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Anatomy, Shoulder and Upper Limb, Hand Adductor Pollicis

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Introduction

The musculature of the hand is deeply intricate, with several superimposed layers of muscles, tendons, and fascial compartments throughout. Complex interactions between these groups modulate specific movements, thus understanding their role in hand biomechanics can greatly enhance clinical evaluation and diagnosis for medical professionals.

The thumb is one of the most important entities of the hand. Its versatility in movement compared to the other digits makes the hand the ultimate tool of elite dexterity. Because the thumb is orientated perpendicular to the other digits, its movements are modulated by a diverse set of specific muscles within the hand. Many muscles contribute to its movements, and one of the most important is the adductor pollicis.

The adductor pollicis muscle is an intrinsic muscle of the hand which lies in the deepest muscular plane of the palm, within the adductor compartment. It is a unique muscle, in that it is triangular shaped with a 2-headed structure. The oblique head originates at the capitate as well as at the bases of the 2nd and 3rd metacarpals, while the transverse head originates from the volar aspect of the 3rd metacarpal. These two heads then merge as the fibers travel laterally, forming the tendon of the adductor pollicis which often contains a sesamoid bone. The tendon then inserts on the medial aspect of the proximal phalanx of the thumb as well as the extensor hood.

Structure and Function

The main function of the adductor pollicis is to adduct the thumb. Because of the altered plane of the thumb in relation to the palm and other digits, adduction, in this case, refers to bringing the thumb into a position of opposition at the center of the palm. Additionally, the adductor pollicis can bring the thumb alongside the palm and index finger.

The ability to adduct the thumb is critical for hand dexterity. Pinching and gripping are the two principal movements that necessitate that the adduction processes of the thumb be intact.

Embryology

Beginning on day 26, week 4 of the fetal period, the upper limb begins to form as a limb bud of mesodermal tissue from somites and the lateral plate. The limb forms in the proximal to distal direction and is controlled by several different signaling centers which produce specific factors that control differentiation. The signaling centers include the apical ectodermal ridge (AER) which controls proximal-distal signaling by inducing differentiation of underlying mesoderm and programmed cell death of interdigital tissue, the zone of polarizing activity (ZPA) which controls radioulnar limb formation via production of sonic hedgehog protein (SHH), and the Wnt pathway which regulates the ventral/dorsal limb axis.[1][2] Disruptions to any one of these three processes can ultimately lead to developmental anomalies of the upper limb.

At about day 36, chondrogenic formations of the digits arise which then begins the entire formation of hand structures. During the sixth and seventh week, early muscle masses are beginning to form throughout the upper extremity and hand. This is the time when the formation of the intrinsic hand muscles begins, including the adductor pollicis development. During week 7, the interdigital apoptosis occurs, allowing the formation of separate digits and followed by ossification of the upper extremity bones in week 8. The majority of upper limb development is complete by week 8, thus developmental abnormalities of the UE are likely to arise in weeks 3 through 8.

Blood Supply and Lymphatics

The deep palmar arterial arch is the main blood supply to the adductor pollicis. The adductor pollicis is an important anatomical landmark for the radial artery. As the radial artery enters the hand, it passes through the two heads of the first dorsal interosseous muscle and then proceeds to pass anteromedially between the two heads of the adductor pollicis. After passing between the two heads, the artery enters into the deep compartment of the hand to form the deep palmar arch.

Superficial lymphatic channels that travel alongside the basilic and cephalic veins drain the hand to the cubital, epitrochlear, and supratrochlear lymph nodes of the elbow. These nodes then drain into the deep brachial and deltopectoral lymph nodes and ultimately terminate at the infraclavicular and axillary lymph nodes.

Nerves

The adductor pollicis is innervated by the deep branch of the ulnar nerve (C8-T1). Understanding the pathway of the ulnar nerve is important for assessing clinical symptomatology of neuromuscular upper extremity injuries. The ulnar nerve is the terminal branch of the medial cord of the brachial plexus and it courses distally, running posterior to the medial epicondyle of the elbow at the cubital tunnel. Once in the forearm, it pierces the two heads of the flexor carpi ulnaris, giving off several branches to innervate two forearm muscles. It then traverses the wrist by traveling superficial to the flexor retinaculum and enters the hand via the Guyon canal. Once in the hand, it divides its superficial and deep branches. The deep branch specifically travels between the muscles of the hypothenar eminence to the deep compartment of the palm to join the deep palmar arterial arch. In addition to the adductor pollicis, the deep branch also innervates the hypothenar muscles, the medial two lumbricals, the interossei of the hand, and the palmaris brevis.

Muscles

Nine total muscles contribute to the diverse movements of the thumb. These muscles can be subdivided into two groups by the location of the muscle fibers in relation to the thumb: extrinsic (muscles in the forearm) and intrinsic (muscles in the hand). The four extrinsic muscles influencing thumb movement include (1) abductor pollicis longus which abducts/extends the MCP joint, (2) extensor pollicis brevis which extends the MCP joint, (3) extensor pollicis longus which extends the MCP/IP joints, and (4) flexor pollicis longus which flexes the MCP/IP joints.

