

Thumb Carpometacarpal Suspension Arthroplasty Using Interference Screw Fixation: Surgical Technique and Clinical Results

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Purpose Arthritis of the thumb carpometacarpal (CMC) joint is a common condition, for which reconstruction using the flexor carpi radialis (FCR) is a standard treatment. We describe the technique and clinical results for thumb CMC arthroplasty using interference screw fixation of the FCR to the first metacarpal through a single incision.

Methods Over 12 months, 29 consecutive CMC arthroplasties were performed in 29 patients using FCR transfer tenotomized at the level of the scaphoid with an absorbable biotenesis screw for fixation. There were 24 women and 5 men, with a mean age of 58 years. Patients were evaluated at a minimum of one year with radiographs, standardized outcome instruments, and measurements of motion and strength. The scaphoid to first metacarpal distance was measured at 2 weeks, 3 months, and greater than 1 year to assess settling.

Results A total of 28 patients were available at a mean of 19 months. No arthroplasties required revision. Postoperative scaphoid to first metacarpal distance was 5.9 mm, which had decreased by a mean of 1.4 mm at final follow-up. There were no side-to-side differences in range of motion or strength in the entire cohort except for lateral key pinch, which was lower on the reconstructed side. The mean postoperative Disabilities of the Arm, Shoulder, and Hand score was 15, and the mean visual analog scale score was 1. Correlations were found between age and lateral key pinch strength for the reconstructed and contralateral sides. There were no significant relationships among Disabilities of the Arm, Shoulder, and Hand score, visual analog scale, radiographic settling, side-to-side strength or range of motion versus gender, Eaton stage, or workers' compensation status.

Conclusions Our series demonstrates excellent clinical outcomes with no revisions at an average of 19 months for this technique. Strength, range of motion, and radiographic settling compare favorably with published results of alternative techniques. Except for lateral key pinch, there was no statistically significant difference in strength compared with the contralateral side. (*J Hand Surg* 2010;35A:913–920. © 2010 Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand.)

Type of study/level of evidence Therapeutic IV.

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ARTHRITIS OF THE THUMB carpometacarpal (CMC) joint is a common condition for which many nonsurgical¹⁻³ and surgical⁴⁻¹⁴ treatments have been reported. Advanced disease in a lower-demand patient is commonly treated with trapeziectomy and ligament reconstruction with tendon interposition (LRTI) using the flexor carpi radialis (FCR) tendon.¹³ The classic technique for LRTI¹³ requires harvest of the FCR through multiple incisions in the forearm and relies on direct tendon-to-tendon suturing to maintain the reconstruction during healing. It has been demonstrated that there is no clear benefit to tendon interposition versus ligament reconstruction alone.¹⁵

Interference screw fixation is gaining popularity within orthopedics as a method of fixation and has been successfully applied in both the upper and lower extremity.¹⁶⁻²³ Screw fixation of tendon to bone has been demonstrated to have greater load to failure than other types of fixation including suture anchors and suture over a bone bridge or button.^{17,21,24} Degradable biotensodesis screws have theoretical advantages over metal interference screws including less stress shielding as they slowly degrade, elimination of additional procedures for hardware removal, and simpler revision surgery if required.²⁵⁻²⁷ We present a consecutive series of patients treated with basilar joint reconstruction using a resorbable interference screw for fixation of the FCR tendon to the first metacarpal base.

MATERIALS AND METHODS

Between February 2006 and March 2007, 31 consecutive patients (31 thumbs) underwent trapeziectomy and ligament reconstruction using the whole FCR with interference screw fixation by a single surgeon for a diagnosis of degenerative arthritis of the thumb CMC joint. All patients had failed a trial of nonsurgical treatment including nonsteroidal anti-inflammatory drugs, splinting, activity modification, and corticosteroid injection. Two patients who had sustained previous notable ipsilateral upper extremity trauma (brachial plexopathy, and painful intra-articular distal radius fracture malunion) were excluded, leaving 29 patients (29 thumbs) for review.

