Immediate thumb opposition following extensor indicis proprius opponensplasty using the wide-awake approach

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BACKGROUND: The wide-awake approach enables surgeons to adjust tendon transfer tension during active movement.

OBJECTIVE: To examine the proximity of the index finger to the thumb in the motor network of the brain during extensor indicis proprius (EIP) opponensplasty, performed under local anesthesia, for restoration of thumb opposition in patients with thenar paralysis caused by advanced carpal tunnel syndrome.

METHODS: Between April 2009 and October 2013, seven patients underwent wide-awake opponensplasty of the EIP in conjunction with carpal tunnel release. Under local anesthesia (lidocaine with epinephrine), the EIP tendon was routed subcutaneously, around the distal ulna and across the palm to the abductor pollicis brevis tendon.

RESULTS: Immediately after severing the EIP tendon over the metacarpophalangeal joint of the index finger, patients exhibited varying degrees of retraction of the proximal end of the EIP tendon into the dorsal subcutaneous space when asked to perform thumb opposition while maintaining active flexion of the index finger. All patients were able to perform palmar abduction of the thumb via the EIP following opponensplasty.

DISCUSSION: The intraoperative data suggest that single, individuated movements of the thumb opposition activate both the thenar muscle and the EIP. Additionally, these phenomena may be explained by activation of a pre-existing neural network, and overlap between the thumb and index finger in the motor cortex.

CONCLUSION: Achievement of immediate thumb opposition without re-education suggests that the index finger and thumb are in close proximity in the motor network of the brain.

Key Words: Carpal tunnel syndrome; Extensor indicis proprius; Opponensplasty; Wide-awake hand surgery

Opposition of the thumb to the other digits is essential for fine prehension during daily activities such as writing, buttoning a jacket, tying a shoe, picking up a coin or turning a key. Inability to oppose the fingers is the most significant motor impairment associated with long-standing, severe carpal tunnel syndrome (CTS) (1,2). Unfortunately, dysfunction that develops after thenar muscle paralysis rarely recovers following carpal tunnel release (CTR), particularly in elderly individuals (3). Therefore, a single-stage procedure, combining CTR and tendon transfer to improve opposition, may be valuable (1,2,4-6). However, issues such as tendon tension and cerebral cortical control of the transferred muscle must be resolved when tendon transfer is contemplated, including during opponensplasty (7). The wide-awake approach enables surgeons to adjust the tension of the transferred tendon during active movement to ensure that the transfer is not overly tight or loose before skin closure (8). The present study examined the proximity of the index finger to the thumb in the motor network of the brain during extensor indicis proprius (EIP) opponensplasty (9), performed under local anesthesia for restoration of thumb opposition in patients with thenar paralysis caused by advanced CTS.

METHODS

Patients
The present study conformed with the Declaration of Helsinki after approval of the authors’ institutional review board. Written informed consent was obtained from all participants. Potential subjects were identified by searching institutional billing records for code G560 of the International Classification of Diseases. Patients with associated conditions, such as cervical radiculopathy or cubital tunnel syndrome, or comorbidities such as diabetes mellitus, hypothyroidism, chronic renal failure or rheumatoid arthritis, were excluded. However, patients with comitant trigger finger or De Quervain tenosynovitis were included. A total of seven patients meeting the inclusion criteria (advanced CTS, loss of thumb opposition and performance of wide-awake opponensplasty of the EIP at the authors’ institution between April 2009 and October 2013) were included. The patient group consisted of two males and five females, with mean age of 62 years (range 56 to 75 years) at the time of the procedure. In six individuals, the dominant hand was affected.

Patients presented with symptoms including digital or palmar pain, numbness in the area of distribution of the median nerve distal to the carpal tunnel and difficulty manipulating objects associated with obvious thenar atrophy. The mean duration of preoperative symptoms was 3.6 years (range 0.5 to 10 years). On electromyography, all patients exhibited abnormally prolonged nerve conduction compatible with a diagnosis of CTS (ie, a distal motor latency >5 ms or absence of compound muscle action potentials in the abductor pollicis brevis [APB]). The mean postoperative follow-up duration was 25 months (range 12 to 40 months).

Operative technique
All operations were performed under local anesthesia, using loupes. Each patient received an injection of 20 mL to 30 mL of 1% (w/v) lidocaine with 1:100,000 epinephrine, delivered to the region of skin incision. Initially, mini-open CTR was achieved through a 1.5 cm to 2 cm incision created using a pneumatic tourniquet (Figure 1A). Following median nerve release, the pneumatic tourniquet was deflated and the tourniquet was not used further during EIP opponensplasty. The EIP was identified over the metacarpophalangeal joint of the index finger, and a small portion of the tendon and extensor hood was removed using a #15 scalpel blade (Figure 1B). The hood was meticulously repaired using interrupted nonabsorbable sutures to prevent any subsequent lag in extension (Figure 1C). The extensor tendon was relieved by creating a small incision over the mid-dorsum of the hand (Figure 1C). An approximately 3 cm curvilinear longitudinal skin incision was created over the dorsal ulnar aspect of the distal part of the forearm and the deep fascia of the forearms; the intermuscular septum between the extensor digiti minimi and extensor carpi ulnaris

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(ECU) was widely excised. The EIP tendon and muscle belly were identified and delivered through this proximal incision (Figure 1D). The distal part of the muscle belly was gently freed by blunt dissection and retracted proximally. A small incision was created over the flexor carpi ulnaris (FCU) tendon at a point 1 cm proximal from the pisiform bone. A wide subcutaneous tunnel, running from the dorsal ulnar incision to this small incision, was then created (Figure 1D). The EIP tendon was passed through the subcutaneous tunnel, over the extensor carpi ulnaris tendon, around the distal ulna (which serves as a pulley) and brought out through the ‘small incision’. The abductor pollicis brevis (APB) tendon is then exposed via a thenar incision made over the radial aspect of the MP joint of the thumb. A tendon retriever is passed beneath the fascia of the APB muscle, running from the thenar incision to the small skin incision in the area of the FCU tendon. The EIP tendon is pulled distally over the FCU tendon through the subcutaneous tunnel and attached to the APB tendon. The tendon tension is slightly tight with the thumb in full palmar abduction and the wrist in a neutral position. The EIP tendon was attached to the APB tendon using multiple, fine nonabsorbable woven sutures (Figure 1F). Tension correctness was verified via active palmar abduction of the thumb. Finally, the thumb incision was closed.

