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ARTICLE

Reverse homodigital dorsoradial flaps for thumb coverage obtained good sensory recovery after a long time follow up

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ABSTRACT

Reverse homodigital dorsoradial flap (RHDF) of the thumb has become a qualified option for the reconstruction of thumb tissue defects. However, the sensory recovery of the flap in long term is still unknown. Therefore, this study focused on the sensory recovery of RHDFs for the coverage of thumb in hand after a long-term follow-up. From January 2010 to March 2011, 18 patients (14 men and four women) were treated consecutively with an RHDF. All the patients were followed up two times. The pain and cold intolerance of the flap were self-reported by the patients. The sensory recovery of the flap was evaluated using Semmes–Weinstein (SW) monofilament, moving two-point discrimination (M-2PD) and static two-point discrimination (S-2PD) tests. The average times of the first and second follow-up were 39 ± 4 and 88 ± 6 months, respectively. The mean value of SW monofilament sensitivity score and M-2PD at first follow-up was significantly higher than that of the second follow-up and contralateral thumb. The mean value of S-2PD at the second follow-up was significantly lower than that of the first follow-up and higher than that of the contralateral thumb. The cold intolerance severity score (CISS) at the first follow-up was higher than that at the second follow-up. No significant difference was found in terms of the pain between the two follow-ups. RHDFs without nerve coaptation for thumb coverage could obtain good sensory recovery after a long-term follow-up.

Abbreviations: RHDF: reverse homodigital dorsoradial flap; CISS: cold intolerance severity score; SW: Semmes–Weinstein monofilament sensitivity score; M-2PD: moving two-point discrimination; S-2PD: static two-point discrimination; VAS: visual analog scale.

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Sensory recovery; reverse homodigital dorsoradial flap of the thumb; sensory rehabilitation

Introduction

The thumb, as the most frequently used finger in hand, has a high risk of injury, such as tissue defect [1]. Several surgical options have been reported to cover the defect. Reverse homodigital dorsoradial flap (RHDF) has recently become a qualified option for the reconstruction of thumb tissue defects, even large-area tissue defects [2,3]. Several authors reported accessible surgical procedures, reliable survival rate and satisfactory sensory and aesthetic recovery after RHDFs for the coverage of thumb soft-tissue defect [2–5].

Sensory recovery of the flap in hand, as one of the most important parameters to be assessed, plays an indispensable role in daily life, such as in protective sensory (thermic sensation and pain sensation) and epicritic sensory (pressure and tactile) recovery. Yu et al. [6] reported two approaches of sensory recovery of flap: central approach and peripheral approach. The central approach depends on the sensory recovery from the original sensory innervation system; it occurs in flap surgery with sensory nerve coaptation. The peripheral approach depends on the peripheral nerve components growing in; it occurs in flap surgery without sensory nerve coaptation. Several authors insisted that nerve coaptation could increase the sensory recovery in the flap compared with peripheral nerve components growing into the flap [7–9]. However, few studies focused on the sensory recovery of the flap in hand without sensory nerve coaptation, especially long-term follow-up studies. Therefore, this study focused on the sensory recovery of RHDFs for the coverage of thumb in hand without neuroanastomosis to study the peripheral approach of sensory recovery in long term.

Materials

From January 2010 to March 2011, 18 patients (14 men and four women) were treated with RHDF consecutively. The mean age of patients was 39 years (range of 18–59 years). The injury types were avulsion ($n = 6$), explosion ($n = 2$) and crush ($n = 10$). The average size of the flap was 3.3 cm × 2.4 cm (ranging from 2.0 cm × 1.5 cm to 4.0 cm × 2.5 cm).

Patients who met the following criteria were included in this study: (1) at least 1.5 cm defect in the length/width of the thumb pulp soft tissue, (2) exposed tendon or bone, (3) flap size $< 10\,cm^2$, and (4) received face-to-face follow up two times. Patients who met the following criteria were excluded: (1) thumb pulp defect < 1.5 cm in length/width, (2) donor site injured, (3) neurorrhaphy, (4) history of hand injury, (5) complex injury and (6) flap size $> 10\,cm^2$.