There were 5 men and 24 women, mean age 58 years (range, 39-71 y), with 18 dominant and 11 nondominant side procedures. Preoperatively, 13 patients were retired, 7 were office workers, 5 had fine-dexterity professions, and 4 had light labor professions. Five patients were workers' compensation cases. The mean age of 46 years (range, 39-54 y) in the workers' compensation cases was significantly younger than the mean age of 60 years (range, 48-71 y) in the remaining



FIGURE 1: A 3- to 4-cm incision marked out dorsally centered on the CMC joint.

cases ($p < .001$). There was no gender difference between these 2 groups. The index procedure was an isolated CMC joint arthroplasty in 22 cases and a combined procedure in 7 cases. The combined procedures included ipsilateral carpal tunnel release in 4 cases, ipsilateral carpal tunnel release and contralateral long finger trigger finger release in 1 case, and ipsilateral carpal tunnel release and cubital tunnel release in 1 case.

We staged the preoperative radiographs according to the system of Eaton and Glickel.²⁸ By this classification, no patients were stage I, 11 were stage II, 15 were stage III, and 3 were stage IV.

Surgical technique

The procedure was performed under regional anesthesia and tourniquet control. We made a 3- to 4-cm longitudinal incision over the dorsal midline of the thumb centered on the trapezium (Fig. 1). Blunt dissection was used to identify and preserve branches of the dorsal sensory radial nerve as well as the radial artery. We incised the first dorsal compartment tendon sheath over the length of the incision and retracted the first compartment tendons. A longitudinal capsulotomy was then made, and the locations of the CMC and scaphotrapezium-trapezoid joints were confirmed with fluoroscopy. The trapezium was subperiosteally dissected of all soft tissue attachments (Fig. 2) and then excised with a rongeur, taking care to preserve the FCR volarly (Fig. 3). The FCR was harvested through



FIGURE 2: The trapezium prepared for excision after subperiosteal dissection of its soft tissue attachments.



FIGURE 4: The guide wire is driven obliquely retrograde through the metacarpal base out the volar side.



FIGURE 3: The FCR tendon intact on the floor of the wound after trapeziectomy.

this approach by applying distally directed traction. We transected the tendon with distally applied tension at the most proximal aspect of the wound in the region of the scaphotrapezium-trapezoid joint. This technique typically yields a tendon length of approximately 4 to 5 cm.

We then used instruments from the Bio-Tenodesis Screw System (Arthrex, Naples, FL). The 2.4-mm guide wire was introduced into the base of the first metacarpal starting in the midline dorsally, one cm distal to the articular margin, angling obliquely in a volar and proximal direction to exit the palmar cortex just distal to the articular margin (in the area of the volar oblique ligament insertion) (Fig. 4). The 4-mm cannulated drill was then passed over the guide wire, and the FCR tendon was then brought through the tunnel from volar to dorsal (Fig. 5). While applying enough traction to the FCR to take the slack out of the tendon, we applied manual pressure to the first metacarpal base toward the second metacarpal base and then inserted the 4 × 10-mm screw into the drill hole for an interference fit, burying the screw within the metacarpal (Fig. 6). Any remaining FCR tendon was then excised. A layered closure including the dorsal capsule was then performed. The average length of the procedure defined as incision time to deflation of the tourniquet before skin closure in this cohort was 33 minutes (range, 26–42 min).

