CMC ARTHOPLASTY: LIGAMENT RECONSTRUCTION WITH TENDON INTERPOSITION

Dan Cerniglia
Mary Beth Flynn
Thomas Quinzi

Abstract

Severe arthritis of the 1st Carpometacarpal (CMC) joint often results in laxity of the anterior oblique and dorsoradial ligaments. Subsequent rupture of the anterior oblique ligament causes a dorso-radial subluxation of the 1st CMC, resulting in extreme functional limitations of the thumb. Conservative methods of therapy attempt to alleviate the patient's symptoms, which normally consist of pain, thumb instability, and dorso-radial subluxation. When conservative therapy fails, surgical intervention can be indicated to improve function and quality of life. Ligament reconstruction with tendon interposition (LRTI) recreates the lax or ruptured anterior oblique ligament by rerouting half of the flexor carpi radialis tendon. Post-surgery, special precautions are made to make sure the surgical site is protected through casting, then splinting, and palmar adduction is avoided. Examination of a patient post-surgery should include active range of motion (AROM) and, if tolerable, passive range of motion (PROM) and palpation. Protocol varies from surgeon to surgeon, but generally consists of physical therapy (PT) started 4 weeks post-op aimed at decreasing pain and increasing range of motion (ROM). After 10-12 weeks post-op patients normally retain normal use of the hand.

Introduction

The 1st CMC joint is a synovial saddle joint. Synovial joints are both the most common and most moveable joints in the body; however, the thumb's (1st) CMC joint is

structurally unique. The saddle descriptor arises from the shape of the trapezium at the joint. Its surface is convex during motions of abduction and adduction, and concave during motions of flexion and extension (Figure 1). This plays a pivotal role in determining joint arthrokinematics.

There are 2 major bone-on-bone articulations[1] worth noting that articulate with the 1st metacarpal. The trapeziometacarpal articulation and scaphotrapezial articulation both play a primary role in severe arthritic conditions of the 1st CMC joint. Degeneration of their articular surfaces can cause pain and severely limit functional use of the thumb. The 1st CMC joint allows for abduction, adduction, flexion, extension, and opposition, making the use of the thumb essential to a plethora of daily tasks. Because of the high amount of activity performed by the thumb, this joint is stressed repeatedly in all planes of motion.

Precipitating Factors

There is a strong association[2] between severe basal joint arthritis and extreme ligament laxity at the thumb. Arthritis of the thumb, presenting clinically as pain near the base of the thumb, can occur from degenerative changes of the articulation between the 1st metacarpal and trapezium, however it is most often idiopathic. Regardless of origin, arthritic conditions at the thumb will often lead to ligamentous laxity.

Sixteen different ligaments support the 1st CMC joint. Specifically of interest are the anterior oblique ligament, also referred to as the volar beak ligament, and the dorsoradial ligament[4]. The anterior oblique ligament (Figure 2) runs from the tuberosity of the trapezium to insert on the volar edge of the 1st metacarpal and is most taut in

positions of thumb abduction, extension, and opposition[3]. The dorsoradial ligament (Figure 2) runs from the dorsoradial tubercle of the trapezium to the dorsal base of the 1st metacarpal[4]. This ligament is taut during all movements of the thumb. Extreme laxity or rupture of the anterior oblique ligament and dorsoradial ligament secondary to severe arthritis results in a dorso-radial subluxation of the 1st CMC joint due to excessive joint instability. If left untreated, the thumb can be further stressed into the characteristic swan-neck deformity[3]. Surgical intervention is aimed towards ligament reconstruction to recreate the passive tension generated by the anterior oblique ligament and dorsoradial ligament, and opening of the joint space to alleviate symptoms of arthritis by partial or complete trapezial excision. Additional risk factors associated with ligament laxity are synovitis, joint space narrowing, osteophyte formation, and ligament attenuation[1].

Indications of Surgery

Patients of CMC Arthroplasty of the 1st CMC joint[1] are typically females, 50-70 years old, who exhibit pain during thumb movements. There is a decreased ability for the individual to perform functional tasks involving opposition, such as opening a jar, and precision grip. Patients often note decreased strength, dexterity, and pain at rest following activities. A more uncommon presentation occurs in 20-30 year olds who exhibit thenar pain, cramping, and pain up the radial side of the arm when writing. These symptoms are usually associated with minor ligamentous laxity and synovitis, which have shown to be alleviated with rest and medication.

