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Revision Ligament Reconstruction Tendon Interposition for Trapeziometacarpal Arthritis: A Case-Control Investigation

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Abstract

Purpose—To test the null hypothesis that there is no difference in patient-reported and objective outcomes of revision ligament reconstruction and tendon interposition (LRTI) compared to primary LRTI.

Methods—This case-control investigation enrolled 10 patients who had undergone revision LRTI at a tertiary care center. All patients had previously undergone primary trapeziectomy with LRTI. Patients with a minimum of two years of follow-up were eligible. All patients completed an in-office study evaluation. Controls (treated only with primary LRTI) were matched from our practice to reach a 1:2 case to control ratio. Outcome measures included Michigan Hand Questionnaire (primary outcome), Quick Disability of the Arm, Hand, and Shoulder (QuickDASH) Questionnaire, VAS for pain and improvement, and physical examination. Statistical analyses were conducted to compare the patient groups.

Results—Revision LRTI patients reported significantly worse outcomes on all measured standardized questionnaires compared with primary patients. The Michigan Hand Questionnaire indicated worse overall outcomes (54 versus 79) as well as worse pain, appearance, and ability to complete activities of daily living. Revision LRTI patients also reported more impairment (QuickDASH 47 versus 23), greater pain (VAS pain 6.3 versus 1), and less improvement after surgery (VAS improvement 2.7 versus 7.9). There was also a significantly higher rate of patient-reported depression in the revision LRTI group (50% versus 10% of primary LRTI patients). We

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Level of Evidence Therapeutic, Level III

did not find a significant difference in objective outcomes of pinch strength, grip strength, and thumb palmar abduction between the two groups.

Conclusion—Following revision LRTI patient-reported outcomes indicate worse perceived function and greater pain than expected following primary LRTI despite similar motion and strength. Revision surgery can be offered in the setting of persistent or recurrent symptoms, but patients should be counseled that improvement of symptoms is unpredictable.

Keywords

Basal joint; thumb arthritis; trapeziometacarpal; LRTI; revision; carpometacarpal

Introduction

The trapeziometacarpal (TM) joint is the most common site of symptomatic osteoarthritis (OA) in the hand and wrist¹. Among the multiple surgical treatment options for advanced TM arthritis, trapeziectomy with ligament reconstruction and tendon interposition (LRTI) has traditionally been the most common procedure performed in the United States². Since its description in 1983, LRTI has been advocated as a reliable treatment for thumb TM OA producing satisfactory reduction in pain and weakness³. Long term studies report “81-95%” satisfactory pain relief^{2,4,5}. Despite this, untreated scaphotrapezoid arthritis, thumb metacarpophalangeal joint hyperextension, first web space contracture, instability, pain, deformity, synovitis, or weakness⁶, can necessitate revision surgery.

Revision surgery after failed trapeziometacarpal surgery is offered with a limited understanding of expected outcomes. Case series report rates of 53-76% relief of pain and improved work and recreational function following revision according to a grading scale developed by Conolly et al. However, these patients underwent a variety of primary and revision procedures and no comparative cohorts were studied⁷⁻⁹.

This study was designed to compare a validated patient-reported measure of hand function (Michigan Hand Questionnaire: primary outcome) and objective outcomes in patients following revision LRTI to a matched cohort having undergone only a primary LRTI. We tested the null hypothesis that patients having undergone revision LRTI after previous trapezial excision and primary LRTI would not differ in patient-reported or objective outcomes from the revision surgery to patients who did not go on to revision.

Methods

After Institutional Review Board approval, this case-control investigation enrolled patients treated for TM arthritis at a single tertiary center. Eligible participants were identified by querying a departmental electronic billing database for Current Procedural Terminology codes “25447” and “26480” performed by any one of five fellowship-trained hand surgeons between April 1996 and January 2013. This CPT code combination is utilized by all surgeons at our institution for both primary and revision LRTI. Inclusion criteria included patients older than 40 years of age who had undergone a primary LRTI with complete trapeziectomy or had undergone a revision (rLRTI) after a prior LRTI and trapeziectomy.

