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Original Article

Efficacy of radial artery superficial palmar branch perforator flap in repairing soft tissue defects in the finger

Guangxin Chen[1*], Shixiang Mu[2*], Dongli Yu[3], Feifei Chen[3], Wenbo Zhang[4], Jinlan Liu[5], Chunmei Li[6]

[1]Department of Hand and Foot Microsurgery, The Second People's Hospital of Liaocheng, Liaocheng, Shandong Province, China; [2]Second Department of Orthopedics and Traumatology, Dezhou Hospital of Traditional Chinese Medicine, Dezhou, Shandong Province, China; Departments of [3]Hand and Foot Reconstructive Surgery, [4]Orthopedic Surgery, Dezhou People's Hospital, Dezhou, Shandong Province, China; [5]Department of Nursing, Affiliated Hospital of Weifang Medical University, Weifang, Shandong Province, China; [6]Department of Orthopedics, Third Weihai Municipal Hospital, Weihai, Shandong Province, China. [*]Equal contributors and co-first authors.

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Abstract: Objective: To observe the efficacy of radial artery superficial palmar branch perforator flap in treating soft tissue defects of the finger. Methods: A total of 74 patients with hand flexor tendon injury admitted to the department of hand surgery were randomly divided into two groups, among which 39 patients treated with flap repair based on the vascular chain of lateral finger cutaneous branches, were assigned to a control group, and the other 35 patients treated with radial artery superficial palmar branch perforator flap were assigned to an observation group. The following aspects of all the patients were assessed and compared: Flap survival rate, total active movement (TAM), pressure pain threshold (PPT), Moorfields motion displacement test (MMDT) results, and complications after surgery. Results: The observation group showed a higher flap survival rate than the control group ($P<0.05$), and also performed better than the control group in terms of TAM, PPT, and MMDT (all $P<0.05$). In addition, the observation group showed a significantly lower complication rate than the control group after surgery ($P<0.05$). Conclusion: Radial artery superficial palmar branch perforator flap is more effective than cutaneous branches-chain flap in treating soft tissue defects of the finger, and contributes to a higher flap survival rate, faster recovery of hand function, and lower complication rate for patients, so it is worthy of popularization and application in clinical practice.

Keywords: Finger soft tissue defect, radial artery superficial palmar branch flap, cutaneous branches-chain flap, efficacy of observation

Introduction

Finger injury, a common clinical injury, is usually caused by factors such as cutting, squeezing, heat or pressure. It is often accompanied by soft tissue defects, so it is particularly difficult to treat if accompanied by finger artery injury [1, 2]. Most finger injuries manifest as irregular wounds. Although such defects are small, they cannot be directly sutured due to the special structure of fingers, and skin grafting is unable to repair wounds as required. Therefore, finger defects are usually repaired through flaps in clinical practice [3, 4]. At present, there are various flaps with their own advantages and disadvantages [5, 6]. Cutaneous branches-chain flap is relatively effective in repairing small-area finger defects, and it is typically adopted for distal parts of extremities for the reason of vascular anatomy, but it has the following disadvantages: it is suitable for only small-area defect repairs during operation, and it can easily bring vasospasms [7, 8]. In 1993, the flap pedicled with radial artery superficial palmar branches was first proposed for the treatment of finger soft tissue defects. However, it was modified into a transverse flap due to the influence of the longitudinal flap on the donor site in 2003, which brought a good efficacy [9, 10]. With the development of microscopy, minimally invasive microsurgery has been increasingly applied clinically in various

departments [11, 12]. In recent years, the free radial artery perforator flap with microscopy provides a good efficacy in minimally invasive treatment for repairing finger soft tissue defects, and can improve the aesthetic appearance of the fingers [13]. Its advantages are as follows: the flaps can be selected and used conveniently; blood vessels are in a constant state facilitate operation; close skin distance between the flap and the operation area, small skin color difference, and less fat in the flap help to avoid bloated skin, and exert positive effects on reconstruction of nerves, tendons, and blood vessels and joint function repair. Its disadvantages are as follows: it is suitable for only small-area finger defects and is a demanding operation, and it may bring palm sensory disorders [14]. There was no definite conclusion on the disadvantages and advantages of the above two surgical methods in clinic practice, so this study made a comparative study on the two methods, and compared the postoperative recovery of them through long-term follow-up observations, so as to provide more basis for clinic practice. Results are reported as follows.

