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Simultaneous Limited Incision Carpal Tunnel Release and Flexor Digitorum Superficialis Opponensplasty Using a Transverse Carpal Ligament Pulley: Surgical Technique and Case Series

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Abstract: Severe thenar muscle atrophy resulting in dysfunctional thumb abduction and opposition is a well-documented finding associated with long-standing severe carpal tunnel syndrome. This problem has been addressed in the past through various opposition tendon transfers. Historically, the Camitz procedure, or its modifications using the palmaris longus tendon, were recommended. However, this procedure requires a long incision in the palm, extensive dissection including the wrist area, and may not produce active thumb pronation. Our surgical technique describes an open limited palmar-only carpal tunnel release with ring finger flexor digitorum superficialis opponensplasty using a slit through the released transverse carpal ligament as a pulley and dual insertion of the tendon in both the extensor hood and the tendon of the abductor pollicis brevis. The Kapandji evaluation of thumb opposition was used to determine the outcome after surgery.

Key Words: opponensplasty, transverse carpal ligament, carpal tunnel syndrome, pulley, tendon transfer, thumb, Kapandji

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The prevalence of thenar atrophy associated with long-standing carpal tunnel syndrome, especially in elderly patients, is well documented in the literature.[1] Reports indicate that recovery of thumb opposition by carpal tunnel release alone may not be expected.[2–4] Reports also indicate that after carpal release alone, return of thumb opposition took many years and satisfactory outcomes were unlikely.[4,5] Hand weakness can result in difficulty using the hand and there may be a need to perform some type of opponensplasty at a later stage. Historically, the Camitz[6] procedure, or its modifications using the palmaris longus tendon, was recommended to restore thumb abduction. However, this procedure requires a long incision in the palm, extensive dissection including the wrist area, and will not produce all the components of thumb opposition including palmer abduction, flexion and pronation.[7,8]

The use of the flexor digitorum superficialis (FDS) as a donor should, however, provide appropriate tension fraction and was recommended for opponensplasty as it produces the required elements of abduction, flexion, and pronation.[9–13]

Reports by Richter and Peimer[14] and Waitayawinyu et al[15] using the FDS resulted in significant improvement in thumb abduction, opposition, and pinch strength. However, both these articles used endoscopic carpal tunnel release, one without a pulley[14] and the other with a pulley at the wrist area.[15]

This surgical technique describes an open limited palmar-only incision utilizing a slit placed through the ulnar flap of the released transverse carpal ligament to create a pulley for the FDS tendon. The insertion site of the tendon is both to the extensor hood and the tendon of the abductor pollicis brevis. The Kapandji evaluation[16] of thumb opposition was used to determine the outcome after surgery.

ANATOMY

The thumb carpometacarpal joint is a multiplanar articulation that relies on the directional pull of its surrounding musculature to function. Opposition and abduction are two of the primary movements of the thumb and are controlled by the opponens pollicis and abductor pollicis brevis, respectively. Both are innervated by branches of the median nerve. Of the intrinsic muscles of the thumb, the opponens pollicis is the only muscle that inserts along the shaft of the first metacarpal, hence it not only elevates the first metacarpal, but also rotates the first metacarpal by its communication into the extensor hood. The abductor pollicis brevis insertion at the base of the proximal phalanx elevates the first metacarpal, which enhances thumb opposition. The anatomy of the flexor retinaculum was studied in detail, where three parts were described: proximal, central, and distal.[17] The central part is the classic transverse carpal ligament and has osseous attachments on the ulnar side to the pisiform and hamate and on the radial side to the tubercle of the trapezium and the scaphoid; histologically, it is like a ligament.[18]

Reports on making a pulley through the flexor retinaculum describe using the distal portion,[4,5,7,12] which potentially has only soft tissue and no bony attachments. The pulley described in this study is planned through the central thicker part of the transverse carpal ligament.[17,18] The pulley location is also in the pisiform hamate area, which is preferred.[19]

INDICATIONS

Patients with long-standing carpal tunnel syndrome with obvious thenar atrophy, loss of thumb abduction, elevation and opposition, and weakness of grip and pinch, without ulnar neuropathy. This is especially the case if the thumb is in a supinated position with the patient unable to bring it out of the palm. The procedure is best indicated in a patient with advanced carpal tunnel syndrome that unlikely improves thumb opposition and abduction following carpal tunnel release alone (Fig. 1). In cases of low median nerve palsy from other reasons, like failed

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FIGURE 1. Thenar atrophy and wasting in a patient with advanced carpal tunnel syndrome. A good indication for the procedure.

median nerve recovery following laceration and repair, there are other options for tendon transfer to restore opposition.