Exclusion criteria included procedures other than LRTI (e.g. Artelon™ spacer or arthrodesis) at the trapeziometacarpal joint, history of infection in the affected hand, arthrodesis prior to or following revision LRTI, and subtotal trapeziectomy during the index procedure (Figure 1). Demographic data are presented in Table 1a and 1b. If a patient underwent bilateral LRTI surgeries, only the first operative thumb was eligible to contribute data to this study to avoid bias imparted by collection of non-independent data from bilateral thumbs of individual patients.

All control LRTI patients had undergone trapeziectomy followed by use of the complete flexor carpi radialis tendon for suspension and interposition. Nine of ten rLRTI patients also underwent this surgery except for one patient, in which allograft was used in the primary surgery.

The decision to proceed with revision surgery was a shared decision between the patient and the surgeon based on patient dissatisfaction with the symptoms and either continued pain, instability, or extruded interposition material (diagnosed via MRI) in the area of the prior TM joint. For the rLRTI procedures, either ipsilateral abductor pollicis longus¹⁰ or extensor carpi radialis longus tendon¹¹ (Table 2) was transferred for suspensionplasty and tendon interposition. This was done based on individual surgeon preference as these options yield similar results to flexor carpi radialis. All included patients underwent only one revision procedure.

Querying our billing database identified 671 LRTI procedures that were potential study participants; from this population there were 425 eligible primary surgeries and 15 eligible revision surgeries (Figure 1). Controls were defined as patients that had only undergone a primary LRTI without knowledge of their clinical outcome; selection for study inclusion was based on matching to the rLRTI patients based on age (± 2 years) and sex (exact match). Eligible control patients were contacted by telephone via random selection until a 1:2 ratio of rLRTI thumbs and control primary LRTI thumbs was reached. Of 15 eligible revision patients, 10 were enrolled. Of the five patients not included in the study, two declined participation because of unwillingness to volunteer their time and three had expired contact information (Figure 1). Of these five patients, their average age was 52 years at the time of index surgery (range 38 to 70 years) and three were female. Revision patients underwent primary LRTI at either an outside hospital (n=6) or our institution (n=4) with subsequent rLRTI at our institution (Tables 1a and 1b). All control patients had their primary LRTI performed at our institution. Operative notes for all index and revision procedures were available for review regardless of performing institution.

Data Collection

Medical records were reviewed to record demographic data, pre-operative symptoms, and pre-operative physical exam findings. Operative notes were reviewed to confirm the type of surgery or surgeries performed.

All study participants were evaluated in person by a member of the research team who was not involved in the perioperative care of the patient. The examiners were a mid-level orthopaedic resident and a trained clinical research coordinator. Each was unaware of the

surgical outcome when interviewing and examining patients but not to the patient group assignment (primary versus revision). Data collected at the time of follow-up evaluation included history of the patient's pre-operative symptoms to confirm medical record data, current symptoms, physical examination, and fluoroscopic imaging. Imaging was performed to rule out metacarpal subsidence or the presence of scapho-trapezial arthritis. Patient-reported outcomes included the Michigan Hand Questionnaire (MHQ: primary outcome)¹², the Quick Disability of the Arm, Shoulder, and Hand questionnaire (QuickDASH)¹³, and Visual Analog Scales (VAS)¹⁴ for pain and global improvement from pre-surgery condition on a scale of 0 to 10. Follow-up examination included single maximum effort grip and lateral key pinch strength to the nearest 1 kg (utilizing the Jamar Hydraulic Hand Dynamometer 5030J1™ and the Jamar Hydraulic Hand Dynamometer 5030J1 Pinch Gauge™), flexion-extension arc of the thumb MCP and IP joint, and radial and ulnar deviation of the wrist measured with a goniometer to the nearest degree.

