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First Dorsal Metatarsal Artery Free Flap for Finger Coverage Defect: A Case Report

Colgajo libre de primera arteria metatarsiana dorsal para déficit de cobertura en dígito de la mano: Reporte de caso clínico

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Abstract

Severe finger injuries with loss of substance and exposure of noble structures are a challenge to avoid amputation. These situations have prompted the development of many local axial flaps to save the digit. Customized free flaps have also been described to provide adequate and good-quality coverage. We present the case of a patient with a severe injury to the ring finger with bone exposure and tendinous damage, with a coverage defect of 4×4 cm. The patient underwent reconstruction with a free flap from the foot, taking the first intermetatarsal artery as the donor vascular axis. The patient kept his finger with mobility at the expense of the proximal interphalangeal (PIP) joint, with good-quality skin, firm clamp, and no pain. The donor area did not present complications. In the hands of a trained team, with adequate indication, these flaps achieve a good esthetic and functional result.
Level of Evidence 3.

Keywords
- coverage defect
- free flap
- metatarsal artery
- upper extremity reconstruction
- microsurgery

Resumen

Las lesiones graves de los dedos con pérdida de sustancia y exposición de estructuras nobles constituyen un desafío para evitar la amputación. Estas situaciones han impulsado el desarrollo de un gran número de colgajos axiales, locales, con el fin de salvar el dígito. Los colgajos libres, tomados a medida, también han sido descritos para dar coberturas adecuadas y de buena calidad. Se presenta el caso de un paciente con lesión grave de dedo anular con exposición ósea y daño tendíneo, con una pérdida de cobertura de 4×4 cm. El paciente fue sometido a una reconstrucción con un colgajo libre del pie, tomando como eje vascular la primera arteria intermetatarsiana. El paciente conservó su dedo con una movilidad a expensas de la articulación interfalángica proximal (IFP), con una piel de buena calidad, pinza firme y sin dolor. La zona dadora no presentó complicaciones. En manos de un equipo entrenado, con indicación adecuada, estos colgajos logran un buen resultado estético y funcional.
Nivel de Evidencia 3.

Palabras Clave
- defecto de cobertura
- colgajo libre
- arteria metatarsiana
- reconstrucción de la extremidad superior
- microcirugía

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Introduction

Serious finger injuries with loss and exposure of noble structures are a challenge for hand surgeons, who are always geared towards reconstruction. As early as 1976, Midgley and Entin[1] described the principles to follow in complex segment injuries: length, strength, position, stability, mobility, and sensitivity.

The need to preserve and cover the fingers has prompted the development of several techniques, which, backed by a thorough knowledge of anatomy and microsurgical techniques, today enable us to access axial and free flaps for reconstruction. The challenge is to provide good-quality coverage, with as much sensitivity as possible, and without causing significant injuries in the donor areas. These coverages must deliver results that are compatible with the onset of early movement and enable early function of the injured hand.

The purpose of the present report is to describe the experience and the clinical result of the reconstruction of a ring finger severely damaged by a dog bite, which evolved into a local infection.

Case Report

A 26-year-old right-handed student presented with a 4-week-old wound on the right ring finger due to a dog bite. The wound was managed with surgical cleaning, tenorrhaphy of the flexor digitorum profundus, and primary closure. It evolved with local infection, tissue necrosis, and coverage defect for amputation of the digit was considered.

Surgical cleaning and resection of the necrotic tissue was performed, evidencing a coverage defect of the ulnar aspect of the ring finger of approximately 4×4 cm at the level of the second phalanx, with loss of the ulnar neurovascular bundle of the digit, exposure of the flexor apparatus, and significant damage to the extensor apparatus (►**Figure 1**). After debridment, the digital nerve deficit was found to be of approximately 1.8 cm in length, on a bed of scar tissue in which uncertain vascularity. Both interphalangeal joints were preserved, stable and with active mobility.

After evaluating the treatment options, we decided to reconstruct the ring finger with a microsurgical neurovascular flap taken from the first web space of the foot using the anatomical principles of a free flap dependent on the first intermetatarsal artery, a resource used both in the reconstruction of thumbs as well as in defects of the foot.

During surgery, after completing cleaning and debridement, the receiving artery and vein were prepared together with the remaining ends of the ulnar digital nerve of the ring finger. A mold of the deficit was taken considering size and shape; and we proceed to carve the flap from the first intermetatarsal space (►**Figure 2**). After identifying and dissecting the intermetatarsal artery, the local venous network and the sensory nerve, the dissection of the flap is completed from distal to proximal, isolating a single vascular pedicle, which is sectioned and released, irrigation was verified (►**Figure 3**).

