

## Original Article

# Effect of transverse wrist crease perforator flap on repairing soft tissue defect of fingers and its influence on hand function

Yefeng Lu<sup>1</sup>, Rongrong Shen<sup>2</sup>, Junhui Zhou<sup>1</sup>, Jiliang Li<sup>3</sup>, Yinwei Huang<sup>1</sup>

<sup>1</sup>Department of Hand and Foot Microsurgery, Yuyao People's Hospital of Zhejiang Province, Ningbo, Zhejiang Province, China; <sup>2</sup>Department of Anesthesia, Yuyao People's Hospital of Zhejiang Province, Ningbo, Zhejiang Province, China; <sup>3</sup>Department of Burn and Plastic Surgery, Hua Mei Hospital, University of Chinese Academy of Sciences, Ningbo, Zhejiang Province, China

Received April 2, 2022; Accepted May 29, 2022; Epub October 15, 2022; Published October 30, 2022

**Abstract:** Objective: To investigate the effect of transverse wrist crease perforator flap repair on sensory nerve function, survival of flap, hand function, hand appearance and satisfaction rate in patients with soft tissue defect of fingers. Methods: This retrospective study was performed in 30 patients admitted to the Hand and Foot Microsurgery Department of our hospital between January 2018 and December 2020. These patients were divided into the control group and the experimental group (15 patients for each group) according to the operative methods. Patients in the control group underwent abdominal flap repair, while patients in the experimental group received transverse wrist crease perforator flap repair. Intraoperative parameters, sensory nerve function, function of finger reconstruction, survival rate of skin flap, degree of scar contracture and flap bloatedness, DASH score, two-point discrimination and satisfaction rate were compared between the two groups. Results: Compared with the control group, the operative time in the experiment group was obviously decreased ( $P < 0.05$ ). There was no difference in amount of bleeding between the two groups. The proportion of sensory nerve function grade S3+ and S4 in the experimental group was significantly increased in contrast to the control group ( $P < 0.05$ ). The total excellent and good rate in function of finger reconstruction in the experiment group was significantly higher than that in the control group, while no difference was found in the survival rate of skin flap and scar contracture between the two groups. Compared with the control group, DASH score, two-point discrimination distance, and degree of flap bloatedness in the experiment group were significantly reduced and the patients' satisfaction rate in the experiment group was remarkably increased (all  $P < 0.05$ ). Conclusion: Transverse wrist crease perforator flap repair plays a critical role in reducing operative time, improving sensory nerve function and recovery of hand function, and alleviating flap bloatedness. It is an optimal treatment for soft tissues defect of fingers.

**Keywords:** Therapeutic effect, transverse wrist crease perforator flap, soft tissues defect, fingers

## Introduction

With the development of industrialization, hand trauma and soft tissues defect of fingers have been common, and account for approximately 30% of emergency trauma [1, 2]. For patients with soft tissues defect of fingers, their work and life quality are seriously impaired [3, 4]. It is very important for patients to repair soft tissues defect of fingers. The essential principles of clinical treatment include good-looking, unchanged fingers length, restored sensory nerve function and hand function [5, 6]. In

clinical practices, it is not suitable to suture directly or graft with free skin because of the special skin structure and low mobility of tissues defect [7, 8]. Therefore, the skin flap repair is very critical for these patients with soft tissues defect. The option of appropriate flap appears to be particularly important in the whole treatment, which not only affects the hand appearance, but also influences the function of hand.

Previous studies reported that abdominal skin flap was one of the most commonly used ori-

## The role of transverse wrist crease perforator flap

gins for traditional repair of skin defect [9, 10]. Abdominal skin flaps have advantages of easy operation, excellent anti-infection ability, wide application, relatively low technical requirements for the surgeons and so on. However, recent studies showed that the blood supply in abdominal skin flaps was not enough, the recovery of sensory nerve function was poor and vascular crisis was frequently observed [11]. In the recent years, transverse wrist crease perforator flap has been employed by more and more surgeons to treat the soft tissues defect of fingers. Some studies reported that the patients with soft tissues defect of fingers could benefit greatly from transverse wrist crease perforator flap repair [12]. Other studies showed that there were some limitations in the repair of transverse wrist crease perforator flap [13]. The reports on therapeutic effect of transverse wrist crease perforator flap are inconsistent. Moreover, few studies for the comparison of therapeutic effect between transverse wrist crease perforator flap repair and abdominal skin flap repair in patients with soft tissues defect of fingers were reported. Recently, transverse wrist crease perforator flap repair has been developed for hand trauma in Hand and Foot Microsurgery Department of our hospital and some experience has been gained. In this study, we aimed to investigating the therapeutic effect of transverse wrist crease perforator flap on the function and appearance of hand in repairing the soft tissues defect of fingers in contrast with abdominal skin flap. The results of this study would provide experimental evidences for clinical treatment of hand trauma.