Statistical Analysis

We planned this study to test a continuous response variable (Michigan Hand Questionnaire) from independent control and experimental subjects with 2 controls per experimental subject. To detect a minimally clinically important difference of 13 points (SD 12) we needed to study 11 experimental subjects and 22 control subjects to be able to reject the null hypothesis with probability (power) 0.8 assuming a type 1 error probability of 0.05¹⁵.

All statistical analyses were performed to compare cases (revision LRTI patients) and controls (primary LRTI patients). Univariate data descriptions provided mean, standard deviation, and ranges of values. Statistical analysis was performed with 2-tailed independent student t-test. Normality of the two groups' MHQ scores were tested, and subsequently a non-parametric test was performed. An exploratory chi-square analysis was used to differentiate the proportion of patients with a self-reported history of depression among the two groups.

Results

The 10 rLRTI patients enrolled (Table Ia) were matched to 20 patients who received primary LRTI without subsequent revision (Table Ib). Average American Society of Anesthesiology status of the study group was 2 and of the control group was 2.25. Control patients were studied in follow up at a median of 79 months (range 31-173 months) with revision LRTI patients seen at a median of 59 months (range 28-121 months).

Nine of 10 rLRTI procedures were performed for persistent pain following primary surgery. Six patients also cited instability and weakness prior to revision. The one patient revised after an initial symptom-free interval following primary LRTI experienced recurrent pain and weakness associated with a displaced tendon interposition graft (Table 2). One patient was noted to have metacarpophalangeal joint hyperextension and underwent concurrent fusion of that joint. No patients were diagnosed with first web space contracture. No patients were diagnosed with or showed signs of complex regional pain syndrome or other neuropathic disorders.

Following revision LRTI, patients reported significantly worse hand function on the Michigan Hand Questionnaire (overall score: 54 vs 79, $P<0.05$) and all of its subscales when compared to the primary LRTI group (Table 3). MHQ scores were not normally distributed (Figures 2 and 3); subsequent non-parametric testing using the Mann-Whitney U test found the results to be different from one another ($p<0.05$). Table 4 details all other patient reported outcomes consistently indicating poorer patient-perceived function after revision surgery. Primary LRTI patients reported less pain at final follow-up compared to rLRTI patients (VAS 1 versus 4.8, $P<0.05$). Sixteen of 20 control patients rated their current pain level at 0 or 1, while only one patient in the rLRTI cohort had pain minimized to this level. Three of 10 patients that had undergone revision reported decreased pain while seven of 10 had the same or worse pain after revision surgery. Of the rLRTI patients, two of 10 perceived overall improvement and eight had no perceived improvement or had worsened thumb function. We did not observe a difference in MHQ scores between dominant and non-dominant hands within groups (Table 5).

Objective examination measures did not distinguish any differences between primary and rLRTI cohorts. Strength measurements were calibrated using previous population-based data observing a 10% strength difference between the dominant and non-dominant hand¹⁶. Grip strength, pinch strength, and palmar abduction after revision surgery were not significantly different from those measures following primary LRTI (Table 4). No patients had evidence of scaphotrapezial arthritis or metacarpal subsidence on fluoroscopy.

Five of 10 rLRTI patients reported a past medical history of depression on a clinic intake questionnaire versus two of 20 control LRTI patients ($P<0.050$).

Discussion

LRTI is a largely successful procedure with satisfactory improvements in pain and function for the treatment of TMC arthritis³. The causes of failure of LRTI include sensory disturbances, tendinitis, graft displacement, persistent pain, instability, infection, and implant migration^{6,17,18}. Revision LRTI is performed either in the setting of mechanical failure of the index operation or to improve subjective pain. Our data indicate that rLRTI, similar to other revision surgeries, is unlikely to eliminate subjective symptoms after primary LRTI^{19,20}.

