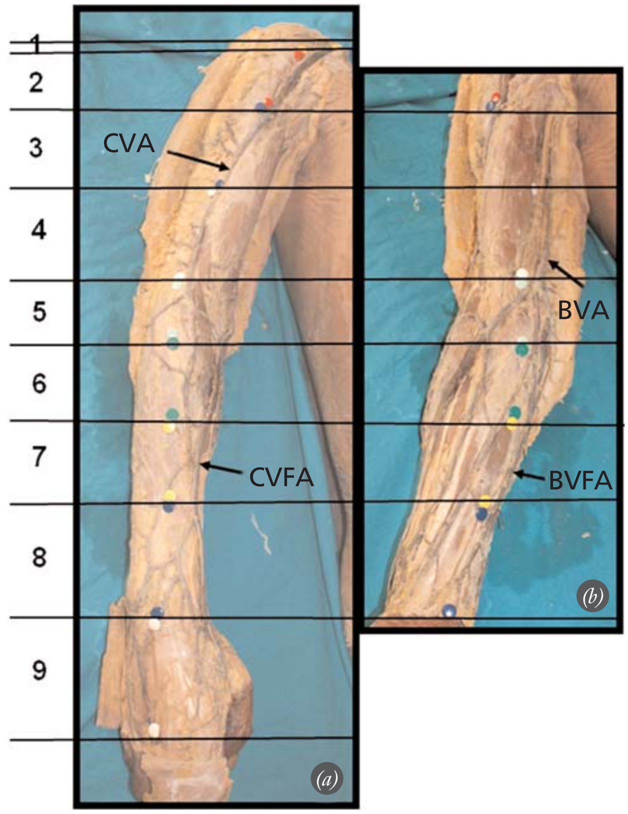

Fig. 1. 1st area: proximal half of the deltopectoral sulcus; 2nd area: distal half of the deltopectoral sulcus; 3rd area: proximal half of the biceps brachii; 4th area: distal half of the biceps brachii; 5th area: the area between the upper margin and lower margin of the cubital fossa; 6th area: the part from the lower margin of the cubital fossa to the mid-level of the forearm; 7th area: the part from the mid-level of the forearm to the distal 1/3 of the forearm; 8th area: the part from the distal 1/3 of the forearm to the styloid processes of the radius and the ulna; 9th area: the part from the styloid processes of the radius and the ulna to the metacarpophalangeal joint. **(a)** CVA: cephalic vein of the arm, CVFA: cephalic vein of the forearm. **(b)** BVA: basilic vein of the arm, BVFA: basilic vein of the forearm. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Results

In 6 of the 16 upper extremities, the cephalic vein of the forearm was found bilaterally at an atypical localization, joining the basilic vein in the antecubital region (Fig. 3). In the classification of the venous valves according to the localizations of the perforating veins, we followed the classification method set by Iimura et al.[11] and determined 3 different valve types. Valve type percentages

