ORIGINAL ARTICLE

Anatomy of septocutaneous blood vessels of the anterior forearm

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ABSTRACT

Aim To measure a calibre of radial and ulnar septocutaneous perforators at the anterior forearm, and to count its number in proximal, middle and distal thirds.

Methods The study was conducted on 50 fresh amputated forearms (trauma, tumours) in the period between January 2012 and December 2021. Forearms were collected from several hospitals in Belgrade, and analysed at the Institute of Anatomy, Medical School, University of Belgrade, Serbia. Injection of ink-gelatin and fine dissection of autopsy material was performed on 30 forearms, and corrosion method with injecting methyl methacrylate for 3D analysis on the other 20 forearms.

Results A mean calibre of septocutaneous perforators on the radial artery was 0.53±0.46 mm (0.2-0.85). Averagely, there were 8.1 radial artery septocutaneous perforators - two perforators on the proximal third, 3.7 on the middle third, and 2.7 on the distal third. The mean calibre of ulnar artery perforators was 0.65±0.35 mm (0.18-1.8). The average number of septocutaneous perforators of the ulnar artery was 5.6; 1.2 on the proximal third, two on the middle third, and 2.2 on distal third.

Conclusion Determination of the origin, calibre and spreading directions of the arterial septocutaneous perforators on the anterior forearm provide quantification of data about arborisation of radial and ulnar septocutaneous perforators at the anterior forearm. Clinical relevance of those anatomical data is in defining of safe locations and dimensions of forearm fasciocutaneous flaps in plastic surgery.

Key words: flap, perforator, radial artery, ulnar artery

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INTRODUCTION

The anatomy, number and origin of septocutaneous vessels of the anterior forearm are of huge importance in the surgery of fasciocutaneous forearm flaps. Forearm flaps are numerous, variable in origin, dimensions and shape (proximally or distally based, pedicle or free). However, their common characteristic is that they are based on a unique vascular system - the septocutaneous vascular system (1-3).

Septocutaneous perforators are blood vessels originating from magistral vessels, radial and ulnar artery at the anterior forearm. They pass through the intermuscular septa (fascia duplicatures), perforate the deep fascia, and branching out, forming so-called fascial plexus (4,5). The most commonly used flap among fasciocutaneous forearm flaps is definitively a so-called Chinese flap, described by Yang Guofan et al. in 1981 (2,3). It belongs to "type C fasciocutaneous flaps", arborizing from the radial artery to supply the fascial plexus and the covering skin. Another important anterior forearm fasciocutaneous flap is the ulnar forearm flap, located in the medial intermuscular septum, between *m. flexor carpi ulnaris* and *m. flexor digitorum superficialis* (2, 6-8).

Good knowledge of the anatomy, topography and calibre of septocutaneous forearm arteries is crucial for clinical success (aesthetic consideration, flap survival, donor-site morbidity) of forearm flap-raising techniques (9). To the best of the authors' knowledge, it is the first study of this kind in our region.

The aim of this study was to investigate a calibre of radial and ulnar septocutaneous perforators at the anterior forearm, and to count its number in proximal, middle and distal thirds.

MATERIAL AND METHODS

Study design and materials

The study of septocutaneous perforating branches of the anterior forearm arteries was conducted on 50 fresh amputated forearms. Upper limbs were mostly amputated due to trauma and tumours in several hospitals in Belgrade (Serbia) during the period January 2012 - December 2021. Forearm's preparation and histological analysis were performed at the Institute of Anatomy, School of Medicine, University of Belgrade, Serbia. The Ethical Committee of the School of Medicine, University of Belgrade, approved the investigation in compliance with the Helsinki Declaration.

Methods

The arterial system was injected by ink-gelatin, with latter microsurgical dissection of septocutaneous arteries in 30 forearms (10). For the remaining 20 preparations the corrosion method of injecting methyl methacrylate was applied to produce resin casts of blood vessels (11), which allowed an accurate spatial analysis of the branching of perforating vessels.