Three prior studies addressing outcomes following revision surgery for TMC arthritis, though not LRTI specifically, revealed modest outcomes^{7,9,21}. Conolly et. al reviewed 17 thumbs that had failed silicone implant arthroplasty ($n=12$), trapeziectomy ($n=4$) or arthrodesis ($n=1$). Failed silicone arthroplasties were treated with implant removal and soft tissue arthroplasty or implant replacement; failed trapeziectomies were converted to silicone arthroplasty. Outcomes were defined based on subjective symptoms reported by the patients: good, complete relief of pain; fair, persisting mild pain and stiffness that interferes with work or hobbies; poor, no relief of pain or any improvement with revision surgery. Nine patients (53%) reported a good outcome, three (18%) reported fair, and five (29%) reported poor results⁷. Renfree et. al reported on 12 thumbs undergoing revision surgery following trapeziometacarpal arthroplasty²¹. The most common indication for secondary surgery was

pain with activities. Revision procedures varied from secondary suspension to scaphotrapezial arthrodesis to neurolysis. Two of 12 patients had good results; five had fair results and five had poor results. Cooney et. al reviewed 17 thumbs who failed primary soft-tissue arthroplasty of the TMC joint for mechanical (due to impingement) pain and/or instability⁹. The primary procedures included Eaton-Littler procedure (n=4), Weilby procedure (n=5), LRTI (n=3), hemiresection of the trapezium (n=2), and trapezial excision with tendon interposition (n=3). Revision procedures varied widely, from interposition using tendon to silicone implants (n=2) and Gelfoam (n=5). Outcome categories of “good, fair and poor” were identical to those defined in the study by Conolly et. al⁷. Thirteen of 17 patients reported good outcomes following revision. In addition to a lack of uniform revision procedures, patients in these studies were not matched to a control cohort and were not assessed with validated outcome measures. Our study adds to this literature by investigating a population with a more homogenous history of primary and revision LRTI as well as enrolling a control cohort drawn from the same clinical setting for comparison. Although we cannot directly compare our outcomes to these existing studies secondary to the heterogeneity of surgical procedures, we view our data as generally consistent with these published data suggesting that revision TMC surgery fails to replicate outcomes realized from most primary TMC surgeries.

Objective functional tests, specifically pinch and grip strength, failed to distinguish the two groups in our study. This finding was unexpected and may speak to the complexity of treating subjectively reported pain, which imperfectly correlates with anatomic findings²². Although our study was not designed to compare objective outcomes of various tendon suspensions, these data suggest that each of the tendons used for LRTI in our population (i.e., FCR, ECRL, APL) can produce comparable final strength and motion of the thumb.

Our population of rLRTI patients reported a higher prevalence of depression compared to control patients. This finding was exploratory as this study was not designed to evaluate the impact of depression on LRTI outcomes. A history of depression has been documented to result in poorer self-reported hand function in patients with TMC arthritis²³. Depressive symptoms have also impacted patients’ self-reported hand function after treatment. Affected patients experience similar absolute improvements in function after treatment but remain at lower levels of function overall, starting and finishing at a lower level than unaffected patients²⁴. In our sample of rLRTI patients, we cannot definitely determine the impact of the comorbidity of depression^{23,24}. We hypothesize that it may have impacted our data in two ways. First, it may simply have contributed to the poorer self-reported final hand function in affected patients which were disproportionately in the revision group. Certainly the persistent pain and poorer function after revision LRTI is a complicated phenomenon that was not associated with objective examination changes in our study. Second, the continuation of greater than expected pain in the affected patients may have increased the probability that these patients were eventually offered and underwent revision surgery as persistent pain was the most common indication for revision. Further dedicated study would be necessary to determine if a history of depression truly predicts the need for subsequent revision LRTI. In this study, depression was reported in the past medical history and does not necessarily indicate current depressive symptoms. It also does not likely capture situational depression resulting from the painful thumb joints.