Postoperatively, after 3 to 5 days, the surgical dressing was removed and a short arm thumb spica splint was fashioned with the interphalangeal joint free. Patients were allowed to remove the splint for hygiene and light activities of daily living. At approximately 4 weeks postoperatively, the splint was discontinued and supervised hand physiotherapy was begun. At 6 weeks, unrestricted active and passive motion of the thumb

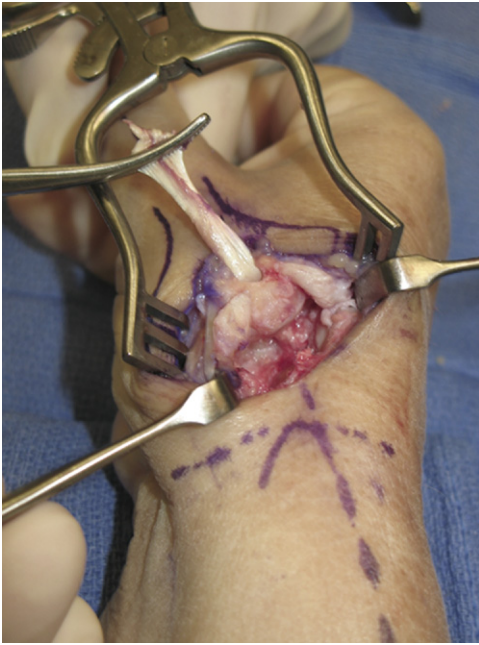


FIGURE 5: The FCR is pulled through the metacarpal drill hole from volar to dorsal.



FIGURE 6: The interference screw is inserted over the wire with traction on the FCR and manual pressure directing the thumb metacarpal base toward the adjacent index.

with progressive strengthening starting at no more than 1 kg (2 lb) resisted pinch was initiated.

Patient assessment

Twenty-eight patients were available for follow-up at greater than one year, with a mean of 19 months (range,

13–26 months). None of the arthroplasties required revision procedures during this time. Patients were evaluated with radiographs at 2 weeks and 3 months, and for the purposes of this study, at greater than 1 year after surgery. The scaphoid to first metacarpal distance was measured to the nearest millimeter on each anteroposterior radiograph of each of the 3 sets, to quantify settling. This was measured using the MedVIEW (Aspyra, Westlake Village, CA) computer imaging software program as the perpendicular distance, in the axis of the CMC joint, between 2 parallel lines drawn across the most proximal portion of the first metacarpal base and the most distal portion of the scaphoid respectively. Care was taken to correct for radiographic magnification.

At the final follow-up visit, patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, a visual analog scale (VAS) for pain (with 0 being “no pain” and 10 being “worst possible pain”), and a functional survey that assessed their return to work, their activity level, the status of the contralateral thumb CMC joint, and their pain medicine requirement. An independent occupational therapist examined patients for bilateral range of motion in radial and palmar abduction and strength in grip at position number 3, lateral key pinch, tip pinch, and tripod pinch using standard grip and pinch dynamometry. For each strength parameter, 3 trials were performed and the mean value was used for analysis.

We used SPSS for Windows (Version 13; Cary, NC) for data management and statistical analysis. Because the data had statistically nonnormal distributions, we used nonparametric statistical methods to analyze the data. The Friedman test was done to compare the reconstructed and contralateral sides with respect to noncategorical variables. The Mann-Whitney test was used to compare independent groups (such as women and men) with respect to noncategorical variables. We obtained scatterplots and Spearman correlations to evaluate the association between noncategorical variables. A .05 significance level (2-tailed) was used for all statistical analyses.

Results

Radiographic analysis revealed a mean scaphoid to first metacarpal distance at 2 weeks after surgery of 5.9 ± 1.5 mm (median, 6.0; range, 3–9 mm). The mean change in scaphoid to first metacarpal distance at 3 months postoperatively was 0.9 ± 0.9 mm (median, 1.0; range, 0–3 mm) and between the 3-month and final follow-up visit was 0.5 ± 0.8 mm (median, 0; range,



FIGURE 7: Anteroposterior radiograph at 18 months demonstrates good maintenance of the arthroplasty space, with settling of 1 mm from a starting scaphoid to first metacarpal distance of 7 mm, to a final 6 mm.

0–3 mm), for a mean additive total of settling of 1.4 ± 1.0 mm (median, 1.0; range, 0–3 mm), or 24% (Fig. 7).