Postoperative treatment

The hand was immobilized in a thumb spica cast, which maintained the wrist in a neutral position and the thumb in full opposition for three weeks. A removable orthoplastic splint was subsequently applied for an additional three weeks at which time rehabilitation was initiated, enabling active motion exercise without resistance. At six weeks, the splint was removed (except at night); however, all patients were advised to avoid using the hand for activities requiring application of >1 kg of force. The splint was finally discarded 12 weeks postsurgery, after which power-pinchling was permitted.

Evaluation

Intraoperative findings and complications, including infection, hematoma and rupture of the transferred tendon, were investigated through medical chart review. Extension deficit at the MP joint of the operated index finger was measured by the surgeon using a standard goniometer.
All patients were asked about donor site morbidity. The preoperative and postoperative extents of active thumb opposition were recorded using the Kapandji scoring system. Each patient was asked to oppose the thumb to the distal phalanx of each finger, and the middle and proximal phalanx of the little finger (10). Scores ranged between 0 (inability to engage in palmar abduction) and 10 (able to touch the base of the little finger). The thumb-to-index pinch-grip strength (Pinch Gauge, B&L Engineering, USA) was measured as a proportion of that on the normal side. Thenar muscle atrophy was graded as severe, mild-to-moderate or absent (11). All grading was performed by a single physician who studied patient charts based on the following criteria: absent – no evidence of thenar muscle atrophy; mild-to-moderate – flattening of the thenar eminence; and severe – excavation along the proximal radial border of the thenar eminence.

**RESULTS**

Intraoperatively, following severance of the EIP tendon over the MP joint of the index finger, all patients immediately exhibited varying degrees of retraction of the proximal end of the EIP tendon into the dorsal subcutaneous space when they were asked to perform thumb opposition while maintaining active flexion of the index finger (Figure 2). In addition, all patients could perform palmar abduction of the thumb through the EIP immediately following opponensplasty (Figure 3). Ulnar nerve compression from the transferred EIP tendon developed in a single patient five weeks after EIP opponensplasty. At eight weeks, division of the FCU tendon at the crossover point, ulnar nerve neurolysis and restoration of FCU tendon continuity beneath the EIP tendon were performed. After an additional eight weeks, ulnar nerve function had returned to normal. There were no intraoperative complications, infections or tendon junction ruptures.

During the final clinical visit, the average loss of extension of the MP joint of the operated index finger was 9° (range 0° to 20°). No donor site morbidity was evident. The average preoperative Kapandji score was 2.2 (range 2 to 3). Postoperatively, the average Kapandji score increased to 9.7 (range 9 to 10). All patients were able to perform many activities of daily life (eg, they could use chopsticks and fasten buttons independently). Preoperatively, compared with unaffected hands, affected hands had a mean thumb-to-index pinch-grip strength of 24% to 56% (mean 39%). The mean pinch-grip strength of the operated hand on final evaluation was 85% (range 64% to 94%) that of the unaffected hand. In terms of thenar muscle atrophy, all seven patients exhibited severe wasting before surgery; however, some thenar muscle recovery was evident in the two patients for whom the follow-up duration was >24 months (one exhibited mild recovery and one moderate recovery).
DISCUSSION
To restore thumb opposition, we prefer to perform EIP opponensplasty as an internal functional splint (12), not a mere internal splint because the patients are able to oppose the thumb immediately after transfer without re-education. In addition, loss of the EIP (as a finger extensor) has only a marginal effect on overall hand function, and the tendon excursion of the EIP is sufficient to replace a lost thenar muscle, although muscle strength is less than that of the sum of thenar muscles (13,14). In our study, the extension deficit of the MP joint of the operated index finger was relatively small, and no morbidity was noted at the donor site. Overall hand function and active thumb opposition (measured via Kapandji scoring and recording of thumb-to-index pinch-grip strength) exhibited reasonable improvements. Furthermore, the EIP acts synergistically with the AFB, rendering rehabilitation and re-education straightforward (9,13,15). In our study, EIP opponensplasty performed under local anesthesia confirmed the existence of a synergistic relationship between the APB and the EIP; immediate thumb opposition was achieved without any need for re-education. Our intraoperative data suggest that the single, individually movement of thumb opposition may activate not only the thenar muscle but also the EIP (15). Tubiana (16) noted that the index finger and thumb had close proximity characteristics. We believe that the proximity in the motor network of the brain finding is supported by our data and by studies using wide-awake EIP to extensor pollicis longus tendon transfer (8). These phenomena may be explained by activation of a pre-existing neural network (8), and facilitation of the work of various motor units by a single cortical neuron (17,18): the thumb and index finger overlap in the motor cortex (19,20). We believe that preoperative muscle synergy, explained by neural connections in the brain, is more important than postoperative re-education because aggressive rehabilitation for motor re-education is usually required after opponensplasty of a nonsynergistic muscle such as the flexor digitorum superficialis (FDS).

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