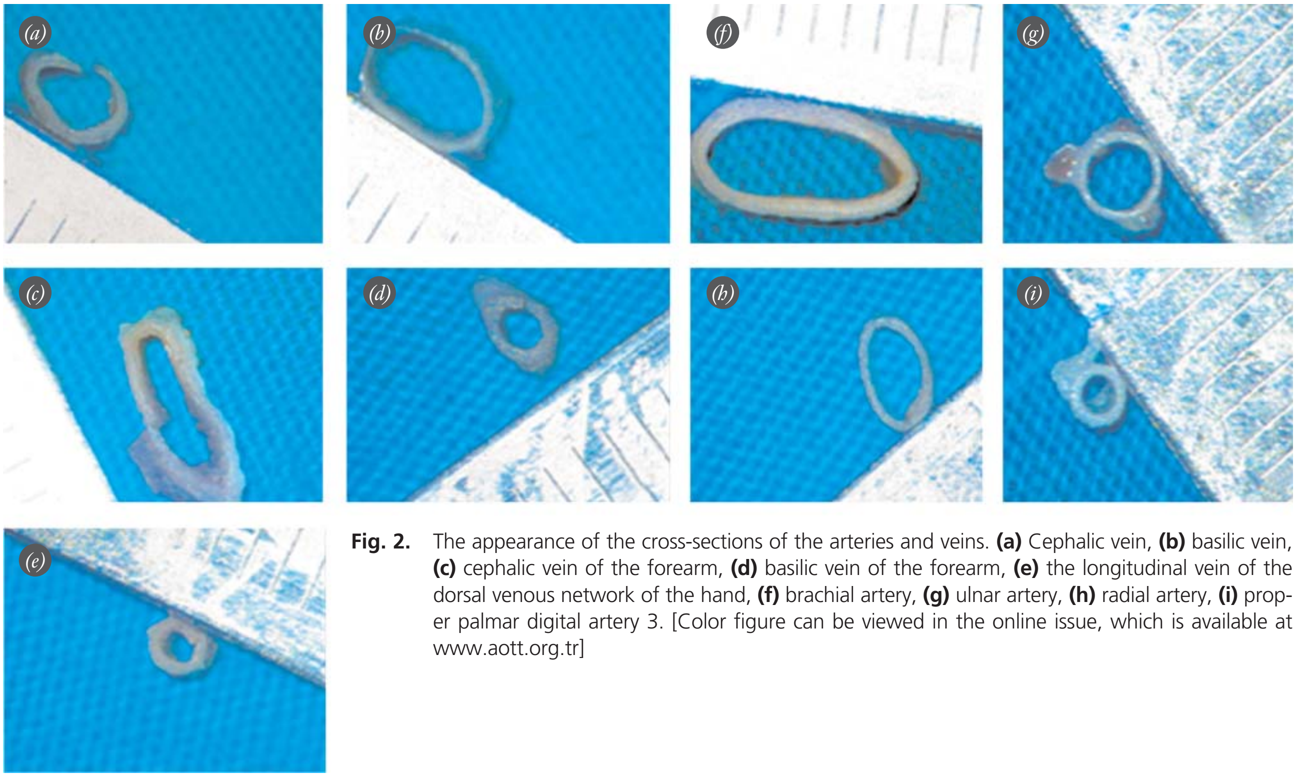

Fig. 2. The appearance of the cross-sections of the arteries and veins. **(a)** Cephalic vein, **(b)** basilic vein, **(c)** cephalic vein of the forearm, **(d)** basilic vein of the forearm, **(e)** the longitudinal vein of the dorsal venous network of the hand, **(f)** brachial artery, **(g)** ulnar artery, **(h)** radial artery, **(i)** proper palmar digital artery 3. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

were calculated by evaluating separately the whole length of the cephalic veins and basilic veins of the 16 upper extremities (Fig. 4) (Table 1). Type 1 valves were more frequently found in the 7th and 8th regions of the cephalic vein as well as in the 4th and 8th regions of the basilic vein.

Three to four longitudinal veins originating in the dorsum of the hand and joining the arch created by the cephalic vein and basilic vein at the 1/3 distal of the forearm had very few perforating veins (Fig. 5). No valves existed distally in the region close to the metacarpophalangeal joint, as far as the perforating vein region. Localizations of the cephalic and basilic venous valves were determined (Table 2).

The cephalic and basilic perforating veins had almost the same distribution in all regions of the cephalic vein. On the other hand, the 4th, 5th and 6th regions of the basilic vein had the maximal number of perforating veins, with mean values of 2.0, 2.2 and 2.3, respectively (Table 2).

Average diameter and wall thicknesses are listed in Table 3. There was a statistically significant positive correlation between the lumen diameters of the right brachial artery and the right basilic vein of the arm ($p=0.047$) and between the lumen diameters of the left ulnar artery and left cephalic vein of the arm ($p=0.037$).

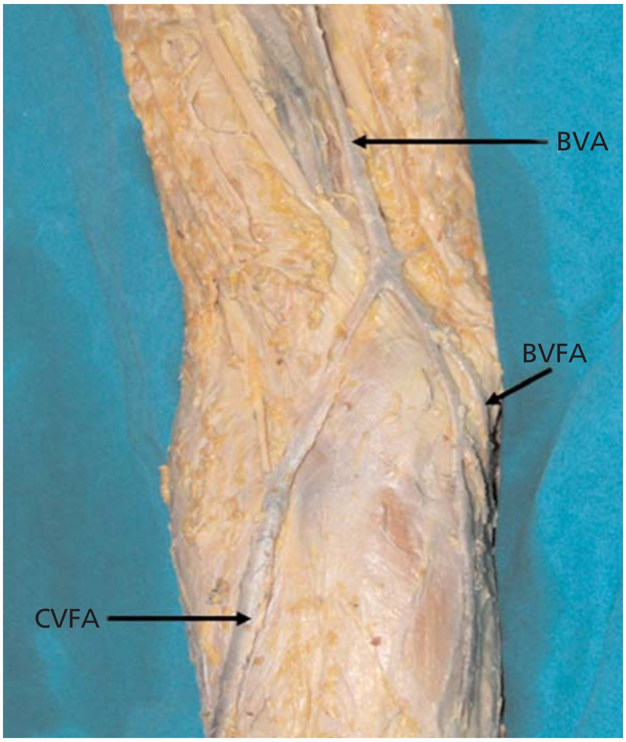

Fig. 3. The appearance of cephalic vein of the forearm was found at atypical localizations, joining with the basilic vein at the antecubital region. BVA: basilic vein of the arm, BVFA: basilic vein of the forearm, CVFA: cephalic vein of the forearm. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

