Injury, Int. J. Care Injured 50 (2019) 848–854

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

A comparison of the bipedicled nerve flap with the Littler flap for reconstructing a neurocutaneous defect of digits

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ARTICLE INFO

Keywords:
Soft-tissue defects
Digital nerve defects
Dorsal branch of the digital nerve
Littler flap

ABSTRACT

Background: Complex digital injuries involving soft-tissue loss and digital nerve defect continues to pose a reconstructive challenge. This study reports the repair of such neurocutaneous defect with the bipedicled nerve flap or the Littler flap and compares the results of the two techniques.
Methods: A retrospective study was conducted in 59 patients who had a neurocutaneous defect in the single digit treated with the bipedicled nerve flap or the Littler flap from Jul 2008 to May 2016. The patients were divided into two groups based on which flap was chosen. At the final follow-up, the two groups were compared for static two-point discrimination and Semmes-Weinstein monofilament scores on both flap and pulp, and pain, cold intolerance and patient satisfaction of the reconstructed digit.
Results: Significant differences were found in static two-point discrimination, pain, cold intolerance, and patient satisfaction ($p < 0.05$). In comparison with the bipedicled flap group, the Littler flap group presented better discriminatory sensation in the flap and pulp, but exhibited higher incidence of pain and cold intolerance in the reconstructed digit. In the donor digits, the bipedicled flap group achieved lower pain incidence. Finally, the bipedicled flap group attained a larger degree of satisfaction than the Littler flap group.
Conclusions: When reconstructing a complex neurocutaneous defect in the digit, choosing the bipedicled nerve flap rather than the Littler flap attains lower incidence of pain and cold intolerance, and higher patient satisfaction. Our results suggest that repair of the transected digital nerves can reduce neuroma incidence.

Introduction

Complex digital injuries involving soft-tissue loss and digital nerve defect continues to pose a reconstructive challenge [1,2]. Due to excellent blood supply, skin texture and sensory quality, Littler flap has been widely used for soft-tissue reconstruction or simultaneously repairing a digital nerve defect through nerve transfer using donor nerve included in the flap [3,4]. However, this flap is characterized by several major drawbacks such as postoperative venous congestion, progressive deterioration of sensibility and hyperaesthesia [5,6]. As an alternative to reconstruct these neurocutaneous defects, we reported a bipedicled nerve flap [7], including the nerve graft harvested from the dorsal branch of the digital nerve. Using this technique, the sensation in the recipient site and the associated nerve defect can be simultaneously reconstructed. However, it is still unclear what differences there are in the results with the use of these two sensate flaps when reconstructing a digital neurocutaneous defect.

Anatomical studies have demonstrated that the dorsal branch of the digital nerve stems from the digital nerve and its distribution is regular in the fingers. This nerve branch travels obliquely across the dorsolateral aspect of the proximal phalanx and ranges from 0.9 to 1.3 mm in diameter in this region [8], which is similar to the digital nerve with 0.6–2.0 mm in diameter between the midpoint of the distal phalanx and the palmar digital crease [9] (Fig. 1). Therefore, the nerve branch can be used as a donor nerve for digital nerve reconstruction, which is the basis for the use of our modified nerve flap. Bipedicled flap was first reported by Teoh et al. [10], in which a dominant dorsal vein was retained with the flap and the digital nerve was left in situ to avoid venous congestion and neurologic complications associated with the Littler flap. Inspired by the technique, we incorporated the nerve graft with the bipedicled flap for reconstructing a digital neurocutaneous defect (Fig. 2).

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https://doi.org/10.1016/j.injury.2019.03.026
0020-1383/

In this study, we used modified bipedicled nerve flap [7] for soft-tissue loss and associated nerve defect in a one-step operation, and evaluated its efficiency in comparison with the Littler flap. Discriminatory sensation, pain and cold intolerance and patient satisfaction were assessed.

