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A new surgical strategy for reconstruction of claw nail deformity

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ABSTRACT

Claw nail deformity is common in patients with fingertip injury. The optimal reconstruction remains unclear. We devised a unique strategy for reconstruction of claw nail deformity. We divided the approach into three parts: soft tissue reconstruction, bone graft and nail bed graft. In the soft-tissue reconstruction, a reverse digital arterial finger flap for the finger or an extended palmar flap advancement with V-Y plasty for the thumb was selected. A part of the distal phalanx of the second toe including periosteum was harvested as a bone graft. A nail bed graft from the big toe was performed. We reconstructed in 11 cases of claw nail deformity using our strategy. All cases achieved significant improvement with no recurrence of the claw nail deformity. Moreover, there was no donor site morbidity.

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Claw nail deformity; bone graft; nail bed graft; reverse digital arterial flap; advancement flap

Introduction

The term 'claw nail deformity' describes a morphologic change of the nail plate characterized by excessive forward curvature. Claw nail deformity is sometimes called 'parrot beak deformity' or 'hook-nail deformity'. The deformity is the result of a soft-tissue defect in the pulp of the fingertip and loss of the distal phalangeal bone. This deformity is common in patients with fingertip injury.

Many approaches for this deformity have been reported. It is reported that a soft-tissue flap, such as an oblique triangular flap, alone cannot fully improve the deformity, because there is no bony support below the nailbed [1]. A bone graft may be required, but a free bone graft to the distal phalanx tends to resorb [2]. Koshima et al. [3] reported free vascularized transfer of the second toe tip including the distal phalanx and nailbed. This procedure may prevent recurrence, but the surgical technique is complicated and leaves the donor site at risk of morbidity.

We devised a unique strategy for claw nail deformity that not only prevents the recurrence of nail deformity, but also minimizes morbidity of the donor site. In this paper, we wanted to investigate patients who had undergone reconstruction of claw nail deformity using our unique strategy, and evaluate the utility of this strategy.

Patients and method

A retrospective study was performed on patients who had received reconstruction for claw nail deformity between 2010 and 2019 at our institution. This study was approved by the Clinical Research Committee at Yotsuya Medical Cube (No. YCR19019). We defined claw nail deformity as sequelae after fingertip amputation at level Allen type III (distal to lunula). Fourteen patients were relevant to this study. Eleven patients were selected for reconstruction using our surgical strategy, but the remaining three patients were excluded because they chose other reconstructive methods (one patient chose partial toe transfer, and the

remaining two patients selected advancement flap). We enrolled 11 cases who underwent reconstruction with our strategy in the present study (10 male and one female). Six cases underwent reconstruction of fingers (four index fingers and two middle fingers). The remaining five cases had reconstruction of their thumbs. All 11 cases were observed for a minimum of 6 months after surgery (mean 11.2 months, median 10; range 6–23 months). Mean age at the time of reconstruction was 35.1 years (median 32; range 16–58).

The affected parts were photographed at the point of final examination more than six months after the operation, and we observed existence of nail plates' curvature due to recurrence of claw nail deformity. Postoperative radiographs were taken at the same time and showed existence of grafted bone resorption.

Our surgical strategy

We divided the approach for claw nail deformity into three parts; soft tissue reconstruction, bone graft, and nail bed graft (Figure 1).

Soft tissue reconstruction

We performed soft-tissue reconstruction, using a reverse digital arterial finger flap [4] on the fingers and an extended palmar flap advancement with V-Y plasty on the thumbs.

Reverse digital arterial finger flap

A skin island flap is made at the base of the proximal phalanx. This flap is created on the ulnar side of the index, middle, and ring finger, and on the radial side in little finger cases (Figure 2(a)). A skin incision is made on the mid-lateral line, the digital vessel is isolated from the digital nerve. As much soft tissue as possible around the digital artery should be preserved to ensure the venae comitantes are included [5]. The proximal palmar arch is the pivot point of the flap for circulation. The flap is transposed to the fingertip defect with ligation of the digital artery at the

proximal site (Figure 2(b)). A skin graft is made on the donor site, and a tie-over bolster dressing applied (Figure 2(c)).