### Materials and methods

#### *General information*

Patients admitted to the Hand and Foot Microsurgery Department of Yuyao People's Hospital of Zhejiang Province for soft tissue defect of fingers from January 2018 to December 2020 were included in this study. Inclusion criteria: Patients with the first unilateral finger soft tissue defect diagnosed according to the criteria of finger soft tissue defect [14]; patients with an age of over 18 years; patients with adequate blood supply in the injured fingers; patients who had undergone the surgery and were able to actively participate in this research. Exclusion criteria:

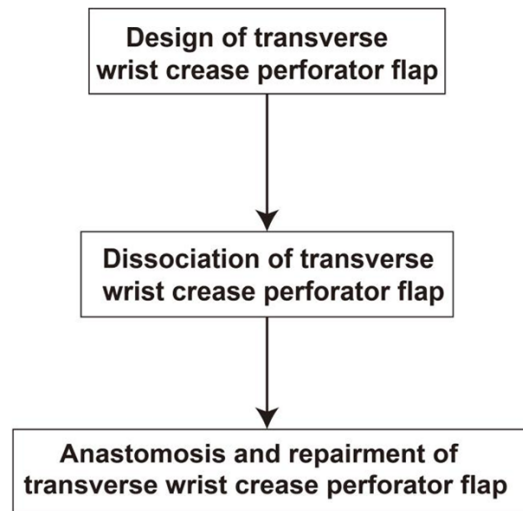
Patients with contraindications to surgery; patients with other traumas; patients with severe cardiovascular, cerebrovascular disease, liver and kidney dysfunction, malignant tumor, hyperthyroidism, diabetes, cognitive impairment or psychiatric diseases; patients received hormonal drugs within 3 months; patients with incomplete medical records; or patients who were unable to cooperate in this study.

A total of 30 patients with soft tissue defect of fingers were included in this retrospective study, and the collected data were analyzed. According to the surgical method, these patients were divided into the control group and the experimental group, with 15 patients in each group. Patients from the control group underwent abdominal flap repair, while patients in the experimental group received thumb dorsal cutaneous neurotrophic flap repair. All patients were followed up for 3 months by telephone interview or outpatient examination. This study was approved by the Ethics Committee of Yuyao People's Hospital of Zhejiang Province.

#### *Methods of surgery*

All the patients underwent repair after debridement using brachial plexus block anesthesia. For stopping bleeding, a rubber band was given in the base of the finger, or a tourniquet was provided in the upper arm. Patients from the control group received the following abdominal flap repair: First, the incision was disinfected and draped. Second, skin flap was originated from the abdomen. According to the area of the perforator, the size of the flap was determined and the perforator vessel was exposed. Third, the skin flap was dissociated with the vascular branch as the center. Finally, wound margin was sutured under no tension using abdominal skin flap. Patients of the experimental group underwent transverse wrist crease perforator flap repair: The skin flap was obtained using the parallel line of the transverse wrist crease at the location of 10 cm from the proximal navicular tubercle as the axis. The proximal and lateral edges of the skin flap were dissociated and the superficial palmar branch of the radial artery was exposed. According to the superficial palmar branch of the radial artery, the skin flap was separated slowly and the pedicle was cut off. Under the

## The role of transverse wrist crease perforator flap



**Figure 1.** The schematic diagram of transverse wrist crease perforator flap repair.

microscope, the superficial palmar branch of the radial artery in the pedicle of skin flap was anastomosed with the artery marked in the recipient area, the palmar cutaneous branch of the median nerve in the pedicle was anastomosed with the digital nerve and its branch in the recipient area, and the vein from skin flap was anastomosed with vein marked in the recipient area, as shown in **Figure 1**.