Patients and methods

The study was approved by the institutional review boards of the participating hospitals. Informed consent and Health Insurance Portability and Accountability Act consents were obtained from each patient.

A retrospective study was conducted with 59 patients who had a combination of soft tissue and digital nerve defects treated using the bipedicled nerve flap or Littler flap. The patients included in the study were selected from all 83 patients who had digit reconstructed with the two sensate flaps in our hand surgery center from Jul 2008 to May 2016. Of these, 13 patients lost to follow-up and 3 patients over 55 years old have been excluded. In addition, 8 patients with multiple-digit injury have also been excluded from the study. Fifty-nine patients remained in the study were divided into two groups. The group reconstructed with the bipedicled nerve flap included 33 patients and the group reconstructed with the Littler flap included 26 patients.

The patients in the Littler flap group were required to meet all of the following criteria: (1) the soft-tissue defect in a region where sensory return is considered important; (2) soft-tissue defect with exposed bone or tendon in only one digit; (3) associated single or double digital nerve defects with 1–4 cm in length; (4) a soft-tissue defect greater than 1.5 cm and less than 4 cm in length; (5) necessity to preserve digit length; and (6) a patient between 15 and 55 years of age. Exclusion criteria included: (1) injury to the course of donor arterial pedicle or donor nerve; (2) nerve defect less than 1 cm or larger than 4 cm; (3) a soft tissue defect $\leq$1.5 cm or $\geq$4 cm in length; (4) multiple-digit soft-tissue defects; (5) extremely contaminated wounds and (6) the defect in a region the flap is unable to reach, such as thumb fingertip.

In the bipedicled nerve flap group, the inclusion criteria were the same as those of the Littler flap group. Exclusion criteria were similar to those of the Litter flap group except criterion (6) the defect in a region the flap is unable to reach, such as distal phalanx of the index and ring fingers, and distal 1/2 middle phalanx and distal phalanx of the middle finger, and distal 1/2 distal phalanx of the thumb.

Surgical technique

Littler flap

When the neurocutaneous defect was in the distal phalanx, the distal end of injured digital nerve was absent, flap transferring without nerve repair was performed to cover the defect. The surgical procedure has been described previously [6]. When the defect was located in the proximal or middle phalanx, the distal end of injured digital nerve could be repaired. The neurorrhaphy was performed between recipient digital nerve and donor digital nerve included in the flap.

Bipedicled nerve flap

A digital Allen test was performed on the intended donor digit to ensure that both digital arteries were intact. According to the size and shape of the defect, the flap was designed on the dorsum of the adjacent finger between the distal half of the proximal phalanx and the distal interphalangeal joint. In the donor digit, the digital artery contiguous to injured digit was chosen as the arterial pedicle of the flap. To obtain the maximal length of the arterial pedicle, the donor artery was dissected from proximal to distal,

