Published in final edited form as:

Plast Reconstr Surg. 2008 August ; 122(2): 505–515. doi:10.1097/PRS.0b013e31817d5419.

Outcomes of Trapeziectomy with a Modified Abductor Pollicis Longus Suspension Arthroplasty for the Treatment of Thumb Carpometacarpal Osteoarthritis

Edwin Y. Chang, MD¹ and Kevin C. Chung, MD, MS²

¹Resident, Section of Plastic Surgery, Department of Surgery, The University of Michigan Health System; Ann Arbor, MI

²Professor of Surgery, Section of Plastic Surgery, Department of Surgery, The University of Michigan Health System; Ann Arbor, MI

Abstract

Purpose—Various arthroplasty procedures have been described for the treatment of thumb carpometacarpal joint (CMC) osteoarthritis. The purpose of this study is to determine the outcomes of patients treated with trapeziectomy and a variation of abductor pollicis longus (APL) suspension arthroplasty.

Methods—18 consecutive patients with osteoarthritis of the thumb CMC joint were treated by a single surgeon (KCC) with trapeziectomy and APL suspension arthroplasty (21 thumbs). The radial slip of the APL was used for the reconstruction. Prospective outcomes data were collected before the operation, and at 3, 6 and 12 months after surgery. Outcomes were assessed with x-rays, grip/key pinch strength, the Jebsen-Taylor test and the Michigan Hand Outcomes Questionnaire (MHQ). Tourniquet time was recorded as well. These results were compared to our retrospective series of 35 flexor carpi radialis (FCR) ligament reconstructive procedures and to the literature.

Results—Immediately after surgery, a 32% loss in CMC height was observed and an additional 11% proximal metacarpal migration was observed at 1 year. The mean grip strength was 11.1 kg pre-operatively, and 7.7 kg, 14.3 kg, and 16.7 kg at 3 months, 6 months and 1 year post-operatively. These results were comparable to published series. The Jebsen-Taylor scores showed a improvement from 47 seconds pre-operatively to 40 seconds at 3 months, 34 seconds at 6 months ($p=0.03$), and 33 seconds at 1 year ($p=0.01$). The MHQ results demonstrated improvements in all domains. Statistically significant improvements were noted in the domains of overall score from 41 to 67 ($p=0.03$), activities of daily living from 43 to 66 ($p=0.01$), work from 41 to 65 ($p=0.05$), patient satisfaction from 25 to 68 ($p=0.01$), and pain decreased from 73 to 30 ($p<0.01$). The mean tourniquet time for the trapeziectomy with APL suspension arthroplasty was 33 minutes, while the mean tourniquet time for trapeziectomy with FCR ligament reconstruction and tendon interposition was 42 minutes ($p=0.02$).

Conclusion—Abductor pollicis longus suspension arthroplasty is a faster and technically easier technique that avoids any additional deficit by using an accessory tendon. Its outcomes are comparable to those in our retrospective FCR series and to published data in the literature. Furthermore, APL suspension arthroplasty gives acceptable patient-rated outcomes especially in pain relief and satisfaction.

Keywords

Abductor pollicis longus; arthroplasty; carpometacarpal osteoarthritis; the Michigan Hand Outcomes Questionnaire

A myriad of surgical procedures have been described for the treatment of thumb carpometacarpal (CMC) osteoarthritis. While arthrodesis may be indicated in heavy laborers (1, 2), many patients are eligible for trapezium excision, either alone or augmented with a variety of ligament reconstruction techniques. While several reports, including a recent randomized trial by Davis et al from the United Kingdom, have demonstrated good functional outcomes and adequate pain relief with trapeziectomy alone (3–6), flexor carpi radialis (FCR) reconstruction has remained the most popular procedure in the United States (7).

Even though the FCR technique has withstood the test of time, a simpler alternative using an expendable slip of the abductor pollicis longus (APL) tendon has received increasing attention (8–13). One advantage of the APL approach is the use of an accessory tendon that has no resultant functional consequence. Although this technique is simpler, the need to create a bone tunnel in the thumb metacarpal for passage of the tendon may be rather cumbersome (14, 15).

The purpose of this paper is to present an alternative APL reconstruction that is a modification of the technique described by Thompson (14). We have eliminated the need for a thumb metacarpal drill hole, making this a simpler and less time-consuming procedure. To establish the effectiveness of this operation, we conducted a prospective outcomes study of the APL suspension arthroplasty by measuring the radiographic, functional and patient-rated outcomes of this technique. In addition, we compared its effectiveness with our previous FCR procedure as well as to other published series.

Materials and Methods

Between September 2004 and February 2007, a consecutive prospective series of 21 trapeziectomy procedures with a modified APL suspension arthroplasty were performed for 18 patients with osteoarthritis of the thumb CMC joint. Mean age was 61 (range 48–77). Fourteen patients were women. Nine patients had left-sided procedures, 6 patients had right-sided procedures, while 3 patients had surgery on both thumbs. Of the 21 procedures, 2 were reoperations for previously failed CMC arthroplasty procedures using the FCR. Eight procedures were performed in combination with other procedures in the same limb.