### *Observed indicators*

Indicators such as the sensory nerve function, function of finger reconstruction, and the survival rate of skin flap are primary ones. Indicators such as the operating time, amount of bleeding, the disabilities of the arm, shoulder and hand scores, degree of scar contracture and flap bloatedness, two-point discrimination, and satisfaction of patients are secondary ones.

The operating time and bleeding amount were compared between the two groups. The sensory nerve function after operation, which was evaluated by the criteria reported by the Neurotrauma Society of National Institute for Medical Research [15] with a total score of 20 points, was compared between the two groups.

Function of finger reconstruction was evaluated according to the results reported by previous studies [16]. The evaluation criteria were as follows: Excellent: The function and the

appearance of the hand were unaffected; Good: There was slight functional limitation in hand and swelling in the appearance; Poor: There was dysfunction of the hand and patients were unable to take care of themselves. The survival rate of skin flap was evaluated according the following criteria [4]: Excellent: The skin flap survived without any adverse reactions such as swelling and chronic ulcers; Good: The flap basically survived with a small part of superficial necrosis, which healed after corresponding treatment; Poor: >50% of flaps showed full-thickness necrosis, which needed further treatment.

The hand symptom and function after surgery were evaluated by disabilities of the arm, shoulder and hand (DASH) scores [17], which included 34 items such as opening tight caps, writing, cooking, making a bed, wearing a pull-over, and so on. A 5-point scale was used for assessing each item based on the severity of symptom and hand function. A higher score indicated a more significantly restricted function of hand.

Degree of scar contracture and flap bloatedness after surgery of the two groups was evaluated. The evaluation criteria were as follows: normal or not obvious scar contracture (-/+); mild scar contracture (+); moderate scar contracture (++) , and severe scar contracture (+++). The evaluation criteria of degree of flap bloatedness were as follows: not obvious or normal bloatedness (-/+), mild bloatedness (+), moderate bloatedness (++) , and severe bloatedness (+++). According to the scope of scar contracture or bloatedness, 0-3 points were assigned.

Two-point discrimination after surgery is the minimum distance distinguished in the repaired area, which was longitudinally examined according to distance (from large to small) [18]. The smaller the two-point discrimination distances, the better the recovery of neurological function.

Satisfaction of patients was assessed by the self-made questionnaire with a total score of 100 points, which included color of the skin, texture, appearance and shape. The criteria were as follows: very satisfied (score >85 points), satisfied (between 60 points and 85 points), dissatisfied (score <60 points).

## The role of transverse wrist crease perforator flap

**Table 1.** Comparison of general information between the two groups

Group	Experimental group (n=15)	Control group (n=15)	t/ $\chi^2$	P
Male/female (n)	8/7	10/5	0.556	0.456
Age (years)	42.1±3.5	43.2±3.9	0.813	0.423
BMI (kg/m <sup>2</sup> )	21.5±0.6	21.7±0.9	0.716	0.480
Hypertension (n)	2	4	0.833	0.361
Diabetes (n)	5	3	0.682	0.409
Course of disease (h)	4.2±0.5	4.6±0.7	1.801	0.083
Cause of injury (n)			1.091	0.779
Cutting injury	5	5		
Smash injury	6	5		
Crush injury	2	4		
Run-over injury	2	1		
Area of soft tissue defect (cm <sup>2</sup> )	1.7±0.4	1.9±0.5	1.210	0.237
Fingers (n)			0.767	0.943
Thumb	2	1		
Index finger	5	6		
Middle finger	4	3		
Ring finger	2	3		
Little finger	2	2		

Note: BMI, body mass index.

**Table 2.** Comparison of the operation time and amount of bleeding between the two groups

Group	Operating time (min)	Amount of bleeding (ml)
Control group	93.7±10.3	76.1±4.9
Experimental group	84.6±9.5	78.3±5.2
T value	2.515	1.193
P value	0.018	0.243

**Table 3.** Comparison of degree of scar contracture and flap bloatedness between the two groups

Group	Scar contracture	Flap bloatedness
Control group	1.2±0.5	2.0±0.7
Experimental group	0.8±0.2	1.5±0.4
T value	1.732	2.402
P value	0.094	0.023

### Statistical analysis

All the data included in this study were analyzed using SPSS statistical software version 24.0 (IBM, USA). The measurement data were expressed as mean ± standard deviation (SD) and compared using t test between groups. The enumeration data were presented as number/percentage (n/%) and compared using

Chi-square between the two groups. The difference was statistically significant when P value was less than 0.05.