Methods

Surgical technique

The surgical procedure was similar to that in a previous article [2]. In general, the flap was designed based on the site, size and

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Figure 1. A case treated with Reverse homodigital dorsoradial flap of the thumb. A: tissue defect on the thumb. B: the design of the flap. C: the appearance of the flap during the surgery. D: the appearance of the donor site during the surgery. E: the appearance of the flap 3 months after surgery. F: the appearance of the donor site 3 months after surgery. G: the appearance of the flap 90 months after surgery. H: the appearance of the donor site 90 months after surgery.

shape of the defect site under local anesthesia with pneumatic tourniquet control [2]. The dorsoradial digital artery was detected from the snuffbox to the middle point of the proximal phalanx, and the pivot point was then marked on the middle third of the radial aspect of the proximal phalanx. The dorsal digital artery and veins of the thumb were included in the pedicle and some subcutaneous tissue was also harvested. After reversal of the pedicle was completed, the flap and skin were sutured loosely to avoid compression of the pedicle or excessive tension on the flap. The donor site wound in most cases could be directly closed (recommend) or covered with the skin graft.

Outcome evaluation

Pain in the flap was reported by the patients through a visual analog scale ranging from 0 to 10 (0 = no pain and 10 = worst pain). The self-administered cold intolerance severity score (CISS) questionnaire was used to measure the cold intolerance of the flap. The Semmes–Weinstein (SW) monofilament, moving two-point discrimination (M-2PD) and static two-point discrimination (S-2PD) tests were selected to evaluate the sensibilities of the flap.

Data analysis

Statistical analyses were performed using SPSS version 19.0 (SPSS Inc., Chicago, IL). The significance level was set at 5%, where $p \leq .05$ was considered statistically significant. In terms of pain score, CISS scores, and follow-up time at two different follow-up groups, we used an independent t-test to compare. The paired t-test was used to test sensory recovery (SW, M-2PD and S-2PD) of two of each among sensory recovery of two different follow-ups and the contralateral side.

Result

Eighteen patients who were followed up two times were included in this study. The average time of the first and second follow-ups were 39 ± 4 and 88 ± 6 months, respectively, and a significant difference was found. All flaps survived, 1/3 out of cases suffered from venous congestion and it could be relieved by cutting some sutures on the pedicle. Partial necrosis was found in two cases healed without additional surgery, but no infection was found. A case is shown in Figure 1.

The mean value of SW sensitivity score on the flap was 4.0 ± 0.5 g at the first follow-up and 3.7 ± 0.4 g at the second

Figure 2. Result of the Semmes–Weinstein monofilament sensitivity score. SW1: Semmes–Weinstein monofilament sensitivity score at the first follow-up; SW2: Semmes–Weinstein monofilament sensitivity score at the second follow-up. SWC: Semmes–Weinstein monofilament sensitivity score on the contralateral side. *Significant difference.

follow-up. The mean value of the SW sensitivity score on the contralateral thumb was 3.6 ± 0.4 g. The mean value of the first follow-up was significantly higher than that of the second follow-up and contralateral thumb in terms of the SW sensitivity score (Figure 2).

The mean value of M-2PD on the flap was 9.3 ± 4.3 mm at the first follow-up and 5.1 ± 1.8 mm at the second follow-up, while that on the contralateral thumb was 3.8 ± 0.7 mm. The mean value of the first follow-up was significantly higher than that of the second follow-up and on the contralateral thumb (Figure 3).

The mean value of S-2PD on the flap was 10.6 ± 4.3 mm at the first follow-up and 5.2 ± 1.6 mm at the second follow-up, while that on the contralateral thumb was 4.8 ± 0.9 mm. The mean value of the second follow-up was significantly lower than that of the first follow-up and higher than that on the contralateral thumb (Figure 4).