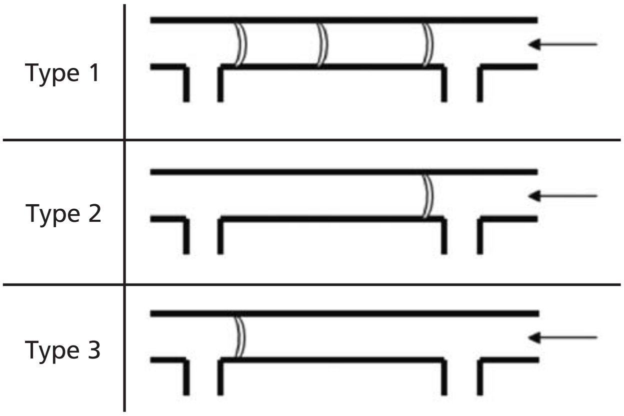

Fig. 4. The 3 different valve types described by Iimura et al.[11] (arrows: direction of the blood flow). Type 1: perforating veins are not present between the adjacent valves; Type 2: the valve is closer to the distal perforating vein than the proximal perforating vein; Type 3: the valve is closer to the proximal perforating vein than the distal perforating vein.

On the other hand, there was a statistically negative correlation between the lumen diameters of the right ulnar artery and right basilic vein of the forearm (p=0.040). When wall thickness measurements of the upper extremity arteries and superficial veins were compared, there was a statistically significantly positive correlation between the left proper palmar digital artery 3 and the left basilic vein of the forearm (p=0.040).

Discussion

Upper extremity vein grafts are highly advantageous as the source of donor grafts in procedures of the upper extremity, such as revascularization, replantation, composite tissue transplantation, free tissue transfer, and arteriovenous shunts.[1-6,8] Local veins of the hand have been used for many years in the procedures such as replantation, where small scale vein grafts are needed. However, for larger scale proximal vascular constructions, such as those used in the palmar region of the hand to the arm, lower extremity vein grafts are preferred.[12-15] Lower extremity veins used in reconstruction procedures of the upper extremity are disadvantageous as they are time consuming and require general anesthesia. To achieve high patency rates in recon-