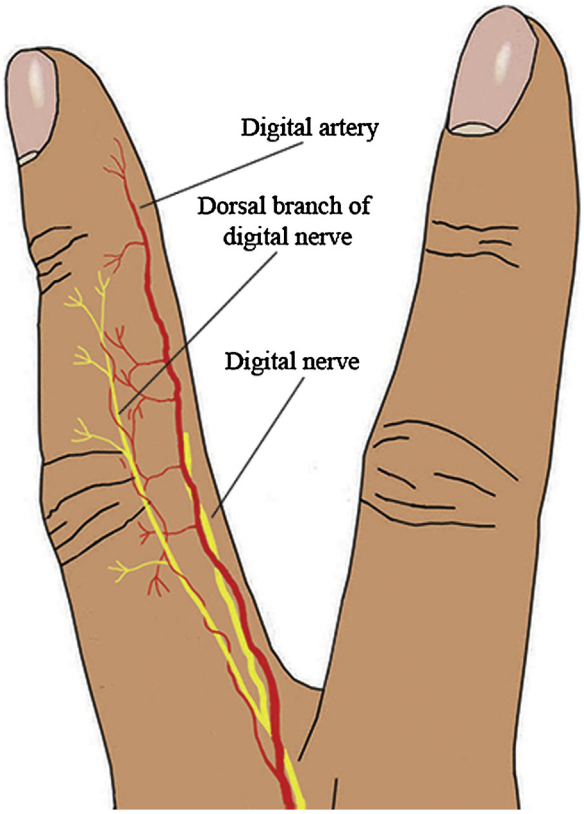

Fig. 1. The dorsum of the middle phalanx is innervated by the dorsal branch of the digital nerve that is stemmed from the digital nerve at the base of the proximal phalanx.

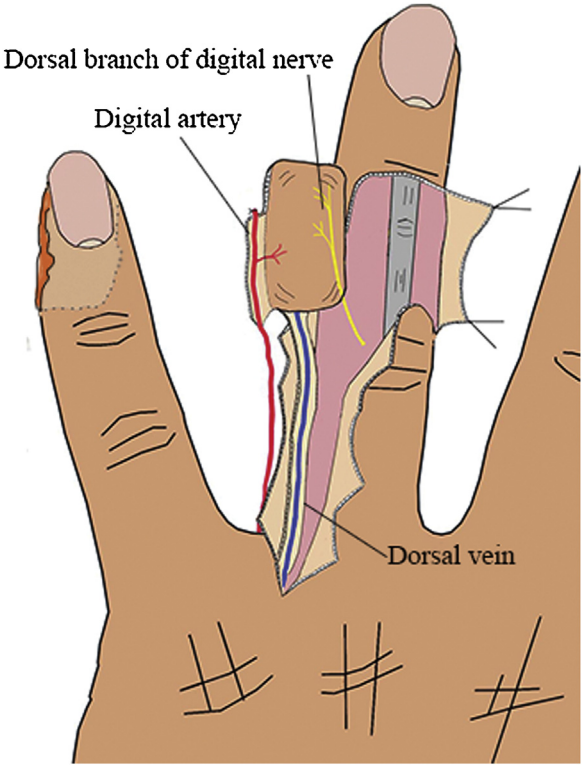

Fig. 2. The flap is supplied by the digital artery and a dorsal vein is retained for flap venous drainage. For sensory reconstruction in the recipient site, the dorsal branch of the digital nerve is included in the bipedicled flap.

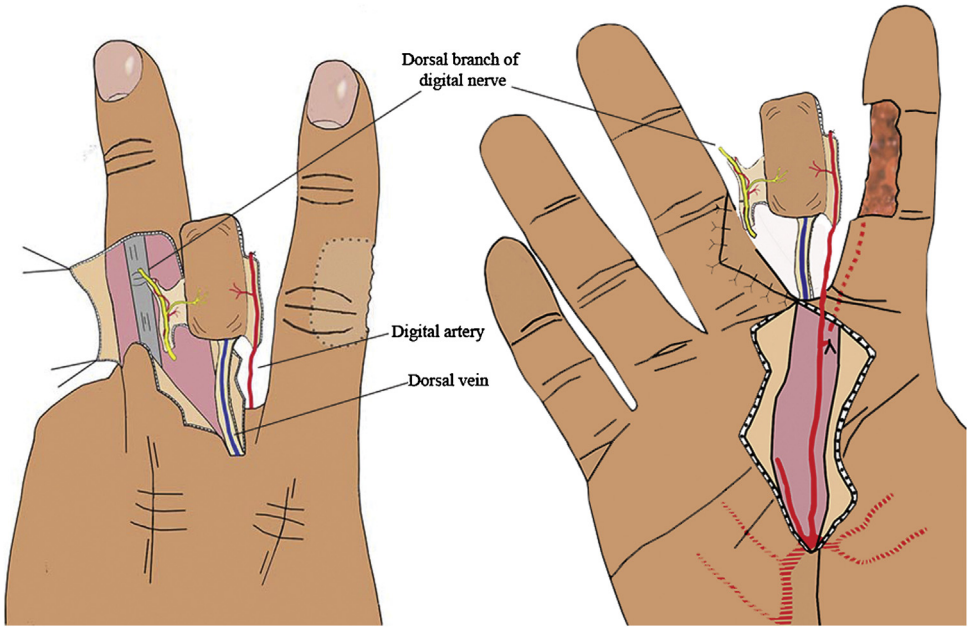

Fig. 3. The dorsal branch of the digital nerve is used as a nerve graft attached with the bipedicled flap for reconstructing a neurocutaneous defect.

