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Original Article

Efficacy of two flap repair techniques for thumb pulp defects

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Abstract: Objective: To compare the efficacy of dorsal thumb neurocutaneous vascular flap and dorsal flap of the index finger in the treatment of thumb pulp defects. Methods: From January 2014 to December 2016, 60 patients with thumb pulp defects admitted to Taizhou Hospital of Zhejiang Province were enrolled in this study. All patients were randomly classified into the observation group and the control group, with 30 patients in each group. Patients in the observation group underwent dorsal thumb neurocutaneous vascular flap for repair of thumb pulp defects, while those in the control group received dorsal flap of the index finger. The operation time, intraoperative blood loss, the rate of postoperative complications, patients' satisfaction with hand appearance, two-point discrimination and flap functions were compared between the two groups. Results: The observation group had substantially shorter operative time and less intraoperative blood loss than the control group (both $P<0.05$). There was insignificant difference in the rate of overall complications between the two groups (6.7% vs. 23.3%, $P=0.148$). Two-point discrimination was significantly lower in the observation group than in the control group (6.5±0.6 mm vs 7.3±0.7 mm, $P<0.001$). No significant difference was noted in the excellent and good rate of postoperative flap functions between the two groups (66.7% vs 73.3%, $P=0.573$). Conclusion: For repair of thumb pulp defects, dorsal thumb neurocutaneous vascular flap is superior to dorsal flap of the index finger in shorter operative time, less postoperative blood loss, higher satisfaction with hand appearance, and better recovery of two-point discrimination of patients. It is a preferred technique for repair of thumb pulp defects.

Keywords: Thumb dorsal cutaneous nerve flap, dorsal flap of the index finger, thumb pulp defect, efficacy

Introduction

Clinically, thumb pulp defect is a common traumatic disease, often associated with exposure of the phalanges of the thumb [1, 2]. Most of the hand activities are completed with the thumb, so the thumb plays a key role in this process [3, 4]. Obviously, thumb pulp defects are of significance in clinical practice [5, 6]. Due to the relatively small range of motion of the skin on the thumb pulp, thumb pulp defects cannot be directly sutured, and free skin grafts are also inappropriate. In such case, flap repair is necessary. Choosing an optimum treatment method is crucial for the appearance and function recovery of the thumb [7].

In repair of thumb pulp defects, great efforts should be made to recover the appearance, length, sensation and motor functions of the thumb [8, 9]. Recently, an increasing number of hand surgeons have performed dorsal thumb neurocutaneous vascular flap or dorsal flap of the index finger to treat thumb pulp defects, but the reports on the efficacy of the surgeries vary greatly [10, 11]. Additionally, there are few reports regarding the differences in the efficacy of dorsal thumb neurocutaneous vascular flap and dorsal flap of the index finger for treatment of thumb pulp defects. Therefore, in this study, we recruited 60 patients with thumb pulp defects as subjects, and randomly divided them into two groups. They were either assigned to receive dorsal thumb neurocutaneous vascular flap or dorsal flap of the index finger. The two surgical techniques were compared, expecting to provide some experimental evidence for the choice of clinical treatment.

Table 1. Baseline characteristics of patients

Variable	Case (n)	Male/ Female	Age (year)	Injury time (h)	Injury cause			Defect area (cm^2)
					Cut injury	Crush injury	Chainsaw injury	
Observation group	30	14/16	37.4±5.2	3.1±0.8	12	13	5	3.4±0.7
Control group	30	17/13	35.8±4.6	2.8±0.6	15	12	3	3.8±0.9
t/χ^2		0.601	1.262	1.643		0.879		1.922
P		0.438	0.212	0.106		0.644		0.060

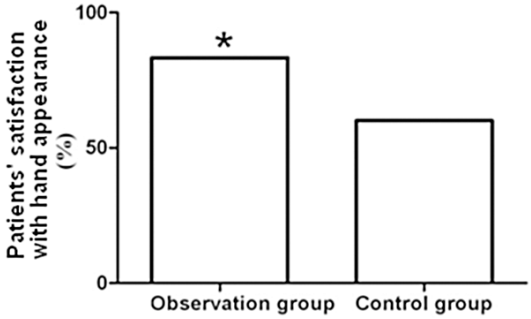

Figure 1. Comparison of patients' satisfaction with hand appearance between the two groups of patients. *P<0.05, compared with the control group.

