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The experience of the free superficial palmar branch of the radial artery perforator flap application

Fang Jie[a,b], Zhang Wenlong[b,*], Song Zhenyou[c], Liu Bin[c], Xie Changping[c]

[a] Graduate School of The North China University of Science and Technology, Hebei, China
[b] Department of Hand Surgery, The Second Hospital of Tangshan, Hebei, China
[c] Department of Hand Surgery of Ren Ji Orthopedic Hospital, Anhui, China

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ABSTRACT

Purpose: The purpose of this study is to retrospect and summarize clinical efficacy and experience of the free perforator flap base on the superficial palmar branch of the radial artery for tissue defect reconstruction in hand.
Method: 17 patients who underwent tissue defect in hands reconstruction by the free superficial palmar branch of the radial artery (SPBRA) perforator flaps in our department from July 2014 to October 2018 were reviewed.
Results: All the flaps in our series application were survival uneventful except one, which was necrosis because of venous thrombosis postoperative 5 days, and then the abdominal pedicle flap was executed to recover the defect in second stage. The first dorsal metacarpal artery flap and the arterial venous flap were utilized to cover the defect in one right index finger and one right ring finger due to the absence variation of the SPBRA. 2 cases presented tension vesicle of superficial skin and 1 case occurred venous congestion. All donor sites were closed primarily. The follow-up period means 13.5 months (range, 4–50 months). The static 2 point discrimination test mean 7.53 mm (range, 4–11 mm). All flaps acquire protective feeling at the latest follow-up. The self-assessment of patients: 13 cases in good, 4 cases in fair.
Conclusion: The goal of physiological reconstruction and esthetic effect can be achieved for hand tissue defect by the free SPBRA perforator flap, multiple tissues of the flap can be contained according to the defect. Even though the SPBRA is variation, arterial venous flap could be applied thanks to abundant superficial cutaneous veins.

Introduction

The hands are an important organ of the body, which play a significant role of aesthetic and function in life quality and societal action [1]. The tissue defect of hand is common, accompanied with tendon, nerve, and artery defect, which should be reconstructed by composite tissue flap. Various flaps were reported to perform reconstruction in literatures, including advanced flaps [2], cross-finger flaps [3,4], local island flaps [4–7] and free flaps [8]. To achieve physiological reconstruction and esthetic efficacy is the goal which is pursued by the hand surgeons. Recently, the injury of donor site is more took account of, and how to maintain balance between minimizing donor site injury and achieving recipient site reconstruction, it is worthy of consideration and exploration for the hand surgeons.

In 1993, Kamei et al. [9] was the first to utilize the thenar flap which supplies by the superficial branch of radial artery. The free flap based on superficial palmar branch of the radial artery (SPBRA) from the flexor aspect of the wrist was first described by Sakai in 2003 [10]. The damage is reduced, and can be made to carry the composite flap with nerve, tendon, and skin texture is soft, and its color is similar to hand. The clinical efficiency has achieved the effect of “like to like”. Ranging from July 2014 through October 2018, 17 consecutive patients whose hands underwent the SPBRA perforator flap reconstruction sequentially in our department. The purpose of this paper is by reviewing and summarizing the results of our clinical application to present our experience.

* Corresponding author at: Clinical Anatomy Laboratory, Second Hospital of Tangshan, Hebei, 063000, China.
E-mail addresses: doctorfang2010@163.com (J. Fang), zhangwenlong2000@163.com (W. Zhang), 627991591@qq.com (Z. Song), 654788188@qq.com (B. Liu), 506994731@qq.com (C. Xie).

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Materials and methods

Anatomical basis

The SPBRA originates from the radial artery and tends to the tubercle of scaphoid bone, then enters the thenar area, at the superficial of the thenar muscles, which associates with the terminal branch of ulnar artery and form the superficial palmar arch [11]. The distance from the original site to the radial styloid process is mean of 12.52 ± 4.972 mm. It sends out perforators artery to supply soft tissue in the thenar area and the palmar wrist, and gives out 2–3 direct skin perforator arteries in the flexor aspect of the wrist area. The diameters of the origin is 1.50 ± 0.327 mm [10,12], similar to the digital proper artery [13]. It has two accompanying veins to constitute the drainage system. There also has abundant cutaneous veins in the wrist region. In wrist region, the palmar cutaneous branch of the median nerve and the median antebrachial cutaneous nerve and the superficial branch of the radial nerve innervate respectively [14]. As Matloub et al. [15] had described detailed anatomy of the palmar cutaneous branch of the median nerve (PCBMN). The PCBMN arises constantly from the radial side of the median nerve, averagely 4.4 cm proximal to PCBMN the distal wrist crease. It runs closely alongside the median nerve under the forearm fascia. Between 1 and 1.5 cm proximal to the wrist crease the PCBMN passed obliquely and radially towards the sheath of the flexor carpi radialis (FCR) tendon. The nerve then becomes intimately adheres to the FCR sheath and typically pierces the ulnar side of the sheath of the FCR. As it emerges from the FCR sheath, but before it enters the tunnel in the flexor retinaculum, the PCBMN typically gives off one or two secondary branches to supply the scaphoid bone in 35 of 40 dissections.