Fig. 1 Volar and ulnar deficits of the middle finger of the right hand at the time of surgical cleaning and debridement.

Fig. 2 Microsurgical flap planning and cast, identification and isolation of the first dorsal metatarsal artery.

Fig. 3 Free flap of the first dorsal metatarsal artery, together with its neurovascular pedicle.

The free flap was placed in the recipient area and fixed with cardinal sutures, neurorrhaphy was performed in addition to arteriorrhaphy and venorrhaphy with Ethilon 9–0 (Ethicon, Inc., Bridgewater, NJ, United States) suture under microscope vision; after releasing the clamp and verifying that it was not congestive, the flap was sutured, and a dermal-epidermal graft was used to cover the remaining deficit area (►**Figure 4**). Closure of the donor area was completed with Ethilon 5-0 suture and a total skin graft (►**Figure 5**).

Fig. 4 Left foot dorsum (donor area), after closure with the implantation of a total skin graft.

Fig. 5 Microsurgical flap positioned, perfused, after vascular anastomosis and neurorrhaphy.

After de procedure, the hand was covered with sterile dressings, immobilized in a plaster cast and elevated. After two days of observation, the patient was discharged for home care.

At 12 days, flexion exercises of the finger were started. At 4 weeks, up to 30° of flexion of the proximal interphalangeal (PIP) joint of the ring finger was achieved, and we confirmed that the flap was vital and the skin grafts on the recipient site were vital. Kinesitherapy began, and, at six weeks, we started with the compressive bandages.

At 3 months, the patient achieved PIP joint flexion of up to 90°, and had recovered sensitivity in the flap and distal areas (►**Figure 6**). The patient remained under follow-up and kinesthetic rehabilitation, and attended a follow-up appointment after 2 years of evolution, when he presented with complete flexion of the PIP joint, and an esthetically adequate and sensitive graft. The patient felt no discomfort in the donor area, and tolerated the same level of sports activity prior to surgery (►**Figure 7**).

Regarding complications, the patient only mentioned the non-recoverable stiffness of the distal interphalangeal joint that was attributed to the adhesions of the extensor apparatus during the infectious process and initial necrosis; however, it was well tolerated by the patient, who confirmed the complication does not prevent him from leading a normal life or hinder his activities of daily living.

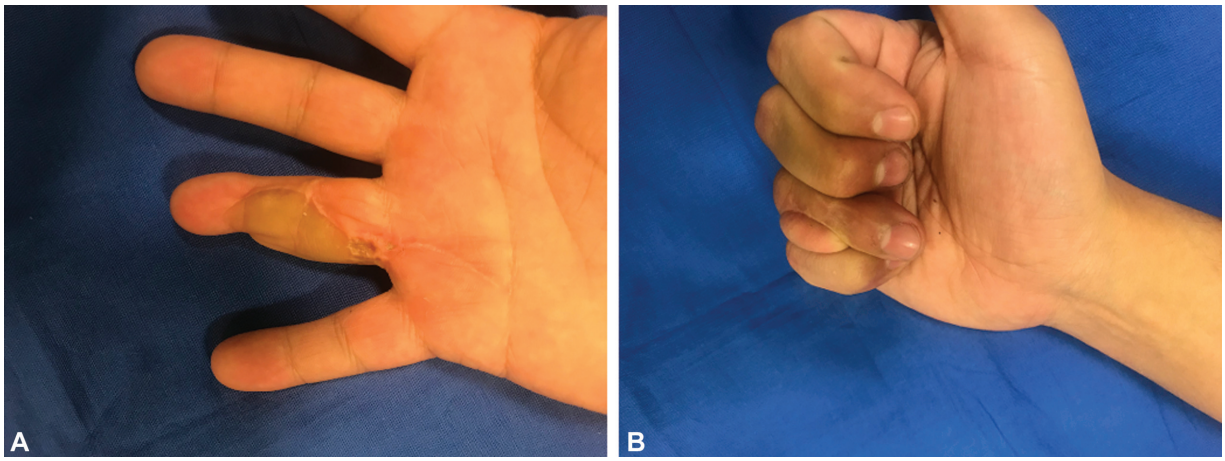

Fig. 6 Right hand ring finger at two years of evolution in extension (**A**) and flexion (**B**).