### Results

#### General information

There were no obvious statistical differences in term of age, gender, body mass index (BMI), underlying disease, types of fingers, course of disease, area of soft tissue defect, and cause of injury between the two groups, as shown in **Table 1**.

#### Comparison of the operation time and amount of bleeding

As shown in **Table 2**, the operation time in the experiment group was 84.6±9.5 min, which was significantly shorter than that in the control group (93.7±10.3) (P<0.05). The amount of bleeding in the experiment group was 78.3±5.2 ml, while it was 76.1±4.9 ml in the control group. There was no significant difference between the two groups.

#### Comparison of degree of scar contracture and flap bloatedness

As shown in **Table 3**, no difference in the degree of scar contracture was found between the

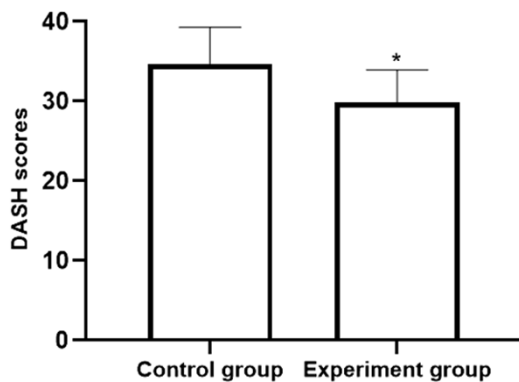
## The role of transverse wrist crease perforator flap

**Table 4.** Comparison of the patients' satisfaction rate between the two groups

Group	Very satisfied	Satisfied	Dissatisfied	Satisfaction rate
Control group (n=15)	8 (53.3%)	4 (26.7%)	3 (20.0%)	80.0% (12/15)
Experiment group (n=15)	12 (80.0%)	2 (13.3%)	1 (6.7%)	93.3% (14/15)

**Table 5.** Comparison of sensory nerve function, function of finger reconstruction and survive of skin flap between the two groups [case (%)]

Group	The proportion of sensory nerve function grade S3+ and S4	The excellent and good function of finger reconstruction	The excellent and good survive of skin flap
Control group (n=15)	8 (53.3%)	11 (73.3%)	14 (93.3%)
Experiment group (n=15)	13 (86.6%)	14 (93.3%)	15 (100%)



**Figure 2.** Comparison of DASH scores between the two groups. Compared with control group, \* $P < 0.05$ . DASH, disabilities of the arm, shoulder and hand.

two groups ( $1.2 \pm 0.4$  vs  $0.8 \pm 0.2$ ,  $P > 0.05$ ). The degree of flap bloatedness in the experimental group was obviously alleviated as compared with that in the control group ( $2.0 \pm 0.7$  vs  $1.5 \pm 0.4$ ,  $P < 0.05$ ).

### Comparison of patients' satisfaction

Compared with control group, the satisfaction rate in the patients of the experiment group was obviously higher (80.0% vs 93.3%,  $P < 0.05$ ), as shown in **Table 4**.

### Comparison of sensory nerve function, function of finger reconstruction and survival rate of skin flap

As shown in **Table 5**, there were 8 cases with sensory nerve function grade S3+ and S4 in the control group, while 13 cases in the experimental group. The proportion of sensory nerve function grade S3+ and S4 in the ex-

perimental group was significantly higher than that in the control group (53.3% vs 86.6%,  $\chi^2 = 3.968$ ,  $P = 0.042$ ).

There were 7 cases with excellent, 4 cases with good and 4 cases with poor function of finger reconstruction from the control group, while there were 11 patients with excellent, 3 patients with good and 1 case with poor function of finger reconstruction from the experiment group. The total excellent and good rate in the experiment group was significantly higher than that in the control group (73.3% vs 93.3%,  $P < 0.05$ ). There were 12 cases of excellent, 2 cases of good and 1 case of poor in term of survive of skin flap from the control group, while there were 14 patients of excellent and 1 patient of good in the survive of skin flap from the experiment group. There was no difference in the total excellent and good rate in survive of skin flap between the two groups (93.3% vs 100%).

