Functional Recovery Following Trapeziectomy and Ligament Reconstruction and Tendon Interposition: A Prospective Longitudinal Study

Neela Janakiramanan, MBBS,* Oliver Miles, MD, BBiom,†‡ Sylvie Collon, MD,* Bradley Crammond, LLM, PhD,§ David McCombe, MBBS, MD,*†‡ Stephen K. Tham, MBBS*†‡

CME Continuing Medical Education

CME INFORMATION AND DISCLOSURES

The Journal of Hand Surgery will contain at least 2 clinically relevant articles selected by the editor to be offered for CME in each issue. For CME credit, the participant must read the articles in print or online and correctly answer all related questions through an online examination. The questions on the test are designed to make the reader think and will occasionally require the reader to go back and scrutinize the article for details.

The JHS CME Activity fee of $15.00 includes the exam questions/answers only and does not include access to the JHS articles referenced.

Statement of Need: This CME activity was developed by the JHS editors as a convenient education tool to help increase or affirm reader's knowledge. The overall goal of the activity is for participants to evaluate the appropriateness of clinical data and apply it to their practice and the provision of patient care.

Accreditation: The American Society for Surgery of the Hand (ASSH) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

AMA PRA Credit Designation: The ASSH designates this Journal-Based CME activity for a maximum of 1.00 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

ASSH Disclaimer: The material presented in this CME activity is made available by the ASSH for educational purposes only. This material is not intended to represent the only methods or the best procedures appropriate for the medical situation(s) discussed, but rather it is intended to present an approach, view, statement, or opinion of the authors that may be helpful, or of interest, to other practitioners. Examinees agree to participate in this medical education activity, sponsored by the ASSH, with full knowledge and awareness that they waive any claim they may have against the ASSH for reliance on any information presented. The approval of the US Food and Drug Administration (FDA) is required for procedures and drugs that are considered experimental. Instrumentation systems discussed or reviewed during this educational activity may not yet have received FDA approval.

Provider Information can be found at http://www.assh.org/About-ASSH/Contact-Us.

Technical Requirements for the Online Examination can be found at https://jhandsurg.org/cme/home.

Privacy Policy can be found at http://www.assh.org/About-ASSH/Policies/ASSH-Policies.

ASSH Disclosure Policy: As a provider accredited by the ACCME, the ASSH must ensure balance, independence, objectivity, and scientific rigor in all its activities.

Disclosures for this Article

Editors

Ryan Calfee, MD, MSc, has no relevant conflicts of interest to disclose.

Authors

All authors of this journal-based CME activity have no relevant conflicts of interest to disclose. In the printed or PDF version of this article, author affiliations can be found at the bottom of the first page.

Planners

Ryan Calfee, MD, MSc, has no relevant conflicts of interest to disclose. The editorial and education staff involved with this journal-based CME activity has no relevant conflicts of interest to disclose.

Learning Objectives

Upon completion of this CME activity, the reader will understand:

- The timeline of postoperative change in pain and motion of the thumb after ligament reconstruction with tendon interposition (LRTI).
- Expected alterations in grip strength associated with LRTI.
- The length of time after LRTI during which outcome measures continue to evolve after LRTI.

Deadline: Each examination purchased in 2021 must be completed by January 31, 2022, to be eligible for CME. A certificate will be issued upon completion of the activity. Estimated time to complete each JHS CME activity is up to one hour.

Purpose Patients undergoing surgery for trapeziometacarpal (TMC) joint arthritis require preoperative counseling on the expectations of surgery. This study aims to document the objective and functional recovery over the initial 12 months following trapeziectomy and ligament reconstruction with tendon interposition (LRTI).

