Chimeric Free Vascularized Metatarsophalangeal Joint With Toe Fillet Flap: A Technique for Reconstruction of the Posttraumatic Metacarpophalangeal Joint With Concomitant Soft Tissue Defect

Marco Pappalardo, MD,*† Vincent G. Laurence, MD,* Yu-Te Lin, MD*‡§

For painful, dysfunctional, posttraumatic metacarpophalangeal (MCP) joints, the free vascularized toe joint transfer may represent a good solution. Successful reconstruction is potentially limited, however, by 2 features of the traditional vascularized metatarsophalangeal (MTP) transfer: inadequate arc of flexion and insufficient soft tissue coverage. The solution to both of these dilemmas lies in the manner of utilizing the donor site. Because of its innate hyperextensibility, rotating the MTP 180° volar to dorsal provides the greatest arc of flexion in the reconstructed MCP. Excellent soft tissue coverage can be provided by elevating the skin paddle of the transferred second toe as a chimeric fillet flap, based on the tibial plantar digital artery. *(J Hand Surg Am. 2018;43(2):193.e1-e6. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

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THE METACARPOPHALANGEAL (MCP) joint plays a critical role in hand function, contributing not only approximately one-third of the potential range of motion (ROM) with respect to flexion but also typically 20° to 30° abduction-adduction, which allows precise positioning at the finger tips for very delicate maneuvers. A less mobile MCP joint, whether due to trauma or to disease, greatly impairs normal hand function and can substantially diminish patient quality of life.[1]

The optimal reconstruction of a dysfunctional MCP joint remains controversial, with no universally accepted solution. Many factors must be considered, including patient age, etiology, extent of injury, the demands the patient will place on the reconstructed joint, and the relative need for stability versus ROM. Potential treatment options are arthrodesis, various implant arthroplasties (such as silicone, pyrocarbon), and vascularized joint transfer (VJT).[1–6] The reconstructive challenge is greater when, in addition to joint-related issues, there are associated composite tissue defects requiring tendon grafts and/or soft tissue coverage.[2] It is for these types of injuries in particular that VJTs excel.

*From the *Department of Plastic Surgery, Vascularized Composite Allotransplantation Center, Chang Gung Memorial Hospital, Linkou; the ‡College of Medicine, Chang Gung University, Taoyuan City; the §Chang Gung Memorial Hospital, Keelung City, Taiwan; and the †Plastic and Reconstructive Surgery, Department of Surgical, Oncological and Oral Sciences, University of Palermo, Italy.*

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Corresponding author: Yu-Te Lin, MD, Department of Plastic Surgery, Chang Gung Memorial Hospital, 222, Mai-Chin Road, Keelung City 204, Taiwan; e-mail: linutcgmh@gmail.com.

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The second toe is commonly considered the best donor for reconstruction of a dysfunctional MCP joint by VJT, with the metatarsophalangeal (MTP) joint providing substantially greater ROM than the proximal interphalangeal PIP joint.[1,6–8] The MTP joint also allows for better growth in young patients because there are 2 physes in the joint.[1,8] The key to obtaining maximal flexion in the reconstructed neo-MCP joint is to make use of the MTP's inherent hyperextensibility, rotating it 180° (volar to dorsal) in the hand.[1,3,8]

Substantial deficits of healthy soft tissue are common with severe MCP injuries requiring reconstruction, and several strategies have been previously used to provide adequate soft tissue coverage at the time of MTP joint transfer. One possibility is to use an elliptically shaped skin flap based on the dorsalis pedis artery, which requires a skin graft to cover the skin flap donor site, creating yet another donor site, adding morbidity to the operation.[9,10] Others have used the plantar skin from the MTP joint transfer, but this thick, glabrous skin is a poor match for the thin, supple skin of the dorsum of the hand.[11] Rather than using these previously described suboptimal solutions, we recommend using all of the skin from the toe and filleting it into an island skin flap perfused by the tibial plantar digital artery (TPDA). This provides a substantial amount of freely mobile soft tissue to cover the neo-MCP joint that is a good match with the adjacent skin and does so without creating an additional donor site.

Moreover, sacrifice of the distal portion of the toe is often required after harvesting the MTP joint.[3,12] Although one could interpose a free bone graft at the second toe donor site defect to restore toe length, it would not restore mobility and a significant gait abnormality would result. Indeed, the cosmesis from the more proximal amputation is actually superior to that obtained with the PIP joint harvest or by attempting to preserve the distal toe with the MTP harvest. Provided the patient is willing, sacrifice of the toe provides for additional soft tissue availability (the "spare parts" concept[13]) while potentially decreasing the morbidity of the donor site.

INDICATIONS AND CONTRAINDICATIONS

The indications for VJT are few, and it is a complex procedure requiring good microsurgical skills and a supportive hospital infrastructure. Ideal patients are young and highly motivated, and also have high-activity requirements.[1,3,7,14] For the right patient, this technique confers substantial benefits, including durability, joint stability, and infection resistance.[12] It allows for the replacement of diseased, fibrotic, nonfunctional tissue with healthy, vascularized tissue, including skin, bone, and tendons, providing a valuable reconstructive option in situations not amenable to other modes of reconstruction.[1]

Vascularized MTP joint transfer is contraindicated in patients with rheumatoid arthritis, other systemic inflammatory conditions that may affect multiple joints, with a history of trauma involving the toe proximal phalanx and/or MTP joint, and in any patients who either lack the motivation or are unable to comply with an extensive postoperative rehabilitation program.

SURGICAL ANATOMY

Both toe MTP and finger MCP joints are bicondylar ellipsoid joints with motion predominantly in the flexion-extension plane. Because of the internal rotation of the lower limbs during embryological development, however, and the resultant inverted positions of flexors and extensors compared with the upper limb, toe MTP joints exhibit relatively limited flexion but excellent extension, whereas there is far more flexion than extension in the MCP joints, reflecting the importance of grip.[3,8,11]

The dominant arterial inflow to the flap is variable, either the first plantar metatarsal artery (FPMA) or the first dorsal metatarsal artery (FDMA). The TPDA, which arises either as a dominant direct communication from the FDMA or as a dominant branch from the common plantar artery to the first web space, supplies the filleted toe skin flap with its distal runoff. An average of 2 or 3 sizable articular branches emanating from either the FPMA or the TPDA, and running perpendicular to it, feed the MTP joint and must be included with the harvested joint (Fig. 1).

Venous drainage can be ensured by using a larger-caliber superficial dorsal vein. It can often be identified by dangling the leg prior to the start of the case.

Flexor digitorum longus (FDL) and brevis (FDB) and extensor digitorum longus are divided distally at their insertions for possible use in the hand, harvested *en bloc* together with the joint, its arterial pedicle, and the skin island with accompanying superficial dorsal vein.

SURGICAL TECHNIQUE

Recipient site: hand

The recipient site is prepared and a tourniquet is used. A lazy S incision is made to expose the damaged joint. Extensor and flexor tendons are carefully