

# Application of Hand Therapy Extensor Tendon Protocol to Toe Extensor Tendon Rehabilitation

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An innovative application of a hand extensor tendon repair protocol was applied by the hand therapy service to toe extensors when the hand surgery service was called in to repair toe extensor lacerations.

Plastic and orthopedic surgeons worked closely with therapists in military hospitals to rehabilitate soldiers afflicted with upper extremity trauma during World War II. Together, they developed treatment protocols. In 1975, the American Society for Hand Therapists (ASHT) was created during the American Society for Surgery of the Hand meeting. The ASHT application process required case studies, patient logs, and clinical hours, so membership was equivalent to competency. In May 1991, the first hand certification examination took place and designated the first group of certified hand therapists (CHT).<sup>1</sup>

In the US Department of Veterans Affairs collaboration takes place between different services and communication is facilitated using the electronic health record. The case presented here is an example of several services (emergency medicine, plastic/hand surgery, and occupational therapy) working together to develop a treatment plan for a condition that often goes undiagnosed or untreated. This article describes an innovative application of hand extensor tendon therapy clinical decision making to rehabilitate foot extensor tendons when the plastic surgery service was called on to work outside its usual comfort zone of the hand and upper extremity. The hand therapist applied hand extensor tendon rehabilitation principles to recover toe extensor lacerations.

Certified hand therapists (CHTs) are key to a successful hand surgery practice. The Plastic Surgery Service at the Malcom Randall

VA Medical Center in Gainesville, Florida, relies heavily on the CHTs to optimize patient outcomes. The hand surgery clinic and hand therapy clinics are in the same hospital building, allowing for easy face-to-face communication. Hand therapy students are able to observe cases in the operating room. Immediately after surgery, follow-up consults are scheduled to coordinate postoperative care between the services.

## CASE PRESENTATION

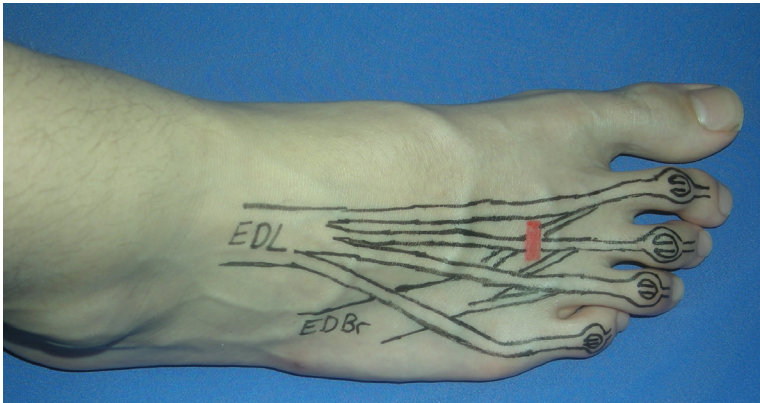
A 66-year-old man with a history of chronic obstructive pulmonary disease and spinal stenosis presented to the emergency department (ED) with a right dorsal foot wound and an exposed lacerated tendon after dropping a mirror on his foot (Figure 1). He was unable to extend his third toe. The ED physician called the in-house plastic surgery service, which can expedite upper extremity tendon injuries to clinic and surgery if indicated.<sup>2</sup>

The next day, the patient was examined in the plastic surgery clinic and found to have a completely lacerated extensor digitorum brevis to the second toe and a completely lacerated extensor digitorum longus to the third toe. These were located proximal to the metatarsal phalangeal joints. Surgery was scheduled for the following week.

In surgery, the tendons were sharply debrided and repaired using a 3.0 Ethibond suture placed in a modified Kessler technique followed by a horizontal mattress for a total of a 4-core repair. This was reinforced with a No. 6 Prolene to the paratendon. The

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**FIGURE 1** Tendon Laceration



Abbreviations: EDBr, extensor digitorum brevis; EDL, extensor digitorum longus. Red box is simulated site of laceration involving the EDL to the third toe and the EDBr to the second toe.

**FIGURE 2** Foot Orthosis With Toe Extension Device



surgery was performed under IV sedation and an ankle block, using 17 minutes of tourniquet time.

On postoperative day 1, the patient was seen in plastic surgery and occupational therapy clinic. The hand therapist modified the hand extensor tendon repair protocol since there was no known protocol for repairs of the foot and toe extensor tendon. The patient was placed in an ankle foot orthosis with a toe extension device created by heating and molding a low-temperature thermoplastic sheet (Figure 2). The toes were boosted into slight hyper extension. This was done to reduce tension across the extensor tendon re-

pair site. All of the toes were held in about 20° of extension, as the extensor digitorum longus (EDL) has a common origin, to aide in adherence of wearing and for comfort. No standing or weight bearing was permitted for 3 weeks.