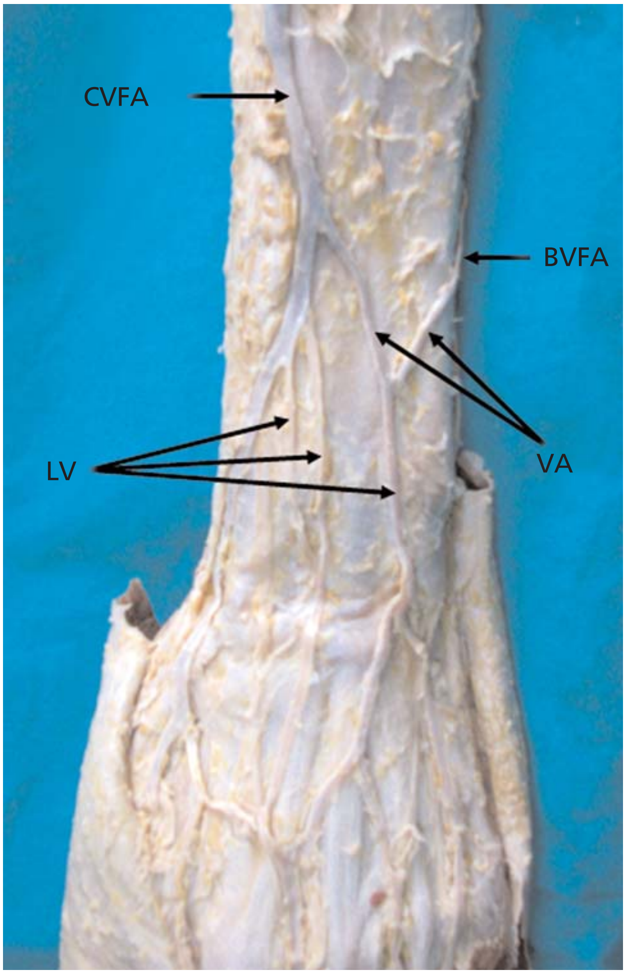

Fig. 5. The appearance of the dorsal venous network of the hand. BVFA: basilic vein of the forearm, CVFA: cephalic vein of the forearm, LV: longitudinal veins of the dorsal venous network of the hand which were drained into the venous arch between cephalic vein and basilic vein of the forearm, VA: venous arch between cephalic vein and basilic vein of forearm. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. Percentages of the valve types of the upper extremity veins.

	Cephalic vein	Basilic vein
Type 1	7.6%	8.1%
Type 2	5.9%	1.2%
Type 3	86.5%	90.7%

Table 2. Number of valves and perforating veins of the upper extremity veins.

	Area	1st	2nd	3rd	4th	5th	6th	7th	8th
Number of valves	Cephalic vein (Arm and forearm)	0.5±0.1	0.6±0.1	0.8±0.1	0.7±0.1	1.1±0.1	0.8±0.1	0.9±0.1	1.5± 0.1
	Basilic vein (Arm and forearm)				1.5±0.1	1.6±0.1	1.6±0.1	1.8±0.1	1.9± 0.1
Number of perforating veins	Cephalic vein (Arm and forearm)	1.4±0.1	1.5±0.1	1.9±0.1	1.6±0.1	1.5±0.1	1.6±0.1	1.4±0.1	1.4±0.1
	Basilic vein (Arm and forearm)				2.0±0.1	2.2±0.1	2.3±0.1	1.6±0.1	1.6±0.1

struction procedures, good knowledge of upper extremity vein anatomy is important, including potential advantages of the graft source, preparatory period and anesthesia type.

For veins used as graft sources in terms of dissection easiness, it is important to know whether the venous pathway is convoluted or not. When examining the upper extremity veins, we noted that the cephalic vein in particular followed a considerably straight pathway between the deltopectoral triangle and cubital fossa. However, in 6 cases (37.5%), the cephalic vein was bilateral at atypical localizations, joining with the basilic vein at the antecubital region. Le Saout et al. reported that in 20% of subjects cephalic veins were either lacking or very thin.[16] Cephalic vein absence was generally seen bilaterally in our study. Our and Le Saout et al.'s[16] studies have shown a high incidence of atypical drainage cephalic vein of the arm. These possible variations should be kept in mind when selecting the cephalic vein of the arm as a graft source.

When assessing the basilic vein, a straight but shorter (compared to the cephalic vein) trace was determined at the proximal of the cubital fossa. However, because of their more convoluted pathways in the forearm than the arm, both of these veins are more disadvantageous during incision and dissection compared to the superficial veins of the lower extremity for use as a graft source.

Valve type and number and their perforating veins affect postoperative complications, such as turbulence or thrombus.[1] For this reason, knowledge about the number and type of valves and number of perforating veins of the donor vein is needed to decrease patency complications. In a study evaluating valve types, Iimura et al. reported that the most common valve type was Type 3 valve (cephalic vein 92.1%, basilic vein 93.3%).[11] Type 3 valve (cephalic vein 86.5%, basilic vein 90.7%) was present at the highest frequency in our study as well. Iimura et al. reported frequency rates of Type 2 valve in the cephalic and basilic veins at 5.9% and 2.2%, and Type 1 valve at 1.9% and 4.4%, respectively.[11] In the current study, Type 2 valve frequency was 5.9% and 1.2% and Type 1 valve 7.6% and 8.1% in the cephalic and basilic veins, respectively. Iimura et al. reported similar percentages in their extensive saphenous vein study.[11] Veins of the upper and lower extremities do not differ in terms of valve types. It is possible to abstain from Type 2 and Type 3 valves, which we found at a frequency of around 90%, by excluding just the lower and upper parts of the perforating veins.

In terms of regional prevalence of valve types, Type 1 valve, accepted as the most inappropriate graft source valve type, is located mainly in the 7th and 8th regions of the cephalic vein and in the 4th and 8th regions of the basilic vein. However, it is not quite possible to avoid using Type 1 valve. Iimura et al. measured the number of valves of the superficial veins of upper extremity.[11] Our study showed a considerable difference between the 1st and 8th regions of the cephalic vein but full compatibility in all regions of the basilic vein with Iimura et al's study.

