The Use of Skeletal Extension Torque in Reversing Dupuytren Contractures of the Proximal Interphalangeal Joint

John M. Agee, MD, Ben C. Goss, MS

Dupuytren contracture of the proximal interphalangeal (PIP) joint can be reversed by an extension torque transmitted from an external device, the Digit Widget, by skeletal pins to the middle phalanx. This extension torque, generated by the same elastic bands dentists use to align teeth, gradually restores length to soft tissues palmar to the PIP joint's axis of rotation. Simultaneously, tissues dorsal to the joint's axis will shorten toward normal length as the PIP progressively straightens. Although the contractile nodules and bands of Dupuytren disease may be excised either before or after reversal of the joint's contracture, a 2-staged approach is preferred: (1) reverse the PIP flexion contracture, and (2) excise the diseased tissue from the straightened finger. We believe this 2-staged approach yields better results. In addition, it is technically easier to avoid injury to nerves and arteries while excising the nodules and bands, when one operates through palmar skin of more nearly normal length. *(J Hand Surg 2012;37A:1467–1474. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Dupuytren, PIP joint contracture, skeletal fixation.

DUPUYTREN DISEASE CAN progressively diminish proximal interphalangeal (PIP) joint motion by shortening all of the palmar soft tissues necessary for normal motion. The underlying cause is excessive flexion torque that results in a contracture of the PIP joint. Reversing moderate to severe flexion contractures of the PIP joint and maintaining gains in active finger extension are challenging tasks for the surgeon. The most effective means for reversing these contractures is to generate an extension torque about the PIP joint. Traditional splints and serial plaster casts are limited in their ability to reverse PIP contractures. Skin on the dorsal side of the finger becomes ischemic at pressures of 35 g/cm^2 (Fig. 1). The pain of ischemia will cause the patient to remove the splint. In fingers with compromised sensation (leprosy and diabetes mellitus), splints that create PIP extension torque adequate to reverse the more severe contractures create swelling, inflammation, and, eventually, ulceration.

We developed the Digit Widget (Fig. 2) specifically to provide the extension torque necessary to reverse severe PIP flexion contractures, while avoiding issues of skin pressure and limited range of motion associated with traditional splints and serial plaster casts. An extension torque about the joint transmits tension forces to both the diseased Dupuytren tissues as well as all other contracted palmar tissues, causing these tissues to increase in length over time.[1,2] It is difficult to determine the etiology of every PIP joint contracture and assess whether the Digit Widget is appropriate; nevertheless, it has been used successfully in reversing PIP joint contractures associated with Dupuytren disease.[3]

INDICATIONS

The Digit Widget is indicated for reversing PIP joint flexion contractures in which the etiology of the torque

From Hand Biomechanics Lab, Inc., Sacramento, CA.

Received for publication January 2, 2012; accepted in revised form April 19, 2012.

J.M.A. is the owner, president, and CEO of, and receives a salary from, Hand Biomechanics Lab. B.C.G. is an employee of, and receives a salary from, Hand Biomechanics Lab.

Corresponding author: John M. Agee, MD, Hand Biomechanics Lab, Inc., 77 Scripps Drive, Suite 104, Sacramento, CA 95825; e-mail: handsandwings@sbcglobal.net.

0363-5023/12/37A07-0029$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2012.04.023

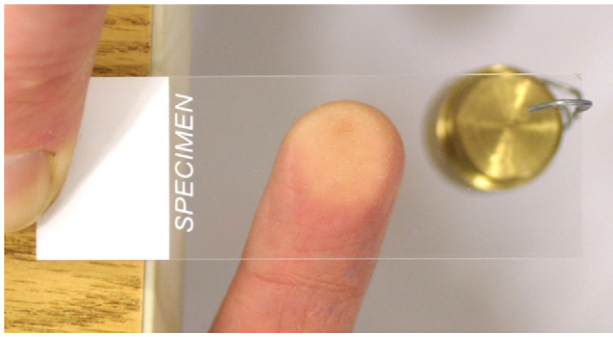

FIGURE 1: To illustrate how skin becomes ischemic at pressures of 35 g/cm^2, a weight hung from a glass slide presses against the finger, blanching the skin.