Prior to adopting the APL suspension arthroplasty, between September 1997 and July 2004, the senior surgeon (KCC) performed 35 consecutive trapeziectomy procedures with the full

FCR tendon for ligament reconstruction. The mean age was 59 (range 44–76). Of the 30 patients, 24 patients were women. Eleven patients had left-sided procedures, 14 patients had right-sided procedures, and 5 patients had bilateral procedures. Five of the procedures were performed in combination with other procedures on the same limb. One procedure was a reoperation for a failed CMC arthroplasty.

Surgical Technique

A 3-cm longitudinal incision is made over the anatomic snuffbox (Figure 1). Dissection is carried down between the extensor pollicis longus and the APL. Branches of the radial sensory nerve are protected throughout the dissection. The radial artery serves as a landmark to the thumb CMC joint as it courses over the scaphotrapezial joint. Cauterization of its small articular branches to the trapezium will allow it to be mobilized and retracted. The trapeziometacarpal joint is exposed through a longitudinal capsulotomy. The trapezium is divided into thirds using an oscillating saw and removed piecemeal with a rongeur (Figure 2). The FCR tendon, which is located in the trapezial groove, is protected during this process. Osteophytes are also removed with a rongeur.

A separate 2-cm chevron incision is made over the first extensor compartment at the radial styloid and slips of the APL are identified (Figure 3). The most radial slip is divided at the musculotendinous junction and delivered into the distal incision (Figure 4). The radial slip is selected because traction of this slip ulnarly will adduct the thumb metacarpal base and correct its lateral subluxation. The tendon slip is dissected free of capsular tissue to its insertion at the base of the thumb. The APL tendon slip is passed under the extensor pollicis brevis tendon and weaved to the extensor carpi radialis longus (ECRL) tendon at its insertion onto the base of the index finger metacarpal (Figure 5). The weaved tendon juncture is secured using 3-0 Ethibond (Ethicon, Somerville, NJ) sutures (Figure 6). Typically, the amount of APL tendon is insufficient for tendon interposition into the trapezial space.

The joint capsule is repaired with 3-0 Vicryl (Ethicon, Somerville, NJ) sutures. Both incisions are closed in a layered fashion with 3-0 Vicryl interrupted deep dermal sutures, followed by 4-0 Monocryl (Ethicon, Somerville, NJ) running subcuticular sutures.

A thumb spica plaster splint is molded with the thumb in slight abduction. At 2 weeks after surgery, the plaster splint is replaced by a thermoplast splint. A progressive range of motion program is initiated after splint removal at 4 weeks after surgery.

Radiographic Measurements

All patients undergoing APL suspension arthroplasty had pre-operative 3-view x-rays of the involved thumb. Post-operative x-rays were obtained at 1 week, 3 months, 6 months and 1 year after the operation. Early post-operative x-rays were available for 18 thumbs, and 1 year post-operative x-rays were available for 12 thumbs. To assess the ability of the reconstruction in maintaining thumb length, we measured pre- and post-operative CMC space in the anteroposterior view as the distance between the distal scaphoid and the base of the metacarpal (Figure 7). This technique was described by Goffin and Saffar (16). The long-term stability of the thumb basilar joint reconstruction was assessed by calculating the

proximal migration in which the percent decrease of CMC space at one year is compared to that at 1 week after the operation.

Objective Functional Assessment

Grip strength, measured with a dynamometer (Jamar; Sammons Preston Rolyan, Bolingbrook, IL) and key-pinch strength, measured with a pinch gauge (B&L engineering, Tustin, CA), were taken pre-operatively, and at 3 months, 6 months, and 1 year post-operatively. The pre-operative and post-operative grip and pinch strength measurements were compared. In addition, the values were also normalized against the contralateral hand for those patients who had unilateral operations only. The pre-operative means were compared to the 1 year post-operative means using the paired Student's t test.

The Jebsen-Taylor test was also administered during the same sessions to simulate activities of daily living. It is an objective and standardized multi-scale measure of hand function with 7 subtests to represent various hand activities (17, 18). Mean 1 year post-operative Jebsen-Taylor test scores were compared against mean pre-operative scores using the paired Student's t test. For objective functional assessment, measurements were taken for 17 patients pre-operatively. Post-operative measurements were taken for 13 patients at 3 months, 10 patients at 6 months and 10 patients at 1 year.

Patient-rated Functional Assessment

The Michigan Hand Outcomes Questionnaire (MHQ) was administered before surgery and at 3 months, 6 months and 1 year after the procedure. The MHQ is a self-administered test that is a reliable, valid and responsive instrument capable of measuring health status domains that are important to patients with hand disorders (19, 20). The 6 domains in the MHQ are (1) overall hand function, (2) activities of daily living (ADL), (3) pain, (4) work performance, (5) aesthetics, and (6) patient satisfaction. All of the MHQ domains are based on a scale between 0 to 100. For all of the domains except pain, the higher the scores, the better the subject's hand performance. For the pain domain, the lower the score, the less pain the subject experiences. Its validity has been shown for a number of common hand disorders (21–24). Pre-operative MHQ results were available for 12 patients. Post-operative results were available for 12 patients at 3 months, 11 patients at 6 months, and 11 patients at 1 year. Effect size was calculated comparing the preoperative and 1 year post-operative means based on Cohen's criteria with an effect size greater than 0.8 demonstrating a large difference between the means (25). The paired Student's t test was used to analyze the pre-operative and 1 year post-operative data.