Extended palmar flap advancement with V-Y plasty

In 1992, Bang *et al* [6] reported a palmar advancement flap with V-Y closure for thumb tip injuries. We extended this flap to the proximal thenar to provide greater flap advancement. Mid-lateral incisions are made on both sides of the thumb, and the flap is transposed distally with V-Y plasty. The vascular pedicle includes the princeps pollicis artery (Figure 3(a)). A mid-lateral incision is made revealing neurovascular bundles. The flap together with neurovascular bundles is detached above the tendon sheath. As

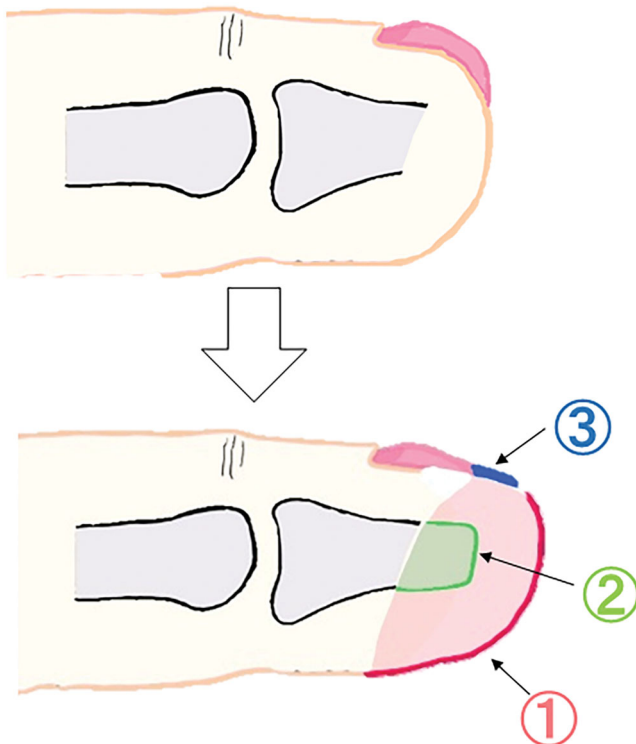


Figure 1. Our surgical strategy for claw nail deformity. ① Soft-tissue reconstruction (red), ② Bone graft (green), ③ nail bed graft (blue).

many as dorsal branches of the digital artery are retained to prevent ischemia of the dorsum of the thumb (Figure 3(b)). The flap can be advanced more than 2 cm (Figure 3(c)). Z-plasty is performed at the level of the finger crease and at the end of the flap to prevent scar contracture (Figure 3(d)).

Bone graft

The most distal part of the distal phalanx of the second toe is harvested for the bone graft. A toe tip incision is made in the distal phalanx (Figure 4(a)). The bone including periosteum is removed distal to the germinal matrix to prevent postoperative nail deformity (Figure 4(b,c)). The grafted bone is fixed with Kirschner's wires, which are removed six weeks postoperatively.

Nail bed grafting

A nail bed graft from the big toe is performed. First, leaving the bilateral paronychium intact, the center of the nail is cut and reflected (Figure 5(a)). The nail bed is harvested from the central region to prevent donor site deformity (Figure 5(b)). After harvesting the nail bed, the nail is replaced and fixed with taping (Figure 5(c)). A nail bed graft is performed simultaneously on the flap. The harvested nail bed is grafted on to the raw surface of the flap and sutured to the surrounding area using fine absorbable suture thread. A tie-over compression dressing is applied.

If we do not need to perform a nail bed graft, soft-tissue reconstruction and the bone graft are performed in one stage. On the other hand, when we perform a nail bed graft, we perform reconstruction in two stages: first soft-tissue reconstruction and nail bed graft, second the bone graft. The reason is because a nail bed graft cannot be grafted directly on the nonvascularized grafted bone.

Results

All three stages of our surgical strategy were applied in seven cases (two fingers and five thumbs). Nail bed grafts were not performed in the remaining four finger cases.

All of the flaps survived. The postoperative photographs showed significant improvement of nail curvature in all cases. The