*From the *Victorian Hand Surgery Associates, Melbourne, Australia; the †Hand Surgery Unit, Department of Plastic Surgery, St Vincent's Hospital, Melbourne, Australia; the ‡Hand and Wrist Biomechanics Laboratory, O'Brien Institute, St Vincent Institute, Melbourne, Australia; and the §Melbourne School of Population and Global Health, University of Melbourne, Australia.*

Received for publication June 17, 2020; accepted in revised form April 20, 2021.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Stephen K. Tham, MBBS, Victorian Hand Surgery Associates, Suite C37, Level 3, Building C, St Vincent's Hospital, 41 Victoria Parade, FitzroyVictoria 3065, Australia; e-mail: stham@bigpond.net.au.

0363-5023/21/4611-0003$36.00/0
https://doi.org/10.1016/j.jhsa.2021.04.036

Methods We prospectively followed 55 patients with symptomatic TMC joint osteoarthritis after trapeziectomy and LRTI. Patients were assessed on functional outcome measures, pain, and objective outcomes of grip, tip and key pinch strength, and range of motion. Outcomes were recorded preoperatively and at 3, 6, 9, and 12 months after surgery.

Results Outcome measures of Disabilities of the Arm, Shoulder, and Hand (DASH), Patient-Rated Wrist Evaluation (PRWE), and pain, improved significantly after surgery at each 3-month interval up to 9 months. Palmar and radial abduction were significantly improved compared to their preoperative ranges, but opposition was unchanged. Power grip significantly exceeded the preoperative strength at 6 months and further increased at 9 months. Tip pinch significantly exceeded the preoperative strength at 12 months. There was no difference in the key pinch strength compared to the preoperative strength.

Conclusions Over a follow-up period of 12 months, trapeziectomy and LRTI is an effective treatment in significantly reducing pain in 80% of patients. Although normal patient-reported outcome measures of DASH and PRWE are not regained, when compared to normative values, these measures are significantly improved; the improvement plateaus at 9 months. Patients can expect to attain 37% and 46% of their eventual measured DASH and PRWE scores, respectively, at 3 months, and 82% and 79% of their eventual measured DASH and PRWE scores, respectively, at 6 months. Grip strength exceeded the preoperative strength by 15% at 6 months and by 30% at 9 months. Tip pinch strength significantly exceeded the preoperative strength by 20% at 9 months. *(J Hand Surg Am. 2021;46(11):963–971.*

Type of study/level of evidence Therapeutic II.

Key words Ligament reconstruction tendon interposition, thumb arthritis, trapeziectomy, trapeziometacarpal joint.

TRAPEZIOMETACARPAL (TMC) joint osteoarthritis is common, especially in postmenopausal women, and surgical treatment is considered when the pain symptoms are sufficiently severe to interfere with activities of daily living despite nonsurgical measures.[1] The efficacy of trapeziectomy with ligament reconstruction and tendon interposition (LRTI) is well documented, although the necessity for LRTI has been questioned.[2–14]

A number of surgical techniques to treat arthritis of the TMC joint have been described, and the variety of ways in which these techniques have been analyzed and reported make it challenging to compare the clinical outcomes of the different procedures or to counsel patients on what to expect from their symptomatic and functional recovery. The published literature on the results within the first 12 months after trapeziectomy is heterogeneous, with different measures of physical and functional recovery.[15–18] While surgery has been shown to yield functional benefits, there is a need for an objective and current resource for the preoperative counseling of patients considering trapeziectomy and LRTI, to prepare these patients for their perioperative recovery.

The purpose of this study was to prospectively document the objective and functional recovery during the first 12 months following trapeziectomy and LRTI using the flexor carpi radialis (FCR) tendon, in order to counsel patients on their expectations after trapeziectomy and LRTI.

