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Hand

The Expanded Application of the Acellular Dermal Matrix: Traumatic Nail Bed Defect of the Digits

Kwang Hyun Park, MD
Soo Jin Woo, MD
Sang Hyun Woo, MD, PhD
Ho-jun Cheon, MD

Summary: Reconstruction of traumatic nail bed defects in the digits is a frequently encountered procedure, yet often presents many challenges. In such scenarios, staged procedures may be required with significant limitations in shape and increased donor site morbidity, particularly when multiple defects are present. In this study, we introduce a simple method for the reconstruction of nail bed defects using an acellular dermal matrix (ADM). The study involved 19 digits with nail defects, which underwent reconstruction using an ADM graft. The surgical procedure was performed on all patients on the day of injury, after which they were promptly discharged. The dimensions of the defect ranged from 0.5 × 0.5 cm to a maximum of 2 × 3 cm (average, 0.9 × 1.4 cm). Final examinations were performed at postoperative 5–11 months (average, 6.6 months). All ADM grafts were successfully taken. Nail growth was observed at an average of 4 months after surgery in the treated finger. The surgical results were retrospectively evaluated using the Zook criteria. Outcomes were "excellent" in 11 patients (57.9%), "very good" in five patients (26.3%), "good" in two patients (10.5%), and "fair" in one patient (5.2%). The expanded application of ADM explored in this study illustrates a straightforward method for the reconstruction of traumatic nail bed defects, providing effective results in a single stage without incurring donor site morbidity. *(Plast Reconstr Surg Glob Open 2024; 12:e5551; doi: 10.1097/GOX.0000000000005551; Published online 24 January 2024.)*

INTRODUCTION

From an epidemiological point of view, most fingernail injuries result from crush or avulsion trauma and involve children and young adults. In approximately 50% of cases, fingernail injuries are associated with phalangeal fractures and nail bed damage. However, methods for reconstructing nail bed defects are limited in the literature, and reconstructing defects that are multiple, large in size, or present with distal phalanx exposure remains challenging.[1,2] This study introduces a one-stage technique for the reconstruction of traumatic nail bed defects with acellular dermal matrix (ADM).

PATIENTS AND METHODS

A retrospective analysis of prospectively collected data was performed. The study was approved by the institutional review board (IRB approval no.: P01-202307-01-012). All patients provided written consent for undergoing the procedures.

Under a brachial plexus block or local anesthesia, the nail plate was extracted to assess the nail bed defect. The first step involved evaluating whether the nail defect could be primarily repaired or required reconstruction. (**See table, Supplemental Digital Content 1,** which displays the algorithm for treatment of nail bed injury. **http://links.lww.com/PRSGO/D35**.) When the defect required reconstruction, the involvement of the sterile matrix and germinal matrix was measured. When the defect did not include the germinal matrix, the ADM (Pelnac, Fenestrated type, Gunze Corp., Osaka, Japan) was used. While using the ADM, the defect was once again evaluated to determine whether it involved full-thickness. The full-thickness defects required cortical drilling on the distal phalanx to provide a vascularized bed for fixation of the ADM (Fig. 1A). The ADM was fixed to the nail bed defect using absorbable sutures (Fig. 1B). A nail plate was sutured in place to protect the ADM graft. After the application of a semi-occlusive

From W Institute for Hand and Reconstructive Microsurgery, W General Hospital, Daegu, South Korea.

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Drs. Park and Woo contributed equally to this work.

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dressing, the patient was discharged on the day of surgery. Patients visited the outpatient clinic once a week to replace the dressing. The nail plate was removed 4 weeks after the surgery. Patients were monitored for evidence of healing, infection, and nail adherence for at least 5 months. All authors evaluated the surgical results at the last follow-up clinic according to the Zook criteria. **(See figure, Supplemental Digital Content 2,** which displays the evaluation of nail bed deformities according to the Zook criteria. **http://links.lww.com/PRSGO/D36**.)

RESULTS

A total of 19 digits underwent reconstruction of traumatic nail defects using an ADM graft. The dimensions of the defects ranged from 0.5 × 0.5 cm to a maximum of 2 × 3 cm, with an average of 0.9 × 1.4 cm with 36.8% of cases associated with distal phalangeal fracture. The follow-up period ranged from 5 to 11 months, with an average of 6.6 months. All ADM grafts were successfully incorporated. New nail growth was observed at an average of 4 months after surgery in the treated finger. Regarding the Zook criteria, outcomes were "excellent" in 11 patients (57.9%), "very good" in five patients (26.3%), "good" in two patients (10.5%), and "fair" in one patient (5.2%). (**See Supplemental Digital Content 2**, **http://links.lww.com/PRSGO/D36**.)