CONTRAINDICATIONS

Limited mobility or instability of the first carpometacarpal joint resulting from advanced degenerative arthritis. High median nerve palsy with potential weakness of the FDS. Scarring and adhesions in the palm or the wrist area from previous surgery. It is best then to consider other options, like using the extensor indicis proprius at a later stage.

POTENTIAL COMPLICATIONS

Some technical problems are possible. The slit made in the ulnar flap of the transverse carpal ligament may not be wide enough to permit the tendon to pass through. The pulley can also rupture if the slit is not made deep enough. None of these issues occurred in these cases because the pulley is reconstructed in the area of the transverse carpal ligament with strong ligamentus bony attachments. However, if this occurs one can plan on extending the incision and reconstructing a pully around the pisiform proximally.

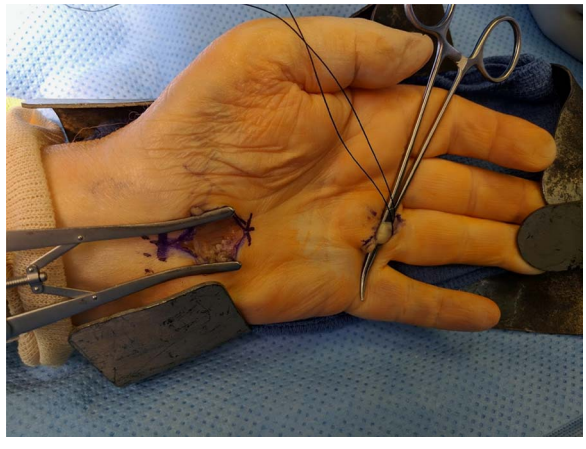

FIGURE 2. CTR limited incision and harvest of ring finger flexor digitorum superficialis tendon. CTR indicates carpal tunnel release.

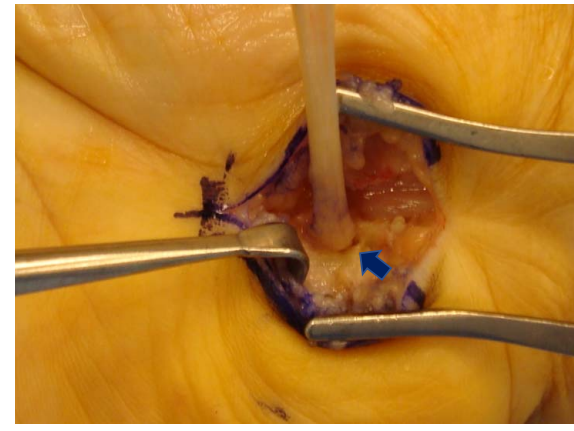

FIGURE 3. The site of the planned pulley (arrow) in the released TCL. TCL indicates transverse carpal ligament.

OPERATIVE TECHNIQUE

(1) Carpal tunnel limited incision: 2 cm longitudinal incision extending 8 to 10 mm distal to the wrist flexion crease in line with the radial border of the ring finger. The deep dissection should include adequate exposure of the transverse carpal ligament as this is where the pulley will be planned.
(2) The transverse carpal ligament is exposed and divided proximally to the level of the wrist flexion crease and distally to the level of the superficial palmar arch. One should stay in the midline to preserve enough ulnar flap of ligament when making the pulley. The median nerve is inspected, and the recurrent motor branch is identified and protected.
(3) The FDS to the ring finger is exposed through an oblique incision proximal to the skin crease at the base of the finger and release of the A1 pulley. Pulling on the tendon should result in flexion of the proximal interphalangeal joint only with no effect on the distal interphalangeal joint. The tendon is divided proximal to Camper's chiasm and is tagged with silk sutures. The proximal carpal tunnel incision is exposed and the FDS tendon is delivered into the carpal tunnel incision (Fig. 2).