Separation of vascular cutaneous territories of perforators of the ulnar and radial arteries was preceded by a longitudinal incision 10 cm long in the cubital fossa and the dissection of the brachial artery tree and its terminal branches. Two catheters were placed in the ulnar and radial arteries, secured with a hook and loop fastener. After the arteries were rinsed by warm water, 20 mL of 5% melted gelatin was simultaneously injected, coloured by a blue and red fine ink. The injection lasted until the skin was stained without overlapping the vascular cutaneous territories. After gelatin had hardened, the dissection was approached.

In the corrosion method (10), two-component methyl methacrylate was used to produce resin blood vessel casts. After mixing the monomers and polymers and adding special dyes, acrylate was injected into the arteries of the forearm through placed catheters. In order for the acrylate injected by perfusion to fill the arterial network and to avoid deformations of the forearm, the injection was performed in a tub filled with warm water. The injection itself was preceded by careful ligation of all blood vessels affected by amputation. It took around five hours for acrylate components to bind and for it to solidify. Corrosion of forearm tissue was performed in 40% NaOH solution, and the corrosion per preparation lasted for a month. The blood vessel cast was ready for analysis after a thorough rinsing with hot water (Figure 1).

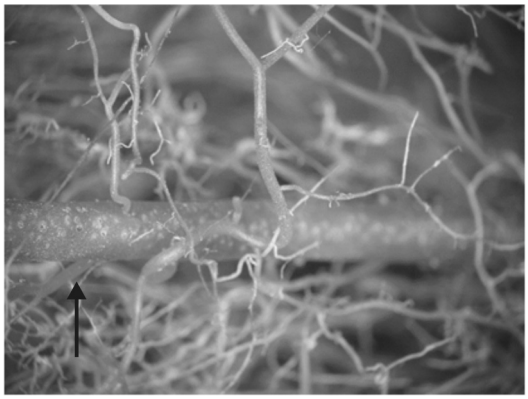

Figure 1. Single septocutaneous perforator, greatly enlarged (corrosion preparation) (Jović D, 2018. y, Institute of Anatomy, School of Medicine, University of Belgrade, Serbia)

Statistical analysis

Descriptive statistic method (average, standard deviation, range) and Student's t-test for comparison of two groups with level of significance p=0.05 were used.

RESULTS

The calibre of 324 septocutaneous perforators on the total of 50 radial arteries at the site of origin was 0.53±0.46 mm (0.20-0.85), and 0.65±0.35 mm (0.20-1.80) at the 224 septocutaneous perforators on the total of 50 ulnar arteries. In relation to the thirds (levels) of the forearm, the mean calibres of radial septocutaneous perforators were 0.95 mm in the proximal, 0.47 mm in the middle, and 0.14 mm in the distal third, while mean calibres of ulnar perforators were 0.95 mm in the proximal, 0.73 mm in the middle, and 0.42 mm in the distal third.

The mean number of radial arteries septocutaneous perforators was 8.1 – in average two perforators in the proximal, 3.7 in the middle, and 2.7 in the distal third, while on the ulnar artery there was a total of 5.6 septocutaneous perforators - 1.2 in the proximal, two in the middle, and 2.2 in the distal third (Table 1).

Table 1. Septocutaneous perforators in proximal, middle and distal forearm thirds (levels)

Septocutaneous perforators	Mean (minimal-maximal) calibre (mm)	Average number of septocutaneous perforators
Radial		
Proximal	0.95 (0.55-1.77)	2
Middle	0.47 (0.20-1.20)	3.7
Distal	0.30 (0.18-0.80)	2.4
Ulnar		
Proximal	0.95 (0.50-1.80)	1.2
Middle	0.74 (0.25-1.60)	2
Distal	0.43 (0.18-0.90)	2.4

Topographical anatomy of septocutaneous perforators of the anterior forearm arteries was rather typical - shortly passing through the forearm fascia, the perforators form two branches which continue to branch out and extend in the longitudinal direction.

