SURGICAL TECHNIQUE

Proximalization of the Vascularized Toe Joint in Finger Proximal Interphalangeal Joint Reconstruction: A Technique to Derive Optimal Flexion From a Joint With Expected Limited Motion

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When used to reconstruct a finger proximal interphalangeal joint, a free toe interphalangeal joint, without modification, cannot meet the motion demands of the finger to allow palm touchdown. This limitation is the direct result of the toe interphalangeal joint having an intrinsic arc of motion that delivers less flexion than that of a normal functioning finger proximal interphalangeal joint. By modifying the inset of the transferred joint to an extra-anatomical more proximal position, this limitation can be overcome. With a mathematical justification highlighted by a clinical illustration, we demonstrate the feasibility and utility of this "proximalization" technique. *(J Hand Surg Am. 2016;■(■):■−■. Copyright © 2016 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Free toe joint, proximal interphalangeal joint, proximalization, reconstruction.

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INDICATIONS

Stiffness is common, expected, and often accepted as an inevitable result after surgery around the proximal interphalangeal (PIP) joint. Causes of stiffness include decreased compliance of supporting ligamentous structures, decreased compliance of the skin and soft tissue envelope, tendon adhesions, persistent edema, or baseline mechanical limitations of a replacement joint.

Vascularized toe joint transfers have been used for reconstruction of damaged or dysfunctional PIP finger joints. This technique confers specific benefits not afforded by implant arthroplasty such as durability, stability, and infection resistance. A free-toe joint also can be transferred with skin and, therefore, can be used in digits with a compromised soft tissue envelope.[1]

Successful reconstruction is often limited by 2 suboptimal features innate to the transferred toe PIP joint: an extensor tendon lag and arc of motion less than that of a normal finger PIP joint.[2,3]

Toe PIP joint motion limitations can be mitigated by positioning the transferred joint more proximal than the anatomical location of the native finger PIP joint. This technique of "proximalization" uses mathematical principles to provide a more functional arc of motion of the resultant digit within the confines of expected subnormal PIP joint motion. As the transferred joint moves proximal toward the metacarpophalangeal (MCP) joint, each degree of PIP joint flexion corresponds to more angular motion of the distal digit.

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Given the power and simplicity of this modification, it should be considered indicated in most patients who are suitable candidates for a free-toe joint transfer. These patients must have adequate proximal phalanx bone stock and length and should have optimum excursion of the tendon(s) that will ultimately power the joint.

CONTRAINDICATIONS

Free-toe joints should not be performed on patients who cannot comply with postoperative rehabilitation programs; those with poor proximal phalanx quality, known connective tissue disorder, rheumatological pathology with baseline global joint dysfunction; or with abnormal musculotendinous function.

SURGICAL ANATOMY

The second toe interphalangeal (IP) joint is often selected for PIP joint reconstruction. Both toe and finger IP joints are bicondylar ginglymus joints with motion only in the flexion/extension plane. Despite this similarity, many toe PIP joints have central slip incompetence and, therefore, an inherent extensor lag. Toe phalanges are smaller and shorter than finger phalanges and toe IP joint arc of motion is limited compared with the finger's average IP joint motion of 110°.

The joint is harvested *en bloc* based off the medial (tibial) digital artery for vascular inflow and a dorsal vein for venous outflow. The tibial digital artery arises either as a dominant direct communication from the first dorsal metatarsal artery or as a dominant branch from the common plantar artery to the first web space. The dorsal veins can be traced back to the saphenous vein if length or increased caliber is required.

SURGICAL TECHNIQUE

The toe can be harvested from either the ipsilateral or the contralateral foot. Foot selection should give consideration to pedicle orientation as it relates to the recipient vessels. Common recipient vessels include palmar digital arteries with dorsal digital veins or radial artery at the "snuff-box" with associated venae comitantes or cephalic vein.

The toe joint is harvested in the fashion described and refined by Lin et al,[1] Strauch and Yu,[4] and Lin and Sassu.[5]

At the hand, the recipient site is prepared under tourniquet control with full exsanguination. A dorsal skin incision is preferred for access to the extensor mechanism. The native extensor mechanism is peeled back from the underlying bone, allowing PIP joint exposure. Transverse osteotomies are made through the proximal and middle phalanges, thus mobilizing the dysfunctional joint, which is freed from surrounding soft tissues and removed. The osteotomies should be taken back to healthy-appearing bone proximally and distally and should protect the underlying flexor tendons if intact.

The proximal phalanx of the free-toe joint flap is shortened just enough to allow provisional insertion into the space created by excision of the dysfunctional native joint. Manual pressure or small-gauge Kirschner wires can be placed to allow provisional fixation and assessment of joint positioning, rotation, angulation, and total range of motion (ROM). If full passive ROM does not allow palm touchdown, the gap distance between fingertip and palm should be determined and recorded (gap distance = x). This distance equals the amount of proximal phalanx shortening needed to place the joint in a position more favorable to achieving fingertip-to-palm contact. Although at this point, either the flap or the native proximal phalanx may be shortened, shortening the native proximal phalanx brings the bone back toward the metadiaphysis where the cancellous-to-cortical bone ratio is higher, thus theoretically improving the healing potential of the osteosynthesis site. If needed, the proximal phalanx of the toe flap can also be shortened. The total length of the new hybrid proximal phalanx, from base to head, should be the original phalanx length less the gap distance "x." Care should be taken to proximalize the joint without excessively shortening the finger. This can be accomplished by shortening the phalanx in a serial fashion and liberally testing the ROM after each ostectomy. Once the desired position has been determined, definitive skeletal stabilization is achieved with Kirschner wires, 24-gauge wire, or both (wires are preferred to plates, given their small footprint/less need for soft tissue stripping). With the MCP and IP joints held fully passively flexed, the extensor digiti communis longus is woven and sutured to the recipient extensor mechanism under maximum tension. This ensures near-full passive flexion will be possible.

Proximalization technique

In this case, we predicted that proximalizing the transferred PIP joint would increase the distal digital arc of motion for every degree of active flexion. This could bring the fingertip closer to the palm during finger flexion, even in the setting of known limitations in motion of the transferred joint. To prove this