Materials and methods

Clinical data

A total of 74 patients with soft tissue defects of one finger, admitted to the department of hand surgery in the Third Weihai Municipal Hospital from February 2017 to March 2019 were selected and randomly divided into two groups using a random number table method. Thirty-nine patients were treated with flap repair based on the vascular chain of lateral finger cutaneous branches as a control group, and the other 35 patients were treated with radial artery superficial palmar branch perforator flap as an observation group. All the enrolled patients were between 18 and 75 years old, with a mean age of 33.5±8.7 years, and signed an informed consent form. The study was approved by the Ethics Committee of Third Weihai Municipal Hospital.

Inclusion criteria

(1) Patients met the diagnostic criteria of finger soft tissue defects [15]; (2) patients whose interval from injury to admission did not exceed 8 h; (3) patients between 18 and 65 years old; (4) patients without other diseases affecting finger joint motion.

Exclusion criteria

(1) Patients with comorbid wound infections, phalangeal fracture, or nerve injury; (2) patients with comorbid trauma in other body parts; (3) patients with comorbid cardiopulmonary insufficiency; (4) patients with comorbid malignant tumors; (5) immunocompromised patients who are on immunosuppressors; (6) patients with comorbid diabetes, comorbid atherosclerosis or hematological diseases.

Methods

The first-stage debridement: debridement was carried out for the wounds of each enrolled patient with brachial plexus nerve blocking anesthesia after his/her admission, which was mainly to remove pollutants and necrotic tissues from the wound surface. Reduction and fixation were performed for complicated fracture, and tendon suture was also performed for complicated tendon fracture. The wound surface was trimmed to meet the requirements of flap transplantation, and it was stopped from bleeding after trimming.

Patients in the control group were treated with treated with flap repair based on the vascular chain of lateral finger cutaneous branches. The cloth pattern was designed with a pedicle by taking the dorsal metacarpal artery or digital proper artery as the starting point of the cutaneous branch. The dorsal metacarpal artery or digital proper artery was correspondingly selected according to the size and position of the wound surface, and the area of the selected flap was larger than the wound surface by 10-20%. The selected flap was incised layer by layer from one side until reaching the superficial layer of the finger extensor tendon aponeurosis using the surface projection of dorsal metacarpal artery or taking the center line of the injured finger as the shaft axis. Subsequently, the opposite side of the skin was incised to the same position, and the flap and pedicle were dissected from near too far, from the superficial layer of the aponeurosis. Sharp dissection should be done carefully to avoid damage to the branches of the axial artery. After flap dissection, whether the vascular supply of the flap was good was evaluated. Finally, tunnels were opened to transfer the flap to the wound, and the nerve of the flap was anastomosed with the nerve stump of the wound surface to promote nerve repair. In addition, the donor area was directly sutured.

Table 1. General data and baseline data of the patients

Project	Observation group (n=35)	Control group (n=39)	X^2/t	P
Sex (male/females)	20/15	24/15	0.677	0.489
Age (years)	33.6±9.1	33.3±8.3	0.148	0.701
Injury site (n)				
Thumb	12 (34.29)	12 (30.77)	0.449	0.978
The index finger	9 (25.71)	10 (25.64)		
The middle finger	4 (11.43)	5 (12.82)		
The ring finger	7 (20.00)	7 (17.95)		
The little finger	3 (8.5)	5 (12.82)		
Injury cause				
Sharp injury	20 (57.14)	21 (53.85)	0.081	0.776
Blunt injury	15 (42.86)	18 (46.15)		
Comorbid tendon injury				
Yes	12 (34.29)	15 (38.46)	0.139	0.709
No	23 (65.71)	24 (61.54)		
Comorbid fracture				
Yes	7 (20.00)	9 (23.08)	0.103	0.748
No	28 (80.00)	30 (76.92)		