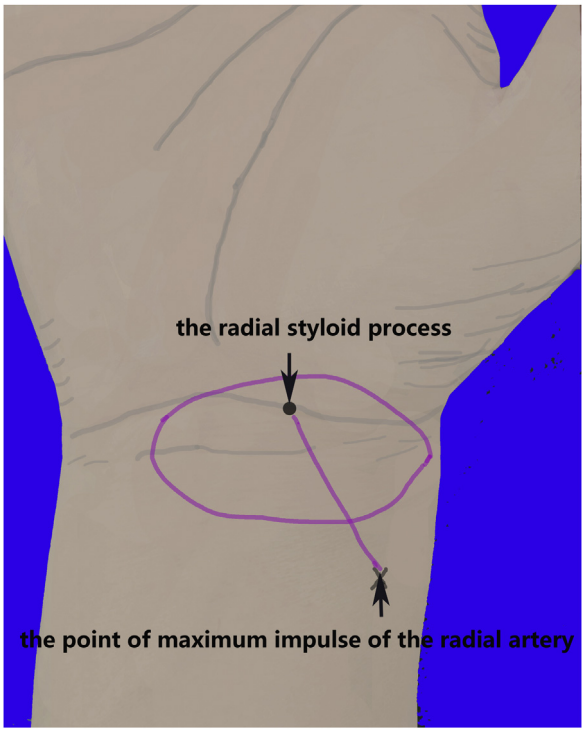

Fig. 1. Schematic diagram of the SPBRA perforator flap design. The "•" represent the radial styloid process, and the "×" represent the point of maximum impulse of the radial artery.

Flap design

The surface projection of the SPBRA is the axis from the point of maximum impulse of the radial artery to the radial styloid process, which should be within the bounds of the flap (Fig. 1). So the flap is designed close to the radial of the wrist crease,then it can include the superficial branch of the radial nerve (SBRN). The flap was dissecting at the superficial layer of the apponeursis of palmaris longus tendon. The flap was thin and approximated thickness to the skin-tissue of hand.

Clinical application

Ranging from July 2014 to August 2017, 17 consecutive patients (4 females and 13 males, and age range, 21–54 years, mean age, 39.29 years) underwent the free SPBRA perforator flap reconstruction sequentially in our department. The involved digitals as follows: thumb (1 case), index (5 cases), middle finger (5 cases), ring finger (4cases), little finger (2 cases), with left hand in 6 cases and right in 11 cases. The mechanism of injuries was as follows: crush injury (8 cases), hot press injury (1 case), roller machine injury (2 cases), ground injury (3 cases), cut injury (2 cases), motor vehicle accident (1 case) (Table 1).

Preoperative color Doppler inspection was utilized to insure the SPBRA and the entry point of the perforators. The flap in the area of the wrist course was designed according to the wound of hand. After debridement of the recipient site was performed, the digital artery and dorsal or volar veins were prepared, and then the pedicle length, flap size and the length of tendon defect were measured. The flap was raised over the superficial layer of the apponeursis of palmaris longus tendon. To dissect the flap edge, with only vascular pedicle attached, the blood circulation was observed before the pedicle was broken. The PCBMN is deeper than the dissection layer of the flap, so it may not be contained. The flap was transferred to the finger, and the SPBRA and the accompanying vein and (or) superficial cutaneous vein were anatomized with the proper digital artery and dorsal and (or) volar superficial cutaneous vein under microscope of a magnification loupe (10×) respectively. The caliber of the SPBRA is similar to that of the proper digital artery to anastomose. While the donor diameter of vein in wrist is larger than in the dorsum of digit, slashing shape of the veins is an effective and necessary method to make the caliber size-matched. A plaster was used to maintain fixation flexor position of the wrist for two weeks.