A wheelchair was issued in lieu of crutches to inhibit the work of toe extension with gait swing-through. Otherwise, the patient would generate tension on the extensor tendon in order for the toes to clear the ground. It was postulated that it would be difficult to turn off the toe extensors while using crutches. Maximal laxity was desired because edema and early scar formation could increase tension on the repair, resulting in rupture if the patient tried to fire the muscle belly even while in passive extension.

The patient kept his appointments and progressed steadily. He started passive toe extension and relaxation once per day for 30 repetitions at 1 week to aide in tendon glide. He started place and hold techniques in toe extension at 3 weeks. This progressed to active extension 50% effort plus active flexion at 4 weeks after surgery, then 75% extension effort plus toe towel crunches at 5 weeks. Toe crunches are toe flexion exercises with a washcloth on the floor with active bending of the toes with light resistance similar to picking up a marble with the toes. He was found to have a third toe extensor lag at that time that was correctible. The patient was actively able to flex and extend the toe independently. The early extension lag was felt to be secondary to edema and scar formation, which, over time are anticipated to resolve and contract and effectively shorten the tendon. Tendon gliding, and scar massage were reviewed. The patient's last therapy session occurred 7 weeks after surgery, and he was cleared for full activity at 12 weeks. There was no further follow-up as he was planning on back surgery 2 weeks later.

## DISCUSSION

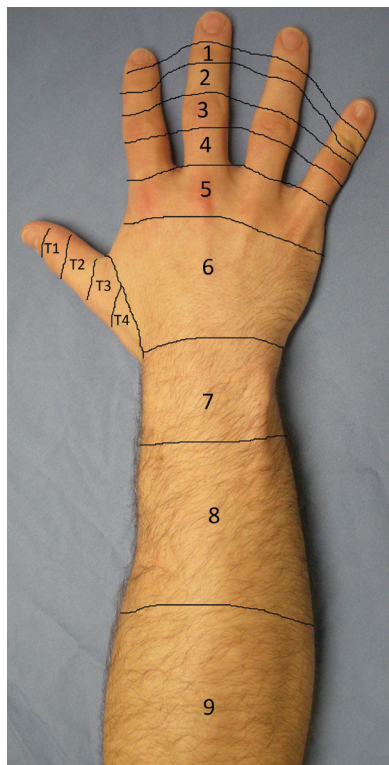
The North Florida/South Georgia Veterans Health System is fortunate to have 4 CHTs on staff. CHTs take a 200 question 4 hour certifying exam after being licensed for a minimum of 3 years as a physical or occupational therapist and completing 4,000 hours of direct upper extremity patient experience. Pass

rates from 2008 to 2018 ranged from 52% to 68%.<sup>3</sup> These clinicians are key to the success of our hand surgery service, utilizing their education and skills on our elective and trauma cases. The hand therapy service applied their knowledge of hand extensor rehabilitation protocols to rehabilitate the patient's toe extensor in the absence of clear guidelines.

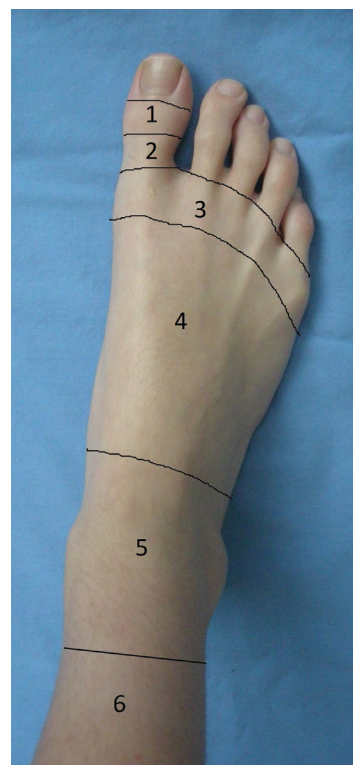
Hand extensor tendon rehabilitation protocols are based on the location of the repair on the hand or forearm. Nine extensor zones are named, distal to proximal, from the distal interphalangeal joints to the proximal forearm (Figure 3). In his review of extensor hallucis longus (EHL) repairs, Al-Qattan described 6 foot-extensor tendon zones, distal to proximal, from the first toe at the insertion of the big toe extensor to the distal leg proximal to the extensor retinaculum (Figure 4).<sup>4</sup> Zone 3 is over the metatarsophalangeal joint; zone 5 is under the extensor retinaculum. The extensor tendon repairs described in this report were in dorsal foot zone 4 (proximal to the metatarsophalangeal joint and over the metatarsals), which would be most comparable to hand extensor zone 6 (proximal to the metacarpal phalangeal joint and over the metacarpals).

