Restoration of Pinch in Intrinsic Muscles of the Hand

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KEYWORDS

• Restoration • Pinch • Intrinsic muscles • Hand

One of the integral functions of the intrinsic muscles is thumb to index finger key and tip pinch. This function is important for many activities of daily living such as using keys, holding eating utensils, getting dressed (buttons and zippers), holding a toothbrush, opening small caps, and tearing open packages. The intrinsic muscles primarily involved in this action are the adductor pollicis (AP) muscle, the first dorsal interosseous (DI) muscle, and the flexor pollicis brevis (FPB) muscle.

ANATOMY

AP Muscle

The AP muscle is composed of 2 heads: transverse and oblique. Both heads are innervated by the motor branch of the ulnar nerve as the nerve passes between the 2 heads. The radial artery also passes between the 2 heads of the AP, from dorsal to palmar, to become the deep arch. The transverse head of the AP is broad and originates from the palmar aspect of the third metacarpal bone and inserts on the ulnar aspect of the thumb proximal phalanx base along with the oblique AP head and the deep head of the FPB. The oblique head originates from the palmar aspects of the second and third metacarpal bones, the capitate bone, the intercarpal ligaments, and the flexor carpi radialis (FCR) sheath. It inserts on the ulnar aspect of the thumb proximal phalanx base via a conjoint tendon that passes through the ulnar sesamoid bone of the thumb metacarpophalangeal (MP) joint. The action of the muscle is to bring the thumb back to the plane of the palm and it is assisted by the FPB and the opponens pollicis.[1]

First DI Muscle

The first DI muscle is bipennate and originates on both the radial side of the second metacarpal bone and the proximal ulnar portion of the first metacarpal bone. It inserts on the radial aspect of the index finger proximal phalanx base and the index finger dorsal tendinous hood. The radial artery passes between the 2 heads as it courses from dorsal to palmar. Innervation of the first DI is the ulnar nerve. Its action is to abduct the index finger from the middle finger and assist the lumbricals in MP joint flexion and interphalangeal (IP) joint extension.[1]

FPB Muscle

The FPB has 2 heads: superficial and deep. The superficial head originates from the trapezium bone and the distal edge of the transverse carpal ligament. It inserts on the radial aspect of the thumb proximal phalanx base through the radial sesamoid bone of the thumb MP joint. The deep head is smaller and originates from the ulnar palmar portion of the first metacarpal bone and inserts on the ulnar aspect of the thumb proximal phalanx base along with the conjoint tendon of the transverse and oblique heads of the AP

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muscle. The superficial head is innervated by the motor branch of the median nerve, and the deep head is innervated by the deep motor branch of the ulnar nerve. The action of the FPB is to flex the thumb MP joint.[1]

PATHOANATOMY

Loss of AP, FPB, and first DI muscle function results in weakness of thumb adduction, thumb MP flexion, and index finger MP stabilization. The patient feels that there is weakness of thumb key and tip pinch, among other activities of daily living stated earlier. Biomechanical studies suggest that up to 80% loss of power pinch occurs in patients with ulnar nerve palsy.[2] In cases of complete ulnar nerve palsy, the only adductor of the thumb remaining is the extensor pollicis longus (EPL)[3]; however, the remaining adduction is weak. If the joints are lax, contraction of the EPL, extensor pollicis brevis (EPB), and flexor pollicis longus (FPL) without the balancing action of the intrinsic muscles results in a concertina Z deformity of the thumb with MP hyperextension and IP joint flexion. Physical examination displays the telltale Froment sign: when the patient attempts to perform key pinch, the IP joint actively flexes as the patient uses the anterior interosseous nerve–innervated FPL to compensate for the lack of the AP, first DI, and portion of FPB function. The Jeanne sign is present if there is MP joint hyperextension.

ETIOLOGY

Several diseases or injuries can adversely affect a person's ability to initiate or generate pinch with adequate strength. Altered anatomy of the thumb or index finger due to trauma, congenital anomalies, degenerative and inflammatory joint disease, or extrinsic muscle/tendon abnormalities can adversely affect pinching mechanics.

Intrinsic muscle weakness affecting pinch primarily occurs as a result of disease involving the ulnar nerve. Most common neural causes include high or low crush injuries, partial or complete nerve laceration, brachial plexus injuries affecting ulnar nerve function, advanced ulnar nerve compression syndromes, cerebral vascular disease, or brain injury. Atypical causes of intrinsic muscle weakness include ulnar artery aneurysms and neuromuscular diseases, such as spastic cerebral palsy creating a thumb in palm deformity.

TREATMENT

When weakness is debilitating, then surgical management may be considered after the patient has completed a course of hand therapy and exercises to optimize compensating muscles. Hand therapy may consist of use of the EPL for adduction and FPL thumb flexion toward the index finger for pinch. Splints to stabilize the thumb MP joint and adaptive devices such as thicker handles for grasp during activities of daily living may be helpful. The goals of reconstructive surgery are to restore thumb adduction, stabilize the index finger MP joint so that the index finger is not pushed ulnarward by the thumb when pinching, and to stabilize the thumb MP and IP joints. Surgical management falls in 3 distinct categories: (1) augmentation of the AP muscle, (2) augmentation of the first DI muscle, and (3) stabilization of the thumb and index finger.

Augmentation of the AP Muscle

The need to restore the AP muscle during key or tip pinch requires use of a strong motor, such as the extensor carpi radialis brevis (ECRB), brachioradialis, flexor digitorum superficialis (FDS) III or IV, extensor indicis proprius (EIP), or extensor digiti quinti. Critical to any muscle tendon transfer to restore adductor function is the ability to maximize excursion, properly set tension, and use a functional pulley with as simple a direction of pull as possible.

Transfer techniques using wrist extensor motors require tendon lengthening with a tendon autograft, such as palmaris longus (PL), half of FCR, EIP, plantaris, or extensor digitorum longus donors. There is a trade-off between taking advantage of wrist extensor motor power and needing to use a tendon graft.

The choice between techniques should be based on several clinical factors. Patient demand, age, intact donor motor innervation, and the presence or absence of any associated functional deficits are critical in selecting a donor motor tendon unit. The main advantage of selecting a wrist extensor as a donor motor is that wrist extension and pinch are synergistic actions. Extrinsic digital extensors are weaker than superficial extrinsic digital flexors, and neither is as strong as a wrist extensor donor. The benefit of using an extrinsic digital motor is the ability to perform direct transfer without tendon graft. The trade-off is related to the amount of pinch strength that can be restored.

ECRB to AP muscle tendon transfer (lengthened via tendon graft)

Whether using the ECRB, the extensor carpi radialis longus as described by Solonen and Bakalim,[4] the extensor carpi ulnaris using the distal ulna as a pulley or brachioradialis as described by Boyes,[5] all thumb adductor tendon transfers using a wrist extensor donor requires a tendon graft extension.