

Extensor Tendon Repair and Reconstruction



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KEYWORDS

• Extensor tendon • Repair • Reconstruction • Grafting • Free flap

KEY POINTS

- Extensor tendon reconstruction requires various complex hand surgery techniques, including direct tendon repair, tendon grafting transfer, and soft tissue reconstruction with local and free flaps.
- Choosing the best reconstruction plan for each individual patient based on the specific defect is crucial.

ANATOMY

Extensor Muscles

Extensor tendons arise from the corresponding extensor muscle bellies that coordinate extension of the wrist and fingers. All of the extensor muscles are innervated by branches of the radial nerve (C6–C8). The extensor muscle bellies arise from 2 main anatomic origins: a superficial and a deep layer.¹ The deep layer of muscles have their origin on the ulna and radius in their mid portion. The deep muscles include the extensor muscles of the thumb and fingers (dorsal compartment 1, 3, and 4): extensor pollicis brevis (EPB), abductor pollicis longus (APL), extensor pollicis longus (EPL), extensor digitorum communis (EDC), and extensor indicis proprius (EIP). The more superficial muscles consist of the extensors of the wrist: extensor carpi radialis longus (ECRL), extensor carpi radialis brevis (ECRB), extensor digiti minimi (EDM), and extensor carpi ulnaris (ECU). The outcropping muscles (APL, EPB, and EPL) originate only from the mid-ulna and interosseous membrane, coursing over the ECRL and ECRB tendons at a level just proximal to the wrist.

Anatomic variations of extensor muscles have been described. The accessory extensor carpi radialis intermedius is found in 12% of hands² and can be used as additional option for tendon

transfers. Another common anatomic variation is an individual extensor muscle of the middle finger, the extensor medii proprius, which is reported to be found in 10% of limbs.³

Extensor Tendon Compartments

The extensor tendons enter the dorsum of the hand via 6 extensor tendon compartments covered by the extensor retinaculum, which spans from the pisiform and triquetrum to the radiopalmar radius. In most patients, the musculotendinous junction is located approximately 4 cm proximal to the wrist joint. As an exception, the EIP tendon carries muscle fibers to the level of the wrist joint. The first compartment on the radio-dorsal aspect of the wrist includes the tendons of the EPB and APL. The second compartment contains the ECRL and ECRB tendons. The third compartment consists only of the EPL tendon bending around the Lister tubercle. The fourth dorsal compartment has 5 tendons: the 4 EDC tendons and the deeper EIP tendon. The fifth and sixth dorsal compartments also only contain one tendon each: the EDM tendon and the ECU tendon, respectively. Although the retinaculum of all of the other compartments are attached to bone, the fifth extensor compartment is a fibrous tunnel, only without any bony attachments.^{4,5}

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Dorsal Hand

Extensor tendons have independent gliding properties but also have connections to their neighboring tendons. The intertendinous connections, connexus intertendinei, or juncturae tendinum play a central role in extensor tendon biomechanics. Located proximal to the metacarpophalangeal joints, these 3 fibrous ligaments connect the extensor tendons of the EDC. Junctura A connects the extensor tendons of the index and long finger, junctura B connects the extensor tendons of the long and ring finger, and junctura C connects the extensors tendons of the ring and small finger.¹ The patterns of the intertendinous connections can be classified into type 1, filamentous band; type 2, fibrous band; and type 3, tendinous band.⁶ The 3 key functions of the intertendinous connections are stabilization of the metacarpophalangeal joints, force distribution during finger extension, and coordination of tendon movements.⁷ In addition, the juncturae limit extension of the middle and ring finger when the other fingers are flexed at the level of the metacarpophalangeal joints.⁴ The function of the intertendinous connections must be considered, especially when examining a potential extensor tendon laceration at the dorsal aspect of the hand. An intact neighboring extensor digitorum communis tendon could mimic finger extension via the intertendinous connection in lacerated tendons, especially when the extensor tendon lacerations are proximal to the intertendinous connections.⁸

The Extensor Mechanism of the Digits

The anatomy of the extensor tendons at the level of the fingers consists of a complex arrangement of the extrinsic extensor tendons and the intrinsic muscle of the hand. The extensor tendons maintain their central orientation at the level of the metacarpophalangeal joints via the sagittal bands, which are a bundle of dense circular fibers originating from the volar plate and the deep metacarpal ligaments. The sagittal bands also prevent hyperextension in the metacarpophalangeal joint. The extensor tendon does not insert on the proximal phalanx. Beyond the sagittal band, the extensor tendon flares slightly into 3 portions: a central, more robust slip, and 2 lateral slips. A contiguous extensor expansion or hood is created. The central slip inserts onto the base of the middle phalanx, whereas the lateral slips pass to the lateral aspect of the proximal interphalangeal (PIP) joint. Distal to the PIP joints, the lateral slips unite with the lateral bands of the intrinsic muscles (see later discussion) forming the conjoined lateral bands. The conjoined lateral bands on either side of the digit course dorsally to merge on the dorsum

of the finger to form the terminal tendon, which inserts at the base of the distal phalanx.

Biomechanically, the extension of the metacarpophalangeal joint is caused by the EDC tendon pulling on the sagittal bands, consequently extending the metacarpophalangeal joint. The central slip and the lateral bands work together to extend the middle phalanx. The terminal tendon extends the distal interphalangeal (DIP) joint.

Intrinsic Muscles

The lumbrical muscles and dorsal and volar interosseous muscles initiate metacarpophalangeal joint flexion before contributing to the extension of the PIP and DIP joints. The dorsal interossei also contribute to digit abduction, whereas the volar interossei contribute to adduction. Each interosseous muscle is innervated by the ulnar nerve. The first and second lumbrical muscles are innervated by the median nerve, whereas the third and fourth lumbrical muscles are innervated by the ulnar nerve. A unique feature of the lumbrical muscles is that they arise from the tendons of the flexor digitorum profundus tendon (FDP) and thus have a mobile origin. The activity of the lumbrical muscles is therefore directly dependent on the integrity of the FDP muscle-tendon system. The lumbrical muscles insert into the extensor expansion at the level of the radial metacarpophalangeal joints of the 2 to 5 digits. They flex the metacarpophalangeal joints while extending the corresponding IP joints, provided that the FDP tendons are relaxed. However, the predominant metacarpophalangeal flexors of the hand are the interossei.¹ The transverse retinacular ligament maintains the precise biomechanical balance of the central slip and the lateral bands. The triangular ligament bridges the gap between the distal aspects of the conjoint tendons before they fuse over the middle phalanx and insert on the distal phalanx.

EXTENSOR TENDON INJURIES

Zones of Injury

Comparable to flexor tendon injuries, extensor tendon injuries are subdivided into 8 zones based on the localization of the injury.⁹ Even-numbered zones are between joints and odd-numbered zones refer to injuries located above joints. The zone of injury is of utmost clinical relevance, because different treatment approaches apply to lacerations in the different zones (**Fig. 1**).

Assessment of Extensor Tendon Lacerations

Because of their superficial exposure close to the skin, extensor tendons are prone to lacerations.

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