Fig. 7 Dorsum of the left foot (donor area) at two years of evolution.

Discussion

Faced with finger injuries, with extensive loss and exposure of noble structures, such as tendons or bones, amputation has often been the treatment of choice.

Reconstruction with microsurgical flap techniques provides a new opportunity for this type of injury, local and free flaps are within the possibilities.

In the case herein reported, the use of an axial homodigital or intermetacarpal flap was considered, but the 4×4-cm defect, which compromised approximately 70% of the diameter of the finger, made its use inadvisable. The homodigital axial flap has been described for defects of up to 2.5×3 cm, which was insufficient for the case herein reported.[2] In addition, the compromise of a collateral artery due to the lesion hindered us from using its pair for a homodigital flap because, during its extraction, the remaining digital nerve would be at risk.

Flaps based on the dorsal metacarpal artery have evolved along with the knowledge of vascular anatomy, extending their usual areas of use distally in the fingers;[3] however, once more its area was insufficient for the defect presented in the case reported, which fell in the ranges of 6.5×1.5 cm.[4]

Another option, which requires microsurgery, is the use of free flaps. For the coverage of hand and digit defects, free flaps provide multiple benefits for the patient and avoid local morbidity in the donor site, options with better cosmetic results due to skin quality, and coverage areas greater than those that could be achieved with a local flap. Since 1994, when Gottlieb and Krieger[5] coined the term *reconstructive elevator*, the concept that the coverage option must be adapted to the functional needs imposed by the defect has been extended, even when it involves the challenge of omitting "simple" options that may not be the most suitable for each case.[2]

In the case of the flap chosen, we are able to deliver a sensitized flap, which we know is important for the ulnar side of a ring finger. In the present case, a 1.8-cm long defect of the ulnar digital nerve was treated on a bed of low vascularity due to recent infection, and satisfactory and functional results were achieved for the patient. The usefulness of vascularized nerve grafts in the context of avascular scar tissue lesions has been described in the literature.[6,7]

The size of the coverage defect was of approximately 4×4 cm, with a compromise of 70% of the circumference of the digit at the level of the second phalanx, and, as we have discussed, the homodigital or local flaps could not solve our problem, and lead to the need to propose a free microsurgical flap against the risk of an almost certain amputation of the digit.

The neurovascular flap of the first metatarsal artery has already been described in 1977 by May et al.[8] in a cadaveric study in which they observed the consistent presence of

communicating arterial branches in the area of the first intermetatarsal space, which enabled the maintenance of the irrigation of the area after the section of the first dorsal metatarsal artery; the authors[7] also described the presence of dorsal sensory branches from the deep peroneal nerve that innervate the area.

The anatomy and variants of the metatarsal arteries have been studied, which enabled the establishment of a pattern for their arrangement according to their relationship with the interosseous muscle of the first space; in the case herein reported, it was a type-1 Gilbert artery,[9] with an independent origin from the dorsal and plantar metatarsal arteries, which greatly facilitates dissection. More recently, Hou et al.[10] have proposed a new classification, which, in addition to referring to the origin and trajectory of the dorsal metatarsal artery, also includes its main branches. Flaps based on the first dorsal metatarsal artery have been widely used locally to cover defects of the dorsum, sole and toes, especially in reverse flow. Excluding the use of this flap for the reconstruction of the thumb,[11] its use, under a microsurgical technique to cover the hand, although more infrequent, has been described in the literature. Since the initial publication by May et al.,[8] its use has appeared sparsely. Rose and Kowalski[12] published a series of 5 cases of digit injuries with digital nerve deficit, in which they used the free flap derived from the first intermetatarsal artery with good and excellent results and few complications, also using the sensory potential of the flap in the recovery of sensitivity in deficits between 5 cm and 8 cm.[12] The versatility of the flap has also been shown even in multi-digit defects, including sensory nerve and extensor halluxis brevis tendon grafts for the repair of multiple defects in severely-injured hands.[13]

Conclusion

Finger injuries with extensive damage and loss of substance represent a challenge for our specialty. As amputation is often an effective solution, reconstruction should also be a treatment to consider.

The use of local flaps often helps us solve these problems, but we have observed that they have limitations.

We presented a case in which the use of a microsurgical free flap was the chosen alternative. Composite free flaps originating from the neurovascular axis of the first intermetatarsal artery have been widely used in hand reconstruction, and their application as a modeled flap to our injury enabled an adequate, effective and efficient solution.

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