starting from the bifurcation of the common digital artery. The accompanying digital nerve was left in the donor digit. The hand was subsequently turned over and a dominant dorsal vein of the flap was identified. The soft tissue 5 mm in width surrounding the vein was harvested with the venous pedicle so as to avoid stretch injury after flap transfer.

When the defect was in the distal phalanx, the distal end of the digital nerve is absent or small and nerve repair is often impossible. Thus, the dorsal branch of the digital nerve could be included in the flap and was sutured with the stump of recipient digital nerve (Fig. 2). When the neurocutaneous defect was in the proximal or middle phalanx, a nerve graft could be used for the nerve reconstruction. The nerve graft was harvested from the dorsal branch of the digital nerve (Fig. 3). To preserve blood supply to the nerve graft, subcutaneous tissue about 1.5–2.0 cm wide between the flap and the nerve graft was retained. The length of the nerve graft depended on the nerve defect size. After the nerve flap was harvested, it was transferred through a wide tunnel into the recipient site. The nerve defect was bridged by the nerve graft in an end-to-end fashion. At last, the donor defect was resurfaced with a full-thickness skin graft and tie-over dressing.

Postoperative management

After surgery, the hand was placed in a dorsal splint with the interphalangeal joints in full extension. At a mean time of 26 days (range, 24–30 d) postoperatively, the splint was removed and all patients exercised the digits with the help of a physical therapist. Meanwhile, tactile stimulation was applied to the flap (bipedicled flap) and the pulp of the injured digit until returning to work.

Evaluation of outcomes

At final follow-up, we measured the flap sensation and the pulp sensation of the reconstructed digit using the static two-point discrimination (2PD) test [11] and Semmes-Weinstein monofilament (SWM) examination [12]. The test points were at the center of the flap and the radial or ulnar portions of the digit pulp. Cold intolerance of the injured digit was assessed using the self-administered Cold Intolerance Severity Score questionnaire [13]. The maximum score was 100; scores were grouped as mild (0–25), moderate (26–50), severe (51–75), and extremely severe (76–100). Pain was given subjectively by the patient using a grading system [14] that included grade 1, none; grade 2, mild, no interference with daily activities; grade 3, moderate, patient works but has some limitation in use of the hand because of pain; and grade 4, severe, cannot work or use hand. The Tinel's sign on the donor and recipient digits was graded as follows: grade 1, none; grade 2, mild, slight tingle; grade 3, moderate, very uncomfortable; and grade 4, severe, patient unable to use hand because of any stimulation of the neuroma [15]. Finally, patients reported their satisfaction with functional recovery of the injured digit according to the Michigan Hand Outcomes Questionnaire that was based on a 5-point response scale [16]. All tests were performed by an independent senior hand surgeon.

Quantitative variables were described as means and standard deviations (for symmetric distribution) or medians and interquartile range (for asymmetric distribution). Categorical variables were described as absolute and relative frequencies (nominal variable) or medians and interquartile range (ordinal variable). Either a *t*-test (symmetric distribution) or Mann-Whitney test (asymmetric distribution) was used to compare the groups in relation to the quantitative outcomes. The Pearson chi-square test was used to evaluate associations among nominal categorical

Table 1
Characterization of the Sample.