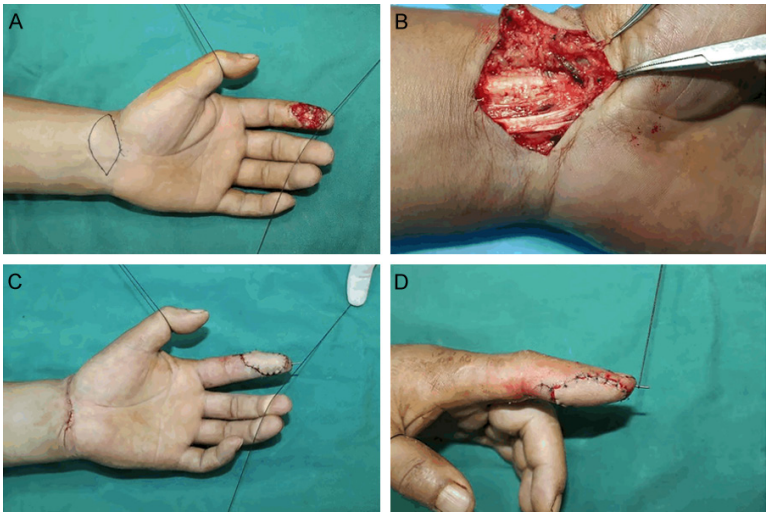

Figure 1. Radial artery superficial palmar branch perforator flap. A. Site selection of radial artery superficial palmar branch perforator flap; B. Incision of radial artery superficial palmar branch perforator flap; C. The perforator flap of the superficial palmar branch of radial artery was sutured to repair the index finger and donor site; D. Repair of soft tissue defect of index finger with flap.

Patients in the observation group were treated with radial artery superficial palmar branch perforator flap. First, the flap point was selected, which was generally selected near the scaphoid bone. There should be radial artery superficial palmar branches perforating into the flap. Under color Doppler ultrasound, the flap was incised by taking the perforation point as the central point of the flap, and the scaphoid bone and the first metacarpophalangeal joint as the proximal and distal ends of the flap, respectively. The radial margin of the flap was first cut off to free the inferior vein branches under the flap, and then the incision was continued along the radial artery superficial palmar branch. The perforating branches were searched for and their sites were identified. Subsequently, the ulnar margin of the flap was incised, and perforating branches should be free in the flap, and should be free as much as possible to meet the needs of operation. The blood supply of the branches should be smooth and sufficient. The flap was made to be freed completely, and then was transplanted to the defect area of skin. The flap edge and the finger wound edge were sutured, and the perforating branches and veins under the flap were respectively anastomosed with the interphalangeal artery and subcutaneous veins. Then the surgery was completed by directly suturing the skin in the donor site.

Postoperative management: both groups received routine treatment such as anti-infection treatment, spasmolysis, and microcirculation improvement after operation. Meantime, the two groups were prohibited from smoking, and measures were taken to intensify their body position management, help them elevate the affected limbs and keep warm of the affected limbs. Dynamic observation was performed to the flap color and temperature, and parts of the pedicle suture were removed in time in case of flap blood stasis or swelling.

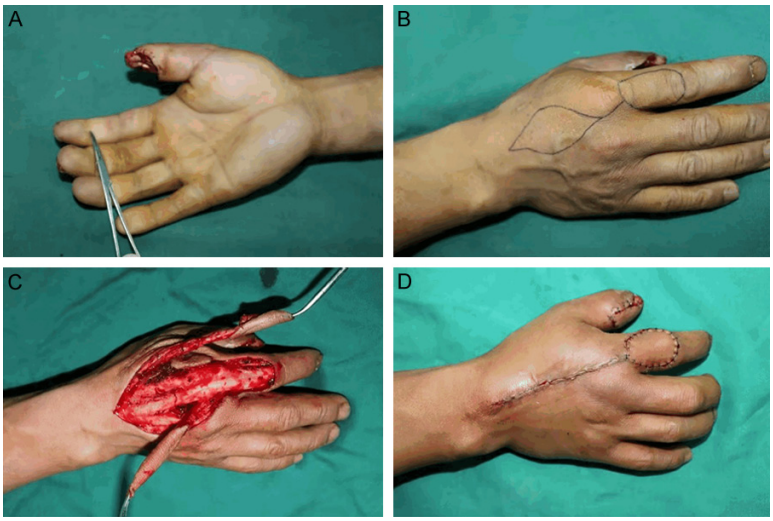

Figure 2. Cutaneous branches-chain flap. Use of the dorsal forefinger flap to repair the thumb and the second dorsal palmar artery to repair the dorsal forefinger. A. Soft tissue defect of the thumb; B. The parts of the flap were selected; C. Incision of cutaneous branch chain flap; D. After repairing the thumb with cutaneous branch chain flap.

Table 2. Flap survival rate

Project	Observation group (n=35)	Control group (n=39)	χ^2	P
Flap survival rate [n (%)]	34 (97.14%)	32 (82.05%)	4.357	0.037

Observation indexes

The flap survival rate of the two groups was evaluated, and flaps without necrosis and inflammatory response, and with normal skin temperature were determined as survival.