The EDL originates on the lateral condyle of the tibia and anterior surface of the fibula and the interosseous membrane, passes under the extensor retinaculum, and divides into 4 separate tendons. The 4 tendons split into 3 slips; the central one inserts on the middle phalanx, and the lateral ones insert onto the distal phalanx of the 4 lateral toes, which allows for toe extension.<sup>5</sup> The EDL common origin for the muscle belly that serves 4 tendon slips has clinical significance because rehabilitation for one digit will affect the others. Knowledge of the anatomical structures guides the clinical decision making whether it is in the hand or foot. The EDL works synergistically with the extensor digitorum brevis (EDBr) to dorsiflex (extend) the toe phalanges. The EDB originates at the supralateral surface of the calcaneus, lateral talocalcaneal ligament and cruciate crural ligament and inserts at the lateral side of the EDL of second, third, and fourth toes at the level of the metatarsophalangeal joint.<sup>6</sup>

**FIGURE 3** Extensor Zones in the Hand



**FIGURE 4** Extensor Zones in the Foot



Repair of lacerated extensor tendons in the foot is the recommended treatment. Chronic extensor lag of the phalanges can result in a claw toe deformity, difficulty controlling the toes when putting on shoes or socks, and catching of the toe on fabric or insoles.<sup>7</sup> The extensor tendons are close to the deep and superficial peroneal nerves and to the dorsalis pedis artery, none of which were involved in this case report.

There are case reports and series of EHL repairs that all involve at least 3 weeks of immobilization.<sup>4,8,9</sup> The EHL dorsiflexes the big toe. Al-Qattan's series involved placing K wires across the interphalangeal joint of the big toe and across the metatarsophalangeal joint, which were removed at 6 weeks, in addition to 3.0 polypropylene tendon mattress sutures. All patients in this series healed without tendon rupture or infection. Our PubMed search did not reveal any specific protocol for the EDL or EDB tendons, which are anatomically most comparable to the extensor digitorum communis (EDC) tendons in the hand. The EDC originates at the lateral epicondyle of the humerus, also

**FIGURE 5** Yoke Splint for Hand Extensor Tendon Rehabilitation



divides into 4 separate tendons and is responsible for extending the 4 ulnar sided fingers at the metacarpophalangeal joint.<sup>10</sup>

Tendon repair protocols are a balance between preventing tendon rupture by too aggressive therapy and with preventing tendon adhesions from prolonged immobilization. Orthotic fabrication plays a key early role with blocking possible forces creating unacceptable strain or tension across the surgical repair site. Traditionally, extensor tendon repairs in the hand were immobilized for at least 3 weeks to prevent rupture. This is still the preferred protocol for the patient unwilling or unable to follow instructions. The downside to this method is extension lags, extrinsic tightness, and adhesions that prevent flexion, which can require prolonged therapy or tenolysis surgery to correct.<sup>11-13</sup>

Early passive motion (EPM) was promoted in the 1980s when studies found better functional outcomes and fewer adhesions. This involved either a dynamic extension splint that relied on elastic bands (Louisville protocol) to keep tension off the repair or the Duran protocol that relied on a static splint and the patient doing the passive exercises with his other uninjured hand. Critics of the EPM protocol point to the costs of the splints and demands of postoperative hand therapy.<sup>11</sup>

Early active motion (EAM) is the most recent development in hand tendon rehabilitation and starts within days of surgery. Studies have found an earlier regain of total active motion in patients who are mobilized earlier.<sup>12</sup> EAM protocols can be divided into controlled active motion (CAM) and relative motion extension splinting (RMES). CAM

splints are forearm based and cross more joints. Relative motion splinting is the least restrictive, which makes it less likely that the patient will remove it. Patient friendly splints are ideal because tendon ruptures are often secondary to nonadherence.<sup>13</sup> The yoke splint is an example of a RMES, which places the repaired digit in slightly greater extension at the metacarpal phalangeal joint than the other digits (Figure 5), allowing use of the uninjured digits.