Intra-operative Data

Operative records were reviewed, and tourniquet times were available for 19 of the 21 APL procedures. Of the 19 procedures, 7 were done in combination with other procedures in the same limb, and 1 was a reoperation. The times for these 8 procedures were excluded from statistical analysis because the additional procedures vary in complexity and do not reflect the actual time for the APL suspension arthroplasty. We collected the tourniquet times for our 24 isolated FCR arthroplasty procedures for comparison with the current series.

Results

Radiographic Evaluation

The results of the radiographic assessment are shown in Table 2. For the APL group, the pre-operative mean CMC space was 11.3 mm, and the 1 week post-operative mean CMC space was 7.6 mm. This represented an initial 32% loss in the height of CMC space. At one year, the CMC space had further reduced to 6.3 mm, an 11% proximal metacarpal migration compared to the one week CMC space. Overall, at one year, the loss of CMC space height was 38% compare to pre-operative measurements. Most of the thumbs remained stable in length over the study period as further analysis showed that a proximal migration of greater than 15% was noted in 3 patients, while the rest showed little or no further loss in the height of the CMC space over the one year follow-up. No metacarpal scaphoid impingement was noted.

The low rate of proximal migration in this series demonstrated long-term stability of the APL reconstruction. These results are comparable to previous series in the literature (Table 6). Overall, the height of the CMC space did not correlate with functional outcomes, pain relief or patient satisfaction. These findings are consistent with many previous studies (8, 26–28).

Functional Outcomes

Table 3 presents the data for grip, pinch strength and Jebson-Taylor test. Both grip and pinch strength showed an initial decrease at 3 months, which subsequently improved to pre-operative level at 6 months. Both grip and pinch strength exceeded the pre-operative measurements at 1 year after the surgery. As expected, the grip strength measurements varied greatly amongst the subjects. When the grip strength measurements were normalized against the contralateral hand, the mean pre-operative grip strength was 86% of the contralateral hand. The percentage decreased to 43% at 3 months, but then improved to 84% at 6 months and 102% at one year. The improvements did not reach statistical significance. The pinch strength measurements showed similar patterns. In this series, the 1 year post-operative pinch and grip strength measurements were comparable to previous studies using ligament reconstruction with APL and FCR tendons (Table 6).

The Jebson-Taylor test scores improved from 47 seconds to 40 seconds at 3 months, 34 seconds at 6 month, and 33 seconds at 1 year. The improvements reached statistical significance at 6 months ($p=0.04$) and 1 year ($p=0.02$) when the patients were able to performed simulated activities of daily living more rapidly. Most of the published series do not use the Jebson-Taylor test and direct comparison is not possible.

Patient-rated Outcomes

The MHQ scores are shown in Table 4. The MHQ results demonstrated improvements in all domains. At one year, the mean overall MHQ score increased from 41 to 67 ($p=0.03$), ADL from 43 to 66 ($p=0.01$), work performance from 41 to 65 ($p=0.05$) and patient satisfaction from 25 to 68 ($p=0.01$). The mean pain score decreased from 73 to 30 ($p<0.01$), but on average, patients still complained of moderate amount of pain. The improvement in pain and

patient satisfaction reached significance after 3 months. The overall MHQ score reached statistical significance after 1 year. The improvement in activities of daily living was statistically significant at 1 year after the operation. The improvement in the categories of hand function and aesthetics failed to reach significance. When the effect size was calculated, all the domains showed large effect. Despite the clinically significant improvements, all patients continue to have moderate functional impairment and pain at one year follow-up.

Tourniquet Time

The mean tourniquet time for the trapeziectomy with APL suspension arthroplasty was 33 minutes, while the mean tourniquet time for trapeziectomy with FCR ligament reconstruction and tendon interposition was 42 minutes (Table 5). This difference is statistically significant ($p=0.02$).

Complications—To date, there has been no joint-related problem in patients who underwent APL reconstruction. One patient had painful dysesthesia in the radial sensory nerve distribution that required neurolysis. Another patient required relocation of a painful neuroma from a branch of the radial sensory nerve. Both patients were successfully treated. One patient developed a localized soft tissue infection that resolved with intravenous antibiotics. Although we did not look for a separate tunnel for the EPB in the first dorsal compartment, there was no complication related to inflammation of the compartment after APL harvest. Review of the literature demonstrated that permanent sensory changes to branches of the radial sensory nerve to be a relatively common complication, which was reported to occur in 2% to 16% of the report cases (11, 13, 29, 30). Less common complications include wound infection, regional pain syndrome, tendon injury and tendon rupture (8, 11, 13, 28). Overall, although arthroplasty with various ligament reconstructions fails to relieve pain in 0% to 40% of the patients (8, 11, 13, 28, 30–34), scaphometacarpal impingement has not been specifically documented.