Variable	Littler Flap Group	Bipedicled Flap Group	P Value
Age (y)	30.9 ± 1.5	29.7 ± 1.6	.613*
Sex			.851†
Male	21(81)	26(79)	
Female	5(19)	7(21)	
Hand dominance			.401†
Yes	22(85)	25(75)	
No	4(15)	8(25)	
Soft tissue defect (cm)	5.0 ± 0.2	5.3 ± 0.1	.131*
Nerve defect (cm)	2.4 ± 0.1	2.5 ± 0.1	.289*
Surgical time (h)	1.6 ± 0.0	1.8 ± 0.1	.026*
Follow-up (mon)	22.6 ± 0.5	22.1 ± 0.4	.452*

A value $P < 0.05$ was set as statistically significant.* *t*-test; † Pearson's chi-square test.

variables (patient sex and hand dominance), and the Mann-Whitney rank-sum test was utilized to assess ordinal categorical variables (cold intolerance, pain, Tinel's sign and patient satisfaction). Level of significance was set at 5 percent, and $p < 0.05$ was considered statistically significant. Analyses were carried out using the SPSS version 16.0 software (SPSS, Inc., Chicago, Ill.).

Results

In the Littler flap group, there were 21 male patients and 5 female patients with an average age of 31 years (range, 16–54 years). The mechanisms of injury were avulsion (n = 9), crushing (n = 15) and cutting (n = 2). Twenty-one (81%) patients underwent injury in hand dominance. The injured digits requiring reconstruction included 6 thumbs, 7 index, 4 long, 4 ring and 5 little fingers. The mean size of soft-tissue defect was 2.6 × 2.0 cm (range, 2.2 × 1.6 cm to 3.3 × 2.0 cm). The mean flap size was 2.8 × 2.1 cm (range, 2.4 × 1.8 cm to 3.5 × 2.2 cm). The length of the nerve defects ranged from 1.5 to 3.2 cm (mean, 2.4 cm). The mean pedicle length was 8.4 cm (range, 5.5–12.2 cm). Flap transfer was carried out acutely in 12 patients and was delayed 1–2 days after the primary surgery in 6 patients. For the remaining 8 patients who underwent secondary skin and soft tissue necrosis, flap transfer was postponed 7–14 days after emergent operation. Of these, flap transfer was performed in 12 patients who had a neurocutaneous defect in the distal phalanx. For 16 patients who had a neurocutaneous defect in proximal or/and middle phalanxes, a combination flap transfer with nerve repair was performed. Full flap survival was achieved in 25 digits, and partial distal flap necrosis was noted in one digit. The mean follow-up period was 23 months (range, 19–27 months) (Table. 1).

Patients in the bipedicled flap group included 26 men and 7 women with an average age of 30 years (range, 18–54 years). The causes of the injuries were avulsion (n = 14) and crushing (n = 19). Twenty-six (79%) patients suffered injury in hand dominance. The injured digits included 3 thumbs, 10 index, 8 long, 5 ring and 7 little fingers. The mean defect size was 2.7 × 2.0 cm (range, 2.3 × 1.8 cm to 3.3 × 2.2 cm), and the mean flap size was 2.8 × 2.2 cm (range, 2.5 × 2.0 cm to 3.5 × 2.2 cm). The length of the nerve defects ranged from 1.5 to 3.8 cm (mean, 2.5 cm), and the nerve graft ranged from 1.7 to 3.9 cm (mean, 2.7 cm) in length. The mean pedicle length was 6.7 cm (range, 5.6–8.5 cm). The operation was performed acutely in 11 patients and was delayed 1–3 days after the primary surgery in 9 patients. Thirteen patients had secondary skin and soft tissue necrosis and flap transfer was delayed 7–20 days after emergent operation. Flap transfer was performed in 9 digits and a combination flap transfer with nerve grafting was performed in 24 digits. We performed nerve grafting on one side in 17 digits and on both sides in 7 digits. Full flap survival and partial flap necrosis were noted in 31 digits and 2 digits, respectively. The average follow-up period was 22 months (range, 18–27 months) (Table 1).