During physical examination, subluxation of the thumb metacarpal base is often noted visually as a dorso-radial prominence due to ligamentous laxity and pull of the

adductor pollicis longus. Palpation of the trapeziometacarpal joint and scaphotrapezial joint causes pain. During mobilization of the trapeziometacarpal joint; cracking, popping, and pain are common symptoms. Radiography of the CMC joint is used to evaluate and quantify joint space narrowing and subluxation. Primary diagnosis should consider medical imaging tests, patient complaints, and results of the physical examination.

After diagnosis, classification of CMC arthritis is determined by using Burton classification (Figure 3) or Eaton classification (Figure 4). Burton classification is a 4 stage scale that takes into account clinical presentation and medical imaging tests. Eaton classification is also a 4 stage scale but eliminates patient complaints and physical examination components, and only includes medical imaging. Stages of classification can be used to suggest surgical techniques that may be most appropriate based on the patients classification (Figure 5).

Regardless of staging, a course of conservative therapy, up to 6 weeks, is prescribed prior to any surgical intervention. Conservative therapy goals include an increase in activities of daily living (ADL) participation and quality of life improvements. Notably, a complete elimination in pain and discomfort is often not a goal associated with conservative therapy. Common conservative therapy treatments are splinting, thenar muscle strengthening, and non-steroidal anti-inflammatory (NSAID) use. Surgery is indicated when conservative therapy has failed.

Surgical Procedure

There are many different surgical options available[1]. They differ based on facility, surgeon, classification stage, and other factors.

Excisional arthroplasty is either a partial or complete excision of the trapezium to decrease pain secondary to joint space narrowing. This surgery however does not address the main pathology of volar beak ligament laxity.

Double arthroplasty increases joint space by partial trapezial excision, addresses ligamentous laxity by reconstruction of the volar beak ligament, and resurfaces the scaphotrapezial joint. Failure to effectively resurface the scaphotrapezial joint would result in pain from arthritic bone on bone contact.

Arthroscopic interpositional procedure debrides the trapezium of arthritic contact surfaces, however it does not address volar beak ligament laxity.

Silicone implant arthroplasty has excellent short term results involving grip and pinch strength, range of motion, and pain alleviation. Long term results are not as promising as they include subluxation, cold creep, bone erosion, and synovitis.

Per literature review, the most common and successful (Figure 6) surgery to address severe CMC arthritis in the thumb is tendon interposition arthroplasty with ligament reconstruction or ligament reconstruction with tendon interposition (LRTI). Prior to surgery, the patient is prepped with sedation medication and a peripheral nerve block[5] to numb the arm. A curvilinear incision is made along the base of the thumb (Figure 7). Following the initial incision, the base of the first metacarpal is exposed by either retracting the abductor pollicis longus (APL) tendon or splitting that tendon along its natural division. Special care is taken to preserve the deep radial artery and superficial radial nerve[7]. In order to fully access the interior of the trapeziometacarpal joint, a capsular incision is performed, and the trapezium is assessed for degenerative change and joint space narrowing. Based on the level of degeneration, lack of joint

space, and the preference of the surgeon, the trapezium is either partially or fully excised[1].

A second incision is performed to identify and expose the flexor carpi radialis (FCR) tendon (Figure 7). A proximal-to-distal cut beginning at the musculotendinous junction of the FCR separates the radial and ulnar portions of the tendon. The ulnar portion of the tendon is harvested for use later in the procedure. It's important to note that the FCR tendon remains attached at the distal end of the cut[6] (Figure 8).

At this juncture, there are several different ways to proceed with surgery. The two most common methods depend on the status of the trapezium and the interposition material available. The first technique involves a complete excision of the trapezium[1]. Two holes are drilled through the base of the first metacarpal and the FCR tendon strip is passed through the holes. The tendon is placed under tension, which places the metacarpal in an abducted and slightly flexed position. The FCR tendon strip is then wrapped around distal intact portion of the FCR tendon and is secured (Figure 9). A portion of the FCR tendon strip may be rolled up on itself and placed in the former trapeziometacarpal joint as a spacer. This is commonly referred to as an “anchovy” (Figure 10). The joint and forearm incisions are then closed and stitched, and the patient is placed in a spica splint for two weeks.