FIGURE 2: Digit Widgets installed on a patient with PIP joint contractures resulting from Dupuytren disease.

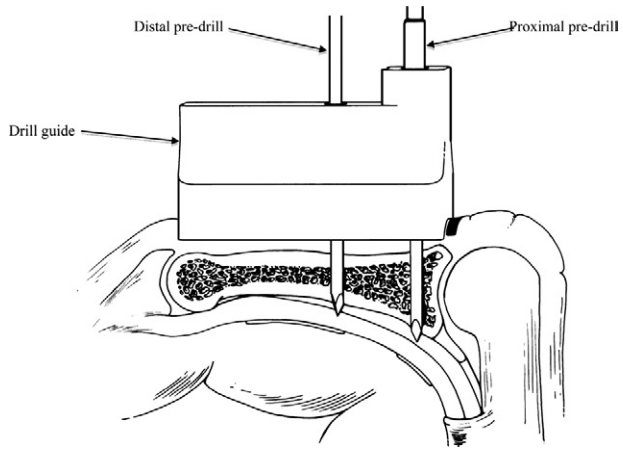

FIGURE 3: Pre-drill pins inserted through the drill guide into the middle phalanx.

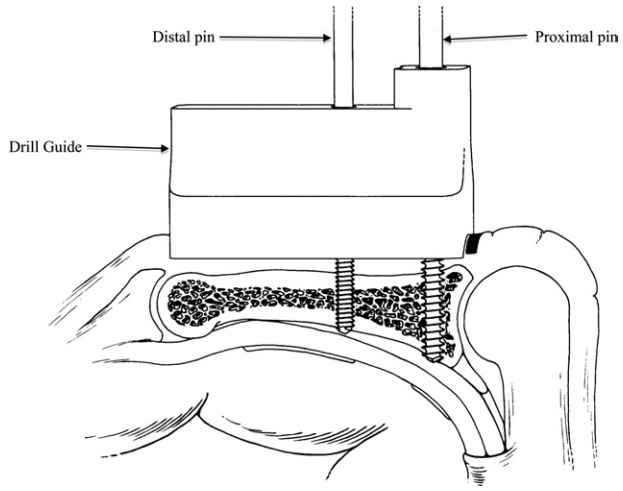

FIGURE 4: Threaded pins inserted through the drill guide into the middle phalanx, but not beyond the palmar cortex.

imbalance that created the contracture is known and the balance between flexion and extension torques can be returned to normal. Although Dupuytren disease remains the dominant etiology, other concomitant abnormalities that create force imbalance across the finger's joints should be considered in a surgical plan designed to optimize restoration of active PIP extension.

CONTRAINDICATIONS

The Digit Widget should not be used for PIP joint contractures in which the anatomy of the joint or its cartilage surface is impaired as a result of arthritis or prior injury. Incongruous, unstable, and arthritic joints demonstrate combinations of gliding and rocking motion that can be diagnosed with anteroposterior and flexion/extension lateral x-rays. As important, the capsular ligaments that suspend the volar plate and the flexor tendon pulleys palmar to the PIP define the moment arms, and thereby the flexion torque created for the PIP by each finger's powerful superficialis and profundus muscle tendon units. Prior pulley injuries, including their surgical incision to facilitate release of the checkrein ligaments,[4] will increase the flexion torque generated by each of these muscle tendons units and create rapid recurrence of a more severe PIP flexion contracture.

TECHNIQUE OF DEVICE APPLICATION

Under digital block anesthesia and with fluoroscopic control, 2 smooth pre-drill pins, aimed by a drill guide, are inserted into the proximal end of the middle phalanx to penetrate both dorsal and palmar cortices (Fig. 3). Threaded pins then replace smooth ones, with each pin rotated in by hand to extend through the phalanx and stop flush with its palmar surface (Fig. 4). Pins that extend palmar to the phalanx may injure the profundus tendon's blood supply and excursion. Skin pressure adjacent to the pins should be relieved by small incisions to prevent ischemia and secondary pin track infection.