DISCUSSION

Quality of soft tissue flaps is important not only in plastic-reconstructive surgery, but also in traumatology - soft tissue coverage is a prerequisite for bony healing of radius/ulnar fractures and non-unions (12,13). Septocutaneous perforators of radial and ulnar artery basically connect forearm's magistral blood vessel with the fascia and the flap itself, forming the basis of its vascularization. Therefore, its number, calibre and morphology are very interesting to plastic surgeons - the greater the number of septocutaneous perforators involved in vascularization and the larger their calibre, the more certain is flap survival (14). The vascular territories of the radial and ulnar arteries complement the view of the blood supply of forearm skin zones. Also, the dominance in vascularization of particular blood vessel contributes to define a limit of forearm raising flap. Thus, the radial forearm flap can be raised from the elbow to the hand flexion toward radial side (15,16), while the ulnar forearm flap can be raised over the same area, toward ulnar side (17).

The mean diameter (calibre) of septocutaneous perforators of the radial artery was 0.53 mm (0.20-0.85) and 0.65 mm (0.18-1.80) of the ulnar artery in our study. If we observe peroforators' dimensions in relation to the thirds (levels) of the forearm, ulnar radial septocutaneous perforators were about 50% wider in middle and distal thirds in comparison to the radial septocutaneous perforators. According to Cormack's and Raspanti's research, the calibre of septocutaneous blood vessels of the radial artery does not exceed 0.5 mm, and there were about six perforators, the most proximal is the largest one, while distally their size decreases (1,2). However, small-calibre blood vessels (<0.8 mm) are not suitable for microsurgical transfer (14).

The mean number of radial arteries septocutaneous perforators in our study was 8.1, and 5.6 septocutaneous perforators of the ulnar artery. The most proximal perforator was located at the beginning of radial artery, while others appeared on each 1-2 cm, along the artery. Therefore, the middle third of the forearm was the richest in terms of the number

and concentration of radial artery perforators, implying that flap raising is the safest in this region.

Radial artery has averagely almost twice more septocutaneous perforators in proximal and middle thirds in comparison to the ulnar artery (statistically significant $p<0.05$), similar as in Bell's and Huang's studies (18,19).

Our results imply that majority of ulnar perforators are located in the distal third, while majority of the radial forearm septocutaneous perforators are located in the middle third. Cormack and associates found that ulnar artery had six to seven perforators (1), while Arnstein and Lewis found two to four perforators (20), which partially support our findings. In comparison to the radial artery septocutaneous perforators, ulnar artery perforators have larger calibres, but their number is on average significantly smaller than the number of radial artery perforators.

In conclusion, most septocutaneous perforators of the radial and ulnar arteries are located in the middle thirds. The calibre of septocutaneous perforators of the radial and ulnar arteries decreases in the proximal-to-distal direction. Due to a large number of septocutaneous blood vessels and a good network of anastomoses between them, radial and ulnar fasciocutaneous flaps can be safely raised from practically all parts of the anterior forearm. The selection of a flap should be based on the need for pedicle length, flap bulk, concerns about radial or ulnar dominance, and surgeon's comfort.

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TRANSPARENCY DECLARATION

Conflicts of interest: None to declare.