The enrolled patients were followed up in the outpatient department at 2 weeks and 12 weeks after surgery, and the recovery of patients' hand function was evaluated with instruments: (1) observation of the total active movement (TAM): the evaluation method was based on the TAM scoring system of the America Society of Surgery of Hand. TAM = the sum of flexion degrees of each joint - the sum of extension limitation degree of each joint [16]. Compared with corresponding fingers on the opposite side, the affected finger was considered as in an excellent, good, medium or poor state when its TAM score ≥90%, ≥75%, ≥50%, or <50%, respectively. The excellent and good rate = the number of cases in an excellent state + the number of cases in a good state/the total number of cases*100%; (2) pressure pain threshold (PPT) evaluation [17] covered three evaluation items: affected hands were evaluated, within 30 seconds, based on the number of supplied steel columns put by the patients' affected hand into the designated mold; the hands of each patient were evaluated, within 30 seconds, based on the alogarithm of the supplied steel columns put by his/her both hands into the designated mold, and the hands of each patient were evaluated based on the number of assemblies accomplished by the hands within 60 seconds. PPT of the affected hand was evaluated by letting each patient carry out designated operations with the affected hand, while PPT of both hands was evaluated by letting each patient carry out designated operations with two hands cooperatively. (3) Moorfields motion displacement test (MMDT) [18] included two items: displacement time and turnover time. Displacement time was the time spent by a patient for placing 60 pieces from their original position to another position according to the specified sequence with his/her affected hand, and the turnover time was the time spent by a patient turning 60 pieces upside down from right side up with his/her affected hand.

The postoperative complication rate includes the incidence of local blisters, bruises and swollen pedicle of the flap.

Statistical analysis

SPSS 22.0 was employed in this study, and continuous variables were expressed by the mean + standard deviation (X ± SD), and analyzed using the independent-sample T test. Enumeration data were expressed as n/%, and analyzed using the Pearson chi-square test. $P<0.05$ indicated a significant difference.

Results

General data and baseline data of the patients

Statistical comparison between the two groups in general data and baseline data revealed that the two groups had no differences in sex, age,

Table 3. Excellent and good rate in TAM score

Project	Excellent	Good	Fair	Poor	Excellent and good rate (%)
Observation group	18 (51.43)	15 (42.86)	2 (5.71)	0 (0.00)	33 (94.29)
Control group	10 (25.64)	19 (48.72)	9 (23.08)	1 (2.56)	29 (74.36)
χ^2					5.391
P					0.020

Note: TAM, Total active movement.

Table 4. PPT score of the patients

Project	Observation group	Control group	t	P
Scores of affected hands				
2 weeks after surgery	8.28±1.17	8.18±1.58	0.321	0.749
12 weeks after surgery	15.93±1.36	14.95±1.82	2.705	0.008
Scores of both hands				
2 weeks after surgery	7.93±1.38	7.88±1.62	0.148	0.882
12 weeks after surgery	15.65±1.65	14.65±1.98	2.449	0.017
Scores of assembling				
2 weeks after surgery	26.30±1.91	26.13±2.22	0.378	0.707
12 weeks after surgery	43.03±1.70	39.60±2.55	7.065	<0.001

Note: PPT, Pressure pain threshold.

injury site, injury cause, comorbid tendon injury, and comorbid fracture, with comparability (all P>0.05). See **Table 1**.

Surgical pictures of the patients undergoing one of the two typical surgical methods

The process of treating finger soft tissue defects by the radial artery superficial palmar branch perforator flap and cutaneous branches-chain flap are shown in **Figures 1** and **2**.

Flap survival rate

The flap survival rate of the observation group was significantly higher than that of the control group (97.14% vs. 82.05%, P<0.05). See **Table 2**.

Excellent and good rate in TAM score

Comparison between the two groups in terms of excellent and good rate of TAM score after surgery showed that the excellent and good rate of the observation group was higher than that of the control group (P<0.05). See **Table 3**.

PPT score of the patients

The observation group was not significantly different from the control group in scores with regards to affected hand, both hands, and assembly at 2 weeks after surgery (all P>0.05), but showed higher scores than the control group at 12 weeks after surgery (all P<0.05). See **Table 4**.

Time consumption in MMDT

The MMDT scores of the two groups revealed that both groups used significantly less displacement time and turnover time at 12 weeks after surgery (both P<0.05), and the observation group was not significantly different from the control group in the two aspects at 2 weeks after surgery (both P>0.05), but had less displacement time and turnover time than the control group at 12 weeks after surgery (both P<0.001). See **Table 5**.

Complication rate of the patients

Comparison between the two groups in complication rate revealed that the observation group showed a significantly higher total complication rate than the control group (P<0.05). See **Table 6**.