The rate of change in the scaphoid to first metacarpal distance decreased significantly after the first 3 months ($p = .049$), with a mean rate of 0.38 ± 0.52 mm per month (median, 0.30; range, 0–2.23) from 2 weeks postoperatively to 3 months postoperatively, and a mean rate of 0.03 ± 0.04 mm per month (median, 0; range, 0–0.15) from 3 months postoperatively to last follow-up.

At final follow-up, the mean range of motion in palmar abduction measured $55^\circ \pm 8^\circ$ degrees (median, 55° ; range, 38° to 70°) on the reconstructed side and $55^\circ \pm 8^\circ$ (median, 55° ; range, 40° to 68°) on the contralateral side. Radial abduction measured $56^\circ \pm 8^\circ$ (median, 55° ; range, 40° to 70°) on the reconstructed side and $55^\circ \pm 8^\circ$ (median, 55° ; range, 40° to 70°) on the contralateral side. There were no statistically significant side-to-side differences in range of motion ($p \geq .05$).

Table 1 lists measurements of strength in grip, lateral key pinch, tip pinch, and tripod pinch. The difference in lateral key pinch strength was the only measurement that was statistically significant ($p = .005$), and was greater on average by 1 kg (2 lb) on the contralateral side. No other side-to-side differences were identified ($p > .05$).

All 15 patients who were working before surgery were able to return to their original level of employment. Fourteen patients were able to participate in recreational activities after surgery and 6 patients believed that their thumb limited their ability to participate in recreational activities. Six patients felt that their thumb

limited their ability to either work or perform their activities of daily living. One patient required medication for treatment of pain in the reconstructed thumb and used nonsteroidal anti-inflammatory drugs regularly. Nineteen patients experienced symptomatic arthritis of the contralateral CMC joint, for which one patient had undergone CMC arthroplasty and 6 were receiving oral medication. The mean DASH score at follow-up was 15 ± 15 (median, 11; range, 0–56), and the mean VAS pain score was 1.1 ± 1.4 (median, 0.5; range, 0–5).

There was one complication noted in the cohort, which involved a painless decrease in sensation in the first dorsal web space that persisted at 16 months, with measurable difference in Semmes-Weinstein monofilament testing compared with the contralateral side (4.31 vs 3.61 g). There were no implant complications noted, such as implant fracture or postoperative inflammatory reaction.

We found statistically significant, negative Spearman correlations between age and lateral key pinch strength for the reconstructed ($\rho = -0.52$, $p = .006$) and contralateral ($\rho = -0.46$, $p = .015$) sides and the contralateral tripod pinch strength ($\rho = -0.45$, $p = .017$). We found no statistically significant Spearman correlations between age and other strength measures or range of motion, radiographic settling, DASH, and VAS. For all of the absolute strength measurements, men had significantly higher values than women, and workers' compensation cases had significantly higher values than other cases. When comparing results based on gender, Eaton staging, and workers' compensation status, we found no statistically significant relationships with respect to DASH, VAS, radiographic settling, side-to-side strength, and side-to-side range of motion. The mean DASH scores of 22.7 ± 15.0 (median, 20.9; range, 6.7–42.5) and 13.6 ± 15.2 (median, 8.3; range, 0–56.3), and VAS scores of 2.4 ± 2.5 (median, 2.3; range, 0–5) and 0.8 ± 1.1 (median, 0.5; range, 0–4) in workers' compensation and non-workers' compensation patients, respectively, also did not achieve statistical significance ($p \geq .05$). The mean DASH scores of 25.8 ± 22.8 (median, 17.5; range, 1.7–56.3) and 12.5 ± 12.4 (median, 7.9; range, 0–47.5) and VAS scores of 2.3 ± 2.2 (median, 2.0; range, 0–5) and 0.8 ± 1.1 (median, 0.3; range, 0–4) in men and women, respectively, also did not achieve statistical significance ($p \geq .05$). The inability to obtain statistical significance may have been due to type II error because of the small sample sizes for men and workers' compensation cases.

