

Reconstruction of Central-Type Nail Bed Defect Using a Subcutaneous Flap and Subsequent Nailbed Graft

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Abstract

Full-thickness nail bed defects with exposure of the distal phalanx are difficult to reconstruct with limited options for bone coverage. A subcutaneous flap can effectively cover bone exposure, followed by a nail bed graft. We report a case of successful nail bed reconstruction using this approach, incorporating a split-thickness nail bed graft. A 59-year-old woman sustained injuries to the nail bed of the right middle finger from a blender blade. The defect, measuring 1.2×0.6 cm, was located in the center of the nail bed with associated bone exposure. Both lateral nail folds remained intact and our aim was to reconstruct the defect without disrupting these structures. A subcutaneous flap incorporating the digital artery was elevated. The flap was then transposed beneath the lateral nail fold and uninjured nail bed to provide coverage for the defect. This technique allowed for the reconstruction of the damaged area while preserving the vascular supply and ensuring adequate soft-tissue coverage. Three weeks post-surgery, the flap survived, and the eponychial folds were all preserved, allowing for a subsequent split-thickness nail bed graft. At 12 months post-surgery, the outcome was evaluated as “very good” according to Zook’s criteria.

Keywords: Nails; Surgical flaps; Finger injury

Introduction

Full-thickness nail bed defects with significant exposure of the distal phalanx present considerable reconstructive challenges because of the lack of a well-vascularized wound bed for graft uptake [1,2]. Given the close anatomical relationship between the bone and nail bed, exposure of the distal phalanx is a common consequence of nail injuries [3]. In such cases, the exposed bone can desiccate rapidly, and scarring of the nail bed may result in a permanent nail deformity [2]. The sterile and germinal matrices, being highly vascularized and histologically delicate structures, pose significant challenges for replacement due to their thin architecture and essential role in nail regeneration [4,5]. Additionally, maintaining the integrity of the surrounding skin structures is essential to minimize deformities in the regrown nail [6].

Successful nailbed grafting requires a stable vascular supply, a smooth and flat surface, and intact structures such as the eponychial folds, which guide nail growth. This study presents a technique utilizing a subcutaneous flap elevated from the volar pulp to cover the exposed distal phalanx. The flap was transposed dorsally, covering the bone exposure of the nail bed while preserving the intact nail bed and lateral nail fold. We present this technique as an effective method for successful reconstruction of full-thickness defects in the central portion of the nail bed, also demonstrating satisfactory results in nail regrowth.

Idea and Innovation

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Idea

A 59-year-old woman presented with a nail bed defect in the right middle finger after an injury caused by a blender blade. The defect involved the majority of the sterile matrix and part of the germinal matrix, measuring 1.2×0.6 cm, with associated bone exposure. It was located in the central portion of the nail bed, while the proximal and lateral nail folds, along with the surrounding skin structures, remained intact. The remaining nail bed measured approximately 4 mm on both lateral sides (Fig. 1). Plain radiography revealed no fractures.

A subcutaneous flap was utilized to address the exposed



Fig. 1. Case presentation. A 59-year-old woman presented with a full-thickness nailbed defect of 1.2×0.6 cm on the right middle finger. Both lateral nail folds and the proximal nail fold were preserved, and the remaining nail bed on both lateral sides measured 4 mm.

bone. A linear incision was made, extending on the radial side wound margin proximally and distally. The flap was elevated based on the distal transverse palmar arch and dissected along the subcutaneous plane, with dimensions of 1.5×1 cm and an average thickness of approximately 1 mm. To facilitate tension-free dorsal transposition, the pedicle including the digital artery, was meticulously dissected to a length of 2 cm.

To preserve the lateral nail fold structure during flap transposition, we exploited the plane between the nail bed and the distal phalanx. Dissection was performed using a freer elevator between the uninjured nail bed and bone on the radial side, advancing towards the volar aspect to create a passage for the flap. The lateral interosseous tendon was incised to reduce flap tension during this process (Fig. 2). Flap circulation was confirmed by observing microbleeding in the subcutaneous fat. To prevent flap circulation compromise by compression after subsequent nail bed grafting, a 3-week observation period was implemented before applying the nail bed graft. The exposed bone was successfully covered during this period, and after 3 weeks, granulation tissue protruding beyond the intact nail bed was excised with a razor blade to achieve a uniform level with the surrounding nail bed surface. After verifying intact preservation of all nail fold structures with no visible synchia, a split-thickness nail bed graft was performed. The left