FIGURE 4. Flexor digitorum superficialis tendon to be tunneled and inserted in the extensor hood and the APB tendon. APB indicates abductor polis brevis.

FIGURE 5. Flexor tendon insertion into the extensor hood. Not seen is the additional insertion in the APB. APB indicates abductor polis brevis.

(4) An ~5 mm longitudinal slit is made halfway through the released ulnar flap of the transverse carpal ligament next to the hook of the hamate on the radial side to create the pulley and accommodate the flexor tendon. The rest of the ligament, which is around 20 mm in length, is left intact. Care should be taken to make the slit deep enough to avoid rupture of the pulley. The slit should allow the tendon to glide freely (Fig. 3).
(5) An incision is made at the radial side of the thumb metacarpophalangeal joint, and the extensor hood and tendon of the abductor pollicis brevis are exposed. The FDS tendon is delivered to the carpal tunnel incision, passed through the transverse carpal ligament pulley from deep to superficial, to be tunneled subcutaneously towards the

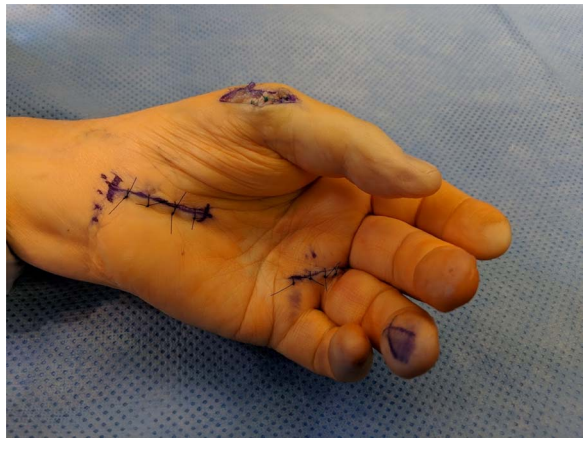

FIGURE 6. Final postoperative photo with the thumb pointing to the index finger with tension adjusted.

TABLE 1. Results

	Dates	Age	Symp.	Diab.	NCS	Tourniquet	Kapandji	Sex	Follow-up
1	1/15/2019	63	YS	Y	Y	91	7	M	3 mo
2	1/12/2019	62	MS	Y	Y	63	6	M	2 mo
3	9/21/2012	60	2Y	N	Y	34	6	F	6 wk
4	12/21/2017	44	YS	Y	Y	37	8	F	10 mo
5	9/18/2007	77	12Y	N	Y	62	8	M	10 wk
6	10/7/2005	72	15Y	N	Y	63	6	M	5 wk
7	12/10/2004	83	YS	N	Y	31	9	M	5 mo
Average		66				54	7		3 mo

Diab. indicates diabetes; F, female; M, male; MS, months; N, no; NCS, nerve conduction studies; Symp., symptom; Y, yes; YS, years.

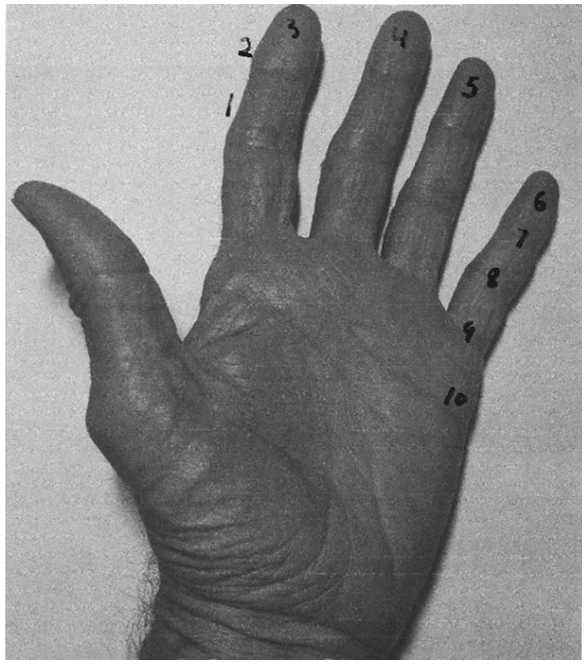

FIGURE 7. Kapandji score.

thumb incision, being careful to avoid the median nerve (Fig. 4).