MATERIALS AND METHODS

Institutional ethics approval was obtained from St Vincent's Hospital (Melbourne) Human Research Ethics Committees (approval number HREC-A 129/14) for a prospective, nonrandomized, interventional study on patients undergoing trapeziectomy and LRTI over a 12-month period from March 2015 to March 2016. Patients were included in this study if they had radiologically confirmed TMC joint osteoarthritis, reported persistent symptoms, and complained of impaired function after a failure of nonsurgical treatment comprising splinting and nonsteroidal anti-inflammatory medication for at least 3 months. Informed consent was obtained from all volunteers as per institutional ethics review board protocol. The exclusion criteria included patients who had previously undergone surgical procedures to the TMC or scaphotrapezium-trapezoid (STT) joints, who

TABLE 1. Patient Demographics

Variable	n (%)
Sex	
Female	45 (82)
Male	10 (18)
Age, y	
Mean	63 (SD, 6.6)
Range	50.5–77.5
Hand dominance	
Right	47 (85)
Left	8 (15)
Affected hand	
Right	28 (51)
Left	27 (49)
Dominant	28 (51)
Nondominant	27 (49)

underwent other procedures to the same hand or thumb at the time of the trapeziectomy and LRTI, and who had systemic inflammatory arthropathy. Three fellowship-trained hand surgeons performed all the procedures.

Baseline demographic information on age, sex, hand dominance, and the affected limb was collected. Preoperative and follow-up outcome measures were assessed at each interval by certified hand therapists not involved in the study.

Outcome measures

Each patient completed the Disabilities of Arm, Shoulder, and Hand (DASH) and Patient-Rated Wrist Evaluation (PRWE).[19–21] Thumb opposition was measured by determining the Kapandji score.[22] Palmar and radial abduction angles were measured using a goniometer placed between the first and second metacarpals. Grip strength (kg) was measured using a Jamar hand dynamometer (Preston Company) in position 2 with the shoulder adducted, elbow flexed at 90°, and forearm and wrist in a neutral position.[23] Lateral key and tip pinch strength (kg) were measured using a Jamar pinch dynamometer (Preston Company), with the average of 3 serial strength measurements recorded.[24] A 10-point visual analog scale (VAS) was used to record pain.[25]

All objective and patient-rated outcome measures were performed preoperatively and at 3, 6, 9, and 12 months after surgery. Radiographic assessments of the thumb TMC joint were performed in 3 planes to confirm the diagnosis before surgery.[26] Any complications were also recorded.

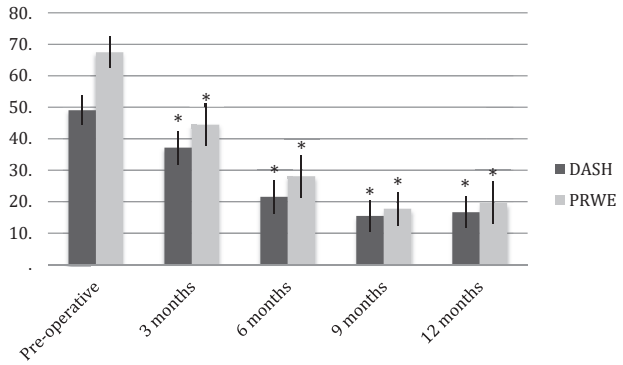

FIGURE 1: Changes in patient-reported outcome measures. *Statistically significant at $P < .05$ compared to preoperative measure.

Surgical technique

All patients underwent trapeziectomy and LRTI using a distally based portion of the FCR tendon, 3–4 mm in width, similar to the procedure originally described by Burton and Pellegrini.[11] Kirschner wires were not used.

The thumb was immobilized in a forearm-based plaster splint for 2 weeks, then in a thermoplastic splint for 4 weeks. A graduated mobilization program was undertaken under the supervision of a hand therapist from 2 weeks after surgery, commencing with unloaded short arc range of motion and opposition, depending on the patient's symptoms. The thermoplastic splint was weaned and a gradual increase in use and loading of the thumb was allowed from the sixth week after surgery. No specific strengthening exercises were performed.

Analysis

Given the absence of a control group, the analysis measured changes in DASH and PRWE scores from baseline values. Generalized estimating equations were used to model the average change in an outcome at each follow-up point, with significance set at a P value $< .05$ and power for a clinically relevant difference for each measure set at 80%. Generalized estimating equations assume that the relationship between time and outcome is linear, but make no other parametric assumptions, unlike alternative statistical methods. Power calculations showed that there was sufficient power to determine clinically relevant differences in outcomes.