The mean VAS of pain on the flap was 1.3 ± 1.1 at the first follow-up and 1 ± 0.9 at the second follow-up, and no significant difference was found (Figure 5). The mean CISS values on the flap were 23.9 ± 20 at the first follow-up and 9.7 ± 9.6 at the second follow-up, and a significant difference was observed. The CISS at the second follow-up was lower than that at the first follow-up (Figure 6).

Discussion

This study found that the sensory recovery of RHDF of the thumb could achieve a more satisfying recovery after a long-term follow-up. The values of SW, M-2PD and S -2PD at the second follow-up were significantly improved compared with those at the first follow-up. The value of S-2PD was significantly higher than that on the contralateral thumb statistically at the second follow-up. However, the value difference was less than 1 mm, which was meaningless from a clinical perspective. No significant difference was obtained in the values of SW and M-2PD between the contralateral thumb and the second follow-up. Sensory recovery of the flap at long-term follow-up was significantly comparable with that on the contralateral thumb pulp.

The superficial branch of the radial nerve is a constant anatomic landmark going under the flap to the first web and dorsal area of the thumb [10]. Nerve coaptation in the flap with the stump of the digital nerve in the injured thumb could be achieved by including the superficial branch of the radial nerve into the flap when dissecting the flap. In this study, nerve coaptation was not performed, and the sensory recovery of the flap depended on the periphery or nether nerve fibers growing into [6]. Masuda Tetsuo et al. suggested that nerve coaptation could improve sensory recovery after reconstruction of thumb soft-tissue defect by using a wrap-around flap [7]. Santanelli Fabio et al. also suggested that major plantar foot reconstruction with free fasciocutaneous flap could repair the nerves and thus improve sensory recovery in long-term results [11]. Blondeel et al. found that nerve repair in free DIEP flaps restored sensation early after surgery, increased the quality and quantity of sensation in the flap and showed a high chance of providing erogenous sensation [8]. However, in this study, the sensory recovery of RHDF of the thumb without nerve coaptation was comparable with that of the contralateral uninjured hand after long-term follow up, indicating excellent sensory recovery. Some authors reported spontaneous sensory recovery of the flap without nerve repair after a longer time recovery [2,12]. However, no article reported the extent of the sensory recovery of the flap and its duration. This study shed light on these questions and provided some evidence.

Factors affecting spontaneous sensory recovery in the flap include patient age, injury type, the employed surgical technique, and duration of follow up [7]. One of the criteria of cases is that the injured area should be on the thumb pulp no more than the interphalangeal joint. Thus, the size of the RHDF of the thumb is rather small at $<10\,cm^2$. Considering the time of recovery as another important reason affecting sensory recovery, the small flap with longer time follow-up could theoretically obtain superior sensory recovery because the peripheral approach was based on the peripheral and basal nerve fibers growing into the flap, and this kind of growing needs some time. Miller reported regenerated axons that grew through the scarred area very slowly (approximately 0.25 mm per day) [13]. The peripheral nerve fiber around the flap in the injured hand was not perfect, particularly because the injury mechanism of the case is related to the blunt. This kind of nerve fiber growing through the scar tissue in between the flap and the tissue around may take more time than usual. The situation above may reveal the reason why the RHDF