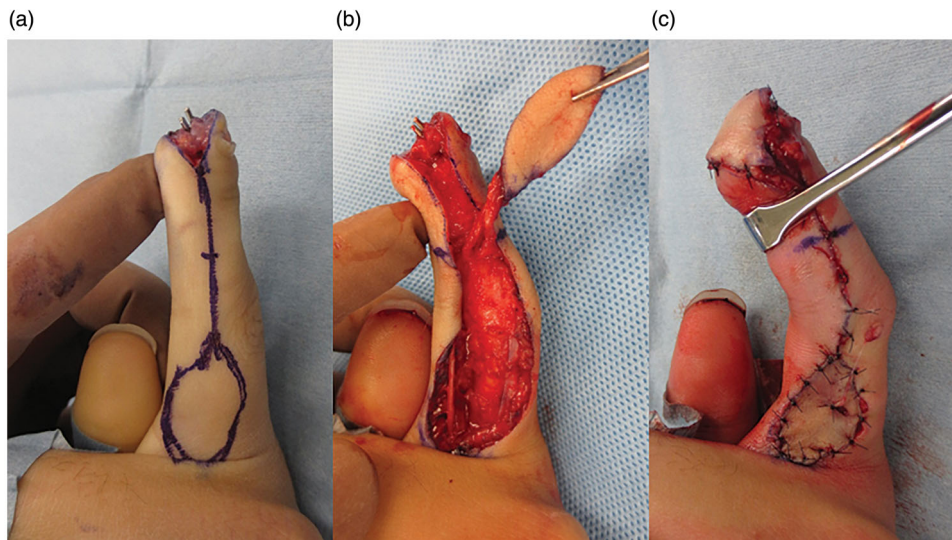


Figure 2. Reverse digital arterial finger flap.

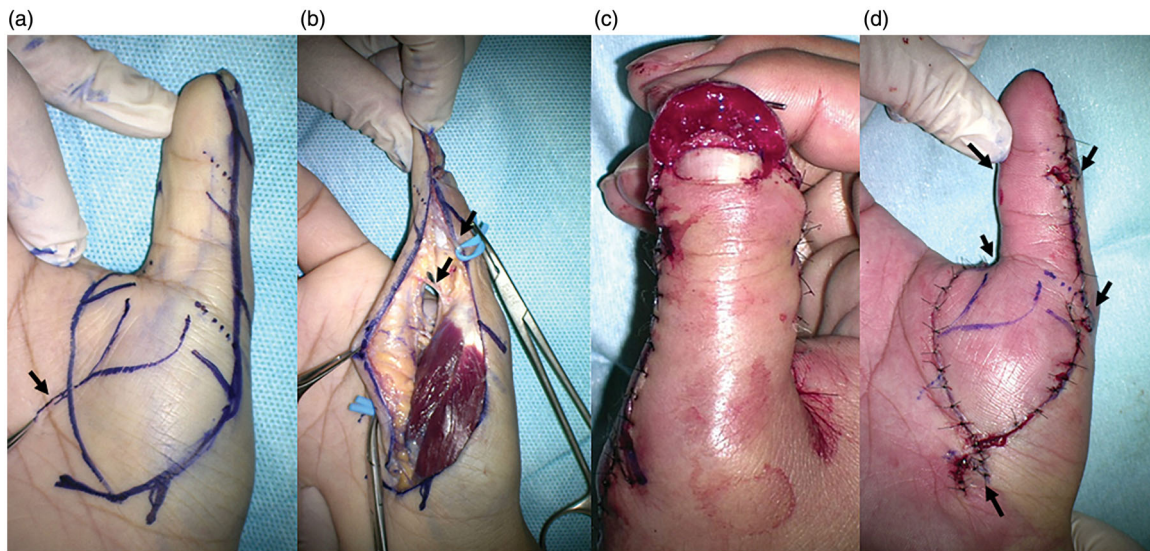


Figure 3. Extended palmar flap advancement with V-Y plasty. a. The black arrows indicates princeps pollicis artery, b. The black arrows indicates dorsal artery branches. d. The black arrows indicates Z-plasty.

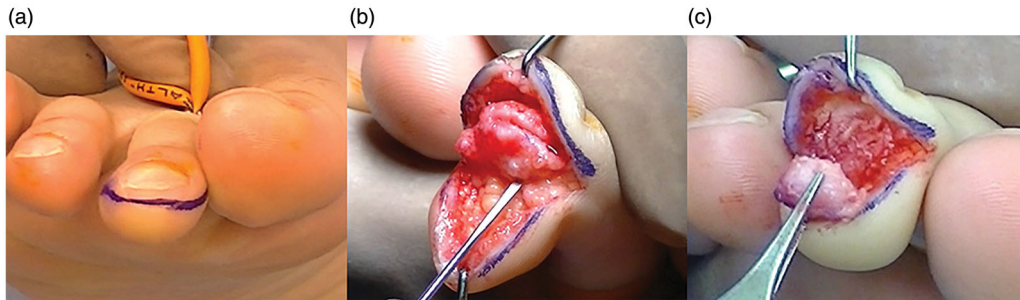


Figure 4. Harvesting the distal part of the distal phalanx of second toe.