Age and sex were expected to be strong predictors of outcomes and were adjusted for in the model by including these variables as fixed covariates in the generalized estimating equations; the coefficients have been included in the Tables. Mulders et al[27] showed that female sex and increasing age are

TABLE 2. Patient-Reported Outcome Measures

Outcome Measure	Mean (95% CI)	*P* Value*	Change From Previous 3 Months, Mean (95% CI)	*P* Value†
DASH				
Preoperative	49.7 (44.3–53.8)			
3 months	37.2 (31.8–42.6)	<.05	-11.9 (-18.3 to -5.4)	<.05
6 months	21.6 (16.2–26.9)	<.05	-15.6 (-21.3 to -9.9)	<.05
9 months	15.5 (10.5–20.5)	<.05	-6.1 (-10.9 to -1.3)	<.05
12 months	16.7 (11.6–21.7)	<.05	1.2 (-2.4 to 4.8)	.51
Sex‡	-4.2 (-12.8 to 4.5)	.35		
Age§	-5.7 (-15.2 to 3.8)	.25		
PRWE				
Preoperative	67.5 (62.4–72.6)			
3 months	44.5 (37.8–51.2)	<.05	-23.0 (-29.6 to -16.4)	<.05
6 months	28.1 (21.4–34.9)	<.05	-16.4 (-23.8 to -9.0)	<.05
9 months	17.8 (12.4–23.2)	<.05	-10.3 (-17.2 to -3.4)	<.05
12 months	19.6 (13.0–26.3)	<.05	1.8 (-3.6 to 7.3)	.51
Sex‡	-6.3 (-15.7 to 3.2)	.19		
Age§	-7.9 (-18.1 to 2.3)	.13		
VAS pain score				
Preoperative	7.2 (6.7–7.6)			
3 months	3.3 (2.7–3.9)	<.05	-3.9 (-4.7 to -3.1)	<.05
6 months	2.4 (1.8–2.9)	<.05	-0.9 (-1.7 to -0.2)	<.05
9 months	1.4 (0.9–1.8)	<.05	-1.0 (-1.6 to -0.4)	<.05
12 months	1.3 (0.7–1.8)	<.05	-0.1 (-0.7 to 0.5)	.79
Sex‡	-0.2 (-1.0 to 0.6)	.58		
Age§	-0.2 (-0.8 to 0.4)	.43		

*Significance was compared to the preoperative measure.
†Significance was compared to the previous 3 months.
‡Sex is the effect of being male compared to being female. Positive numbers denote higher scores for males and negative numbers denote lower scores for males.
§Age is the effect of being over 60 years compared to being under 60 years.

TABLE 3. Distribution of VAS Score at 12 Months

VAS Score	Number of Patients
0	20
1	23
2	3
3	4
4	3
5	0
6	2

positively correlated with an increased PRWE. The small number of men enrolled (n = 10) precluded a full comparison of outcomes by sex.

RESULTS

There were 68 patients enrolled in the study. Of these, 12 patients had insufficient follow-up data recorded and 1 patient underwent an ipsilateral shoulder procedure in the early postoperative period. Thus, 13 patients were excluded from the final analysis. The results from 55 patients were analyzed. Patient demographics are outlined in Table 1. The mean patient age was 63 years, and 82% of the patients were women. Preoperative radiological evidence of STT arthritis was found in 23 patients.