CASE (#19)

A 48-year-old man presented after a machine injury with about 1 × 0.5 cm full-thickness defect of the nail bed on the right index finger. An ADM was applied using absorbable sutures after the cortex of the distal phalanx was drilled. The extracted nail plate was trimmed and placed to protect the ADM graft. The nail achieved an excellent rating at a 4-month follow-up (Fig. 2).

Takeaways

Question: How can we address nail bed defects, especially when multiple sites are involved?

Findings: In nail bed defects with an intact germinal matrix, reconstruction using acellular dermal matrix is a straightforward approach that does not require a donor site and leads to good surgical outcomes.

Meaning: The expanded use of acellular dermal matrix in nail bed defect reconstruction facilitates the treatment of multiple defects through a simple, one-stage surgery, eliminating the need for a donor site.

DISCUSSION

Due to their prominence at the fingertips, fingernails are the most frequent sites of hand injuries. Managing nail bed injuries can be challenging and controversial, especially when involving large-area defects with distal phalanx exposure or multiple nail bed defects. Nail bed repairs are warranted to promote further nail plate growth and prevent the development of irregular and nonadherent nail plates. Yang et al reported on their experience using a cross-finger fascial flap combined with a split-thickness toenail bed graft.[3] Lee et al recommended the use of a thenar fascial flap followed

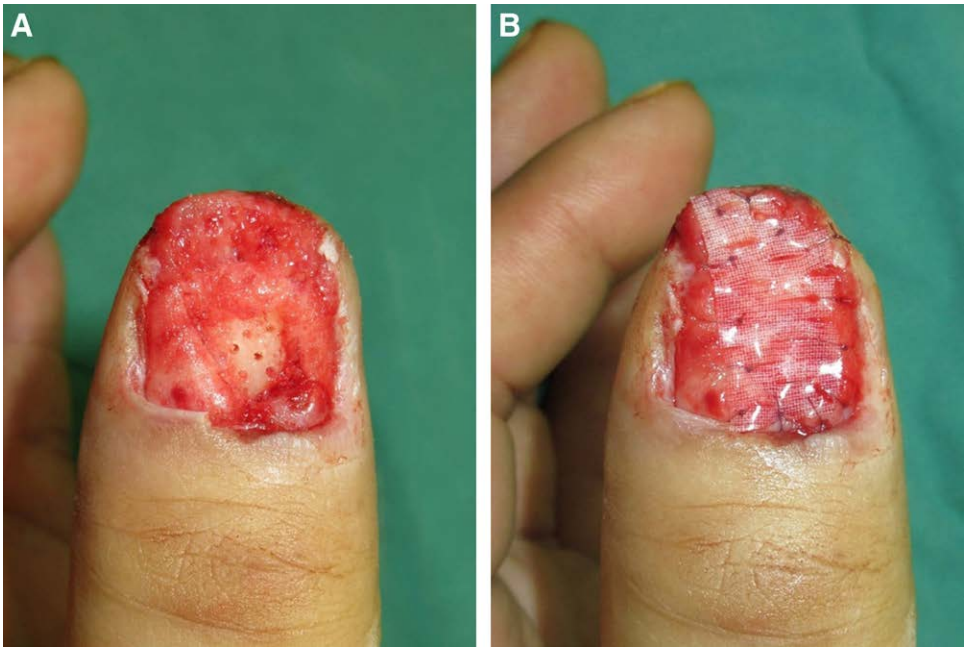

Fig. 1. Demonstration of the surgical technique of ADM application. A, A 0.8 × 0.7 cm-sized full-thickness nail bed with bone exposure, followed by cortical drilling. B, Fixation of ADM with absorbable sutures.

