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Original Article

Therapeutic effect of thumb dorsal cutaneous neurotrophic flap repair on thumb pulp defect

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Abstract: Objective: To explore the therapeutic effect of thumb dorsal cutaneous neurotrophic flap repair on sensory nerve function, hand function, hand appearance and complications in patients with thumb pulp defect. Methods: This retrospective study was performed in 80 patients who were admitted in the Department of Orthopaedic Emergency in Zhejiang Quhua Hospital for thumb pulp defect between January 2017 and January 2019. These patients were divided into the control group and the experimental group (40 patients in each group). Patients in the control group were treated with abdominal flap repair. For patients in the experimental group, they received thumb dorsal cutaneous neurotrophic flap repair. Sensory nerve function, DASH score, two-point discrimination, degree of flap bloatedness, degree of scar contracture, and complications were compared between the two groups. Results: Compared with the control group, the proportion of sensory nerve function grade S3+ and S4 in the experimental group was significantly increased (P=0.039). DASH score, two-point discrimination distance, and degree of flap bloatedness in the experimental group were significantly reduced when compared with the control group (all P<0.001). There were no significant differences on degree of scar contracture (P=0.052) and complications between the two groups (P=0.176). Conclusion: Thumb dorsal cutaneous neurotrophic flap repair plays an important role in the improvement of sensory nerve function, recovery of hand function, reduction of two-point discrimination distance, and alleviation of flap bloatedness, indicating that it could be used as an ideal treatment for thumb pulp defect.

Keywords: Therapeutic effect, thumb dorsal cutaneous neurotrophic flap, thumb pulp defect, abdominal flap

Introduction

Thumb plays an important role in hand function. With the development of industrialization, thumb pulp defect has been commonly observed in hand trauma. For patients with thumb pulp defect, their work and life quality are seriously affected [1, 2]. It is practically significant for patients to repair their thumb pulp defect. Good-looking, unchanged thumb length, and restored sensory nerve function and hand function are essential principles of clinical treatment [3]. Due to the special skin structure and low mobility of thumb pulp defect, it is not applicable to suture directly or graft with free skin. However, flap repair is useful [4, 5]. The selection of appropriate flap for patients with thumb pulp defect plays an important role in the recovery of sensory nerve function, hand function, and hand appearance.

Abdominal flap is one of the most commonly applied flaps in traditional repair of skin defect [6]. Advantages of abdominal flap repair are easy operation and excellent anti-infection ability, making it widely used in clinical practice. However, there are some shortcomings: blood supply of the flap is easily affected by the change of body position; the recovery of sensory nerve function is poor; vascular crisis is frequently observed [7, 8]. Recently, thumb dorsal cutaneous neurotrophic flap has been applied by more and more orthopaedic surgeons to treat thumb pulp defect. However, reports on its therapeutic effect are inconsistent [9, 10]. Moreover, there are few reports on the comparison of therapeutic effect between thumb dorsal cutaneous neurotrophic flap repair and abdominal flap repair. Here, thumb dorsal cutaneous neurotrophic flap was applied to repair thumb pulp defect, and the therapeutic effect on sensory nerve function, hand function, hand appearance, and complications were evaluated to provide experimental evidence for the treatment.

Table 1. Evaluation criteria of sensory nerve function

Grade	Evaluation criteria
S0	Totally disappeared sensory innervation
S1	Recovery of deep pain
S2	Limited recovery of superficial sensation and tactile sensation
S3	Recovery of superficial sensation and tactile sensation; no hypersensitivity
S3+	Recovery of superficial sensation and tactile sensation; no hypersensitivity; recovery of partial two-point discrimination
S4	Complete recovery of sensation

Materials and methods

General information

Patients admitted in the Department of Orthopaedic Emergency in Zhejiang Quhua Hospital for thumb pulp defect from January 2017 to January 2019 were enrolled in this study. All patients were followed up for 3 months by outpatient examination or telephone interview.

Inclusion criteria: Patients with the first unilateral thumb pulp defect were diagnosed according to the criteria of thumb pulp defect [11]; patients aged over 18 years old; patients with adequate blood supply at the thumb tip; patients would like to have the operation and could actively take part in this study.