There are five intrinsic muscles which help facilitate thumb movement. With regards to the intrinsic muscles, the first group can be classified as the thenar eminence, a group of three muscles at the base of the thumb which includes (1) the abductor pollicis brevis which abducts the MCP and flexes the IP joint, (2) flexor pollicis brevis which flexes the MCP joint, and (3) the opponens pollicis which opposes/adducts the thumb. The final two intrinsic muscles include the

first dorsal interosseous muscle and the adductor pollicis which both participate in thumb adduction.

Physiologic Variants

Within the two heads of the adductor pollicis, they can be subdivided into nine different fascicles. With nine different fascicles, there is considerable variation in regards to exact origins and insertions.[3] Each head of the muscle contains two layers of fascicles. The transverse head contains two palmar and two dorsal fascicles, while the oblique head contains three dorsal and two palmar fascicles. With the nine different fascicles, there are a number of minor reportable differences which give variation in the biomechanical properties of individual thumbs.

Surgical Considerations

Surrogate Marker for Malnutrition

The thickness of the adductor pollicis muscle (TAPM) has been proposed recently as a relatively accurate marker of malnutrition in surgical patients.[4][5] As malnutrition is a significant cause of morbidity and mortality in surgical cases, utilizing this measurement may better help to diagnose this and improve outcomes. Currently, the data is not very strong to support regular use of this measurement, but it is nonetheless being investigated as a potential option to assess malnutrition moving forward.

Thumb-in-Palm Deformity

One of the most common manifestations of cerebral palsy in the upper extremity is the thumb-in-palm deformity. This is characterized by a fixed contraction of the thumb at the MCP joint into the palm. Because of the dynamic interplay of many muscles on thumb positioning and movement, correcting significant deformity poses a unique surgical challenge. There are two main muscle issues which lead to the thumb-in-palm deformity in cerebral palsy[6]:

1. Spasticity and contraction of thenar adduction muscles
2. Weakness of voluntary control of thenar abduction muscles

Mild thumb-in-palm deformities can be initially treated with a combination of botulinum toxin injections, occupational therapy, and splinting.[7] Indications for surgery include functional impairment of the grasp and pinch functions secondary to the deformity. The surgery typically is performed in children from age 7 to 10 as the patients usually can properly rehabilitate from the surgery. Contraindications to deformity correction includes a patient's lack of cognitive aptitude to rehabilitate properly in the post-operative state [8].

The most common type of thumb-in-palm deformity is a type 1 deformity where the first digit is adducted across the palm.[6] The main surgical plan in the correction of this deformity is three-tiered:

1. Release/lengthen spastic muscles: Releasing the adductor pollicis muscle in the palm can achieve this.[9]
2. Augment the weak/flaccid muscles: Rerouting of the extensor pollicis longus to the first dorsal compartment increases the strength of the muscle.[10]
3. Stabilize the joint if unstable.

Several other surgical techniques are available to correct this particular deformity along with additional different subtypes of the thumb-in-palm deformity. This surgery, combined with a patient dedicated to post-operative rehabilitation, typically has a very good prognosis in regards to regaining dexterity.

Clinical Significance

Ulnar Nerve Entrapment

Assessment of the adductor pollicis function is often utilized as a diagnostic measure for potential ulnar nerve entrapment at the elbow. These patients typically present with intrinsic muscle atrophy, leading to weakened pinch and grasp strength, difficulty turning keys, and difficulty with activities requiring manual dexterity. Clinically, patients may display compensatory thumb IP joint flexion (via flexor pollicis longus, innervated by the anterior interosseous nerve) in the setting of compromised thumb adduction strength (i.e. positive *Froment sign*). Contralateral comparison is facilitated by asking the patient to grasp a sheet of paper on opposite ends at the same time [11][12].

Thumb Collateral Ligament Injury [13]

Injury to the ulnar collateral ligament (UCL) of the thumb occurs secondary to hyperabduction or hyperextension mechanisms imposed at the MCP joint. Thumb UCL-based injuries range from purely ligamentous injuries to nondisplaced or displaced avulsion fractures of the base of the proximal phalanx of the thumb. In displaced injuries, surgery is required secondary to the so-called Stener lesion, which constitutes a bony or ligamentous injury that has displaced above the adductor aponeurosis. These injuries are often called by their respective eponyms, “Skier’s” thumb (acute) or “Gamekeeper’s” thumb (chronic) and these specific injuries are unable to heal without surgical repair.

Neuromuscular Blockade Monitoring

Assessment of the movements of the adductor pollicis via ulnar nerve stimulation is a common way to monitor neuromuscular blockade in the field of anesthesia.[14] It is critical to monitor the levels of neuromuscular blockade to accurately avoid complications of ventilatory support. For example, assessment of the level of neuromuscular blockade prior to extubation is critically important as the patient must have adequate diaphragm strength before respiratory support is removed. The test is performed by placing electrodes on the anterior portion of the forearm and delivering electrical signals in order to stimulate the nerve. Because the ulnar nerve innervates additional muscles other than the adductor pollicis, the palm, and other four digits are typically taped down in order to isolate the thumb’s movements only. An accelerometer is then attached to the thumb which is capable of objectively recording the kinematic responses to the specific nerve stimuli delivered via the electrodes. Anesthesiologists are then able to deliver customized signals via the electrodes, and the accelerometer recordings are then able to guide subsequent medication and treatment delivery based on the level of neuromuscular blockade.

Questions

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