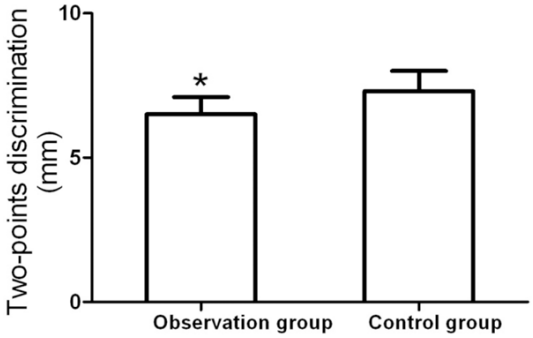

Figure 2. Comparison of two-point discrimination of patients between the two groups. *P<0.001, compared with the control group.

Materials and methods

General data

This study got approval from the Ethics Committee of Taizhou Hospital of Zhejiang Province. Patients or their families provided written informed consent prior to surgery. Sixty patients with thumb pulp defects treated in Taizhou Hospital of Zhejiang Province from January 2014 to December 2016 were enrolled in this study. In terms of a random number table, they were assigned to undergo dorsal thumb neurocutaneous vascular flap (observation group, n=30) or dorsal flap of the index finger (control group, n=30) for repair of thumb pulp defects. Inclusion criteria for patients in this study were the following: An age of older than 18 years old; confirmed thumb pulp defect, no other traumas, fine blood supply at the fingertip of the thumb; no surgical contraindications, active cooperation in the study. Exclusion criteria were as follows: contraindication to brachial plexus anesthesia; severe hepatic and renal dysfunction; cardio and cerebrovascular disease; existing factors affecting wound healing such as hormone administration, hyperthyroidism, and type 2 diabetes; the reluctance to undergo surgical treatment by patients or their families.

Surgical procedures

Dorsal thumb neurocutaneous vascular flap: After successful brachial plexus anesthesia, surgery was performed under tourniquet control. After routine disinfection and sterile draping, skin flap design was made according to thumb pulp defect. An incision was made with the proximal interphalangeal joint of thumb as a rotating point, and the line running from the radial thumb carpometacarpal joint, going through the joint between metacarpophalangeal joint and the thumb as an axial line. The skin was incised layer by layer. Subcutaneous tissue was separated to expose the dorsal cutaneous nerve and the dorsal arteries and veins of the thumb. The flaps were lifted in the superficial extensor tendons, and transferred to cover the wound of thumb pulp defect. Under the microscope, skin was sutured to anastomosing the cutaneous nerve end with the intrinsic finger nerve end. Flaps were sutured under tension-free conditions. The wound in the donor area was treated with full thickness skin grafting under pressure dressing.

Dorsal flap of index finger

Brachial plexus anesthesia was performed, followed by exsanguination with tourniquet. After

Table 2. Flap functions of the two groups

Variable	Case (n)	Excellent	Good	Fair	Poor	Excellent and good rate (%)
Observation group	30	11	9	10	0	66.7%
Control group	30	16	6	8	0	73.3%
χ^2						0.317
P						0.573

routine disinfection and sterile draping, skin flap design was conducted according to thumb pulp defect. An incision was made at the dorsal proximal phalangeal index finger, with the first dorsal metacarpal artery as the rotating point and the line linking the second metacarpus and the metacarpal-phalangeal joint of index finger as the axial line. Tissues were separated layer by layer and free flaps were dissected beneath the dorsal interosseous muscle which contained the first dorsal metacarpal artery, vein, and the superficial branch of the radial nerve. Thumb pulp defects were covered with flaps. Meanwhile, the superficial branch of the radial nerve was anastomosed with the intrinsic finger nerve end. Flaps were sutured under tension-free conditions. The donor area was covered with full thickness skin grafting under pressure dressing.

Outcome measures

Primary outcomes: Primary outcomes in this study were patients' satisfaction with hand appearance, two-point discrimination, and flap function.