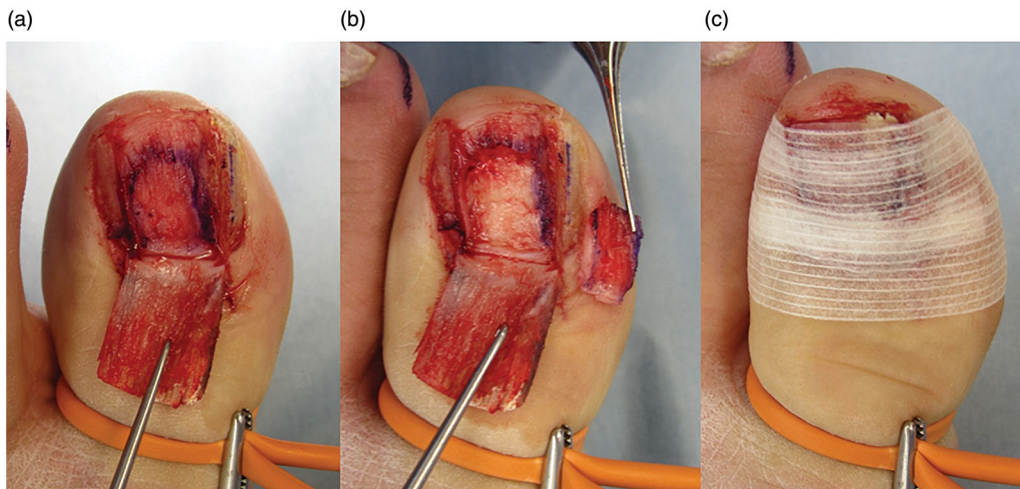


Figure 5. Harvesting the nail bed from the big toe.

radiographs revealed that the grafted bone survived in nine out of 11 cases, but was absorbed in the two thumb cases.

Case reports

Case 1

A 17-year-old man had a claw nail deformity of the left index finger after a fingertip injury. We performed soft-tissue reconstruction and bone grafting. Reverse digital arterial finger flap transfer

and a bone graft from the second toe were performed at the same time. Nine months after surgery, the grafted bone had survived and the claw nail deformity was markedly improved. The nail length of the left index finger after surgery was much shorter than right index finger (Figure 6).

Case 2

A 38-year-old man had a claw nail deformity of the right thumb after a fingertip injury. We made a soft tissue reconstruction, nail

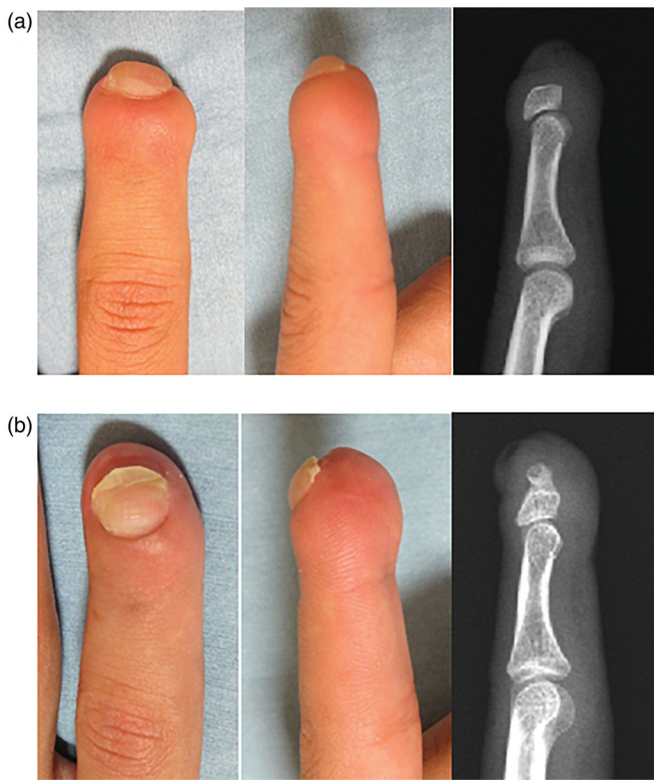


Figure 6. 17-year-old man, left index finger. (a) Preoperatively, a-1: frontal view, a-2: lateral views, a-3 lateral view in X-ray. (b) Nine months after reconstruction with a reverse digital arterial finger flap and bone grafting from the second toe. b-1: frontal view, b-2 lateral view, b-3 lateral view in X-ray.

bed graft, and a bone graft. First, an extended palmar flap advancement with V-Y plasty and a nail bed graft was carried out and 38 days later, a bone graft was performed. Eight months later majority of the grafted bone was resorbed. The claw nail deformity was improved and no claw nail recurred. The nail length was extended compared with preoperative one (Figure 7).