Exclusion criteria: Patients had contraindications to surgery; patients with defect in the lateral or back of the thumb or other trauma; patients had severe cardiovascular and cerebrovascular disease; patients with liver and kidney dysfunction; patients had malignant tumor; patients with hyperthyroidism or diabetes; patients had cognitive impairment or psychiatric diseases; patients had hormonal drugs within 3 months; patients with incomplete medical records; patients were unable to cooperate in this study.

In total, 80 patients with thumb pulp defect were recruited in this retrospective study, and the data were analyzed. Based on the surgical method, these patients were assigned to the control group and the experimental group (40 patients in each group). Patients in the control group received abdominal flap repair, while patients in the experimental group were treated with thumb dorsal cutaneous neurotrophic flap repair.

This study was approved by the Ethics Committee of Zhejiang Quhua Hospital. Informed consent was signed by the patients or their family.

Surgical methods

Patients in the control group were treated with abdominal flap repair. First, patients placed in supine position were locally anesthetized. Second, routine debridement and hemostasis were performed, and wound edge was marked. Finally, wound margin was sutured under no tension using abdominal flap, which was designed according to the area of thumb pulp defect.

For patients in the experimental group, they received thumb dorsal cutaneous neurotrophic flap repair. The flap was designed based on the area of thumb pulp defect. The line between the radial side of metacarpophalangeal and thumb joints and the radial side of the thumb wrist metacarpal joint was axis, while the proximal side of the thumb interphalangeal joint was the rotation point. First of all, the wound was sterilized and draped after brachial plexus was successfully anesthetized. Second, the tissue was separated layer by layer, and dorsal radial arteriovenous nerve and cutaneous nerve were dissected. Thereafter, the flap was lifted in the superficial layer of extensor tendon, and transferred to cover the defect surface. Finally, a perfect anastomosis was completed between intrinsic nerve stump and cutaneous nerve stump. Tension-free suture method was applied in the whole process. Wound area of the flap in both groups was treated with full-thickness skin grafting, and compression bandaging was performed.

Outcome measures

Sensory nerve function at 3 months after surgery was evaluated according to the evaluation criteria (**Table 1**) published by the Neurotrauma

Table 2. Basic data

Group	Experimental group (n=40)	Control group (n=40)	t/χ^2	P
Male/female (n)	24/16	25/15	0.103	0.748
Age (years)	46.5±3.9	45.9±3.5	0.724	0.471
BMI (kg/m^2)	21.92±0.53	22.14±0.71	1.470	0.146
Hypertension (n)	3	2	0.213	0.644
Diabetes (n)	4	3	0.157	0.692
Course of disease (h)	3.4±0.7	3.6±0.9	1.109	0.271
Cause of injury (n)			1.044	0.903
Cutting	15	16		
Crush	9	7		
Smash	6	8		
Run-over	7	5		
Others	3	4		
Area of thumb pulp defect (cm^2)	2.90±0.52	3.11±0.73	1.470	0.146

Note: BMI, body mass index.

Society of National Institute for Medical Research [12]. Total score was 20 points.

DASH score was applied to assess the hand symptom and function at 3 months after surgery [13]. Totally, 34 items like opening tight caps, writing, cooking, making a bed, and wearing a pullover were included in the assessment. Based on the severity of symptom or hand function, a 5-point scale was applied to perform the evaluation of each item. A higher score represents a more significantly restricted hand function.

Two-point discrimination was the minimum distance distinguished by the repaired defect, which was longitudinally inspected according to distance (from large to small). It was evaluated at 3 months after surgery [14]. The larger the two-point discrimination distance, the worse the recovery of neurological function is.

Degree of scar contracture at 3 months after surgery was assessed based on the evaluation criteria below: normal or not obvious scar contracture (-/+); mild scar contracture (+); moderate scar contracture (++), and severe scar contracture (+++). According to the scope of scar contracture, 0-3 points were recorded. The evaluation criteria of degree of flap bloatedness were described as following: not obvious or normal bloatedness (-/+), mild bloatedness (+), moderate bloatedness (++), and severe bloatedness (+++). Similarly, 0-3 points were recorded based on the scope of bloatedness.

The incidence of complications such as arteriovenous crisis, infection, and flap necrosis were compared between the two groups. Complication rate = (arteriovenous crisis + infection + flap necrosis)/the total number of patients × 100%.