### Comparison of DASH scores

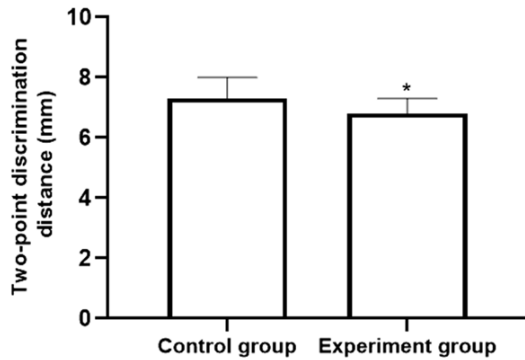
The DASH score in the experimental group was  $29.8 \pm 4.1$ , while it was  $34.6 \pm 4.7$  in the control group. Significant difference was observed in DASH scores between the two groups ( $P < 0.05$ ), as seen in **Figure 2**.

### Comparison of two-point discrimination distance

Two-point discrimination distance in the experimental group was  $6.8 \pm 0.5$  mm, which was significantly shorter than  $7.3 \pm 0.7$  mm in the control group ( $t = 2.251$ ,  $P = 0.032$ ), as shown in **Figure 3**.



## The role of transverse wrist crease perforator flap



**Figure 3.** Comparison of two-point discrimination distances between the two groups. Compared with control group, \* $P < 0.05$ .

### Discussion

Hands not only have the precise structure but also possess many functions. They are indispensable organs for survival and life of human. Hand trauma is one of the most common clinical diseases, which is characterized with acute and severe condition. In term of structure, thickness and texture, the skin of fingers is different from the other organs. Previous studies showed that subcutaneous tissues of fingers were dense, not easy to peel off, and rich in sensory corpuscles and sensory nerve endings [19, 20]. For patients with soft tissues defect of fingers, timely and effective repair treatment could restore the hand function of patients to a large extent and at the same time maximally maintain the normal appearance of the hand. At present, it remains to be a great challenge to surgeons to reconstruct the appearance and function of hand.

There are many methods of repair treatments for soft tissues defect of fingers. It was reported that skin flap repair treatment is a more effective method. Each method of repair has its advantages and disadvantages [21, 22]. Transverse wrist crease perforator flap was used to repair the soft tissues defect of fingers in this study. Compared with other skin flap, transverse wrist crease perforator flap has significant advantages. The anatomy of this skin flap is relatively stable. The location of the blood vessels is superficial, and the skin flap is easy to obtain. The caliber of the blood vessels in the donor areas are similar to those in the recipient areas, which reduces the difficulty of vascular anastomosis, the time of operation

and the surgical risk. Transverse wrist crease perforator flap is considered to belong to the axial skin flap with its own feeding artery. Some studies reported that this kind of skin flap had strong anti-infection ability, and high survival rate and flap quality, due to rich blood supply after the repair treatment [13]. Moreover, transverse wrist crease perforator flap is close to the recipient areas, indicating that the skin color, texture and tissue structure in the donor areas are similar to those in the recipient areas. Some studies revealed that this type of skin flap was full, soft, wear-resistant and has good function [23]. Another study reported that transverse wrist crease perforator flap possessed the realistic shape, and covered linear scar in the donor areas [12, 24]. In addition, transverse wrist crease perforator flap has cutaneous nerve, which can be anastomosed with the proper digital nerve in the recipient area. This could be helpful for restoration of protective sensations in fingers. In this study, the results showed that the operation time in the experiment group was shorter than that in the control group, and the total excellent and good rate in function of finger reconstruction from experiment group was significantly higher than that in the control group. However, the differences were not statistically significant in bleeding amount and the survival rate of skin flap between the two groups, which may be caused by the limited number of patients included in this study.