Discussion

A variety of surgical treatments of osteoarthritis of the thumb CMC joint have been described, which include arthrodesis (1, 2), biologic interposition (8, 32, 34–42), trapezium excision (3–6), joint replacement arthroplasty (43–45), and ligament reconstruction (8–14, 27–31, 33, 36, 42, 46–48). In recent years, procedures that combine trapeziectomy with various ligament reconstructions have become the mainstay of surgical treatment for thumb CMC osteoarthritis. These procedures unite the treatment principles of trapezium excision to remove the eroded joint surfaces with reconstitution of the supporting ligaments of the thumb metacarpal to restore its stability and prevent axial shortening.

The shallow saddle joint architecture of the thumb basal joint has little intrinsic osseous stability and relies on surrounding ligaments to limit metacarpal base translation during its movements. Ligament laxity and repetitive forces lead to synovitis and premature degenerative changes (49, 50). During thumb motion, especially opposition, rotational forces with concomitant axial loading promote greater articular wear at the volar aspect of the trapeziometacarpal joint. In addition, the radial traction force exerted by the APL muscle

acts in conjunction with the pulling of the adductor pollicis to translate and dislocate the trapeziometacarpal joint (31). Ligament reconstruction with half of the FCR has been shown to stabilize the thumb basal joint and retard progression of osteoarthritis (32, 49, 51). The success of this procedure in treating patients with hypermobility of the thumb CMC joint is the foundation for use of FCR to stabilize the thumb metacarpal after trapeziectomy.

The anatomic basis for the FCR ligament reconstruction is the recreation of the anterior oblique ligament (also termed palmar oblique ligament or carpometacarpal ligament), which is believed by many to be the key stabilizer of the thumb. This ligament originates from the volar edge of the trapezium and inserts at the volar edge of the thumb metacarpal base (52). Despite the popularity and clinical success of basal-joint reconstructive procedures that include volar ligament reconstruction (32, 35, 47), there is not a complete agreement regarding the principal ligamentous stabilizer of the thumb CMC joint. Cadaver and radiographic studies have identified other structures such as the dorsoradial, posterior oblique and intermetacarpal ligaments (52, 53), which may also have substantial contribution to the stability of the thumb basal joint. In fact, the importance of the intermetacarpal ligaments is underscored by multiple studies demonstrating satisfactory results of simple trapeziectomy without ligament reconstruction (3–6).

Our variation of APL reconstruction seeks to reinforce the intermetacarpal ligament. With its strong distal insertion intact, the APL tendon anchors the thumb metacarpal base to the index finger metacarpal base to achieve both axial and translational stability after trapeziectomy. Furthermore, the use of the APL tendon to suture to the ECRL tendon not only reduces, but directly counteracts the radial deforming force applied by the APL muscle. The APL reconstruction also offers several other advantages over FCR reconstruction and the traditional APL reconstruction as described by Thompson (14), which requires a drill hole in the bone. By obviating the need to expose the base of the thumb to create the bone tunnel, the integrity of the intermetacarpal ligament is also preserved. This procedure is technically easier than the FCR procedure by a simpler donor tendon harvest and attachment sequence.

In this study, we also compared the results of the APL reconstruction to a retrospective consecutive series of patients who underwent trapeziectomy with FCR reconstruction by the senior surgeon (KCC). FCR reconstruction had a higher rate of major complications, including 4 painful joint subluxations; the 2 groups had similar rate of minor complications such as wound infection. When the tourniquet times were analyzed, trapeziectomy with APL suspension arthroplasty had a significantly shorter mean tourniquet time compared to trapeziectomy with FCR ligament reconstruction and tendon interposition. The outcomes of our APL series are also compared to the results of various ligament reconstructions in the literature. Functional comparison and radiographic assessment revealed results similar to previous studies using both FCR and APL reconstructions (11, 13, 27, 29, 30, 33, 47, 48).

Although nearly all studies report excellent patient rated outcomes, most of the studies on the treatment of osteoarthritis of the thumb CMC joint were conducted before the availability of validated patient-rated outcome measures and in a retrospective manner. As the result, comparison to previous series is rather difficult. Patient- rated outcomes using the

MHQ demonstrated statistically significant improvement in the domains of overall function, ADL, satisfaction, and pain. The largest and most immediate improvement was seen in the domains of satisfaction and pain relief, in which significant improvement was noted as soon as 3 months post-operatively. Despite the significant improvements in several categories, patients still have residual difficulties with their hand. The decrease in grip strength to 43% of the opposite unoperated hand at 3 months after surgery is quite a large decrease that the patients must be made aware during consultation for this procedure. Over the course of the one year follow-up period, the grip strength did return to preoperative values. The patient-rated outcomes results reflected the limitations of all current surgical treatments, which are still inadequate in restoring anatomy and metacarpal stability. The fact that patients are satisfied with current imperfect treatments may highlight the debilitating nature of this disease.