REFERENCES

1. Weinzweig N, Chen L, Chen ZW. The distally based radial forearm fasciosubcutaneous flap with preservation of the radial artery: an anatomic and clinical approach. Plast Reconstr Surg 1994; 94:675-9.
2. Raspanti A, Delcroix L, Ghezzi S, Innocenti M. Study of the tendinous vascularization for the compound radial forearm flap plus flexor carpiradialis tendon. Sur Radiol Anat 2016; 38:409-5.
3. Altiparmak M. Fasciocutaneus and/or myocutaneus flaps versus perforator flaps: systematic review and meta-analysis for reconstruction of ishial pressure sores. Eur J Plast Surg 2020; 43:211-7.
4. Xie RG. Medial versus lateral approach to harvesting of anterolateral thigh flap. J Int Med Res 2018; 46:4569-8.
5. Kerr RP, Hanick A, Fritz M.A. Fascia lata free flap reconstruction of limited hard palate defects. Cureus 2018 21;10:e2356.
6. Hwang K, Han JY, Chung IH. Hypothenar flap based on a cutaneous perforator branch of the ulnar artery: an anatomic study. J Reconstruction Microsurg 2005; 21:297-4.
7. Hyuon HH, Yong SCh, In BK, Sang HK, Young JJ. A perforator from the ulnar artery and cutaneous nerve of the hypothenararea: An anatomical study for clinical application. Microsurgery 2017; 37:49-6.
8. Mathy JA, Moaveni Z, Tan ST. Perforator anatomy of the ulnar forearm fasciocutaneus flap. J Plast Reconstr Aesthet Surg 2012; 65:1076-5.
9. Chang EI, Liu J. Prospective comparison of donor-site morbidity following radial forearm and ulnar artery perforator flap harvest. Plast Reconstr Surg 2020; 145:1267-7.
10. Camuzard O, Foissac R, Clerico C, Fernandez J, Balaguer T, Ihrai T, de Peretti F, Baqué P, Boileau P, Georgiou C, Bronsard N. Inferior cubital artery perforator flap for soft-tissue coverage of the elbow: anatomical study and clinical application. J Bone Joint Surg Am 2016; 98:457-8.
11. Ilic M, Milisavljevic M, Malikovic A, Laketic D,Eric D, Boljanovic J, Dozic A, Stimec BV, Manojlovic R. The superficial palmar branch of the radial artery: a corrosion cast study. Folia Morphol (Warsz) 2018; 77:649-6.
12. Rollo G, Luceri F, Bisaccia M, Lanzetti RM, Luceri A, Agnoletto M, Llaquet-Leiva AA, Mangiavini L, Meccariello L. Allograft versus autograft in forearm aseptic non-union treatment. J Biol Regul Homeost Agents 2020; 34:207-5.
13. Rollo G, Luceri F, Pasquino A, Pichierri P, Tomarchio A, Bisaccia M, Garagnani L, Biserni M, Agnoletto M, Marmotti A, Mangiavini L, Meccariello L. Bone grafiting combined with Sauvé-Kapandji Procedures for the treatment of aseptic distal radius non-union. J Biol Regul Homeost Agents 2020; 4(Suppl. 3):213-5.
14. Kastenbauer E, Tardy EM. Aestetische und Plastische Chirurgie an Nase, Gesicht und Ohrmuschel. 2nd ed. Stuttgart, New York: Georg Thieme Verlag, 2002.
15. Daya M, Nair V. Free radial forearm flap lip reconstruction: a clinical series and case reports of technical refinements. Ann Plast Surg 2009; 62:361-7.
16. Lane JC, Swan MC, Cassell OC. Closure of the radial forearm donor site using a local hatchet flap: Analysis of 45 consecutive cases. Ann Plast Surg 2013; 70:308-4.
17. Hakim SG, Trenkle T, Sieg P, Jacobsen HC. Ulnar artery-based free forearm flap: review of specific anatomic features in 322 cases and related literature. Head Neck 2014; 36:1224-9.
18. Bell RA, Schneider DS, Wax MK, Superfiatial ulnar artery; a contraindication to radial forearm free tissue transfer. Laryngoscope 2011; 121:933-6.
19. Huang JJ, Wu CW, Lam WL, Nguyen DH, Kao HK, Lin CY, Cheng MH. Anatomical basis and clinical application of the ulnar forearm free flap for head and neck reconstruction. Laryngoscope 2012; 122:2670-6.
20. Arnstein PM, Lewis JS. Free ulnar artery forearm flap: modification. Br J Plast Surg 2002; 55:356-7.