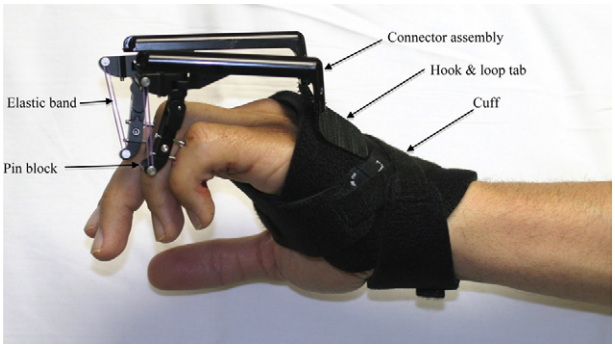

FIGURE 5: Cuff secured to patient's hand with connector assembly linking the pin block to the cuff. The elastic band connected between posts on the pin block and connector assembly creates the torque for PIP extension.

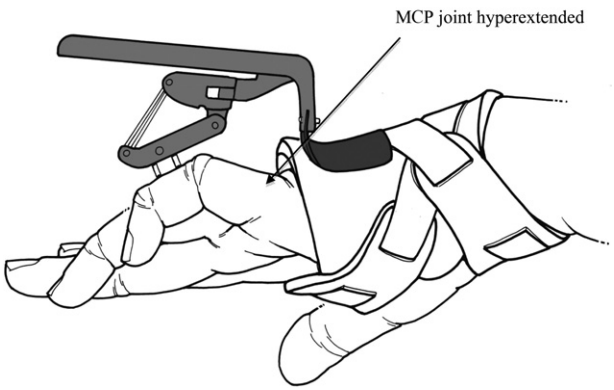

FIGURE 6: Digit Widget installed on a little finger with hyperextension of the MCP joint.

With its cuff wrapped to the hand, the pin block is clamped to the phalangeal pins distally; then, its connector assembly is linked proximally to the cuff by a hook and loop tab (Fig. 5). The weakest elastic band initiates extension torque to begin reversal of the PIP contracture. The dorsal position of the device permits hand use during the weeks required to straighten the finger.

In PIP contractures associated with a metacarpophalangeal (MCP) joint that hyperextends (Fig. 6), addition of the MCP flexion strap, linked to the cuff by a hook and loop tab, prevents MCP hyperextension (Fig. 7). A neutral to slightly flexed MCP joint markedly enhances active PIP extension by the extrinsic finger extensor muscles. Two PIP extension forces, torque from the patient's muscles and torque from the Digit Widget, work in synergy to reverse the PIP flexion contracture.

TECHNIQUES FOR RESTORING ACTIVE PIP EXTENSION

There are 2 distinctly different approaches; our preference is presented first.

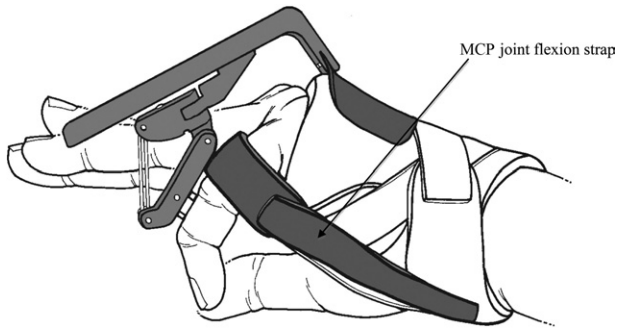

FIGURE 7: Attachment of the Digit Widget MCP flexion strap to prevent hyperextension of the MCP joint and optimize extension torque to the PIP joint.

Two-stage approach

First, reverse the PIP contracture; then, weeks later, surgically excise the contractile bands and nodules. Extension torque is initiated across the PIP joint using the elastic bands provided with the device. Three different-strength elastic bands (light, medium, and heavy) are supplied, with the magnitude of the torque defined by the strength of the band used (Fig. 8). Although no data exist to determine the optimal torque for a given patient, the goal of treatment is to use the least torque that continues to improve joint extension. Titrate the effect each force creates, starting with the light elastic band, monitoring both PIP joint extension and the finger's response to the torque. Although the strength and the number of elastic bands may be increased as needed, excessive torque should be avoided because it causes pain, swelling, and decreased active PIP joint motion. The elastic bands should be removed intermittently each day. Free of extension torque, active flexion and extension of all 4 fingers as parallel units help minimize finger stiffness while creating internal pressures that pump edema out of the finger. We flex and extend our own fingers to teach each patient how the interconnected muscles and tendons of our ulnar 3 fingers can optimize the active motion of the postoperative finger or fingers. The ulnar fingers remain jealous of the elegant and independent index. It rarely suffers from PIP contractures, and when it does, it is easiest to rehabilitate.