Our study has several inherent limitations. First, the rLRTI cohort was small, though this was expected from the infrequency of revision LRTI's performed. Study enrollment fell short of our intended sample size by 1 rLRTI patient. Other revision LRTI patients were excluded secondary to use of artificial spacers, partial trapeziectomy, or a subsequent procedure (Table 1). However, the substantial difference between groups on our primary outcome measure exceeded our proposed minimally relevant difference that then reached statistical significance. Second, patient-reported outcomes are subject to recall bias, particularly rLRTI patients who are recalling results after their primary procedure. In particular, the VAS is vulnerable to being a reflection of patient satisfaction with the perioperative experience rather than surgical outcome. In part for that reason, we chose to make the MHQ our primary outcome measure comparing current function and pain scores among the cohorts. MHQ and DASH data were not available prior to rLRTI for the study group; therefore, a comparison of pre- and post-op outcome measures could not be performed. Third, the average follow-up of rLRTI patients was shorter than that of primary LRTI patients; however, all patients had at least two years of follow-up, at which time we believe outcomes to have plateaued². Fourth, evaluation and data analysis were not blinded to the assessors. Fifth, cohorts were not matched by occupation; there was inadequate data to assess demand on subjects' hands.

Following revision LRTI, patient-reported outcomes indicate worse perceived function and greater pain than expected. This does not support the null hypothesis that outcomes of revision LRTI are equal to that of primary LRTI. We suggest that if revision LRTI is being considered in the setting of persistent or recurrent symptoms, patients should be counseled that complete resolution, or even consistent improvement, of symptoms is unlikely. This is especially true when pain exists with evidence of subsidence, which may not be an adequate indication for revision²⁵. This has not prevented us from offering revision LRTI in the setting of an identifiable and presumed modifiable cause of persistent symptoms, but we now approach revision LRTI with caution for the patient without an identifiable cause as the likelihood of improvement is unpredictable.

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not applicable

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Figure 1.
Inclusion and Exclusion Criteria for selection of revision ligament reconstruction and tendon interposition (LRTI) cohort

rLRTI = revision ligament reconstruction and tendon interposition group

Figure 2.
Histogram of Michigan Hand Questionnaire Score for study group

LRTI = ligament reconstruction and tendon interposition

Figure 3.
Histogram of Michigan Hand Questionnaire Score for control group

Table 1a

Revision LRTI Patient Demographics

Patient ID	Age	Sex	LOIS	Operative Thumb	Dominant Hand	Occupation	Education Completed
1	73	F	TC	L	R	Retired secretary	Some college or associates
2	55	M	OSH	L	R	Aircraft mechanic	College graduate
3	65	M	TC	L	R	Helicopter door gunner	Professional/graduate school
4	69	F	TC	L	A	Librarian	Professional/graduate school
5	62	F	OSH	L	R	Librarian	Professional/graduate school
6	66	F	OSH	L	R	Warehouse	Some college or associates
7	81	F	TC	R	R	Homemaker	High school
8	55	M	OSH	R	R	Copying, Morse code	Some college or associate
9	59	M	OSH	L	R	Mechanic	Some college or associate
10	73	F	OSH	L	R	Teacher	Professional/graduate school

LOIS = location of index surgery; TC = tertiary center where data was collected; OSH = outside hospital; for operative thumb and dominant hand, L = left, R = right, A= ambidextrous

Table 1b

Primary LRTI (Control) Patient Demographics

Patient ID	Age	Sex	LOIS	Operative Thumb	Dominant Hand	Occupation	Education Completed
11	73	F	TC	L	R	Teacher	College graduate
12	63	M	TC	L	L	Family dentist	Professional/graduate
13	65	M	TC	R	L	Office Work	College graduate
14	71	F	TC	L	R	Teacher	Some college or associate
15	62	F	TC	L	R	Clinical dietitian	Professional/graduate
16	65	F	TC	L	R	Therapist	Professional/graduate
17	75	F	TC	L	R	Office Work	College grad
18	55	M	TC	L	R	Office Work	Some college or associate
19	58	M	TC	R	R	Electrical construction	Some college or associate
20	71	F	TC	R	R	Homemaker/sales	Professional/graduate
21	66	F	TC	L	R	Office Work	High school graduate
22	63	F	TC	R	R	Teacher	Professional/graduate
23	60	F	TC	R	R	Orthodontic assistant	College graduate
24	62	F	TC	R	R	Homemaker	College graduate
25	65	M	TC	L	L	Sales	College graduate
26	63	F	TC	L	R	Homemaker	High school graduate
27	69	F	TC	R	R	Secretary	Some college or associate
28	60	M	TC	R	R	Shipping	Some college or associate
29	59	F	TC	L	R	Office Work	College graduate
30	62	F	TC	R	R	Homemaker	College graduate