Statistical methods

All data were analyzed using SPSS statistical software version 21.0. The measurement data were expressed as mean ± standard deviation ($\bar{x}$ ± sd). Independent sample t test was used for inter-group comparison, while paired t-test was applied for before-after comparison within the same group. The enumeration data were expressed as number/percentage (n/%); comparison was conducted with chi-square test. The difference was statistically significant when *P* value was less than 0.05.

Results

Basic data

There were no significant differences concerning age, gender, body mass index (BMI), underlying disease, course of disease, area of thumb pulp defect, and cause of injury between the two groups (P>0.05, **Table 2**).

Sensory nerve function

There were 14 cases of sensory nerve function grade S0-S3 in the control group, and 6 cases

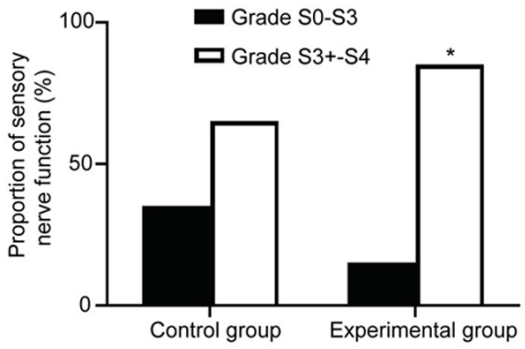

Figure 1. Comparison of sensory nerve function. Compared with the control group, *P<0.05.

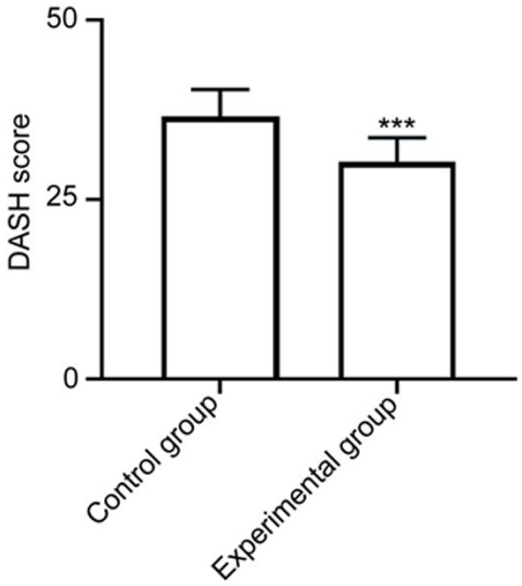

Figure 2. Comparison of DASH score. Compared with the control group, ***P<0.001.

in the experimental group. Compared with the control group, proportion of sensory nerve function grade S3+ and S4 in the experimental group was significantly increased (65.00% vs 85.00%, χ^2=4.267, P=0.039; **Figure 1**).

DASH score

DASH score in the experimental group was significantly lower than that in the control group (30.2±3.4 vs 36.5±3.8, t=9.961, P<0.001; **Figure 2**).

Two-point discrimination distance

Two-point discrimination distance in the experimental group was significantly decreased when

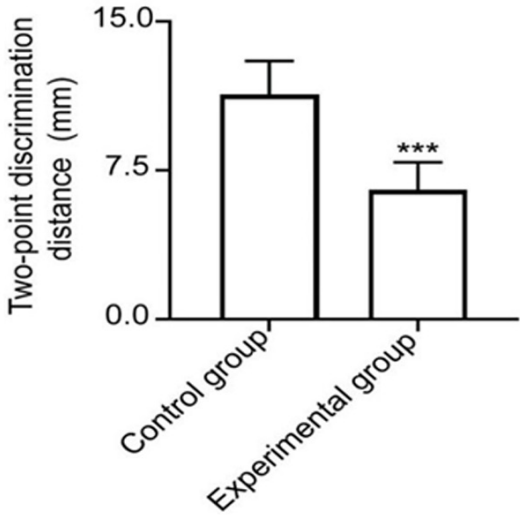

Figure 3. Comparison of two-point discrimination distance. Compared with the control group, ***P<0.0001.