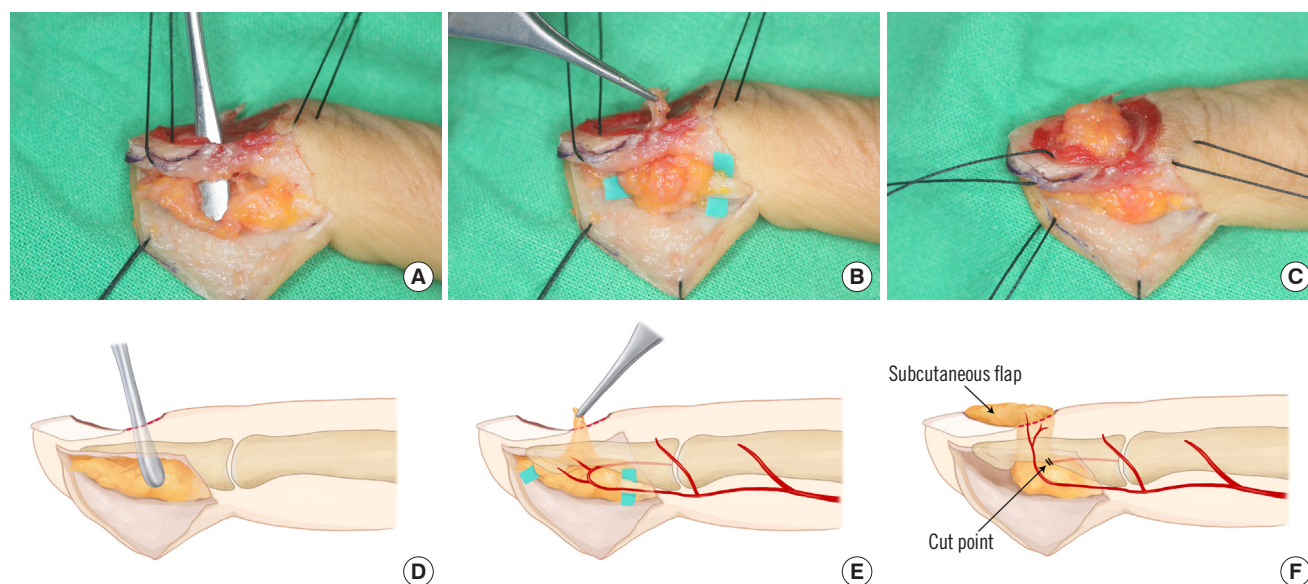


Fig. 2. Surgical procedures and schematic diagram. (A) To preserve the integrity of the intact nail bed and eponychial fold, a dissection plane was established between the distal phalanx and the nail bed, advancing towards the radial aspect. (B) The subcutaneous flap was elevated as thinly as possible while preserving the pedicle containing the digital artery. It was then passed through the created opening. To minimize distortion of the nail fold and compression of the flap, the portion of the flap crossing the opening was further thinned. (C) Appearance of the flap after transposition. (D-F) Schematic diagram of the surgical procedures.

big toe was used as the donor site, and the nail bed graft was prepared using a digital tourniquet and digital block. The nail plate was elevated, and a graft measuring 1.2×0.6 cm was harvested, ensuring that the size of the sterile matrix and germinal matrix matched accordingly. The split-thickness graft was harvested with a razor blade using a freehand technique under loupe magnification (Fig. 3). The toenail was reinserted into the eponychial fold of the donor toe, and trephination over the toenail performed to prevent subungual hematoma.

One week post-surgery, the graft was confirmed to have successfully taken. The grafted nail bed demonstrated growth patterns consistent with the adjacent uninjured nail bed, matching in both rate and direction of growth. At the 12-month follow-up, the nail had grown without major deformities such as split nail. The outcome was evaluated as “very good” (grade B) according to Zook’s criteria. No significant differences were observed in the volume of the distal finger pulp between the operated and contralateral fingers, and no morbidity was observed at the donor site. The patient was satisfied with the outcomes (Fig. 4).

The study was approved by the Institutional Review Board of Gwangmyeong Sungae Hospital (IRB No. KIRB-2024-N-

011). Written informed consent was obtained for the publication of this case report and the accompanying images.

Discussion

Fingernails are highly susceptible to injury because of their prominent location on the fingertips. However, reconstructive options for near-total loss of the sterile matrix are limited, and the optimal management of nail bed defects remains a subject of debate. In cases of partial sterile matrix loss, several techniques may be employed, including advancement of the sterile matrix, revision amputation, and dermal grafting [7]. However, for full-thickness sterile matrix defects with significant exposure of the distal phalanx, more complex approaches are required.

Sheehan [8] introduced the concept of composite nail bed grafting in 1929, which remains a viable option for treating small nail bed defects where the underlying bone is exposed. However, the success of graft survival is limited when the defect is large because of the poor vascularity of the exposed bone [1,2,9]. Microvascular transfer of a toenail can yield excellent results; however, this method is limited by the size mis-



Fig. 3. Split-thickness nail bed graft performed on vascularized flap bed. (A) The subcutaneous flap provided coverage for the exposed bone while preserving all eponychial folds intact. (B) The left big toe was used as the donor site. The graft was harvested to match the size of the missing sterile and germinal matrices. (C) The harvested graft was inset into the recipient site.