TABLE 1. Pinch and Grip Strength at Final Follow-Up

Side	Grip	Lateral Key Pinch	Tip Pinch	Tripod Pinch
Reconstructed	19 ± 11 kg (60 ± 25 lb) 26 kg; 11–69 kg (57 lb; 25–152 lb)	5 ± 2 kg (13 ± 4 lb) 5 kg; 4–9 kg (12 lb; 8–20 lb)	5 ± 1 kg (10 ± 3 lb) 5 kg; 2–9 kg (10 lb, 5–20 lb)	6 ± 2 kg (13 ± 5 lb) 5 kg; 3–12 kg (12 lb; 6–26 lb)
Contralateral	28 ± 11 kg (61 ± 25 lb) 24 kg; 11–64 kg (53 lb; 25–140 lb)	7 ± 3 kg (15 ± 6 lb) 6 kg; 2–13 kg (14 lb; 5–29 lb)	5 ± 2 kg (11 ± 4 lb) 5 kg; 3–10 kg (10 lb; 6–23 lb)	6 ± 2 kg (14 ± 4 lb) 6 kg; 4–11 kg (13 lb; 8–24 lb)

Data represent mean ± SD and median; range.

DISCUSSION

Arthritis of the thumb CMC joint is a common condition with many surgical treatment options when conservative measures fail. Gervis⁶ initially described trapeziectomy in 1949 as a treatment for advanced arthritis of the thumb CMC joint, and since that time many variations have been described, including trapeziectomy with interposition,⁵ LRTI,¹³ and trapeziectomy with hematoma distraction.¹⁴ Although there remains no clear consensus on the ideal reconstructive procedure, LRTI remains the most common procedure performed for this condition. Tendon interposition has not been shown to provide superior outcome over ligament reconstruction alone.^{15,29}

We report a technique using ligament reconstruction through a single incision with fixation provided by a bioabsorbable interference screw. Advantages include a single incision for reconstruction and tendon harvest and potentially improved tendon fixation to the thumb metacarpal, compared with traditional fixation techniques. Average tourniquet time was 33 minutes. With this fixation method, we allowed patients to use a removable orthosis after surgery and remove this for hygiene and light activities of daily living. Although comparative literature suggests no clinical benefit to tendon interposition compared with ligament reconstruction alone,¹⁵ for those who prefer to use the remaining FCR as an anchovy-type spacer, the technique of tendon harvest presented here does not typically provide enough residual length to do so.

Screw fixation has been gaining popularity as a method of fixation of soft tissue to bone and has been successfully applied to elbow medial collateral ligament reconstruction,¹⁶ tenodesis of the long head of the biceps,¹⁷ anterior cruciate ligament reconstruction,¹⁸ MCP collateral ligament reconstruction,^{20,21} distal biceps repair,¹⁹ ankle stabilization,²² and split tibialis anterior transfers.²³

The biomechanical strength of interference screw fixation compared with other fixation types has been

studied in several models. Kusma et al,¹⁷ in a porcine model of biceps long head tenodesis, found greater ultimate failure load for interference screws compared with a suture anchor, ligament washer, keyhole technique, and bone tunnel technique. Also in a biceps tenodesis model, Richards et al.²⁴ found interference screw fixation to have greater resistance to pullout than suture anchor fixation. Lee et al.,²¹ in a human cadaveric model, tested MCP collateral ligament reconstruction using flexor tendon graft fixation strength with a 4.0-mm biotenodesis screw compared with headless compression screws, sutures over a button, and a suture anchor. They found the biotenodesis screw to have statistically significant higher tensile strength and stiffness compared with the other 3 fixation types. Jeys et al,³⁰ in an ankle stabilization model, showed interference screw fixation load to failure to be nearly twice that of suture anchors.