Discussion

Kumar and Satku [1] demonstrated that the nail bed in the normal digit is entirely supported by the terminal phalanx and suggested that claw nail deformity could develop in reconstructed fingertips when there is no support from the bone. They reported that it therefore could not be corrected with skin flap transfer alone. Dumontier et al. [7] reported homodigital advancement flap to sustain the nail and nail bed, and patients with no recurrence had an average of 37.6% bone loss compared to 8.3% in patients who had a recurrence. Atasoy et al. [8] proposed the antenna procedure to splint the nail bed straight with multiple Kirschner wires; however, the nail deformity tended to recur after removing the Kirchner wires [9].

In order to prevent recurrence, it is necessary for bone or solid tissue as a substitute for bone to be located below the nail bed. On the other hand, to date, reconstruction with a local flap and bone graft has been reported to be associated with the problem of resorption of the grafted bone [2]. Koshima et al [3] recommended a trimmed second toe tip including the distal phalanx and the short nail bed as a vascularized composite flap for the deformity. Their method can prevent grafted bone resorption and gain length of the nail due to nail bed reconstruction. It can be an ideal method for the recipient site, but its technique is

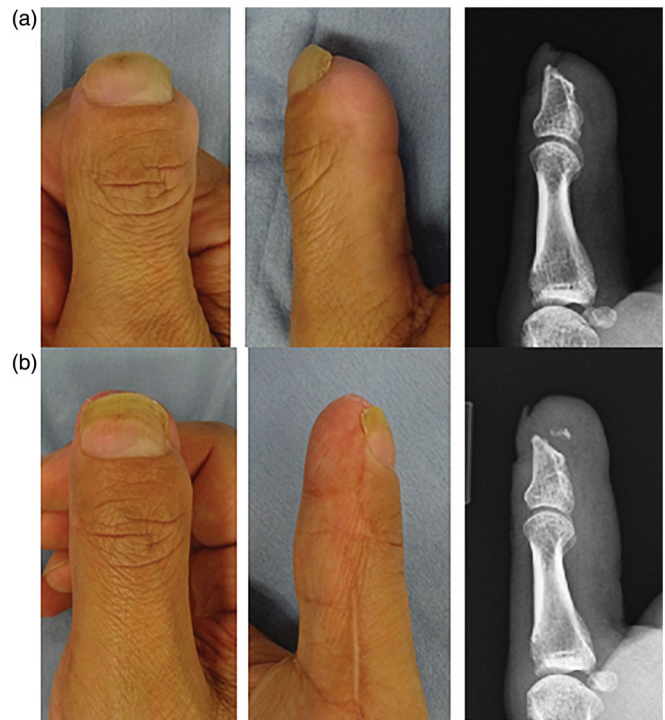


Figure 7. 38-year-old man, left index finger. (a) Preoperatively, a-1: frontal view, a-2: lateral views, a-3 lateral view in X-ray, (b) Nine months after reconstruction with a reverse digital arterial finger flap and bone grafting from the second toe. b-1: frontal view, b-2 lateral view, b-3 lateral view in X-ray.

complicated, the operation time is longer, and the donor second toe has postoperative deformity.

We propose a new strategy for claw nail deformity. Our technique involves soft-tissue reconstruction, bone grafting and nail bed grafting, which we consider separately. There are many reports about reconstruction for fingertip amputation with methods that are similar to our strategy. In these cases, even thenar flap [10] and VY advancement flap [11] can prevent nail deformity. We suggest that reconstruction for claw nail deformity is more difficult than that for fingertip amputation because a claw nail deformity has scar contracture. So, the soft tissue bulk like thenar flap or VY advancement is insufficient for reconstruction of a claw nail deformity. In the soft-tissue reconstruction, we selected a reverse digital arterial finger flap for the finger and extended palmar flap advancement with V-Y plasty for the thumb. A reverse digital arterial finger flap can provide sufficient volume for claw nail deformity of the finger. Another advantage of this flap is its relative simplicity. Extended palmar flap advancement with V-Y plasty for the thumb is an improvement on previous reports: In 1946, Moberg [12] described the palmar advancement flap for the treatment of thumb tip injuries in which a skin graft must be performed on the skin defect occurring after flap advancement, and Bang et al [6] reported a palmar advancement flap with V-Y closure that can be advanced 1.8 cm. We extended the flap to the thenar eminence and performed artery dissection to the princeps pollicis artery. The dissection is simple and the flap can be advanced more than when only the neurovascular bundles are dissected. In our method, the flap can be advanced almost 3 cm and also can provide sufficient volume to the thumb tip. We believe that these flaps are the most suitable for soft-tissue reconstruction of claw nail deformity.