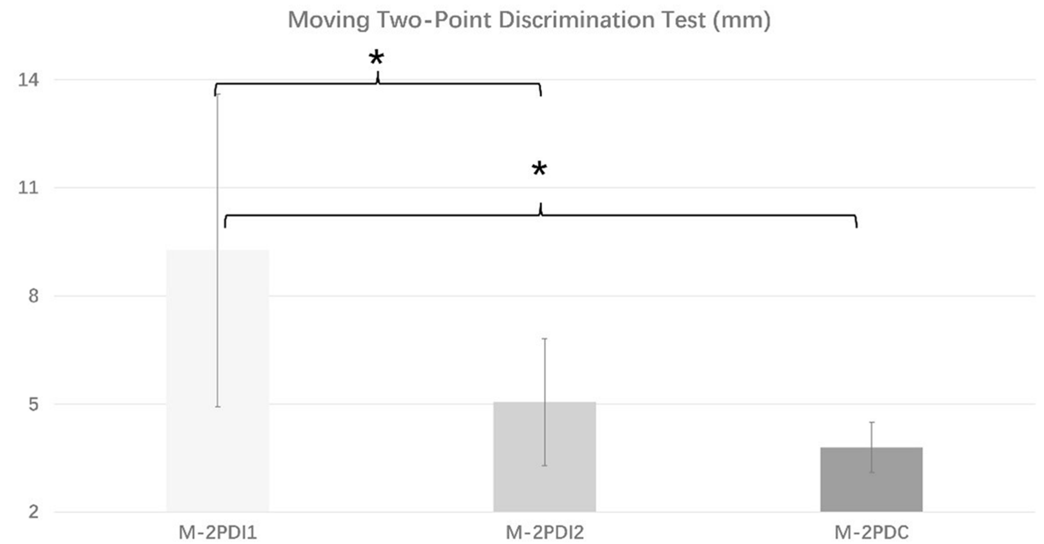

Figure 3. Result of the moving two-point discrimination. M-2PD1: moving two-point discrimination at first follow-up; M-2PD2: moving two-point discrimination at the second follow-up. M-2PDC: moving two-point discrimination on the contralateral side. *Significant difference.

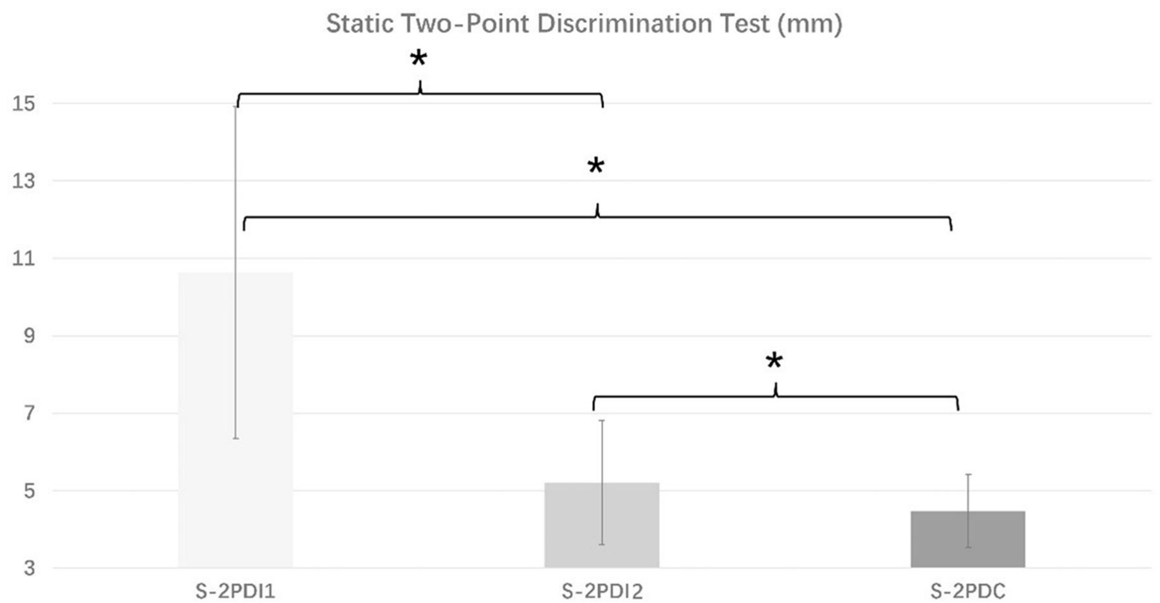

Figure 4. Result of the static two-point discrimination. S-2PD1: static two-point discrimination at first follow-up; S-2PD2: static two-point discrimination at the second follow-up. S-2PDC: static two-point discrimination on the contralateral side. *Significant difference.

of the thumb could achieve a good sensory recovery after a long-term follow-up.