An average of 2.0, 2.2 and 2.3 perforating veins were found in the 4th, 5th and 6th regions of the basilic vein, respectively, in our study. However, in the cephalic vein, there was an almost equal distribution between regions in the number of perforating veins. With the assumption that valves existed near the perforating veins, we concluded that the 4th, 5th and 6th regions of the basilic vein grafts in particular will have great risks, due to both the number of valves and the number of perforating veins. Although there is no exact knowledge about the concentration of valves in different regions of the superficial veins of the upper extremity, our dissections revealed that as number of valves increased, number of perforating vessels also increased.

Table 3. Diameters and wall thicknesses of the brachial, ulnar, radial and proper palmar digital arteries and the cephalic, basilic veins of the forearm and medial vein of the dorsum of the hand.

	Brachial artery	Ulnar artery	Radial artery	Proper palmar digital artery 3	Cephalic vein of the arm	Basilic vein of the arm	Cephalic vein of the forearm	Basilic vein of the forearm	Medial vein vein of the dorsum of the hand
Diameter right side (mm)	4.04±1.00	2.04±0.36	2.34±0.50	0.91±0.25	1.84±1.20	3.51±2.49	2.09±1.41	1.21±0.46	1.38±0.48
Diameter left side (mm)	3.88±0.87	2.18±0.50	2.72±0.65	0.77±0.26	1.78±0.37	2.88±1.28	1.99±1.06	1.48±0.71	1.15±0.47
Mean diameter (mm)	3.96±0.94	2.12±0.43	2.54±0.57	0.85±0.25	1.81±0.78	3.20±1.88	2.04±1.24	1.35±0.59	1.27±0.48
Thickness right side (mm)	0.43±0.06	0.36±0.09	0.37±0.09	0.33±0.07	0.25±0.08	0.47±0.18	0.31±0.12	0.30±0.04	0.27±0.05
Thickness left side (mm)	0.43±0.09	0.33±0.06	0.35±0.10	0.29±0.08	0.25±0.05	0.39±0.10	0.35±0.08	0.26±0.07	0.26±0.06
Mean thickness (mm)	0.43±0.08	0.35±0.07	0.36±0.09	0.32±0.08	0.25±0.07	0.43±0.14	0.33±0.10	0.29±0.06	0.27±0.05

Three to four longitudinally tracing veins, originating from the region close to the metacarpophalangeal joint and draining into the venous arch between the cephalic vein and basilic vein of the forearm, contained no valves at all. These veins were evaluated as ideal graft sources for appropriate scaled arteries.

The upper extremity veins were examined for long vein graft and/or arteriovenous loop processing in free tissue transfer due to recipient vessel problems. In the 3rd and 4th region of the cephalic vein, a 10 to 12 cm segment of the vein was determined as the source of long vein graft including the least number of valves and perforating vessels. It was concluded that this region of the cephalic vein was inappropriate for long vein graft, whereas it could be an alternative to the saphenous vein for intermediate segment graft.

Compatibility between the vein as the graft source and the artery to be reconstructed in terms of the diameter and wall thickness is important for possible risks of asymmetric dilatations such as aneurysms at the anastomose side causing turbulence and thrombus.[1] Although, with some microsurgical techniques (e.g. end-to-side anastomosis, oblique arteriotomies/venotomies), problems in vessel diameters can be solved, the lumen diameters in end-to-end anastomosis of superficial veins of the upper extremity might be important. In our study, lumen diameters and wall thicknesses of the brachial, radial, ulnar and proper palmar digital arteries as well as the cephalic and basilic veins were measured (Table 3). Regarding wall thickness, small arteries are more compatible with larger veins. In this respect, it should be kept in mind that veins, with their thin walls and histological features, are able to dilate more than arteries.[17] Wall thickness increases with vein diameter. Using small diameter veins as graft sources decreases the risk of dilatation to some extent. However, due to smaller wall thickness, small diameter veins leaves the graft unprotected to external pressures.[17] As formaldehyde fixed cadavers were used in this study, vessel wall thickness, diameter and vessel wall elasticity could be affected by fixation. For this reason, the dynamical processes related to arteries and veins were not evaluated.

In conclusion, findings of this study on the superficial veins of the upper extremity can help to provide a database for the use of these veins as the graft donor sources in microsurgical reconstructions. The choice of upper extremity vein grafts should depend on the clinical scenario and microsurgeon’s experience.

Conflicts of Interest: No conflicts declared.

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