No significant difference was found between the two groups regarding patient age, sex, hand dominance, soft-tissue defect size, nerve defect size and follow-up period. Operating time of bipedicled flap is longer than that of Littler flap (p = 0.026) (Table 1). In both groups, partial flap necrosis healed without surgical intervention. We found no signs of wound infection.

Sensory recovery

At final follow-up, the mean static 2PD of the flaps was 7.6 mm (range, 5–12 mm) in the Littler flaps and 9.3 mm (range, 6–13 mm) in the bipedicled nerve flaps, with a significant difference (p = 0.0002). The Littler flap presented better discriminatory sensation than the bipedicled nerve flaps. The mean SWM score was 3.92 (range, 3.61–4.56) in the Littler flaps and 3.94 (range, 3.61–4.56) in the bipedicled nerve flaps. We found no significant difference between the two groups (p = 0.4798) (Table 2).

Table 2
Comparison of the reconstructed digits.

Variable	Littler Flap Group	Bipedicled Flap Group	*P* Value
2PD of flap (mm)	7.6 ± 0.3	9.3 ± 0.3	.0002*
SWM of flap (g)	3.9 ± 0.1	4.0 ± 0.1	.480*
2PD of pulp (mm)	7.7 ± 0.5	9.0 ± 0.3	.018*
SWM of pulp (g)	4.0 ± 0.1	4.0 ± 0.1	.866*
Cold intolerance	0 (0–20)	0 (0–0)	.041#
Pain	1 (1–2)	1 (1–1)	.031#
Tinel's sign	1 (1–2)	1 (1–1)	.030#
Patient satisfaction	5 (4–5)	5 (5–5)	.028#

A value $P < 0.05$ was set as statistically significant. 2PD, 2-point discrimination; SWM, Semmes-Weinstein Monofilament. *, *t*-test; #, Mann-Whitney rank-sum test.

For the pulp of reconstructed digits, the mean static 2PD was 7.7 mm (range, 5–10 mm) in the Littler flap group, and 9.0 mm (range, 6–12 mm) in the bipedicled flap group, respectively. SWM score was 3.96 (range, 3.61–4.56) in the Littler flap group and 3.92 (range, 3.61–4.56) in the bipedicled flap group. We found a significant difference in static 2PD (p = 0.0183), but no significant difference in SWM between the two groups (p = 0.8658). In comparison, Littler flap group obtained better discriminatory sensation in the pulp innervated by repaired digital nerve. Collectively, Littler flap group exhibits better sensibility in both flap and the pulp of the reconstructed digits (Table 2).

Joint motion of donor digits

The range of motion of the donor digit was measured by a goniometer. Of the donor digits, the ROM of the proximal and distal interphalangeal joints were 101° (range, 90° to 110°) and 70° (range, 45° to 90°) in the Littler flap group and 100° (range, 90° to 110°) and 69° (range, 40° to 90°) in the bipedicled flap group. No significant difference was found between the two groups (Table 3).

Cold intolerance and pain

In the reconstructed digits, the median (range) cold intolerance score was 0 (0–20) in the Littler flap group and 0 (0–0) in the bipedicled flap group according to the Cold Intolerance Severity Score. A significant difference was seen between the 2 groups (P = 0.0408). By comparison, the bipedicled flap group presented lower incidence of cold intolerance in the reconstructed digits. In addition, the median (range) pain score was 1 (1–2) in the Littler flap group and 1 (1–1) in the bipedicled flap group, with a significant difference (P = 0.0313). The bipedicled flap obtained lower pain incidence in the reconstructed digits. According to the grading system of Tinel's sign, 6 patients were grade 2 (slight tingle), 5 patients were grade 3 (moderate tingle), and the remaining 15 patients were grade 1 (no tingle) in the Littler flap group. Of the bipedicled flap group, 5 patients were grade 2 and the

Table 3
Comparison of the donor fingers.