Although this study presents a good prospective assessment of outcomes for this technique, it falls short in providing adequate comparison between APL and FCR reconstruction, especially in the functional outcomes. Our FCR series was reviewed in a retrospective manner and did not provide an equivalent quality of outcomes data to provide a meaningful comparison to the APL series. The comparison to other published series is also difficult because most other studies were retrospective and did not report patient-rated outcomes.

We chose trapeziectomy with APL suspension arthroplasty instead of the FCR reconstruction as our principal surgical treatment for thumb CMC arthritis for several reasons. The use of APL tendon avoids weakening or sacrificing the FCR, an important wrist flexor. It also offers the advantage of being technically easier and faster to perform. The goal of surgical treatment of thumb CMC osteoarthritis is a pain-free and stable thumb with good strength. This study suggests that trapeziectomy with a modified APL suspension arthroplasty not only achieves treatment goals in manner comparable to previously published results but also provides good patient satisfaction.

References

1. Stark HH, Moore JF, Ashworth CR, et al. Fusion of the first metacarpotrapezoid joint for degenerative arthritis. *The Journal of bone and joint surgery*. 1977; 59:22–26. [PubMed: 833170]
2. Mattsson HS. Arthrodesis of the first carpo-metacarpal joint for osteoarthritis. *Acta orthopaedica Scandinavica*. 1969; 40:602–607. [PubMed: 5378123]
3. Hollevoet N, Kinnen L, Moermans JP, et al. Excision of the trapezium for osteoarthritis of the trapeziometacarpal joint of the thumb. *Journal of hand surgery (Edinburgh, Lothian)*. 1996; 21:458–462.
4. Davis TR, Brady O, Dias JJ. Excision of the trapezium for osteoarthritis of the trapeziometacarpal joint: a study of the benefit of ligament reconstruction or tendon interposition. *The Journal of hand surgery*. 2004; 29:1069–1077. [PubMed: 15576217]
5. Dell PC, Brushart TM, Smith RJ. Treatment of trapeziometacarpal arthritis: results of resection arthroplasty. *The Journal of hand surgery*. 1978; 3:243–249. [PubMed: 659819]
6. Varley GW, Calvey J, Hunter JB, et al. Excision of the trapezium for osteoarthritis at the base of the thumb. *J Bone Joint Surg Br*. 1994; 76:964–968. [PubMed: 7983129]
7. Pellegrini VD Jr, Burton RI. Surgical management of basal joint arthritis of the thumb. Part I. Long-term results of silicone implant arthroplasty. *The Journal of hand surgery*. 1986; 11:309–324. [PubMed: 3711603]

8. Kaarela O, Raatikainen T. Abductor pollicis longus tendon interposition arthroplasty for carpometacarpal osteoarthritis of the thumb. *The Journal of hand surgery*. 1999; 24:469–475. [PubMed: 10357523]
9. Robinson D, Aghasi M, Halperin N. Abductor pollicis longus tendon arthroplasty of the trapezio-metacarpal joint: surgical technique and results. *The Journal of hand surgery*. 1991; 16:504–509. [PubMed: 1861036]
10. Rutegard JN, Eriksson C, Olsson K. Tendon arthroplasty for treatment of trapeziometacarpal arthrosis. *Scandinavian journal of plastic and reconstructive surgery and hand surgery / Nordisk plastikkirurgisk forening [and] Nordisk klubb for handkirurgi*. 1994; 28:295–298.
11. Saehle T, Sande S, Finsen V. Abductor pollicis longus tendon interposition for arthrosis in the first carpometacarpal joint: 55 thumbs reviewed after 3 (1–5) years. *Acta orthopaedica Scandinavica*. 2002; 73:674–677. [PubMed: 12553517]
12. Sigfusson R, Lundborg G. Abductor pollicis longus tendon arthroplasty for treatment of arthrosis in the first carpometacarpal joint. *Scandinavian journal of plastic and reconstructive surgery and hand surgery / Nordisk plastikkirurgisk forening [and] Nordisk klubb for handkirurgi*. 1991; 25:73–77.
13. Sirotakova M, Figus A, Elliot D. A new abductor pollicis longus suspension arthroplasty. *The Journal of hand surgery*. 2007; 32:12–22. [PubMed: 17218171]
14. Thompson J. Surgical Treatment of Trapeziometacarpal Arthrosis. *Advances in Orthopaedic Surgery*. 1986:105–120.
15. Rab M, Gohritz A, Gohla T, et al. [Long-term results after resection arthroplasty in patients with arthrosis of the thumb carpometacarpal joint: comparison of abductor pollicis longus and flexor carpi radialis tendon suspension]. *Handchir Mikrochir Plast Chir*. 2006; 38:98–103. [PubMed: 16680665]
16. Goffin D, Saffar P. A radiological technique for measurement of the height of the trapezial cavity. Applications in pre- and post-operative assessment in osteoarthritis of the base of the thumb. *Ann Chir Main Memb Super*. 1990; 9:364–368. [PubMed: 1705133]
17. Jebsen RH, Taylor N, Trieschmann RB, et al. An objective and standardized test of hand function. *Archives of physical medicine and rehabilitation*. 1969; 50:311–319. [PubMed: 5788487]
18. Sharma S, Schumacher HR Jr, McLellan AT. Evaluation of the Jebsen hand function test for use in patients with rheumatoid arthritis [corrected]. *Arthritis Care Res*. 1994; 7:16–19. [PubMed: 7918721]
19. Chung KC, Hamill JB, Walters MR, et al. The Michigan Hand Outcomes Questionnaire (MHQ): assessment of responsiveness to clinical change. *Annals of plastic surgery*. 1999; 42:619–622. [PubMed: 10382797]
20. Chung KC, Pillsbury MS, Walters MR, et al. Reliability and validity testing of the Michigan Hand Outcomes Questionnaire. *The Journal of hand surgery*. 1998; 23:575–587. [PubMed: 9708370]
21. Chung KC, Kotsis SV, Kim HM. A prospective outcomes study of Swanson metacarpophalangeal joint arthroplasty for the rheumatoid hand. *The Journal of hand surgery*. 2004; 29:646–653. [PubMed: 15249089]
22. Chung KC, Wei FC. An outcome study of thumb reconstruction using microvascular toe transfer. *The Journal of hand surgery*. 2000; 25:651–658. [PubMed: 10913205]
23. Mandl LA, Galvin DH, Bosch JP, et al. Metacarpophalangeal arthroplasty in rheumatoid arthritis: what determines satisfaction with surgery? *The Journal of rheumatology*. 2002; 29:2488–2491. [PubMed: 12465140]
24. Sammer DM, Kawamura K, Chung KC. Outcomes using an internal osteotomy and distraction device for corrective osteotomy of distal radius malunions requiring correction in multiple planes. *The Journal of hand surgery*. 2006; 31:1567–1577. [PubMed: 17145375]
25. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*. 2 Ed. Hillsdale, NJ: Lawrence Earlbaum Associates; 1988.
26. Downing ND, Davis TR. Trapezial space height after trapeziectomy: mechanism of formation and benefits. *The Journal of hand surgery*. 2001; 26:862–868. [PubMed: 11561239]