Another common technique involves partial excision of the trapezium[6]. A hole is drilled in the trapezium from the palmar surface to the distal surface. An additional hole is drilled into the base of the first metacarpal in the direction of the dorsal-radial surface of the base of the thumb. This technique utilizes a life-saver shaped costochondral allograft as an interposition structure, which is placed in the available

trapeziometacarpal space. The FCR tendon is passed through the holes in the trapezium, through the costochondral allograft, and the holes in the base of the first metacarpal. The tendon is placed under tension and is secured to itself using sutures (Figure 8). The incision site is closed, and the patient is placed in a spica cast for 5 weeks.

Case Example

The following case is taken from email collaboration with Jessica Serron, PT in October 2014. “A 51 year old female presented to the clinic 5 weeks post-op right CMC arthroplasty. The flexor carpi radialis tendon was used. 4 days earlier the patient saw the surgeron, her cast was removed and she was given a splint. Patient stated her pain level ranged from 4/10 to 7/10. Prior to surgical intervention, the patient had been experiencing thumb pain for years and it was interfering with her job as a secretary. She had no physical therapy intervention prior to surgery. Patient stated she needed to be able to write and type for work. Upon physical examination, the patient presented with edema, scar sensitivity and significant limitations in right thumb IP and MP flexion ROM as well as wrist ROM.”

Post-LRTI, it is of utmost importance to protect the surgical site. The thumb will be casted initially, followed by the patient wearing a thumb spica splint at all time, except during periods of PT. During PT sessions, it is important to stabilize the CMC joint when performing range of motion techniques at the IP and MCP joints of the 1st digit. The patient should especially avoid palmar adduction as it will overstress the healing joint. Additionally, strength training is generally not emphasized because the

thumb strengthens from performing daily activities (Jessica Serron, PT, email communication October 2014).

A typical examination of a patient post-surgery is largely dependent on the patient's pain. If the patient is highly irritable, AROM of the 1st CMC, MCP, and IP joints may only be assessed at first. This allows for the patient to remain in control of the movement and the surgical site is not overly stressed. If tolerated by the patient, palpation and PROM can be assessed as well. It is also important to assess the AROM and PROM of the wrist and forearm from wrist flexion, extension, pronation, and supination.

Protocol for a patient post-surgery is highly dependent upon the surgeon. Generally the following guidelines are provided (Jessica Serron, PT, email communication October 2014):

1. At 4 weeks post-op, AROM and PROM are started for thumb, finger, and wrist ROM. Exercises should include emphasis on circumduction, palmar abduction, and radial abduction of the thumb. PROM techniques should avoid extension and abduction at the 1st CMC. Flexion and adduction should be avoided as well to ensure the surgical site is preserved. Scar mobilization techniques should also be used to prevent scar tissue adhesions and hypersensitivity. Techniques to decrease tissue swelling should be applied as well.
2. Goals for 4 to 6 weeks typically include decreasing edema, decreasing pain, and increasing ROM.
3. Isometric thenar strengthening[7] is usually started between 6 and 8 weeks. The splint is often discontinued around 8 weeks.

4. At 10 to 12 weeks, the patient can return to normal use of the hand.

A more conservative protocol, outlined by Neumann and Bielefeld[7] (Figure 11), is another example of a protocol that a physical therapist may use. It is always best to confirm the patient's plan of care with the surgeon if no protocol is given.

Conclusion

CMC arthritis of the thumb is a condition associated with extreme laxity and potential rupture of the anterior oblique and dorsoradial ligaments, joint space narrowing, and degenerative changes to joint surfaces. If and when conservative therapy fails to effectively treat patient's symptoms, CMC arthroplasty is indicated. Several different techniques are available to address the underlying symptoms. The most common technique is ligament reconstruction with tendon interposition, with partial or complete trapezial excision. Following surgery, patients undergo a course of physical therapy to regain thumb range of motion and strength.