Another important factor to be discussed was sensory rehabilitation, which may play a vital role in the sensory recovery of the flap in hand. After the first follow-up, the patients who need to work using their thumb frequently could achieve a satisfactory recovery than those who were afraid to use or rarely used their thumb. Thus, the patients without satisfying sensory recovery were suggested to intensify the use of the flap area during work, including simple touching, pressing or massage. The improvement of sensory recovery of the flap at the second follow-up could be mostly attributed to the sensory recovery of patients who did not achieve a satisfactory sensory recovery at the first follow-up. The improvement of sensory recovery after the first follow-up may be related to sensory rehabilitation.

The topic of sensory reinnervation after either local or free flap has been a subject of debate for many years and from our study, it seems that reinnervation is not necessary since the outcome in this study is comparable to non-reinnervation. Yu et al. [6] reported two approaches of sensory recovery of flap: central approach and peripheral approach. Huang et al. found better sensory recovery with using sensate flaps compared to non-sensate [14]. The sensate flaps make full use of the original nerve fiber to get reinnervation by the central approach. Whereas the non-sensate flaps need to create a brand-new nerve system by nerve ending growing into the flap from the peripheral tissue by peripheral approach, which needs more time because of the limited growing speed of the nerve ending. Thus, faster sensory recovery in the sensate flap is understandable. Additionally, it is also understandable that flaps with large sizes are recommended to perform nerve coaptation. The flap in the finger with limited size may not need. Just like Sun et al. found that reverse dorsoradial flaps for thumb coverage show increased sensory recovery with smaller flap sizes with a short-term follow-up [14]. Factors affecting spontaneous sensory recovery were complicated and multifactorial. Many authors tried to understand what really influences the final result of sensory recovery among all factors including local conditions, type of

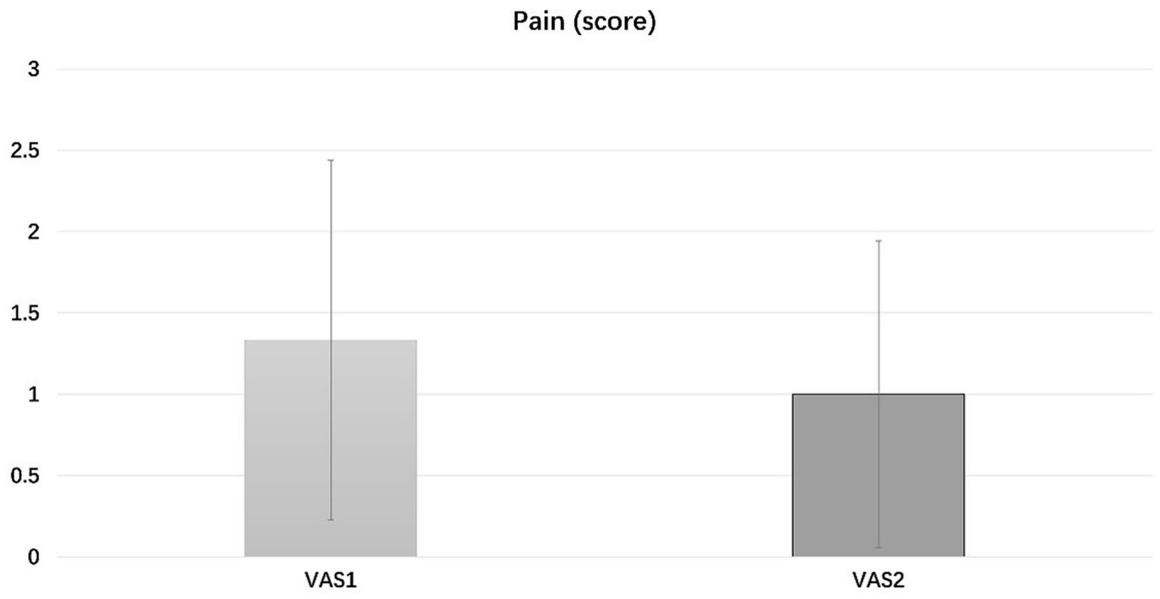

Figure 5. Result of the pain score. VAS1: visual analog scale at first follow-up; VAS2: visual analog scale at second follow-up. *Significant difference.