Variable	Littler Flap Group	Bipedicled Flap Group	*P* Value
DIP (°)	70.4 ± 3.6	69.4 ± 3.2	.834*
PIP (°)	101.3 ± 1.1	99.7 ± 1.2	.349*
Pain	1 (1–2)	1 (1–1)	.026#
Tinel's sign	1 (1–1)	1 (1–1)	.033#

A value $P < 0.05$ was set as statistically significant. DIP: total active motion of distal interphalangeal joint; PIP, total active motion of proximal interphalangeal joint. *, *t*-test; #, Mann-Whitney rank-sum test.

Table 4
Correlation Analysis.

Variable	Pearson r Value	*P* Value
2PD of flap (mm) & Satisfaction	0.02	0.883
Pain of reconstructed digit & Satisfaction	–0.668	< .0001

A value P < 0.05 was set as statistically significant. 2PD, 2-point discrimination.

remaining 28 patients were no tingle in the reconstructed digits. A significant difference was found between the 2 groups ($P = 0.0274$). These results suggest the bipedicled flap group presents lower incidence of painful neuroma in the reconstructed digits as compared to the Littler flap group (Table 2).

On the donor sites, we found a significant difference in pain and Tinel's sign between the two groups. The bipedicled flap group exhibited lower pain incidence than Littler flap group (Table 3).

Patient satisfaction

According to the Michigan Hand Outcomes Questionnaire, the median (range) patient satisfaction score of the Littler flap group was 5 (4–5) and that of the bipedicled flap group was 5 (5–5). A significant difference was seen between the 2 groups ($P = 0.0256$). The bipedicled flap group obtained larger satisfaction degree than the Littler flap group (Table 2).

Correlation analysis

The influence of flap sensation and pain of the reconstructed digit on patient satisfaction was studied in all 59 patients from the two groups. We found that flap sensation was not related to patient satisfaction ($P = 0.8831$, $r = 0.020$). A significant negative correlation existed between pain score of the reconstructed digit and patient satisfaction score ($P < 0.0001$, $r = -0.6675$), suggesting the pain on the reconstructed digit was highly related to patient satisfaction (Table. 4).

Fig. 4 presents a case in which a Littler flap was used for sensory reconstruction of a pulp defect in the little finger. Fig. 5 shows a case in which a bipedicled nerve flap was used for the pulp reconstruction. Figs. 6 and 7 show a case in which a bipedicled nerve flap was transferred with a donor graft for reconstructing a neurocutaneous defect in the index finger.

Discussion

When a digital nerve defect is associated with a soft-tissue loss, few techniques are available for simultaneous reconstruction of two types of tissue injuries. In this article, we used our modified bipedicled nerve flap [7] for reconstructing such neurocutaneous defect and achieved lower incidence of pain and cold intolerance in

Fig. 4. (*Left*) A neurocutaneous defect on ulnar aspect of distal phalanx of the little finger. (*Center*) A Littler flap was harvested form the middle finger. (*Right*) The appearance of the little finger 4 months after surgery.

Fig. 5. (*Above left*) A similar neurocutaneous defect in the little finger. (*Above right*) A bipedicled flap was harvested from dorsum of the middle finger. Ulnar digital artery (*asterisk*) was used as an arterial pedicle and a dorsal vein (*pound sign*) was harvested as a venous pedicle of the flap and a dorsal branch of the digital nerve (*arrow*) was included in the flap. (*Below left*) The defect was covered with the flap. (*Below right*) The reconstructed little finger 7 weeks after surgery.

Fig. 6. (*Above left*) A soft-tissue loss associated with ulnar digital nerve defect on the proximal phalanx of the index finger. (*Above right*) A bipedicled nerve flap, including an arterial pedicle (*asterisk*) and a venous pedicle (*pound sign*), was harvested from the dorsum of the middle finger. The digital nerve dorsal branch (*arrows*) was harvested as a nerve graft attached with the flap. (*Below left*) The nerve gap was bridged with the nerve graft. (*Below right*) The defect was covered with the flap.