The toe extensors do not have the juncturae tendinum connecting the individual EDL tendons to each other, as found between the EDC tendons in the hand. These connective bands can mask a single extensor tendon laceration in the hand when the patient is still able to extend the digit to neutral in the event of a more proximal dorsal hand laceration. A case can be made for closing the skin only in lesser toe extensor injuries in poor surgical candidates because the extensor lag would not be appreciated functionally when wearing shoes. There would be less functional impact when letting a toe extensor go untreated compared with that of a hand extensor. Routine activities such as typing or getting the fingers into a tight pocket could be challenging if hand extensors were untreated. The rehabilitation for toe extensors is more inconvenient when a patient is nonweight bearing, compared with wearing a hand yoke splint.

## CONCLUSION

The case described used an early passive motion protocol without the dynamic splint to rehabilitate the third toe EDL and second toe EDB. This was felt to be the most patient and therapist friendly option, given the previously uncharted territory. The foot orthosis was in stock at the adjacent physical therapy clinic, and the toe booster was created in the hand therapy clinic with readily available supplies. Ideally, one would like to return structures to their anatomic site and control the healing process in the event of a traumatic injury to prevent nonanatomic healing between structures and painful scar adhesions in an area with little subcutaneous tissue. This patient's tendon repair was still intact at 7 weeks and on his way to recovery, demonstrating good scar management techniques. The risks and benefits to lesser toe

tendon repair and recovery would have to be weighed on an individual basis.

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### Author disclosures

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### Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of *Federal Practitioner*, Frontline Medical Communications Inc., the US Government, or any of its agencies.

### References

1. Hand Therapy Certification Commission. History of HTCC. <https://www.htcc.org/consumer-information/about-htcc/history-of-htcc>. Accessed November 8, 2019.
2. Coady-Fariborzian L, McGreane A. Comparison of hand emergency triage before and after specialty templates (2007 vs 2012). *Hand (N Y)*. 2015;10(2):215-220.
3. Hand Therapy Certification Commission. Passing rates for the CHT exam. <https://www.htcc.org/certify/exam-results/passing-rates>. Accessed November 8, 2019.
4. Al-Qattan MM. Surgical treatment and results in 17 cases of open lacerations of the extensor hallucis longus tendon. *J Plast Reconstr Aesthet Surg*. 2007;60(4):360-367.
5. Wheeless CR. Wheeless' textbook of orthopaedics: extensor digitorum longus. [http://www.wheelessonline.com/ortho/extensor\\_digitorum\\_longus](http://www.wheelessonline.com/ortho/extensor_digitorum_longus). Updated December 8, 2011. Accessed November 8, 2019.
6. Wheeless CR. Wheeless' textbook of orthopaedics: extensor digitorum brevis. [http://www.wheelessonline.com/ortho/extensor\\_digitorum\\_brevis](http://www.wheelessonline.com/ortho/extensor_digitorum_brevis). Updated March 4, 2018. Accessed November 8, 2019.
7. Coughlin M, Schon L. Disorders of tendons. <https://musculoskeletalkey.com/disorders-of-tendons-2/#s0035>. Published August 27, 2016. Accessed November 8, 2019.
8. Bronner S, Ojofeitimi S, Rose D. Repair and rehabilitation of extensor hallucis longus and brevis tendon lacerations in a professional dancer. *J Orthop Sports Phys Ther*. 2008;38(6):362-370.
9. Wong JC, Daniel JN, Raikin SM. Repair of acute extensor hallucis longus tendon injuries: a retrospective review. *Foot Ankle Spec*. 2014;7(1):45-51.
10. Wheeless CR. Wheeless' textbook of orthopaedics: extensor digitorum communis. [http://www.wheelessonline.com/ortho/extensor\\_digitorum\\_communis](http://www.wheelessonline.com/ortho/extensor_digitorum_communis). Updated March 4, 2018. Accessed November 8, 2019.
11. Hall B, Lee H, Page R, Rosenwax L, Lee AH. Comparing three postoperative treatment protocols for extensor tendon repair in zones V and VI of the hand. *Am J Occup Ther*. 2010;64(5):682-688.
12. Wong AL, Wilson M, Girnary S, Nojoomi M, Acharya S, Paul SM. The optimal orthosis and motion protocol for extensor tendon injury in zones IV-VIII: a systematic review. *J Hand Ther*. 2017;30(4):447-456.
13. Collocott SJ, Kelly E, Ellis RF. Optimal early active mobilisation protocol after extensor tendon repairs in zones V and VI: a systematic review of literature. *Hand Ther*. 2018;23(1):3-18.