Results

All the flaps in our series application survived except one case that the flap had necrosis due to venous thrombosis 5-day postoperation, and the abdominal pedicle flap was then performed to close the defect. The use of perforator flap was abandoned and the first dorsal metacarpal artery flap was utilized to cover the defect in right middle finger because of the variation of absence of the SPBRA. The arterial venous flap was utilized for the other absence variation case for decreasing damage of the donor site. 2 cases presented tension vesicle of superficial skin, which survived completely after dressing daily. 1 cases occurred venous congestion 2 days postoperatively, stitches of the flap edge were removed, and completely survived. All donor sites were closed primarily. The average follow-up period was 13.5 months (range, 4–50 months). The static 2 point discrimination test mean 7.53 mm (range, 4–11 mm). All flaps get protective feeling at latest follow-up. The self-assessment of patients was used to assess outcome of the recovery. There is a visual analog scale ranging from 0 (completely disappointed) to 10 (completely satisfied) and the results were divided into three classes (good 10–8, fair 7–5, poor <5) [12]. There are, and 13 cases in the good class, and 4 cases in the fair class. The detailed results were summarized in Table 2.

Table 1
Clinical data from the 17 patients.

Case	Age (y),Sex	Injury	Affected Fingers	Defect Size(cm^2)	Flap Size(cm^2)	No. of a/v/n
1	48y/M	Crush injuries	Left middle finger	3.0 × 2.2	3.0 × 2.5	a,1;v,2;n,1
2	25y/M	Hot press injuries	Left little finger	3.5 × 2.0	4.0 × 2.5	a,1;v,2;-
3	49y/M	Crush injuries	Left index finger	3.0 × 2.5	3.5 × 3.0	a,1;v,2;n,1
4	41y/M	Roller machine injuries	Left ring finger	2.0 × 1.6	2.5 × 2.0	a,1;v,1;n,1
5	42y/M	Cut injuries	Right ring finger	3.5 × 2.3	4.0 × 3.0	a,1;v,2;-
6	40y/F	Crush injuries	Right index finger	2.5 × 2.0	3.0 × 2.5	a,1;v,1;n,1
7	50y/M	Crush injuries	Left index finger	3.5 × 2.5	4.0 × 3.0	a,1;v,2;-
8	25y/M	Crush injuries	Right thumb	3.0 × 2.5	3.5 × 3.0	a,1;v,2;-
9	49y/ F	Ground injuries	Right middle finger	2.5 × 1.8	4.5 × 3.0	a,1;v,2;n,1
10	54y/ F	Ground injuries	Right ring finger	2.2 × 1.8	2.5 × 2.0	a,1;v,1;-
11	53y/ M	Cut injuries	Right ring finger	2.8 × 2.5	3.5 × 3.0	a,1;v,2;-
12	27y/ M	Roller machine injuries	Right middle finger	4.0 × 2.5	4.5 × 3.0	a,1;v,2;-
13	36y/ M	Motor vehicle accidents	Right middle finger	3.0 × 2.0	3.5 × 2.5	a,1;v,1;-
14	27y/ M	Crush injuries	Left index finger	2.7 × 1.8	3.2 × 2.5	a,1;v,1;-
15	21 y/ M	Roller machine injuries	Right middle finger	3.5 × 2.0	4.0 × 2.5	a,1;v,2;-
16	32y/ F	Crush injuries	Right little finger	3.5 × 2.3	4.0 × 2.5	a,1;v,2 ;-
17	49y/ M	Ground injuries	Right index finger	3.5 × 2.0	4.0 × 2.5	a,1;v,2;-
mean	39.29y			3.04 × 2.14	3.60 × 2.65	a,1;v,1.71;n,0.29

a, artery; v, vein; n.

Table 2
Results of postoperative follow-up data and complications of clinical application.

Case	Flap survival	Complication	Addinational operation	S-2PD test(mm)	Self-assessment	Follow-up
1	Complete	–	–	7	10	12
2	Complete	–	De-fatting	9	8	50
3	Complete	–	–	4	9	10
4	Complete	Tension vesicle	–	9	7	12
5	Complete	–	–	5	10	10
6	Complete	–	–	6	8	8.5
7	Complete	–	–	8	8	20
8	Complete	–	–	10	6	14
9	Complete	Tension vesicle	–	10	7	12
10	Complete	–	–	9	8	10
11	Complete	–	–	11	8	4
12	Complete	–	–	5	10	18
13	Complete	Venous congestion	–	9	5	9
14	Complete	–	–	7	8	12
15	Complete	–	–	6	9	6
16	Complete	–	–	7	9	10
17	Complete	–	–	6	10	12
mean				7.53	8.18	13.5

S-2PD, static two-point discrimination.