Table 3. Degree of scar contracture and flap bloatedness ($\bar{x}$ ± sd)

Group	Degree of scar contracture	Degree of flap bloatedness
Control group	1.1±0.5	2.3±0.8
Experimental group	0.9±0.4	1.2±0.6
t	1.975	6.957
P	0.052	<0.001

compared with the control group (6.5±1.4 mm vs 11.3±1.7 mm, t=13.780, P<0.001; **Figure 3**).

Degree of scar contracture and flap bloatedness

As shown in **Table 3**, the degree of flap bloatedness in the experimental group was significantly lower than that in the control group (P<0.001); however, there was no significant difference on degree of scar contracture between two groups (P=0.052).

Complications

There was no significant difference in total complication rate between the two groups (17.50% vs 7.50%, P=0.176, **Table 4**).

Discussion

Compared with skin in other parts, skin in the abdomen of thumb is different in structure,

Table 4. Comparison of the incidence of complications (n (%))

Group	Infection	Arteriovenous crisis	Flap necrosis	Total complication rate
Experimental group (n=40)	2	1	0	3 (7.50%)
Control group (n=40)	3	2	2	7 (17.50%)
χ^2				1.829
P				0.176

thickness and texture. The subcutaneous tissue of skin in the abdomen of thumb is dense, restricted in degree of activity, not easy to peel off, and rich in sensory nerve endings and sensory corpuscles. These are all histological characteristics of skin in the abdomen of thumb. As one of the most important fingers, thumb accounts for about 50% of hand function [14, 15]. During the repair of thumb pulp defect, not only the wound needs to be repaired, but also sensory nerve function and hand function need to be restored. Currently, orthopaedic surgeons are faced with the great challenge of reconstructing hand function [16].

There are many treatments for thumb pulp defect, and flap repair is a more effective one. Thumb dorsal cutaneous neurotrophic flap repair, which was first reported by Brunelli, was applied in our study to treat thumb pulp defect [17]. Dorsal cutaneous nerve of thumb is often accompanied by artery and vein, providing nerve and skin at the corresponding site with blood supply [18]. Cutaneous branch of the first dorsal metacarpal artery is the main blood supply of flap. Venous return is mainly depended on the endovascular network and accompanying veins, and sensory nerve function is predominantly controlled by superficial branches of the radial nerve branches [19]. Here, our results showed that the incidences of arteriovenous crisis, infection, and flap necrosis in the experimental group were lower than that in the control group. However, these differences were not statistically significant, which might be caused by the inadequate number of patients enrolled in our study.

Main vessel and nerve are not damaged during the repair of thumb dorsal cutaneous neurotrophic flap. The anastomosis of radial nerve existing in the superficial branch of flap and intrinsic nerve helps to accelerate recovery of sensory nerve function. However, there is no cutaneous innervation in abdominal flap. Fixation is not required in thumb dorsal cutaneous neurotrophic flap repair. This is beneficial for the promotion of early functional exercise of thumb and adjacent fingers, and the avoidance of stiffness of interphalangeal joints induced by long-term fixation. In this study, our results displayed that the proportion of sensory nerve function grade S3+ and S4 in the experimental group was significantly increased when compared with the control group; meanwhile, DASH score and two-point discrimination distance were significantly lower than those in the control group. These results indicate that the therapeutic effect of thumb dorsal cutaneous neurotrophic flap repair on thumb pulp defect is satisfactory, which was basically consistent with the conclusion made by Muyldermans et al. [20]. The texture and color of thumb dorsal cutaneous neurotrophic flap is similar to fingertips. In addition, the flap is anti-friction and moderate in skin thickness, resulting in alleviated bloatedness. However, there are no metacarpal horizontal stripes in abdominal flap. Moreover, its delicateness and ductility are poor. Here, our results showed that there was no significant difference on the degree of scar contracture between the two groups. Compared with the control group, the degree of flap bloatedness in the experimental group was significantly decreased. These results were basically consistent with those reported ones by Deng et al. [21].

However, this is a single-centered and short-term follow up study conducted in insufficient number of patients. A multi-centered and long-term follow up study will be performed in an amplified number of patients to confirm our conclusion.

In summary, satisfactory sensory nerve function, excellent hand function, alleviated flap bloatedness, and fewer complications are realized through thumb dorsal cutaneous neurotrophic flap repair, suggesting that it could be used as an ideal treatment for the repair of thumb pulp defect.

Disclosure of conflict of interest

None.

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