During the process of transverse wrist crease perforator flap repair, main vessels and nerves are not impaired. The anastomosis of nerve existing in the superficial branch of this skin flap and intrinsic nerve can promote the recovery of sensory nerve function [25]. However, abdominal skin flap has no cutaneous innervation. Fixation is not required for transverse wrist crease perforator flap repair, which is beneficial for the promotion of early functional exercise of fingers, and the avoidance of stiffness of interphalangeal joints caused by fixation. The results of this study showed that the proportion of sensory nerve function grade S3+ and S4 in the experimental group was obviously higher compared with the control group. In additional, DASH score and two-point discrimination distance were remarkably lower than those in the control group. These results suggested that the therapeutic effect of trans-

## The role of transverse wrist crease perforator flap

verse wrist crease perforator flap repair on soft tissues defect of fingers was satisfactory, which was basically in accordance with the results reported by Di et al. [26]. The texture and color of transverse wrist crease perforator flap was similar to finger tissues. Further, this kind of flap was anti-friction and moderate in skin thickness, which could alleviate the appearance of bloatedness. However, there are no horizontal stripes in abdominal skin flap, resulting in poor delicateness and ductility. The results of this study showed that there was no statistical difference for the degree of scar contracture between the two groups. Compared with the control group, the degree of flap bloatedness in the experimental group was obviously reduced. The patients' satisfaction regarding treatment was significantly higher in the experiment group. These results were basically similar to those revealed by Cheng et al. [27].

There were some limitations in this study. This is a single-centered study with small sample size and short-term follow up. A multi-center study with long-term follow up is necessary to further confirm the conclusion.

In summary, transverse wrist crease perforator skin flap repair treatment for soft tissues defect of fingers has the advantages of short operation time, good sensory nerve function recovery, excellent hand function, alleviated flap bloatedness, and high patients' satisfactory, indicating that this is an optimal treatment for the repair of soft tissues defect of fingers.

### Disclosure of conflict of interest

None.

**Address correspondence to:** Yinwei Huang, Department of Hand and Foot Microsurgery, Yuyao People's Hospital of Zhejiang Province, No. 800 Chengdong Road, Chengdong New District, Yuyao 315400, Zhejiang Province, China. Tel: +86-0574-62629999; Fax: +86-0574-62633569; E-mail: huangyinwei\_yy@163.com

### References

[1] Tang L, Zhou X and Zou YG. One-stage coverage of multi-digital pulp defects with sensate flaps from the foot. *Injury* 2022; 53: 1557-1561.

- [2] Durgut F, Ozdemir A, Ergin M, Gulec A and Acar MA. Comparison of the modified moberg flap versus first dorsal metacarpal artery flap for thumb pulp reconstruction. *Ann Plast Surg* 2022; 88: 277-281.
- [3] Estawrow MA and Gad AM. Reliability of perforator-based UPM flap for coverage of little finger and dorsal hand defect. *Plast Reconstr Surg Glob Open* 2022; 10: e4130.
- [4] Du W, Zhu F, Zhang H, Yang J, Zhuang W and Hou Q. Another new attempt to repair finger pulp defects: retrograde island flap bridge transfer of the adjacent phalangeal artery combined with vascular pedicle tubular skin grafting. *J Int Med Res* 2022; 50: 3000605221082892.
- [5] Adani R, Tang JB and Elliot D. Soft and tissue repair of the hand and digital reconstruction. *J Hand Surg Eur Vol* 2022; 47: 89-97.
- [6] Safa B, Lee DC, Park J, Koh SH, Kim JS, Roh SY, Lee KJ and Hong MK. Reconstruction of digit soft tissue defects with the fourth common digital artery perforator flap. *J Hand Surg Am* 2021; [Epub ahead of print].
- [7] Bordianu A and Leoveanu FI. Hand soft tissue reconstruction with dorsal metacarpal artery perforator (Quaba) flap. *J Med Life* 2021; 14: 731-736.
- [8] Mendame Ehya RE, Bounda GA, Xiao W, Yu A and Wen Q. Clinical effectiveness of dorsal branch skin flap of proper palmar digital artery with distal pedicle in repairing of fingertip soft tissue defect: a 1-year prospective study in a chinese tertiary referral teaching hospital. *J Hand Surg Asian Pac Vol* 2021; 26: 265-273.
- [9] Sabo VY. Functional outcome of staged reconstruction of blast injury of the hand. *Niger J Clin Pract* 2021; 24: 1404-1409.
- [10] Al-Qattan MM, Alammam AK, Alfaqeeh FA, Altamimi LA, Alfehaid NS, Mahabbat NA and Pant R. Pedicled abdominal flaps for hand reconstruction in adults: physiotherapy of the attached hand. *Plast Reconstr Surg Glob Open* 2021; 9: e3474.
- [11] Wagner RD, Carr L and Netscher DT. Current indications for abdominal-based flaps in hand and forearm reconstruction. *Injury* 2020; 51: 2916-2921.
- [12] Sakai S. Free flap from the flexor aspect of the wrist for resurfacing defects of the hand and fingers. *Plast Reconstr Surg* 2003; 111: 1412-1420.
- [13] Fan ZQ, Yu BF, Zeng Q, Cai B, Xia GM and Huang SH. The free neurovascular transverse wrist crease flap for repairing soft tissue defects of the fingers: clinical outcomes of multiple centers. *J Orthop Surg Res* 2019; 14: 365.
- [14] Yan H, Zhang F, Akdemir O, Songcharoen S, Jones NI, Angel M and Brook D. Clinical appli-