Many factors determine how quickly a PIP joint will respond to extension torque, including the degree and chronicity of the contracture, the presence of scar from prior surgery, the magnitude of the torque applied, and the response of each patient's soft tissues to the extension torque. The end point for maximum extension is best appreciated by a graph, supplied with the device, that plots the angle of maximum PIP joint extension

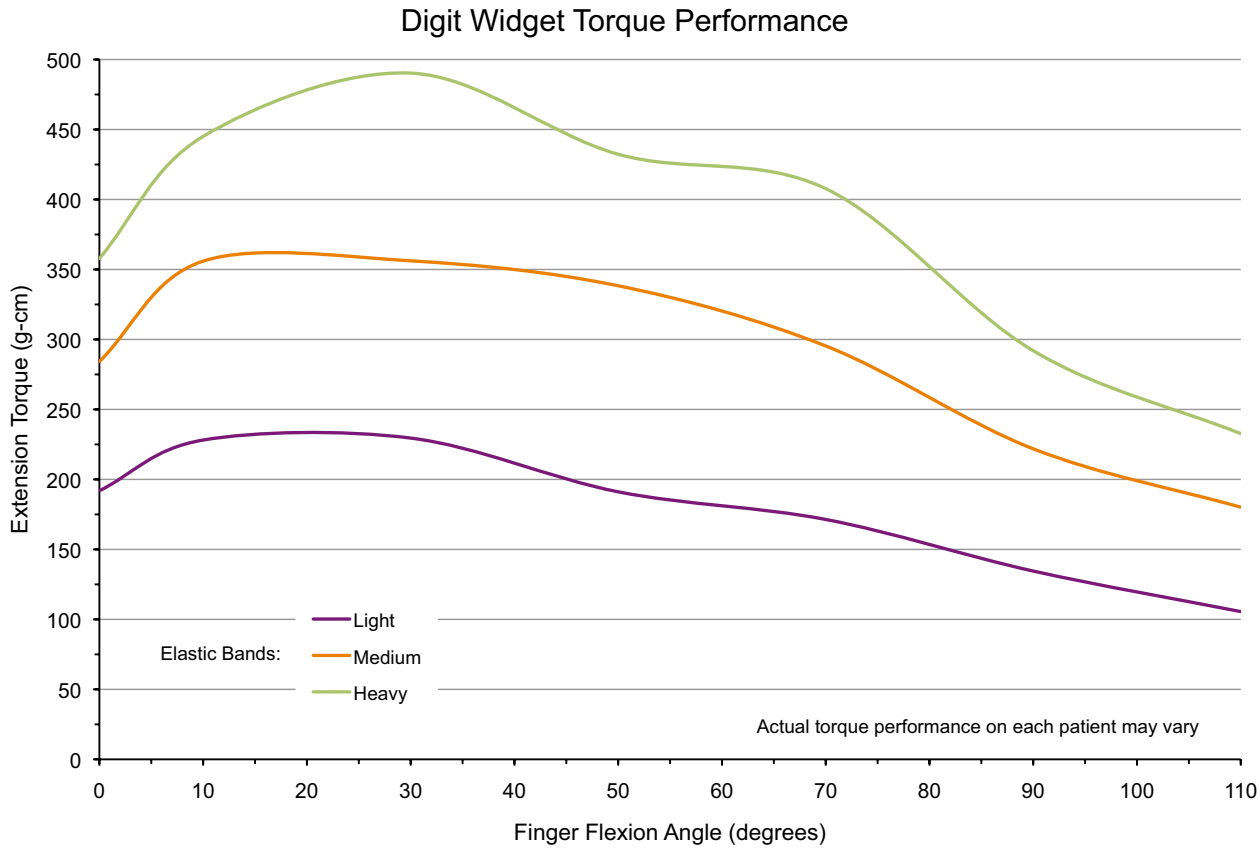

FIGURE 8: Extension torque generated by heavy, medium, and light elastic bands over the complete range of finger flexion angles.

against time (Fig. 9). The reversal of each PIP contracture is graphically illustrated by the change in the slope of the curve. Extension torque should be continued for approximately 2 weeks after maximum PIP extension is obtained. These additional weeks of extension force minimize elastic recoil of the PIP joint back into flexion.