Fig. 7. Six months after surgery. (*Left*) Volar view. (*Right*) Dorsal view.

the reconstructed digit, and higher a larger degree of satisfaction when compared to traditional Littler flap.

Free neurocutaneous flaps [1,17,18] have been used for simultaneous repair of soft-tissue and digital nerve defects. These techniques achieved sufficient recovery of sensation but prolonged surgery, anatomical variations, the need for microsurgery and the risk of anastomosis failure limit its application. Lai et al. [19] reconstructed similar defects using the reverse digital artery neurovascular cross-finger flap and obtained static 2PD of 6 and 7 mm in the digit pulp in two separate cases. Although the disadvantages of the use of a free flap are avoided, this technique requires a minimum attachment period of 2 weeks. Littler flap can be an alternative for reconstructing a neurocutaneous defect by nerve transfer using the donor digital nerve included in the flap, even though it causes neurologic complications of the donor finger [5,6]. In 2013, the authors used the bipedicled nerve flap [7] to repair such defect in 9 digits, which exhibited sufficient sensory recovery in the pulp with acceptable donor site morbidity. However, the limitations of this study include its small sample size and its lack of a comparative design. We thus enlarged example size and compared our modified technique with the Littler flap so as to objectively evaluate its effectiveness of the treatment of such complex digital injury.

Our comparative study revealed that Littler flap presented better discriminatory sensation than bipedicled nerve flap in both flap and the pulp of the reconstructed digits. Interestingly, the patients treated with the bipedicled nerve flap attained a higher level of satisfaction, which is a critical indicator of the quality of health care [20]. Combined with the result of the non-correlation between sensory restoration and patient satisfaction, this sensory improvement by Littler flap transferring may not translate into a higher satisfaction. Additionally, Littler flap exhibited higher incidence of cold intolerance than bipedicled nerve flap, but the results may not have a causal relation with the reconstructive techniques because cold intolerance is influenced by multiple factors [16].

Painful neuromas may occur at the stumps of the digital nerves, which cause psychological and physical morbidity [21]. In comparison with the Littler flap, use of the bipedicle nerve flap achieved a lower pain incidence and may decrease the incidence of painful neuroma at nerve stump. When transferring a bipedicled nerve flap, the stumps of digital nerve were all repaired and connected with donor nerve branch. But for the reconstruction with the Littler flap, the nerve stumps were not repaired. The neurotization between nerve stump and donor nerve may provide a more effective pathway for the regenerating axons from the stumps and thus offers an available prophylaxis against digital neuroma formation [22,23]. A high correlation between pain and patient satisfaction strongly suggests pain prevention is more important than sensory restoration when reconstructing a digital neurocutaneous defect. It may become one valuable option for achieving better prognosis by means of repairing the stumps of digital nerve for painful neuroma prevention. Additionally, resecting the nerve branch may result in symptomatic neuroma at the proximal end of the donor nerve, though it was not noted in our series. Burying its proximal end into healthy soft tissue or muscle, may make it less symptomatic [24]. Finally, although a longer operating time is required for transferring a bipedicled nerve flap, postoperative complications, including wound infection and reaction to anesthesia, were not found in our study.

In our experience, the best indication for the use of the Littler flap is a soft-tissue defect in the region where sensory recovery is considered important, but not a neurocutaneous defect. The benefit of our modified techniques may be to reinforce the repair of transected digital nerves, which is most likely to contribute to neuroma prevention.

Conclusion

Although the bipedicled nerve flap requires longer operating time for reconstructing a complex neurocutaneous defect in the digit, it attains lower incidence of pain and cold intolerance, and higher patient satisfaction when compared to Littler flap. Our results suggest that repair of the transected digital nerves can reduce digital neuroma incidence, and pain prevention is more important than sensory recovery.

Conflict of interest

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

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