Patients' satisfaction with hand appearance was compared between the two groups. The patients subjectively evaluated whether they were satisfied or dissatisfied with repair of thumb pulp defects.

Two-point discrimination was assessed in the two groups. Two-point discrimination was supposed to be used to longitudinally test the smallest distance between two points that a patient can discern in the area of thumb pulp defects. The testing was performed from the largest to the smallest distance, with smaller distance indicating better neurologic function recovery of thumb.

Flap function was also observed in the two groups. At one year, patients were assessed for flap functions primarily from ten domains (skin color, appearance, sweating, texture, temperature, skin grafting, sense of touch, sense of pain, two-point discrimination, and stability of holding objects). Each domain was subdivided into three classes of 10, 5 and 0 points. Scores of flap function range from 0 to 100, with higher scores indicating better flap function (excellent 80-100 points, good 60-79, fair 40-59, and poor less than 40). Excellent and good rate = (Number of excellent cases + number of good cases)/total number of cases *100%.

Secondary outcome measures

Secondary outcome measures included operative time, intraoperative blood loss, and postoperative complications of patients. The two groups were compared in operative time, intraoperative blood loss, and the rate of postoperative complications. Postoperative complications covered infection, arteriovenous crisis, and flap necrosis.

Statistical analysis

All data analyses were made with the SPSS statistical software, version 21.0. Measurement data were represented as mean ± SD. The independent-sample t-test was utilized for comparisons between the groups. Count data were described as percentages, and comparisons between the groups were made using the χ^2 test. $P<0.05$ was considered significantly different.

Results

Baseline characteristics of patients

All patients had unilateral thumb pulp defect, each with a defect area of 1.1*1.4 cm^2 to 2.0*2.8 cm^2. There was insignificant difference in age, gender, cause of injury, injury time, and defect area between the two groups (all $P>0.05$; **Table 1**).

Patients' satisfaction with hand appearance

In the observation group, 25 patients were satisfied with postoperative hand appearance and 5 were dissatisfied; the proportion of patients who were satisfied with hand appearance was 83.3%. In the control group, 18 patients

Table 3. Operation time and intraoperative blood loss of the two groups

Variable	Case (n)	Operative time (min)	Intraoperative blood loss (mL)
Observation group	30	76.8±35.7	50.3±26.2
Control group	30	120.4±46.9	67.1±30.5
t/χ^2		4.052	2.289
P		<0.001	0.026

Table 4. Postoperative complications of the two groups

Variable	Case (n)	Infection	Arteriovenous crisis	Flap necrosis	Overall complication
Observation group	30	1	1	0	2 (6.7%)
Control group	30	2	3	2	7 (23.3%)
χ^2		0.000	0.268	0.517	2.092
P		1.000	0.612	0.492	0.148

were satisfied with postoperative hand appearance and 12 were dissatisfied; the proportion of patients who were satisfied with hand appearance was 60%. The difference in the proportion of patients who showed satisfaction with surgery was statistically significant between the two groups (χ^2=4.022, P=0.045; **Figure 1**).

Two-point discrimination of patients

Two-point discrimination was 6.5±0.6 mm in the observation group, as compared with 7.3±0.7 mm in the control group. There was a statistically significant difference between the two groups (t=4.753, P<0.001; **Figure 2**).

Flap functions of patients

The excellent and good rate of flap functions was 66.7% (20/30) in the observation group, and 73.3% (22/30) in the control group. The difference was statistically insignificant (P> 0.05; **Table 2**).

Operative time and intraoperative blood loss

Significantly shorter operative time and less intraoperative blood loss were found in the observation group than in the control group (both P<0.001; **Table 3**).

Postoperative complications of patients

The rate of overall complications was 6.7% in the observation group, and 23.3% in the control group, and insignificant difference was seen between the two groups (P=0.148; **Table 4**).

Discussion

The thumb is the most important finger of the hand, performing over 50% of the entire hand functions [12, 13]. The thumb pulp has special histological features, rich sensory corpuscles and nerve endings, dense subcutaneous tissue, difficult dissection, and small range of motion. Repair of thumb pulp defect is involved in repair of wound surface, appearance and functions of the hand. Therefore, thumb pulp defect is important, and also brings great challenges to hand surgeons.