With the PIP straighter, or straight, and the length of the palmar skin restored toward normal, the bands and nodules of Dupuytren disease are surgically excised.

When the postoperative wounds are adequately healed to start active range of motion exercises, MCP joints that hyperextended preoperatively must continue to be splinted in slight flexion postoperatively to ensure the distal transmission of extrinsic finger extensor forces to the finger's PIP joint. This technique of splinting the MCP joint in flexion should be continued until the skin of the finger regains much of its soft and compliant nature; this is a subjective call, but one that surgeons and hand therapists easily recognize.

Single-stage approach

At a single surgery, the bands and nodules of Dupuytren disease are excised and the Digit Widget's pins are threaded into the middle phalanx. Postoperatively, when the palmar wound is adequately healed to tolerate distraction (typically 10–14 d), the device is clamped to the pins and extension torque is initiated to reverse the PIP joint's contracture.

The residual contracture of the PIP joint capsule and volar plate combine with short palmar skin to require an initial postoperative position of PIP flexion. In some patients, this postoperative flexion compromises restoration of maximum PIP extension.

Given the choice, patients will pick the single-stage approach. However, the 2-stage approach produces superior restoration of active PIP joint extension compared with the single-stage approach.[3,5,6]

POSTOPERATIVE CARE

Patient instructions

- Elastic bands should be replaced daily.
- Active finger flexion is preferred over passive. For active finger flexion exercises, extension torque may be temporarily suspended by either removing the elastic band or detaching the hook and loop tab from the cuff.