27. Tomaino MM, Pellegrini VD Jr, Burton RI. Arthroplasty of the basal joint of the thumb. Long-term follow-up after ligament reconstruction with tendon interposition. *The Journal of bone and joint surgery*. 1995; 77:346–355. [PubMed: 7890782]
28. Lins RE, Gelberman RH, McKeown L, et al. Basal joint arthritis: trapeziectomy with ligament reconstruction and tendon interposition arthroplasty. *The Journal of hand surgery*. 1996; 21:202–209. [PubMed: 8683047]
29. Varitimidis SE, Fox RJ, King JA, et al. Trapeziometacarpal arthroplasty using the entire flexor carpi radialis tendon. *Clinical orthopaedics and related research*. 2000:164–170. [PubMed: 10660710]
30. De Smet L, Vanfleteren L, Sioen W, et al. Ligament reconstruction/tendon interposition arthroplasty for thumb basal joint osteoarthritis preliminary results of a prospective outcome study. *Acta orthopaedica Belgica*. 2002; 68:20–23. [PubMed: 11915454]
31. Brunelli G, Monini L, Brunelli F. Stabilisation of the trapezio-metacarpal joint. *Journal of hand surgery (Edinburgh, Lothian)*. 1989; 14:209–212.
32. Eaton RG, Lane LB, Littler JW, et al. Ligament reconstruction for the painful thumb carpometacarpal joint: a long-term assessment. *The Journal of hand surgery*. 1984; 9:692–699. [PubMed: 6491213]
33. Kleinman WB, Eckenrode JF. Tendon suspension sling arthroplasty for thumb trapeziometacarpal arthritis. *The Journal of hand surgery*. 1991; 16:983–991. [PubMed: 1748769]
34. Nylen S, Juhlin LJ, Lugnegard H. Weilby tendon interposition arthroplasty for osteoarthritis of the trapezial joints. *Journal of hand surgery (Edinburgh, Lothian)*. 1987; 12:68–72.
35. Eaton RG, Glickel SZ, Littler JW. Tendon interposition arthroplasty for degenerative arthritis of the trapeziometacarpal joint of the thumb. *The Journal of hand surgery*. 1985; 10:645–654. [PubMed: 4045141]
36. Damen A, van der Lei B, Robinson PH. Bilateral osteoarthritis of the trapeziometacarpal joint treated by bilateral tendon interposition arthroplasty. *Journal of hand surgery (Edinburgh, Lothian)*. 1997; 22:96–99.
37. Dell PC, Muniz RB. Interposition arthroplasty of the trapeziometacarpal joint for osteoarthritis. *Clinical orthopaedics and related research*. 1987:27–34. [PubMed: 3595001]
38. Froimson AI. Tendon interposition arthroplasty of carpometacarpal joint of the thumb. *Hand clinics*. 1987; 3:489–505. [PubMed: 3693418]
39. Menon J, Schoene HR, Hohl JC. Trapeziometacarpal arthritis-results of tendon interpositional arthroplasty. *The Journal of hand surgery*. 1981; 6:442–446. [PubMed: 7276474]
40. Weilby A. Tendon interposition arthroplasty of the first carpo-metacarpal joint. *Journal of hand surgery (Edinburgh, Lothian)*. 1988; 13:421–425.
41. Barron OA, Eaton RG. Save the trapezium: double interposition arthroplasty for the treatment of stage IV disease of the basal joint. *The Journal of hand surgery*. 1998; 23:196–204. [PubMed: 9556256]
42. Kriegs-Au G, Petje G, Fojtl E, et al. Ligament reconstruction with or without tendon interposition to treat primary thumb carpometacarpal osteoarthritis. Surgical technique. *The Journal of bone and joint surgery*. 2005; 1(87 Suppl):78–85. [PubMed: 15743849]
43. Swanson AB. Disabling arthritis at the base of the thumb: treatment by resection of the trapezium and flexible (silicone) implant arthroplasty. *The Journal of bone and joint surgery*. 1972; 54:456–471. [PubMed: 5055148]
44. Kessler I, Axer A. Arthroplasty of the first carpometacarpal joint with a silicone implant. *Plast Reconstr Surg*. 1971; 47:252–257. [PubMed: 5101682]
45. de la Caffiniere JY, Aucoeur P. Trapezio-metacarpal arthroplasty by total prosthesis. *The Hand*. 1979; 11:41–46. [PubMed: 488776]
46. Atroshi I, Axelsson G. Extensor carpi radialis longus tendon arthroplasty in the treatment of primary trapeziometacarpal arthrosis. *The Journal of hand surgery*. 1997; 22:419–427. [PubMed: 9195450]
47. Burton RI, Pellegrini VD Jr. Surgical management of basal joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty. *The Journal of hand surgery*. 1986; 11:324–332. [PubMed: 3711604]