LOIS = location of index surgery; TC = tertiary center where data was collected; OSH = outside hospital; for operative thumb and dominant hand, L = left, R = right

Table 2

Reason for revision in rLRTI patients; tendon used during revision

Patient ID	Indication for revision	Patient symptom(s) prior to revision	Tendon used for revision
1	Subsidence	Pain	ECRL
2	Persistent pain operative site	Pain	APL
3	Subsidence. MCPJ hyperextension	Pain, instability	APL
4	Dislocated interposition	Pain	n/a *
5	Subsidence	Pain, weakness	ECRL
6	Subsidence	Pain, weakness	ECRL
7	Subsidence	Pain	APL
8	Subsidence	Pain, weakness	ECRL
9	Subsidence	Pain	ECRL
10	Hypermobility of TMC joint	Pain, instability, weakness	APL

APL = abductor pollicis longus tendon; ECRL = extensor carpi radialis longus tendon

MCPJ = metacarpophalangeal joint TMC = trapeziometacarpal

* Displaced anchovy re-inserted; no new tendon used

Table 3

Michigan Hand Questionnaire Scores in LRTI versus rLRTI patients *

	Control	rLRTI	p-value
Overall			
	79 (30-99, ± 17)	54 (35-74, ± 13)	<0.05
Activities of Daily Living			
	82 (32-97, ± 16)	58 (32-74, ± 13)	<0.05
Work			
	73 (10-100, ± 26)	56 (5-75, ± 18)	0.1
Pain **			
	56 (20-85, ± 20)	83 (20-100, ± 18)	<0.05
Appearance			
	85 (56-100, ± 16)	64 (44-100, ± 23)	<0.05
Satisfaction			
	71 (4-100, ± 27)	31 (17-54, ± 13)	<0.05

* Values are represented as Mean (Range, $\pm$ SD)

** Higher pain score denotes worse pain; higher score denotes better outcome for other categories

Table 4

Subjective and Objective Outcomes for control patients (LRTI only) versus revision patients (rLRTI following LRTI)

	Control	rLRTI	p-value
VAS Improvement: 0 = no improvement; 10 = 100% improvement			
after LRTI	7.9 (2.5-10, SD 1.8)	2.7 (0-8.1, SD 1.5)	<0.05
after rLRTI	n/a	3.6 (0-8.8, SD 2.6)	<0.05
VAS Pain: 0 = no pain; 10 = debilitating pain			
after LRTI	1.0 (0-5.0, SD 1.1)	6.3 (2.0-10, SD 3.2)	<0.05
after rLRTI	n/a	4.8 (0.4-9.0, SD 2.9)	<0.05
QuickDASH: Higher score indicates more disability			
	23 (2-70, $\pm$ 19)	47 (30-64, $\pm$ 11)	<0.05
Pinch Strength (kg) *			
	11 (5-21, $\pm$ 6)	8 (3-14, $\pm$ 4)	0.12
Grip Strength (kg) *			
	49 (16-106, $\pm$ 27)	45 (11-94, $\pm$ 25)	0.71
Palmar Abduction (degrees)			
	63 (45-80, $\pm$ 9)	58 (45-89, $\pm$ 15)	0.41

VAS = visual analog score; QuickDASH = Quick Disability of the Arm, Shoulder, and Hand Questionnaire; kg = kilograms

* Strength measurements calibrated for 10% difference in strength between dominant and non-dominant hand

Table 5

Average Michigan Hand Questionnaire Overall Score for Non-Dominant and Dominant Hands in study and control groups

	rLRTI	Control
Non-dominant	53	76
Dominant	56	86