Cases report

Case 2

A 25-year-old man, whose left little finger was suffered hot press injure by machine, that resulted in dorsal tissue necrosis (Fig. 2A). After debridement, the extensor tendon of the little finger was exposed (Fig. 2B). Five days later, second debridement was applied, and there was no wound infection. The defect size was 3.5 cm × 2.0 cm. The free SPBRA perforator flap was designed in the wrist course to resurface, and the flap size was 4.0 cm × 2.5 cm (Fig. 2C–D). The radial proper artery was anastomosed with the SPBRA, and two superficial cutaneous veins were anastomosed with dorsal cutaneous veins (Fig. 2E).The donor site was closed primarily. The flaps survived completely (Fig. 2F). De-fatting was implemented ten months at the postoperation of the flap transferring. At the latest 50 months follow-up, satisfactory function and appearance recovery were attained, the crease of dorsal of the PIP regenerate clearly (Fig. 2G).

Case 8

A 25-year-old man, suffered left thumb was burned by ultrasonic welding, and resulting in dorsal skin, and extensor tendon and partial dorsal bone coloboma (Fig. 3A). After debridement, the skin defect size was 3.0 cm × 2.5 cm, extensor tendon defect size was 2.0 cm (Fig. 3B). The free SPBRA perforator flap is designed in the wrist course to resurface, and the flap size is 3.5 cm × 3.0 cm, combined with palmar longus tendon in 3.0 cm, the flap was dissected over the superficial layer of the aponeurosis of palmaris longus tendon (Fig. 3C). The ulnar proper artery was anastomosed with the SPBRA, two superficial cutaneous veins were anastomosed with dorsal cutaneous veins (Fig. 3D). The donor site was closed primarily. The flaps survived completely. After follow-up 14 months, satisfactory function and appearance recovery were attained (Fig. 3E–H).

Case 17

A 49-year-old man, whose suffered left index finger as injury of ground injury by cement board, resulting in partial tissue of radial fingertip defect, with nailbed partial coloboma, the distal phalanx catagmatic and exposed (Fig. 4A–B). After debridement, the skin defect size was 3.5 cm × 2.0 cm. The free SPBRA perforator flap was designed in the wrist course to resurface, the flap size was 4.0 cm × 2.5 cm (Fig. 4C), and the flap was dissected over the superficial layer of the aponeurosis of palmaris longus (Fig. 4D). The ulnar proper artery was anastomosed with the SPBRA, one of

Fig. 2. The left little finger was suffered hot press injure by machine, that resulted in dorsal tissue necrosis (Fig. 2A). The extensor tendon of the little finger was exposed (Fig. 2B). The free SPBRA perforator flap was designed in the wrist course to resurface, and the flap size was 4.0 cm × 2.5 cm (Fig. 2C–D). The appearance of the time of pastoperation (Fig. 2E). At the latest 50 months follow-up, the function and appearance recover satisfied (Fig. 2F–G).

the two veins were anastomosed with dorsal and volar cutaneous vein, respectively (Fig. 4E). The donor site was closed primarily. The flaps survived completely. At the latest 12 months follow-up, satisfactory function and appearance recovery were attained (Fig. 4F–H).

Discussion

In our series, the fifteen SPBRA perforator flaps survived (survived rate 93.3%) except one which the flap was necrosis due to venous thrombosis. Although, the variation of SPBRA was found during operation, we find that the method of revising the SPBRA perforator flap to the arterial venous flap still survived without accidentally. The numerous methods of reconstruction in finger tissue defect have reported in literatures. The commonly used to reconstruct defect in hand includes the digital artery island flap, the dorsal metacarpal artery flap, the posterior interosseous artery flap and the flap base on above-wrist cutaneous branch of ulnar artery [4,13–16]. However, the significantly exposed scar in the hand affects aesthetics. Hence, a more concealed donor site is necessary.

To retrospect and summarize clinical efficacy and experience of the free perforator flap base on the superficial palmar branch of the radial artery for tissue defect reconstruction in hand, we discover that the flap has a excellent advantage different from the above mentioned common flaps. It is worth emphasizing that the flow-through type of the flap can be used to bridge the proper digital artery with the suitable caliber and cover the defect simultaneously. Additionally, the donor site could be primarily closed and without the second donor site damage for skin-grafting, then aesthetic appearance could be acquired.