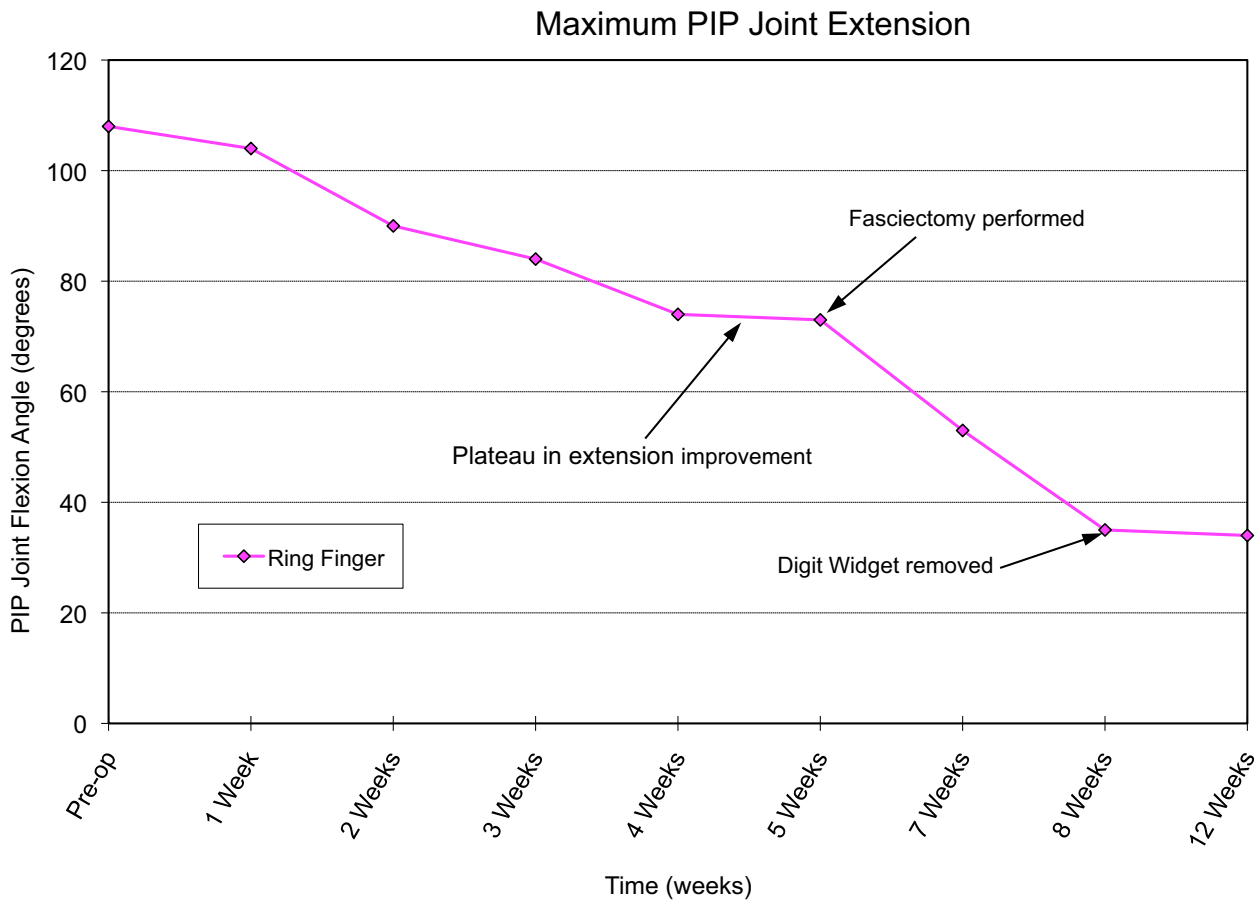

FIGURE 9: Improvement in PIP joint extension from preoperatively until 1 month after removal of the Digit Widget.

- The device should be kept free of foreign bodies and substances such as hand lotion or antibiotic ointment, which may compromise the ability of the connector assembly to slide freely.
- The cuff and connector assembly may be removed for washing or showering.
- The patient should be instructed in pin track care using the surgeon's method of choice.

Office removal of the device

Remove the connector assembly and cuff, and then unclamp the pin block from the pins. Manually unscrew the pins from the middle phalanx using a large needle holder.

CLINICAL CASE

A 41-year-old man with recurrent Dupuytren disease had contractures of 95° and 100° in the ring and little fingers, respectively (Fig. 10). Because this case was performed before we completely understood the benefits of the 2-stage approach described above, we used a combination of the 2 described approaches. During the surgical installation of a device on each finger, we used

FIGURE 10: Patient preoperatively: Dupuytren contractures of 95° and 100° on the ring and little fingers.

2 short transverse incisions to divide bands to the little finger that originated in the palm and in the area of the MCP joint. We made a single transverse incision to divide a band at the ring finger MCP joint flexor crease. Extension torque was initiated 1 week after surgery. After 3 weeks of extension torque, the ring and little fingers improved to 55° and 50°, respectively (Fig. 11). After 8 weeks of extension torque, improvement in PIP extension reached a plateau at 25° for both the ring and little finger PIP joints (Fig. 12). After 9 weeks of extension torque, we performed a fasciectomy on each

FIGURE 11: Patient after 3 weeks: Extension torque improved the flexion contractures to 55° and 50° on the ring and little fingers.

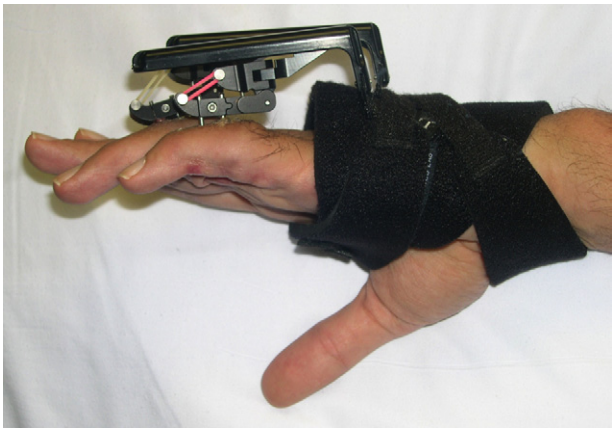

FIGURE 12: Patient after 8 weeks: Improvement in PIP joint extension reached a plateau at 25° for both the ring and little fingers.