Metal and bioabsorbable interference screw fixation have been directly compared in multiple clinical series in the anterior cruciate ligament (ACL) literature. Most series have shown no clinical differences in pain, functional scores, or graft stability.^{31–33} Weiler et al.,³⁴ in the first study examining the biomechanical properties of Achilles tendon healing for ACL reconstruction with bioabsorbable interference screw fixation in a sheep model, found that at no point after time 0 was loss of fixation a method of failure. Early failure at 6 and 9 weeks was due to intrasubstance failure near the screw insertion site, which calls into question whether the screw insertion changes the mechanical properties of the tendon. Later failure at up to 52 weeks was due to osteoarthritic avulsion.

We observed no complications related to the interference screw fixation in this series, but several have been reported, primarily in the ACL literature. Screw fracture upon insertion has an incidence between 0.2% and 7% in the ACL literature,^{32,35} and late fracture has occurred up to 3 years after surgery.^{36,37} Intra-articular

screw migration^{38,39} and prolonged joint effusions^{31,39} have also been reported.

We demonstrate no revisions at an average of 19 months, with good functional outcome, minimal pain, and range of motion and strength that are no different from the contralateral side (with the exception of lateral key pinch strength) using the described technique. We demonstrated an inverse relationship between age and strength in both lateral key and tripod pinch. This relationship may partially explain the increased overall strength in the workers' compensation patients, because they were significantly younger than the other patients in the cohort ($p < .001$). All of our patients were able to return to their original line of work and over half participated in recreational activities, with a small percentage perceiving limitations in activities owing to their arthroplasty. Our radiographic results showed minimal settling overall, with two thirds of the total settling occurring within the first 3 months and a decreasing rate of settling over time.

These findings compare favorably with other series of trapeziectomy with ligament reconstruction in the literature. Retrospective studies report a mean lateral key pinch between 4 kg (8 lb) and 5 kg (11 lb) at similar follow-up.^{40–49} Our mean measured key pinch of 6 kg (13 lb) is slightly greater than that previously reported. Range of motion in palmar (55°) and radial (56°) abduction in our series appears greater than^{15,41,44,45,49} or equivalent to⁴⁶ series that have reported these measures at similar follow-up. Radiographic settling is difficult to compare with historical controls, as several different techniques have been used to measure thumb height. In addition, the clinical relevance of maintaining the arthroplasty space has been questioned,^{15,50} although one series reported a correlation between thumb height and key-pinch force.⁵⁰ Our settling of 1.4 mm (24%) at one year appears similar to, if not less than, most other series that used comparable measuring techniques after similar length of follow-up.^{40,41} One exception is the settling rate of Varitimidis et al, who used the whole FCR and reported 0.9 mm of settling at 42 months.⁴⁹

This study has certain limitations. Although it is simply a case series with no control group, we believe the excellent results in our cohort for this new technique without major failures suggest there may be a benefit to proceeding with a prospective comparative trial. Our disproportionately small sample size for men and workers' compensation cases raise the possibility of type II error in our subgroup analysis. Although preoperative DASH, VAS, range of motion, and strength measurements would have been beneficial to put the postoperative data into perspective, those data were not available

for this retrospective review. Most complications associated with poly-L-lactide implants, such as the screw used in this series, occur within the first year in the ACL literature²⁶; most commonly there is an implant fracture at the time of surgery and prolonged joint effusions, but later complications may occur. Late fracture of the implant has been reported at greater than one year, but is rare—less than 1% of cases.³⁷

The increased cost of the implant used in this series has to be considered relative to suture alone in the more traditional LRTI procedure. In this case, the screw eliminates the morbidity and surgical time of additional incisions for FCR harvest and the risk of forearm skin tethering.⁵¹ The increased strength of interference screw fixation compared with traditional methods may also provide the opportunity for accelerated rehabilitation and a decreased duration of immobilization. This would require further study to demonstrate but could provide economic benefit if it were to provide faster return to work time, because 50% of our cohort was employed at the time of surgery.

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