Although, the PCBMN was commonly described to innervate the flap as a sensory flap to reconstruct defect of hand in literatures [10,12], it has not definitely described whether the branches enter

Fig. 3. The left thumb was burned by ultrasonic welding, and resulting in dorsal skin, and extensor tendon and partial dorsal bone coloboma (Fig. 3A). The free SPBRA perforator flap is designed in the wrist course to resurface, and the flap size is 3.5 cm × 3.0 cm, combined with palmar longus tendon in 3.0 cm (Fig. 3C). Intraoperative flap excision was finished (Fig. 3D). After follow-up 14 months, the function and appearance recover satisfied (Fig. 3E–H).

into the wrist crease where the flap designs area. And in our anatomical study, we discover the PCBMN enters into the tunnel between the superficial layer and the thicker deep layer of the flexor retinaculum at the level of the distal wrist crease (Fig. 5). Besides, in our series patients, all the patients have recovered protective sensation at the last follow-up, and the result of 2PD of the defect acquired mean 7.53 mm, even if there is no dominated nerve reservation in the flap. We agree with Lee et al. [17], that due to the basis of neurotization, abundant nerve endings, tactile corpuscles in hand, and touch practice frequently in daily life and working, which can promote recovery. Moreover, there is the tendency that the younger patients obtain better results, and the volar recipient sites are superior to the dorsal sites in our patients.

The flap also has general advantages which are thin, pliable, with good skin texture, and hairless, which correspond to the reconstructive principle of replacing “like with like”. And it can be used as multiple types: parallel or perpendicular the long axis of digital is a conclusion, the flap is uniquely positioned to reconstruct the small defect in hand, which can match to the optimal reconstructive treatment [18], and composite tissue flap that consists of the Palmaris longus tendon is a useful for grafting to reconstruct the defect of the hand. Even though the embarrassed donor site scar, just like a suicide trace, within our follow-up, several patients in this study preferred to choose the donor site in the wrist rather than the common flaps in hands. Because they considered the scar in hands are harder to be covered, and a bracelet or watch can cover the scar easily in the wrist, especially in summer. Furthermore, the tourniquet and anesthesia are convenient and are similar to the above mentioned common flaps in the same operative field. Meanwhile, none of main arteries will be damaged such as the radial artery and ulnar artery.

Fig. 4. The left index finger as injury of ground injury by cement board, resulting in partial tissue of radial fingertip defect, with nailbed partial coloboma, the distal phalanx catagmatic and exposed (Fig. 4A–B). The free SPBRA perforator flap was designed in the wrist course to resurface, the flap size was 4.0 cm × 2.5 cm (Fig. 4C). Intraoperative flap excision was finished (Fig. 4D). The appearance of the flap at the time of the pastoperation (Fig. 4E). At the latest 12 months follow-up, the function and appearance recover satisfied (Fig. 4F–H).

There is 20%–30% of the blood supply of the distal tuberosity of the scaphoid is provided by the superficial palmar branch of the radial artery [19]. The potential impact of blood supply on the scaphoid bone because of the SPBRA defect is the limitation of our study and need further research to exploration. And the cases in our series less and the result lack control group are the other limitations, therefore, the work of gather as much cases as possible and collect much objective evaluation to statistical analysis continues to make more consummate.

The flap size is limited and will not enough to cover the length and width more than 6.0 cm × 4.0 cm. And 3%–34% of the superficial palmar arch comes with variations [20,21] and it would be injured by interoperation dissection or no perforator artery enter into the tissue. The general solution is giving up the flap and choosing the second donor site. Nevertheless, injury will increase significantly. So preoperative Doppler examinations are more helpful in identifying the artery location and controlling the damage for patients. Moreover, due to the cutaneous veins are abundant in the wrist and forearm, so we advocate to contain two or more cutaneous veins while dissect the flap, if the SPBRA absents, then transformed into an arterial venous flap as us to use, which could decrease injury and avoid embarrassment during operation. Furthermore, so even if the satisfied sensory could be achieved [10,12,22], the “pillar pain” should be paid attention to because of the injury of PCBMN or its branches [23–25].Congestion was the significant issue of the arterial venous flap, and some authors advised to increase anastomosis quantity of drainage veins [26]. We advocate that the flow-through technique should be adopted to anastomose, which can distribute artery pressure and play a role of drainage vein to alleviate the pressure of the venous [27].

Fig. 5. Volar regional anatomy of wrist.

Conclusion

For hand tissue defect, the goal of physiological reconstruction and esthetic effect could be achieved by the free s SPBRA perforator flap. Furthermore, multiple tissues of the flap could be contained according to the need of the defect. Even though the SPBRA is variation, arterial venous flap could be applied for its abundant cutaneous veins. It is easy to harvest, and the process of operation which produces limited psychological pressure to the surgeon. It's worth being popularized in clinics.

Compliance with ethical standards

N/A.

Declaration of Competing Interest

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

The study is not supported by any public, commercial or other nonprofit sector.

Informed consent of all clinical cases has been signed.

The study was approved by the committee of medical ethics of the participating hospitals.

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