## The role of transverse wrist crease perforator flap

- cations of venous flaps in the reconstruction of hands and fingers. *Arch Orthop Trauma Surg* 2011; 131: 65-74.
- [15] Elliot D, Adani R, Hyun Woo S and Tang JB. Repair of soft tissue defects in finger, thumb and forearm: less invasive methods with similar outcomes. *J Hand Surg Eur Vol* 2018; 43: 1019-1029.
- [16] Hattori Y, Tamemoto T and Niu A. Partial second toe pulp flap transfer for the coverage of great toe hemipulp flap donor site. *Plast Reconstr Surg Glob Open* 2022; 10: e4152.
- [17] Spark T, Godlwana L, Ntsiea V, Du Plooy E and van Rensburg CJ. Functional outcomes after flexor tendon repair of the hand. *Turk J Phys Med Rehabil* 2019; 65: 318-326.
- [18] Kodaira S and Fukumoto K. Use of distal hypothenar perforator free flaps for pulp defects. *J Hand Surg Asian Pac Vol* 2020; 25: 20-25.
- [19] Dagdelen D and Aksoy A. Evaluation of neurotized hypothenar free perforator flaps used for fingertip reconstruction. *Ann Plast Surg* 2020; 84: e1-e6.
- [20] Mitsunaga N, Mihara M, Koshima I, Gonda K, Takuya I, Kato H, Araki J, Yamamoto Y, Yuhei O, Todokoro T, Ishikawa S, Eri U and Mundinger GS. Digital artery perforator (DAP) flaps: modifications for fingertip and finger stump reconstruction. *J Plast Reconstr Aesthet Surg* 2010; 63: 1312-1317.
- [21] Lee Y, Woo SH, Kim YW, Lee YH and Baek GH. Free flaps for soft tissue reconstruction of digits. *Hand Clin* 2020; 36: 85-96.
- [22] Yang J, Tang Y, He H and Fu S. Repair of soft tissue defects of the fingers with medial plantar venous flap. *Rev Assoc Med Bras* (1992) 2018; 64: 501-508.
- [23] Zhao M, Tian D, Shao X, Li D, Liu J, Zhao L, Li H, Wang X, Zhang W and Li J. Clinical application of micro transverse flap pedicled with superficial palmar branch of radial artery from palmar wrist to repair skin defect of finger. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2013; 27: 1475-1479.
- [24] Zheng DW, Li ZC, Shi RJ, Sun F, Xu L and Shou KS. Thumb reconstruction via a pedicled flap based on the superficial palmar branch of the radial artery from the wrist crease area. *J Plast Reconstr Aesthet Surg* 2015; 68: 1581-1587.
- [25] Zhang GL, Meng H, Huang JH, Hong XF, Zhang HS, Liu XT, Luo HY and Liu WY. Reconstruction of digital skin defects with the free wrist crease flap. *J Reconstr Microsurg* 2015; 31: 471-476.
- [26] Di HP, Xia CD, Xing PP, Li Q, Han DW, Xue JD and Cao DY. Clinical effects of repair of wounds in fingers after electrical burn with wrist perforator free flaps. *Zhonghua Shao Shang Za Zhi* 2017; 33: 557-561.
- [27] Cheng D, Hu J, Cui S, Zhang J, Li D, Shi R, Xu L and Shou K. Clinical observation of superficial branch of radial artery wrist crease flap for repairing ring tissue defect of fingers. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2017; 31: 837-840.