(6) The FDS tendon is split further in 2 parts. The first part is passed through a slit made through the extensor hood at the metacarpophangeal joint and sutured back to itself using 3-0 ethibond suture (J& J Medical Devises) (Fig. 5). The tension is adjusted whereby the thumb should be in pronation pointing to the index finger with the wrist in neutral position (Fig. 6). The final tension adjustment is completed by doing wrist tenodesis effect with wrist flexion allowing the thumb interphalangeal extension and wrist extension causing thumb interphalangeal flexion. The other part of the tendon is then sutured using figure of eight 3-0 ethibond to the tendon of the abductor pollicis brevis. The authors found that pulling on the extensor hood first will cause the thumb to rotate while the attachment to the abductor pollicis brevis will help on abduction. Any extra tendon is discarded.

The incisions are closed, and the thumb is splinted in a thumb spica in opposition for 4 weeks. The splint should include the wrist and the thumb interphalangeal joint. Encourage the patient to work on the range of motion of the ring finger proximal interphalangeal joint to avoid a flexion contracture.

REHABILITATION

Four weeks: start range of motion, splinting, hand-based C-bar during the day and at night, and stretching exercises.

Six weeks: occasional C-bar splint for stretching the first web, range of motion, touch other digits, peg boards for dexterity, thumb rotation, foam blocks for thumb and hand strength, opening jars, and grasping activities.

CASE SERIES

Institutional Review Board was approved to identify and review the medical records of the patients. The authors reviewed their experience with this surgical technique, from January 2000 to December 2019, and were able to find 15 patients/16 hands, which had carpal tunnel release and flexor digitorum opponensplasty simultaneously using the described procedure, to enhance thumb opposition. Three patients had type 2 diabetes.

RESULTS

Only 9 patients had electronic medical records, 2 were excluded. One left the country and the other had crushing injury that resulted in carpal tunnel syndrome and thenar atrophy several months later. Ages ranged from 44 to 83 years old. That left 7 patients to report. All patients had nerve conduction studies of the thenar muscles that confirmed denervation in the abductor pollicis brevis and the opponens pollicis. Five patients had the left hand affected. Tourniquet time varied from 31 to 91 minutes with an average of 54 minutes and the follow-up from 5 weeks to 10 months, with an average of 3 months. A postoperative Kapandji score from 6 to 9 was obtained in the 7 patients with an average score of 7 (Table 1, Fig. 7).

DISCUSSION

The palmaris longus was recommended specifically for tendon transfer for patients with carpal tunnel syndrome and thenar atrophy. However, an anatomic and biomechanical study of thumb opposition, reported that the best outcome results when the FDS is used. The palmaris longus was the least effective.[20]

Reports for simultaneous carpal tunnel release and opponensplasty are sparse. Naeem and Lahiri[7] reported on 6 cases in 2 years, Richter and Peimer[14] reported on 51 cases in over 21 years, and Waitayawinyu et al[15] reported on 52 cases in 4 years. The total number of patients that had carpal tunnel release only was not reported in these studies. In our search of thousands of patients that had carpal tunnel release cases at our institution in the period reported, only 15 patients/16 hands had the simultaneous procedure. This may explain the wide difference in the numbers reported in the literature. It is then difficult to assess how often simultaneous surgery is recommended and actually performed and reported.

This surgical technique uses a small incision in the palm and allows direct visualization and exposure of the median nerve and planning for pulley reconstruction under direct vision. This is different than other techniques using a flexor retinaculum pulley.[4–7,21] The site of insertion of the FDS tendon is into the extensor hood to enhance opposition in addition to the tendon of the abductor pollicis brevis.[22,23]

The weakness of this study is the small number of cases and the short follow-up time. However, considering that the patients with carpal tunnel syndrome mostly suffer from pain, numbness and loss of sensation, and present early before weakness, in addition to the successful outcome following carpal tunnel release alone, there are only few patients that require this simultaneous opposition procedure.

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