References

1. Matullo K, Ilyas A, Thoder J. CMC arthroplasty of the thumb. *HAND*. 2007;2(2):232-239.
2. Dias R, Chandrasenan J, Rajaratnam V, Burke F. Basal thumb arthritis. *Postgrad Med J*. 2007;83(975):40-43.
3. Neumann D. *Kinesiology of the musculoskeletal system foundations for rehabilitation.* 2nd ed. United States: Mosby Elsevier; 2010:251-252.
4. Kim R, Strauch R. Anatomy. Ligament Stabilization of the Unstable Thumb Carpometacarpal Joint Web site. https://www.inkling.com/read/operative-techniques-orthopaedic-surgery-vol-3-1st/chapter-hwf-25/ligament-stabilization-of-the. Updated 2014. Accessed 11/4, 2014.
5. CMC arthroplasty. CMC Arthroplasty: What to Expect Web site. http://www.bidmc.org/Centers-and-Departments/Departments/Orthopaedic-Surgery/Services-and-Programs/Hand-and-Upper-Extremity-Surgery/Our-Team/Charles-S-Day/~/media/1BA43E61F1DD4422A0C7B12A67F4B02B.pdf. Accessed 11/4, 2014.
6. Trumble T, Rafijah G, Gilbert M, Allan C, North E, McCallister W. Thumb trapeziometacarpal joint arthritis: Partial trapeziectomy with ligament reconstruction and interposition costochondral allograft. *J HAND SURG-AM*. 2000;25A(1):61-76.
7. Neumann D, Bielefeld T. The carpometacarpal joint of the thumb: Stability, deformity, and therapeutic intervention. *J Orthop Sports Phys Ther*. 2003;33(7):386-399.

8. Froimson A. Tendon interposition arthroplasty of carpometacarpal joint of the thumb. *Hand Clinics*. 1987;3(4):489-505.

Appendix

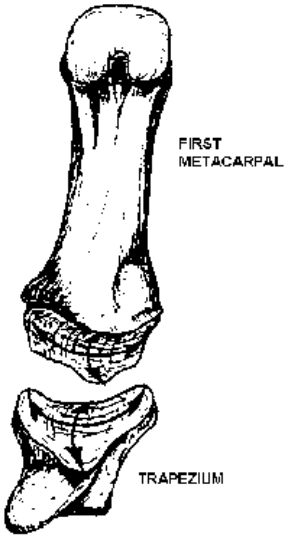

Figure 1. The bone on bone articulation between the 1st metacarpal and trapezium is shown with a posterior view. Note the trapezium and its anterior-posterior convex surface and medial-lateral concave surface.
Referenced from: http://moon.ouhsc.edu/dthompso/namics/gifiles/firstcmc.gif

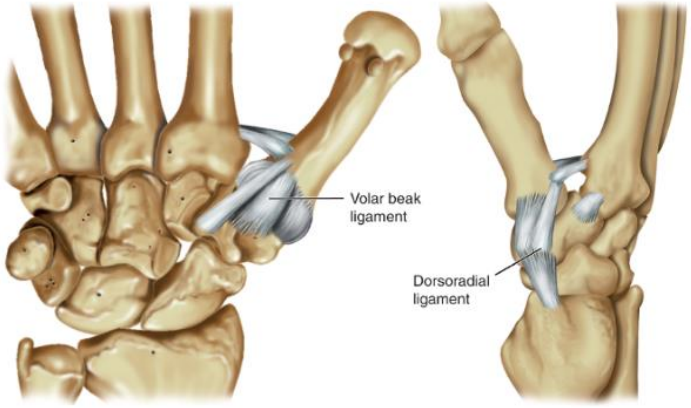

Figure 2. The anterior oblique ligaments (volar beak ligament), and dorsoradial ligaments origin and insertion are shown by posterior and lateral views, respectively, of the hand.
Referenced from: https://www.inkling.com/read/operative-techniques-orthopaedic-surgery-vol-3-1st/chapter-hwf-25/figure-hwf-25-1

Table 1 Burton classification system for trapeziometacarpal arthritis [6, 7].

Staging	Characteristics
Stage I	Pain
	Positive grind test
	Ligamentous laxity
	Dorsoradial subluxation of the trapeziometacarpal joint
Stage II	Instability
	Chronic subluxation
	Radiographic degenerative changes
Stage III	Involvement of the scaphotrapezial joint or less commonly the trapeziotrapezoid or trapeziometacarpal joint to the index finger
Stage IV	Stage II or III with degenerative changes at the metacarpophalangeal joint

Figure 3.[1] Shown is the Burton classification system. Each stage is determined by clinical presentation, and/or medical imaging.

Table 2 Eaton classification system for trapeziometacarpal arthritis [1, 6–8].