FIGURE 13: Patient after 12 weeks: Extension torque was resumed 2 weeks postfasciectomy, with ring and little finger contractures at 35° and 30°.

FIGURE 14: Patient after 22 weeks: Flexion contractures of 16° and 29° on the ring and little fingers.

finger. When extension torque was resumed, 2 weeks postfasciectomy, ring and little finger contractures were 35° and 30°, respectively (Fig. 13). After extension torque for an additional 6 weeks, the devices were removed and the ring and little finger contractures were 26° and 19° respectively. After 5 weeks in therapy, the ring and little finger contractures were 16° and 29°, respectively (Fig. 14). The patient achieved full flexion in both fingers.

PEARLS AND PITFALLS

All PIP joint flexion contractures result from a torque imbalance. There is either

- too much flexion torque,
- not enough extension torque, or
- a combination of the two.

As the angular degree of each PIP flexion contracture increases, an extension torque is created for its MCP joint (Fig. 15). This force imbalance is created as PIP flexion pulls the extensor hood mechanism distally, thereby creating increased torque to extend the MCP. On the flexor side of the finger, resting tension in the profundus and superficialis tendons is incrementally reduced by their proximal translation, to create a decrease in flexion torque on the palm side of the MCP joint. This simple model of increased extension and reduced flexion torques at the finger's MCP joint reveals how a PIP contracture creates a torque imbalance for its MCP joint, favoring extension.

With an MCP torque imbalance favoring extension, if the tissues palmar to the MCP are compliant enough for the joint to gradually hyperextend, the extensor tendon will gradually lift off the dorsal side of the metacarpal head to increase its moment arm and thereby create additional torque for MCP hyperextension (Fig. 16). Dorsal displacement of the extensor tendon at the level of the MCP joint tensions the transverse fibers of its extensor hood mechanism and thereby limits proximal excursion of the extensor tendon and its central slip required for PIP extension.

Whereas advanced degrees of an MCP flexion contracture may complicate surgery for Dupuytren disease,

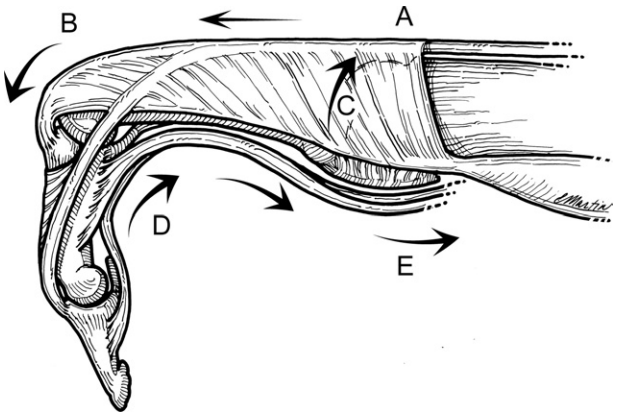

FIGURE 15: A PIP flexion contracture creates an extension torque for its MCP joint by pulling the extensor hood mechanism distally (A to B), creating increased torque to extend the MCP (C). In addition, the resting tension in the profundus and superficialis tendons is reduced by their proximal translation (D to E), creating a decrease in flexion torque on the palm side of the MCP joint. Therefore, a PIP flexion contracture creates a torque imbalance that favors extension of its MCP joint.

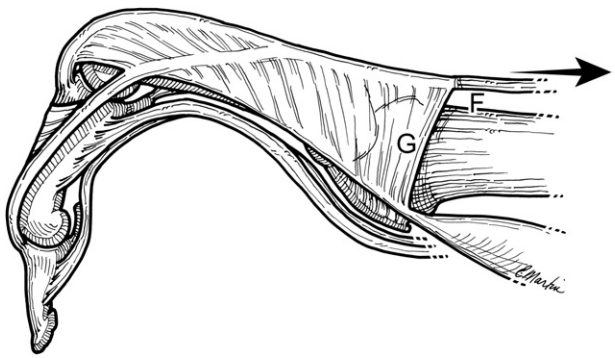

FIGURE 16: As compliant palmar tissues enable the MCP joint to hyperextend, the extensor tendon gradually lifts off the dorsal side of the metacarpal head to increase its moment arm (F) and create additional torque for MCP hyperextension. Dorsal displacement of the extensor tendon at the level of the MCP joint tightens the transverse fibers of its extensor hood mechanism (G), limiting the proximal excursion of the extensor tendon and its central slip that are required for PIP extension.