When the distal phalanx of the second toe was harvested for bone grafting, the length of the harvested bone was a maximum of about 8 mm in length. This length may be insufficient to

reconstruct if there is a large absence, but in our experience, it is enough to improve nail curvature of claw nail deformity. One of the reasons why we chose distal phalanx of the second toe is that the periosteum around the bone can be preserved. Patterson et al. [13] reported that transferring nonvascularized toe phalanx while preserving the periosteum is well survived in cases of symbrachydactyly. There were many cases in which the grafted bone survived in this series, even though it is generally believed that a bone graft on top of a phalanx is easily absorbed. We suggest that having a sufficient volume of flap around the grafted bone and the periosteum contribute to survival of the grafted bone. Sano et al [2] reported that the grafted bone was resorbed after surgery for fingertip deformity with a V-Y flap, iliac bone graft and nail bed graft. The V-Y flap might have insufficient volume for reconstruction of claw nail deformity, and almost none of the periosteum might remain on the grafted iliac bone. There was no postoperative deformity of the second toe if the germinal matrix was preserved. We think distal phalanx of the second toe is one of the best donor sites. We performed bone grafts as large as possible as a consideration of bone resorption to some extent because there is a limit to the length of bone which we can harvest from the second toe. The grafted bone in our two thumb cases was absorbed. The deformity improved, and there was no recurrence in both cases. We formed two hypotheses regarding this result. The first is that the grafted bone changed to solid tissue, and was stable enough to support the nail. The second is that adequate soft tissue bulk (like extended palmar flap advancement with V-Y plasty) could prevent claw nail deformity. Netscher [14] implied that soft tissue bulk alone prevents long-term hook nail, even with bone loss. However, we believe that prevention of grafted bone resorption results in the most stable reconstruction. We may need to investigate the cause of resorption of the grafted bone.

Harvesting from the central position of the nail bed of the big toe prevents postoperative nail deformity at the donor site. A nail bed graft provides lengthening of the nail and esthetic improvement. Lee et al. [15] reported correction of nail deformity by an iliac bone graft and a skin flap experienced some cases of coherence between the nail plate and the underlying skin. This is caused by the lack of the nail bed. We predict they could have prevented phenomena if a nail bed graft had been performed.

The points to note in this strategy is as follows.

1. Elevate enough volume of flap for soft tissue reconstruction. It can be prevention of grafted bone resorption. (We select reverse digital arterial flap and extended palmar flap advancement with V-Y plasty.)
2. Harvest distal phalanx as large as possible distal to the germinal matrix while preserving the periosteum around it.
3. Perform a nail bed graft to compensate for the lack of nail bed. And harvest from the central position of the nail bed of the big toe to prevent postoperative nail deformity at the donor site.

Some limitations exist in this study. First, the extent of grafted bone resorption is not measured, only visually assessed. We need to investigate grafted bone resorption in more detail. Second, the observation period is too short. Sano et al. [2] reported a case in which the grafted bone completely disappeared within eight years postoperatively even though it had survived for the first year after the operation. Third, this study cannot perform functional evaluation of the reconstructed fingers or thumbs. Further

investigation is recommended to confirm the long-term benefit of our strategy.

Conclusion

We report a strategy for claw nail deformity using soft tissue reconstruction, bone graft and nail bed graft. We suggest that a reverse digital arterial finger flap is the best selection for soft tissue reconstruction of the fingers, and extended palmar flap advancement with V-Y plasty for the thumb. A bone graft from the distal phalanx and a nail bed graft from the great toe minimized donor site morbidity. All cases had no recurrence of the deformity and no donor site morbidity.

Disclosure statement

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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There are no relevant financial or non-financial competing interests to report.

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