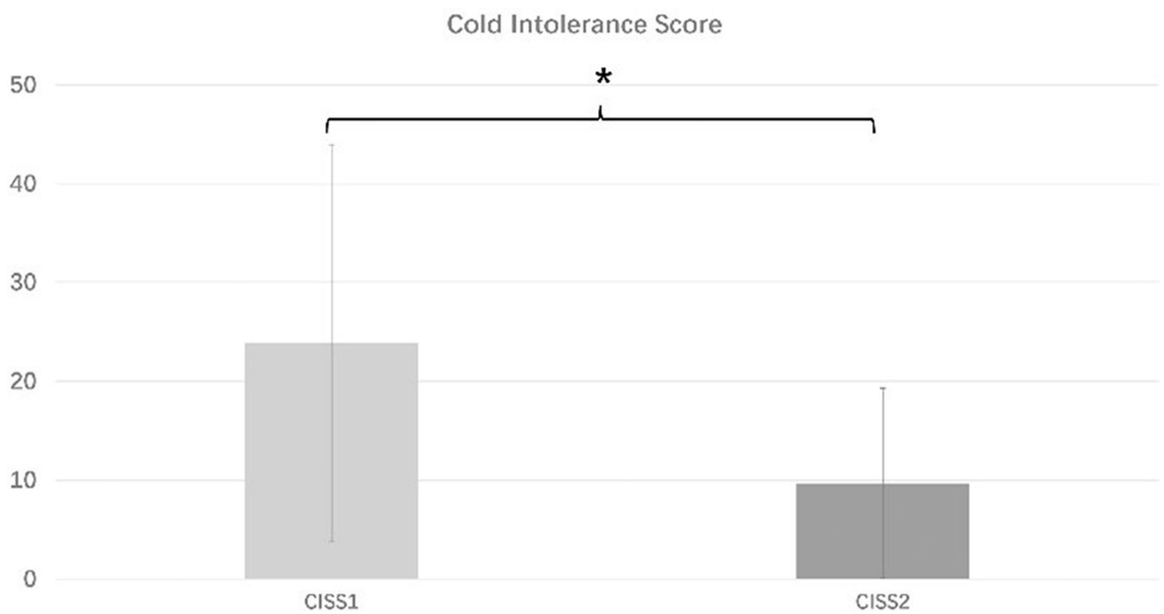

Figure 6. Result of the cold intolerance score. CISS1: cold intolerance severity score at first follow-up; CISS2: cold intolerance severity score at the second follow-up. *Significant difference.

injuries, size of the flap and rehabilitation. In our opinion, the right surgical techniques like nerve coaptation according to the size of the flap and the adequate postoperative interventions like sensory rehabilitation are the factors we have to pay more attention to because these factors are under our control, not like the preoperative conditions of each case are uncontrollable.

Some limitations should be acknowledged. First, nerve coaptation in the flap was not included as a control group to further explore the characteristics of the sensory recovery of the flap. Second, the relationship between the size of the flap and sensory recovery was not revealed. The previous study has proven that the sensory recovery of the flap has a strong relationship with its size [2]. Third, quantification of sensory rehabilitation was not performed. The importance of sensory rehabilitation in the sensory recovery of the flap could not be figured out. A future study with blinded and randomized design and quantified sensory rehabilitation should be performed.

Disclosure statement

None of the authors of this manuscript have any commercial association that might pose or create a conflict of interest with the information presented in the submitted manuscript.

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