just enough contracture, or the addition of a splint to prevent MCP hyperextension, actually enhances distal transmission of tension forces across the MCP to extend the PIP (Fig. 17). Restoring central slip tension and excursion are critical issues in obtaining and maintaining active PIP joint extension after reversal of the PIP contracture.

This tendency of the finger's PIP and MCP joints to become clawlike is greater on the little and ring fingers,

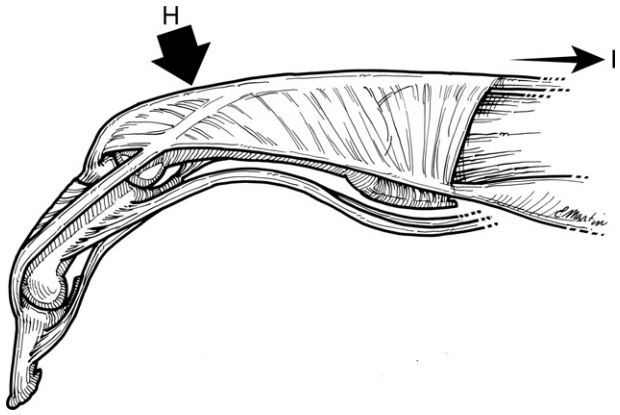

FIGURE 17: Although advanced degrees of an MCP flexion contracture may complicate surgery for Dupuytren disease, just enough contracture or the addition of a splint to prevent MCP hyperextension (H) actually enhances distal transmission of tension forces (I) across the MCP to extend the PIP. Restoring central slip tension and excursion are the 2 critical issues in obtaining and maintaining active PIP joint extension after reversal of the PIP contracture.

because their carpometacarpal joints have an arc of active motion. In contrast, the absence of carpometacarpal motion of the middle and index fingers decreases the fingers' tendency to collapse into a claw. This explains, in part, why the worst Dupuytren contractures occur on the ulnar 2 fingers.

An extension torque transmitted by skeletal pins will typically reverse the PIP contracture. However, it is difficult to maintain what appears to be a notable improvement in active PIP extension if its flexor profundus and superficialis have gained a larger lever arm than specified in Mother Nature's design, by the pulley's or joint capsule's prior injury or surgical release. Most important, once the device reverses the contracture, increased flexion torque from increased flexor tendon moment arms will guarantee the PIP joint's rapid return into flexion. If one cannot reconstruct these precious pulleys, and we cannot, recurrent contracture will occur in the patient's finger.

COMPLICATIONS

The etiology of most persistent or recurrent PIP contractures can be traced to our incomplete preoperative understanding of the force imbalance that created the contracture.

REFERENCES

1. Brandes G, Messina A, Reale E. The palmar fascia after treatment by the continuous extension technique for Dupuytren's contracture. J Hand Surg 1994;19B:528–533.

2. Bailey A, Tarlton J, Van Der Stappen J, Sims T, Messina A. The continuous elongation technique for severe Dupuytren's disease: a biochemical mechanism. J Hand Surg 1994;19B:522–527.
3. Craft R, Smith A, Coakley B, Casey W, Rebecca A, Duncan S. Preliminary soft-tissue distraction versus checkrein ligament release after fasciectomy in the treatment of Dupuytren proximal interphalangeal joint contractures. Plast Reconstr Surg 2011;128: 1107–1113.
4. Watson H, Light T, Johnson T. Checkrein resection for flexion contracture of the middle joint. J Hand Surg 1979;4A:67–71.
5. Messina A, Messina J. The continuous elongation treatment by the TEC device for severe Dupuytren's contracture of the fingers. Plast Reconstr Surg 1993;92:84–90.
6. Citron N, Messina J. The use of skeletal traction in the treatment of severe primary Dupuytren's disease. J Bone Joint Surg 1998;80B: 126–129.