Staging	Radiographic Characteristics
Stage I	Normal or slightly widened trapeziometacarpal joint
	Normal articular contours
	Trapeziometacarpal subluxation (if present up to one third of the articular surface)
Stage II	Decreased trapeziometacarpal joint space
	Trapeziometacarpal subluxation (if present up to one third of the articular surface)
	Osteophytes or loose bodies less than 2 mm in diameter
Stage III	Further decrease in trapeziometacarpal joint space
	Subchondral cysts or sclerosis
	Osteophytes or loose bodies 2 mm or more in diameter
	Trapeziometacarpal joint subluxation of one third or more of the articular surface
Stage IV	Involvement of the scaphotrapezial joint or less commonly the trapeziotrapezoid or trapeziometacarpal joint to the index finger

Figure 4.[1] The stages of the Eaton classification system are determined only by medical imaging.

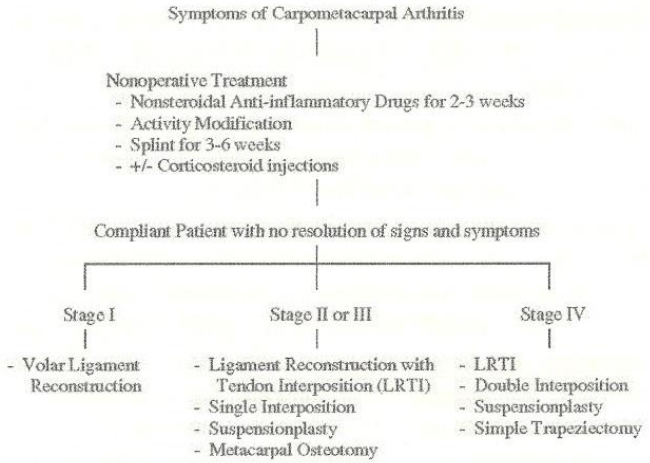

Figure 1 Flow diagram for treatment of carpometacarpal arthritis [1].

Figure 5.[1] Flow chart to determine surgical intervention based on classification scaling. Note that the stages are representative of both Burton and Eaton classification.

Table 1. Secondary Qualitative Outcomes

Feature	*Contralateral*	*Before Surgery*	*After Surgery*	*p Value**
Grip strength (kgf)	22.0 ± 5.9	16.0 ± 5.2	21.0 ± 6.8	<.01
Pinch strength (kgf)	5.5 ± 1.1	3.4 ± 1.4	4.6 ± 1.5	<.01
Palmar abduction	52° ± 8°	45° ± 8°	50° ± 9°	<.05
Radial abduction	52° ± 10°	48° ± 7°	50° ± 9°	>.05
MCP joint motion	61° ± 18°	59° ± 24°	58° ± 21°	>.05
IP joint	79° ± 17°	78° ± 21°	74° ± 15°	>.05
TM distance (mm)	NA	5.0 ± 4.0	50.6 ± 4.5	<.01
Subluxation	NA	0.21 ± .11	0.16 ± .13	<.05

MCP, metacarpophalangeal; IP, interphalangeal; NA, not applicable.
*Comparison of preoperation values with postoperative values.

Figure 6.[6] Shown are secondary qualitative outcomes for LRTI. P-values <.05 indicate statistical significance of post-surgical values compared to pre-surgical values.

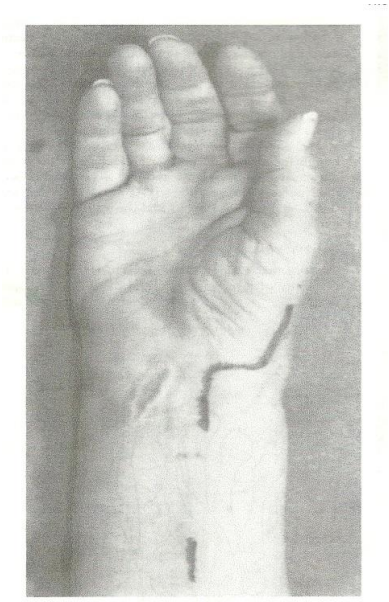

Figure 7.[6] Marked is the initial curvilinear incision site along base of the thumb and incision site for the FCR.