48. Sai S, Fujii K, Chino H, et al. Tendon suspension sling arthroplasty for degenerative arthritis of the thumb trapeziometacarpal joint: long-term follow-up. *J Orthop Sci.* 2004; 9:576–580. [PubMed: 16228674]
49. Eaton RG, Littler JW. Ligament reconstruction for the painful thumb carpometacarpal joint. *The Journal of bone and joint surgery.* 1973; 55:1655–1666. [PubMed: 4804988]
50. Barron OA, Glickel SZ, Eaton RG. Basal joint arthritis of the thumb. *The Journal of the American Academy of Orthopaedic Surgeons.* 2000; 8:314–323. [PubMed: 11029559]
51. Freedman DM, Eaton RG, Glickel SZ. Long-term results of volar ligament reconstruction for symptomatic basal joint laxity. *The Journal of hand surgery.* 2000; 25:297–304. [PubMed: 10722822]
52. Nanno M, Buford WL Jr, Patterson RM, et al. Three-dimensional analysis of the ligamentous attachments of the first carpometacarpal joint. *The Journal of hand surgery.* 2006; 31:1160–1170. [PubMed: 16945721]
53. Imaeda T, An KN, Cooney WP 3rd, et al. Anatomy of trapeziometacarpal ligaments. *The Journal of hand surgery.* 1993; 18:226–231. [PubMed: 8463585]

Figure 1.
Skin incision.

Figure 2.
Trapezium is exposed through a longitudinal capsulotomy, sectioned and removed piecemeal.

Figure 3.
A large slip of APL is harvested through a proximal counter incision.

Figure 4.
ECRL is identified at the base of the index metacarpal. The harvested slip of APL is delivered into the distal incision.

Figure 5.
Schematics of the APL suspension arthroplasty.

Figure 6.
The tendon slip is passed under the first extensor compartment tendons and weaved to ECRL at the base of the index metacarpal.

Figure 7.

Radiographic reference points for measurement of the height of the CMC space.

Line (a) is the line projected through the radial articular surface of the index metacarpal and the trapezium.

Line (b) is the line tangent to the thumb metacarpal base and perpendicular to line (a).

Line (c) is the line tangent to the distal extreme of the scaphoid and perpendicular to line (a).

The distance between line (b) and line (c) is the height of the CMC space.

M1 = thumb metacarpal,

M2 = index metacarpal,

T = trapezium,

S = scaphoid.

Table 1

APL patient demographic data

Number of procedures	21
Gender distribution (F/M)	14/ 4
Age (range)	61 (48 – 77)
Female (years)	60 (48 – 77)
Male (years)	63 (55 – 70)
Laterality of procedure	
Right	6
Left	9
Bilateral	3
Combined procedures	8
Re-operation	2

Table 2

Radiographic Data

	Pre-operative $\pm$ SD (range)	Post-operative $\pm$ SD (range)	% Loss of CMC space	CMC space at 1 year $\pm$ SD (range)	% Proximal migration
APL ⁺ , mm (n=12)	11.3 $\pm$ 2.7 (6.8 to 15.8)	7.6 $\pm$ 1.9 (3.8 to 11.5)	35%	6.3 $\pm$ 1.7 (3.8 to 9.4)	11%
FCR LTRI ⁼ , mm (n=6)	10.9 $\pm$ 2.0 (8.5 to 12.7)	6.8 $\pm$ 2.5 (3.7 to 8.5)	39%	*	*