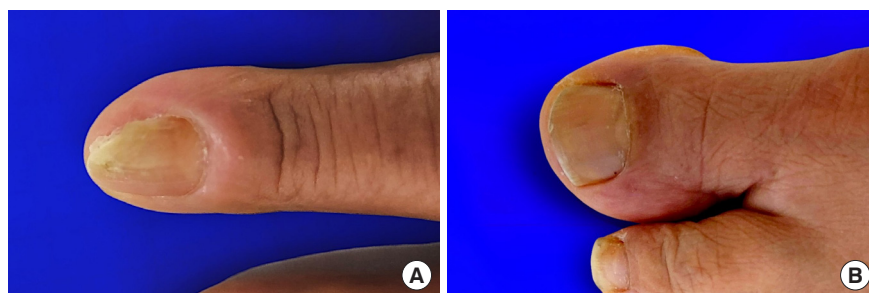


Fig. 4. Postoperative results at 12-month follow-up. (A) Nail regrowth demonstrates minimal deformity with preserved eponychial fold structure and intact nail apparatus components. Outcome was assessed as “very good” (grade B) per Zook’s criteria. Patient reports satisfaction with aesthetic and functional outcomes. (B) Donor site (left big toe) exhibits no morbidity.

match between the donor toenail and recipient site, potential donor site morbidity, and the learning curve and complexity of microsurgical techniques [10].

Various alternative techniques have been introduced for nail bed defect bone coverage. An acellular dermal matrix with a split-thickness skin graft was introduced for nail bed reconstruction by Liu et al. [11]. Though this method can minimize donor site morbidity and functional deficits, it is not suitable for large or complex defects, particularly those with bone exposure. Another approach, introduced by Lee et al. [12], involves the use of a thin thenar fascial flap to cover exposed bone, with subsequent nail bed grafting. Although this method provides a healthy vascular bed, it can lead to joint stiffness due to immobilization prior to flap division. Park et al. [13] introduced the use of a subcutaneous flap followed by a secondary composite graft.

In our case, the defect was centrally located on the nail bed with the surrounding eponychial folds preserved, making our approach particularly suitable for this type of presentation. A key advantage of this technique is its ability to maintain the integrity of the unaffected nail bed structures and eponychial folds, which is essential for the quality of the regrowing nail. However, this method is not always applicable in cases involving fingertip defects or considerable bone exposure, and other reconstructive methods may need to be considered.

Herein, the subcutaneous flap provides well-vascularized thin tissue that serves as an ideal bed for subsequent nail bed grafting. The two palmar digital arteries form an anastomotic loop at the lunula level, known as the distal transverse palmar arch [14]. The central arteries branch out from this arch [15]. Given the anatomical characteristics of the arch, distal circulation can be preserved on both sides when the arch is incised. Severing the arch allows the use of an artery to form a subcutaneous flap with a long pedicle, enabling flexible transposition to cover bone exposure on the dorsal aspect of the distal phalanx.

During dorsal transposition of the flap, several additional efforts were made to preserve the lateral nail fold in order to minimize potential nail deformity. First, the incision was made at a sufficient distance from the lateral nail fold to avoid damaging the nail apparatus during surgery. The flap was elevated to an average thickness of approximately 1 mm, keeping it as thin as possible. To pass the flap beneath the lateral nail fold, a tunnel was dissected in the plane between the distal phalanx and the remaining nail bed. Also, to further minimize pressure on the flap, the lateral interosseous ligament of the

distal phalanx was incised. Compared to microsurgical techniques, our approach is less technically demanding and more straightforward compared.

Because the subcutaneous flap lacks a cutaneous component, assessment of flap circulation presented some challenges. Intraoperatively, flap viability was evaluated by observing microbleeding from adipose tissue under microscopic magnification, which confirmed adequate perfusion. Reassessing microbleeding after suturing of the flap mitigated potential circulatory compromise due to excessive flap tension. Three weeks postoperatively, after confirming flap survival, a split-thickness nail bed graft was performed over the well-vascularized recipient site.

In conclusion, the subcutaneous flap presents a valuable option for reconstructing complex nail bed defects with exposed bone. Its long pedicle facilitates flexible transposition, making it particularly advantageous for addressing soft-tissue defects at the fingertip and full-thickness defects in the sterile matrix. Preservation of the intact eponychial folds is crucial when the defect is confined to the central portion of the nail bed. Utilizing the space beneath the nail apparatus as a practical route for flap transposition allows for successful coverage of bone exposure while maintaining the integrity of the eponychial folds. This technique offers a reliable solution for challenging nail bed reconstructions, potentially improving both functional and aesthetic outcomes.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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