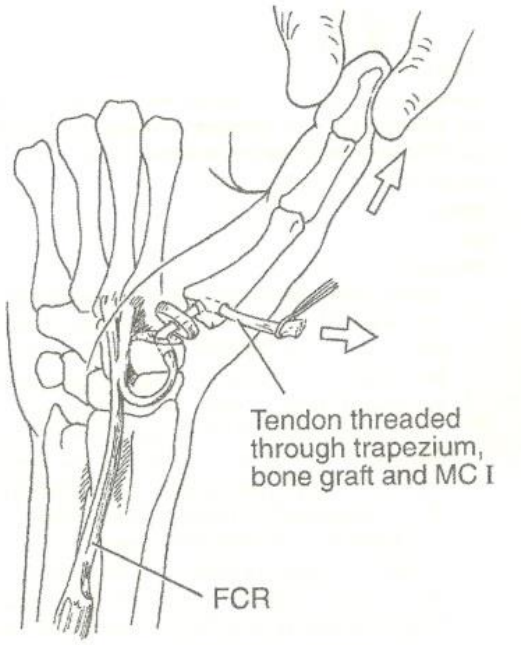

Figure 8. The strip of the FCR is threaded through the trapezium, the carved allograft cartilage, and the base of the thumb metacarpal (MCI).

Figure 8.[6] Shown is the FCR remaining attached at its distal insertion site and ½ of the FCR tendon being weaved through the trapezium and metacarpal base.

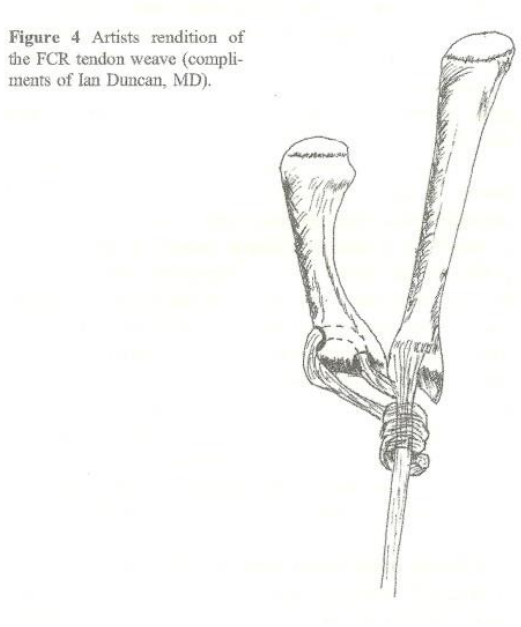

Figure 9.[4] The FCR tendon is shown being wrapped around itself near the distal insertion site.

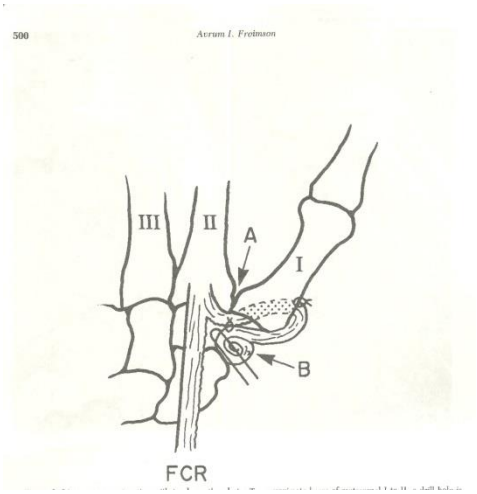

Figure 10.[8] The FCR tendon is rolled up and placed into the trapeziometacarpal space. This is an example of the “anchovy” technique.

TABLE 6. A typical postsurgical therapy program following a ligament reconstruction tendon interposition (LRTI).

Approximate Timetable	Therapeutic Intervention
• Postoperative d 1 through wk 4	• Apply thumb spica cast • Instruct in continuous elevation of upper extremity • Perform active range of motion (ROM) to nonimmobilized digits
• Postoperative wk 4 through wk 8	• Remove cast, fabricate wrist-carpometacarpal (CMC) immobilization splint; to be worn at all times except during exercise • Perform active ROM to all joints of the wrist and hand, except the thumb CMC joint • Perform passive ROM to the CMC joint; include abduction and extension only • Flexion and adduction must be avoided to protect the surgically incised dorsal side of the capsule
• Postoperative wk 8	• Progress exercise to include active thumb palmar abduction, opposition, and circumduction • Perform isometric thenar strengthening in the direction of palmar abduction
• Postoperative wk 12	• Progress strengthening exercise to include nonisometric thenar abduction and lateral pinch • Remove splint for light activities only
• Postoperative wk 13 through wk 16	• Discontinue wrist-CMC immobilization splint as indicated • Continue thenar abduction and key pinch strengthening exercises • Return to work with light duty restrictions • Engage in moderate functional activities
• Postoperative wk 16 through wk 24	• Resume vocational or avocational activities

Figure 11.[7] Outlined is a possible therapy program after LRT1 as developed by Neumann and Bielefeld.