Discussion

Finger soft tissue defects are usually accompanied with abnormal sensation of fingers, incoordination of fine motions, differences in skin color and other effects during recovery with surgery. If they are accompanied with nerve, tendon or bone injuries, they become more difficult to treat, so a better surgical method has searched for in clinic practice [19]. Radial artery superficial palmar branches are the main arteries supplying blood to the wrist, and their anatomical locations that are relatively constant [20]. A study found that radial artery superficial palmar branch perforator flap contributed to a higher flap survival rate and a more beautiful finger appearance in repairing finger soft tissue

Table 5. Time consumption in MMDT

Project	n	Displacement time (s)		t	P	Turnover time (s)		t	P
		2 weeks after surgery	12 weeks after surgery			2 weeks after surgery	12 weeks after surgery		
Observation group	35	351.08±26.04	271.15±34.28	634.217	<0.001	317.68±28.38	240.08±26.02	58.924	<0.001
Control group	39	349.08±25.77	306.95±25.68	323.971	<0.001	313.70±25.78	266.08±25.74	153.907	<0.001
t		0.345	6.185			0.656	4.492		
P		0.731	<0.001			0.514	<0.001		

Note: MMDT, Moorfields motion displacement test.

Table 6. Complication rate of the patients

Complication	Observation group (n=35)	Control group (n=39)	χ^2	P
Local blisters	5 (14.29)	7 (17.95)		
Bruises	6 (17.14)	10 (25.64)		
Swollen pedicle of flap	8 (22.86)	13 (33.33)		
Total incidence	19 (54.29)	30 (76.92)	4.226	0.040

defects [21], and this study also found that this method contributed to a higher flap survival rate than the cutaneous branches-chain flap, which was consistent with the above research results.

In terms of hand function recovery after surgery, this study evaluated the hand function recovery with various methods, and found that the TAM, PPT, and MMDT results of the patients from the two groups at 12 weeks after surgery were significantly better than those at 2 weeks after surgery, and the observation group under the radial artery superficial palmar branch perforator flap performed better than the control group under the cutaneous branches-chain flap. A study on radial artery superficial palmar branch flap alone revealed that the observation group had significantly improved life quality score, and showed significantly decreased flap necrosis, significantly improved hand function, and reduced postoperative pain [22], and another study concluded that radial artery superficial palmar branch flap could improve the hand function of the patients with finger soft tissue defects and relieves their postoperative pain [23]. In terms of postoperative complications, the observation group showed a significantly lower complication rate than the control group, which was mainly due to the following facts: cutaneous branches-chain flap required flap rotation during flap transplantation, and the most abundant blood supply was at the fascia, so too much connective tissue between the fascia and the pedicle at the rotation point were not conducive to rotation. It affected blood supply of the flap and survival of the flap, increased the complication rate, and was not conducive to postoperative recovery [24, 25]. In contrast, radial artery superficial palmar branch flap was beneficial to tissue blood supply due to its abundant venous network under the flap, and it could not only repair nerve and tendon, but also reconstruct blood vessels under microscopic technology. The reconstruction of blood vessel was beneficial to the growth of damaged tissues of the flap, and the reconstruction of blood vessels and venous networks were beneficial to the dissipation of blood stasis and venous return, thus reducing the occurrence of complications [14]. There are branches of the radial nerve, median nerve and cutaneous nerve under the flap [26]. Radial artery superficial palmar branches can generate 1-3 cutaneous branches to nourish the skin of the wrist that spread to distal parts, so these cutaneous branches are retained when the skin flap is transplanted. In addition, a study had reported that the length of radial artery superficial palmar branch flap could be up to 2.40±0.34 cm [20], and one other study showed that a longer flap was more conductive to postoperative aesthetics of fingers and trauma alleviation of fingers in the donor site [27].

In this study, the sample size is small, so it needs to be further expanded for future research, and the follow-up time is short, so the follow-up time also needs to be increased to study the effects of the two surgery methods on the recovery of hand functions.

To sum up, radial artery superficial palmar branch perforator flap is more effective than cutaneous branches-chain flap in treating fin-

ger soft tissue defects, and contributes to a high flap survival rate, fast recovery of hand functions, and low complication rate for the patients, so it is worthy of popularization and application in clinical practice.

Disclosure of conflict of interest

None.

Address correspondence to: Chunmei Li, Department of Orthopedics, Third Weihai Municipal Hospital, No. 80 Qilu Avenue, Weihai 264205, Shandong Province, China. Tel: +86-0631-5960961; Fax: +86-0631-5960961; E-mail: lichunmei92du@163.com

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