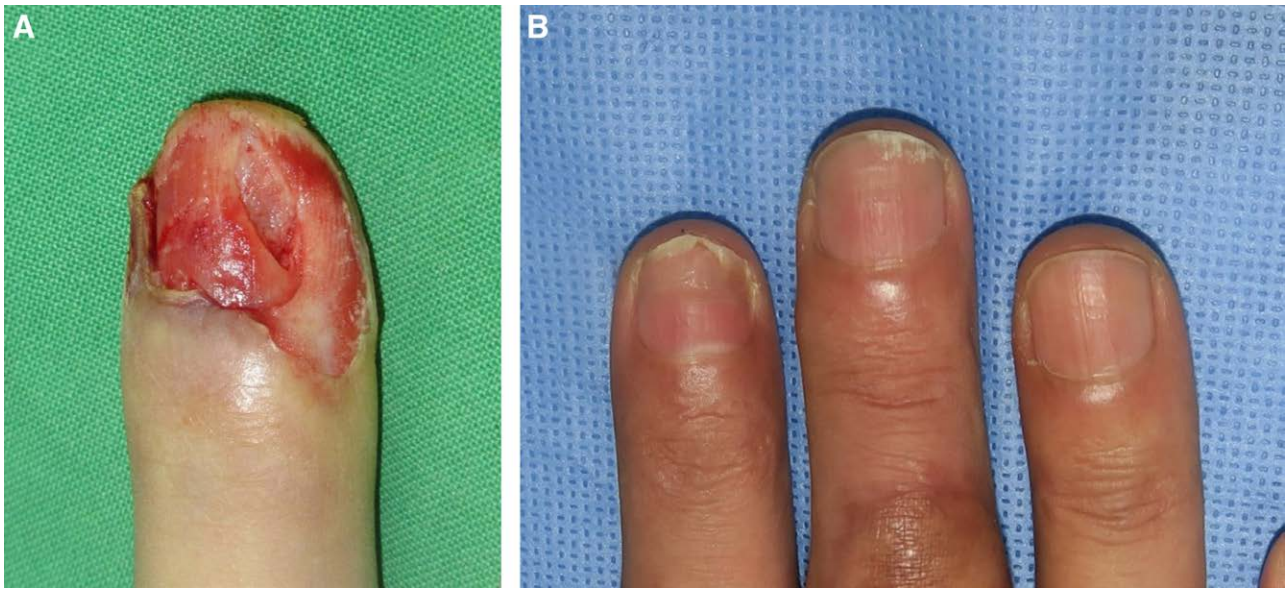

Fig. 2. A 48-year-old male patient with a nail bed defect on the right index finger. A, Full-thickness nail bed defect. B, Postoperative result at 5 months, graded as excellent.

by subsequent nail bed grafting.[4] However, these approaches possess several limitations when multiple fingers are involved. Furthermore, most published reconstructive techniques for large nail bed defects involve a secondary donor site and a longer hospital stay.[5]

Recently, use of ADM for reconstructive purposes has broadened the horizons of available surgical methods. This study illuminates an extended application of ADM by demonstrating the feasibility of one-stage reconstruction for extensive and multiple nail bed defects. The ADM used in this study is derived from a soluble atelocollagen, a purified type 1 collagen extracted from porcine tendon.[6,7] It exhibits an average pore size of 70–110 μm, which is larger than other ADMs. This substantial pore size not only prevents tissue capsule formations but also facilitates cellular migration into the matrix.[8,9]

Using ADM for nail bed defect reconstruction offers several benefits. Firstly, the technique is inherently uncomplicated and can be conducted on an outpatient basis, enabling an expedited return to daily activities for patients. Also, a pivotal observation in surgical outcomes was the successful graft take. It can be attributed to sufficient blood flow at the fingertips and comparatively small defect size, both indicators of a favorable prognosis for graft survival.[6] Another advantage is its applicability without requiring a donor site, proving especially valuable in situations where traditional surgical interventions are impracticable due to defects across multiple fingers. Furthermore, postoperative results showed that all patients exhibited no signs of infection or graft loss, underscoring the safety of the technique. The atelocollagen mirrors the structural properties of endogenous collagen, and during production, pepsin is used to remove highly antigenic telopeptides from the collagen, thereby creating a matrix with reduced antigenicity and diminishing the probability of immune responses and graft failure.[8] Additionally, the postoperative outcomes showcased aesthetically favorable results, notably in the nail shape. Using a natural or synthetic nail plate facilitates optimal alignment during nail regeneration and provides an extra protective layer. Lastly, the economic impact cannot be overlooked. Although ADMs carry a substantial cost, they prove to be cost-effective for repairing nail bed defects because only a small amount is required. The ADM is priced at US $4 per cm^2, making it an attractive option for patients and healthcare systems due to its generally lower cost compared with traditional grafting techniques.[6]

This study contributes valuable and consistent results across many patients, enhancing existing reports that were limited by a lack of case numbers and case presentation.[9,10] However, we were unable to verify to what extent the taken ADM is histologically analogous to a true sterile matrix. Still, ADM in skin has demonstrated enduring efficacy. It has the capacity to generate a dermis that resembles the true dermis in substantial full-thickness defects, which is conjectured to function similarly in the nail. Although nail bed defect reconstruction using ADM is a simple surgical technique, it is important to acknowledge its limitations. Careful consideration is necessary in determining the suitability of using ADM for a specific nail bed defect, as outlined by the provided algorithm (**Supplemental Digital Content 1**, **http://links.lww.com/PRSGO/D35**).

Ho-jun Cheon, MD
W Institute for Hand and Reconstructive Microsurgery
W General Hospital
1632 Dalgubeol-daero, Dalseo-gu #42642
Daegu, South Korea
E-mail: jjokjjebi@hanmail.net

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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