There are many methods for flap repair of thumb pulp defects. Dorsal thumb neurocutaneous vascular flap and dorsal flap of the index finger, two clinically commonly-used techniques for repair of thumb pulp defects, were performed in this study. Dorsal thumb neurocutaneous vascular flap was initially reported by Brunelli et al. [14]. Dorsal cutaneous nerves of the thumb run along with blood vessels, which not only nourish the nerves, but also supply blood to the skin of the corresponding parts [15]. Dorsal flap of the index finger was firstly reported by Foucher et al. [16]. The superficial branch of the radial nerve dominates the sensation of the flaps. The blood flow to the flap is predominantly supplied by the constantly-running cutaneous branches of the first dorsal metacarpal artery. The venous return lies mainly on the accompanying veins and the rete vasculosum in the tissue [17]. Both repair techniques for thumb pulp defect are somehow effective, but the differences between them remain unclear.

In our current study, the patients in the observation group underwent dorsal thumb neurocutaneous vascular flap for repair of thumb pulp defects, whereas those in the control group received dorsal flap of the index finger. The results demonstrated shorter operative time and less intraoperative blood loss in the obser-

vation group than in the control group, which might be attributed to the fact that dorsal thumb neurocutaneous vascular flap was so simple to operate that there was no need of arteriovenous anastomosis under the microscope [18]. The rate of postoperative complications (including infection, arteriovenous crisis, and flap necrosis) was lower in the observation group than in the control group, but the difference was statistically insignificant. It may be related to the small sample size of this study. Studies have indicated that the dorsal cutaneous neurotrophic flaps of the thumb results in rich blood supply, high survival rates, and strong anti-infective activity [19]. Arteriovenous crisis is mostly characterized by flap congestion and swellings as well as blister formation, which might be caused by disorder of venous return [20, 21]. In patients with dorsal flap of the index finger, a great number of free veins were required during the operation which resulted in loss of free veins, eventually leading to disorder of venous return. Moreover, the pedicles of the flaps were so tight that they were susceptible to blocking or compression, affecting blood supply. In patients with dorsal thumb neurocutaneous vascular flap, venous return should run through open channel to avoid blocking or compression of the pedicles of the flaps, affecting blood supply [22]. Therefore, we believe hold that during the surgery efforts should be made to avoid damage to the veins and multiple anastomosis veins, increasing venous return patency. The proportion of patients who were satisfied with hand appearance in the observation group was significantly larger than that in the control group. This may be due to the facts that the observation group had no flap necrosis. All flaps survived, the texture of the flaps was in good condition, and the distance from the donor area to the donor area was short, which met the requirements for near transfer.

A study has revealed that anastomosing the cutaneous nerves with the intrinsic nerves of the thumb is mainly to reconstruct sensory function [23]. Our current study showed that the sensory functions of patients in the two groups recovered to some extent after nerve anastomoses, but two-point discrimination was significantly lower in the observation group than in the control group. This might be attributed to the fact that the flaps of the patients in the observation group had superficial branches of the radial nerve and the sensory functions recovered well. All achesthesia may occur after the dorsal flap of the index finger is transferred to the thumb pulp, and the sensation of the thumb pulp mistakes for the dorsal sensation of the index finger in the brain localization [24, 25]. At one year of follow-up, there was insignificant difference in flap functions between the two groups, suggesting that both flap repair techniques are appropriate for repair of thumb pulp defect, which is basically consistent with the results reported by Tan et al. [26].

In conclusion, dorsal thumb neurocutaneous vascular flap for repair of thumb pulp defects resulted in shorter operative time, less postoperative bleeding, simpler operation, patient s' higher satisfaction with hand appearance and better two-point discrimination than dorsal flap of the index finger. It is an ideal technique for repair of thumb pulp defect and worthy of extensive use in clinical practice. However, there are still some limitations in this study, such as a small sample size, single-center, and no long-term follow-ups for flaps. Additional multi-center studies with larger sample size and longer-term follow-ups are needed for further validation.

Disclosure of conflict of interest

None.

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