* Secondary to the retrospective manner of data collection, insufficient number of long-term post-operative x-rays were available for patients who underwent FCR reconstruction

+ APL suspension arthroplasty

= FCR ligament reconstruction with tendon interposition

Table 3

Functional Outcomes Data

	Pre-operative $\pm$ SD (n=17)	3-months $\pm$ SD (n=13)	6-months $\pm$ SD (n=10)	1-year $\pm$ SD (n=10)	p-value *
Grip strength, kg	11.1 $\pm$ 9.6	7.7 $\pm$ 5.7	14.3 $\pm$ 6.9	16.7 $\pm$ 8.3	0.13
Grip strength, % contralateral	86 $\pm$ 44	43 $\pm$ 16	84 $\pm$ 44	102 $\pm$ 34	0.18
Key pinch, kg	4.9 $\pm$ 2.9	4.4 $\pm$ 1.7	5.7 $\pm$ 2.2	5.8 $\pm$ 2.9	0.43
Key pinch, % contralateral	89 $\pm$ 18	64 $\pm$ 19	84 $\pm$ 29	93 $\pm$ 36	0.93
Jebsen-Taylor, sec	47 $\pm$ 17	40 $\pm$ 14	34 $\pm$ 5	33 $\pm$ 4	0.02

* p value calculated using the paired Student's t test comparing pre-operative mean and 1 year post-operative mean

Table 4

Michigan Hand Outcomes Questionnaire Data*

Domain	Pre-operative (n=12)	3-month post-operative ± SD (n=12)	6-month post-operative ± SD (n=11)	1-year post-operative ± SD (n=11)	Effect size [#]	p value ⁺
Overall	42 ± 18	58 ± 17	61 ± 12	67 ± 20	1.4	0.03
Function	51 ± 27	56 ± 17	66 ± 11	67 ± 21	0.6	0.48
ADL =	43 ± 26	59 ± 20	63 ± 17	65 ± 27	0.8	0.01
Work	41 ± 25	52 ± 24	52 ± 13	65 ± 24	1.0	0.05
Pain	73 ± 16	47 ± 22	42 ± 17	30 ± 26	2.7	< 0.01
Aesthetics	61 ± 25	74 ± 22	66 ± 16	67 ± 26	0.2	0.38
Patient satisfaction	29 ± 19	54 ± 23	64 ± 25	68 ± 26	2.1	0.01

* All of the MHQ domains are based on a scale between 0 to 100. For all of the domains except pain, the higher the scores, the better the subjects' hand performance. For the pain domain, the lower the score, the less pain the subject experienced.

+ p value calculated using the paired Student's t test comparing pre-operative mean and 1 year post-operative mean

= Activity of daily living

Effect size calculated using the standardized mean difference between pre-operative mean and 1 year post-operative mean

Table 5

Tourniquet Time

	APL, min (n=11)	FCR, min (n=23)	p-value
Mean tourniquet time ± SD (range)	33 ± 8 (24 to 47)	42 ± 11 (29 to 66)	0.02

⁺ p value calculated using the independent Student's t test comparing mean tourniquet time for APL suspension arthroplasty and FCR LRTI

Table 6**Representative Studies of Trapeziectomy and Ligament Reconstruction**

Study	Number of procedures	Procedure	Pinch strength, kg	Pinch strength, % contralateral	Grip strength, kg	Grip strength, % contralateral	CMC space, mm	Loss of CMC space	Proximal metacarpal migration
Present study	21	APL	5.8	96%	16.7	106%	7.6	35%	11%
Present Study	35	FCR					7.2	39%	
Saehle et al, 2002 ⁽¹¹⁾	55	APL	3.6	78%	20	89%	5		
Sirotkova et al, 2007 ⁽¹³⁾	104	APL	5.1 ^U 4.9 ^B	89%	18 ^U 16.9 ^B	90%	7.8	45%	
Burton and Pellegrini, 1986 ⁽⁴⁷⁾	25	FCR	6.7 ^M 4.4 ^F		33.7 ^M 15 ^F			50%	11%
Kleinman and Eckenrode, 1991 ⁽³³⁾	40	FCR	5.1	97%	18.9	101%		42%	
Tomaino et al, 1995 ⁽²⁷⁾	24	FCR	4.9		24.6				13%
Varitimidis et al, 1999 ⁽²⁹⁾	62	FCR	4.6	110% ^D 68% ND	22.3	105% ^D 76% ND	7.8		
De Smet et al, 2002 ⁽³⁰⁾	31	FCR	5		26		6	41%	
Sai et al, 2004 ⁽⁴⁸⁾	22	FCR	2.6	104%	17.6	98%	8.1	44%	

APL Variations of APL suspension arthroplasty

FCR Variations of FCR ligament reconstruction

U Patients with unilateral disease

B Patients with bilateral disease

M Male patients

F Female patients

D Dominant hand

ND Non-dominant hand