Compared to their preoperative baseline measures, all patient-reported outcome measures were improved after surgery and reached statistically significant levels by 3 months (Fig. 1). Both DASH and PRWE improved significantly at each 3-month interval to 9

TABLE 4. Objective Outcome Measures

Outcome Measure	Mean (95% CI)	*P* Value*	Change From Previous 3 Months, Mean (95% CI)	*P* Value†
Kapandji score				
Preoperative	8.2 (7.9–8.6)			
3 months	7.7 (7.3–8.1)	<.05	-0.5 (-1.0 to 0.0)	<.05
6 months	8.4 (8.2–8.7)	.35	0.6 (0.4–1.1)	<.05
9 months	8.5 (8.3–8.7)	.24	0.1 (-0.2 to 0.3)	.63
12 months	8.5 (8.3–8.7)	.18	0.0 (-0.2 to 0.2)	.93
Sex‡	0.5 (0.1–0.9)	<.05		
Age§	-0.1 (-0.5 to 0.3)	.61		
Palmar abduction, degrees				
Preoperative	44 (41–47)			
3 months	47 (45–50)	<.05	3 (0–7)	<.05
6 months	47 (44–50)	.09	0 (-3 to 3)	.85
9 months	50 (46–53)	<.05	3 (-0 to 6)	.07
12 months	51 (48–53)	<.05	1 (-2 to 4)	.60
Sex‡	5.8 (-1.1 to 12.7)	.10		
Age§	-5.1 (-9.2 to -1.1)	<.05		
Radial abduction, degrees				
Preoperative	43 (40–46)			
3 months	45 (42–48)	.25	2 (-1 to 5)	.25
6 months	47 (44–50)	<.05	2 (-1 to 5)	.13
9 months	47 (4–50)	.05	0 (-4 to 3)	.71
12 months	47 (44–50)	<.05	0 (-3 to 3)	.79
Sex‡	7.1 (0.0–14.25)	<.05		
Age§	-3.7 (-8.7 to 1.3)	.15		
Power grip strength, kg				
Preoperative	17.1 (15.0–19.3)			
3 months	15.6 (13.5–17.8)	.12	-1.5 (-3.4 to 0.4)	.12
6 months	19.6 (17.6–21.7)	<.05	4.0 (2.4–5.7)	<.05
9 months	22.5 (20.2–24.7)	<.05	2.9 (1.3–4.4)	<.05
12 months	23.0 (20.7–25.3)	<.05	0.5 (-1.0 to 2.1)	.49
Sex‡	13.1 (6.6–19.5)	<.05		
Age§	-0.9 (-4.8 to 3.0)	.65		
Key pinch strength, kg				
Preoperative	4.2 (3.4–4.9)			
3 months	3.0 (2.5–3.5)	<.05	-1.2 (-1.9 to -0.4)	<.05
6 months	4.0 (3.5–4.6)	.72	1.0 (0.6–1.5)	<.05
9 months	4.5 (3.9–5.0)	.46	0.5 (0.0–0.8)	<.05
12 months	4.6 (4.1–5.0)	.27	0.1 (-0.3 to 0.6)	.59
Sex‡	1.9 (0.6–3.3)	<.05		
Age§	0.0 (-1.0 to 1.0)	.97		
Tip pinch strength, kg				
Preoperative	3.5 (2.9–4.1)			
3 months	2.6 (2.1–3.1)	<.05	-0.9 (-1.6 to -0.3)	<.05
6 months	3.7 (3.2–4.2)	.50	1.1 (0.7–1.5)	<.05

(Continued)

TABLE 4. Objective Outcome Measures (Continued)

Outcome Measure	Mean (95% CI)	*P* Value*	Change From Previous 3 Months, Mean (95% CI)	*P* Value†
9 months	4.1 (3.6−4.7)	.08	0.4 (0.1−0.8)	<.05
12 months	4.3 (3.9−4.8)	<.05	0.2 (-0.3 to 0.7)	.38
Sex‡	2.4 (1.1−3.6)	<.05		
Age§	0.2 (-0.7 to 1.0)	.72		

*Significance was compared to preoperative measure.
†Significance was compared to the previous 3 months.
‡Sex is the effect of being male compared to being female. Positive numbers denote higher scores for males and negative numbers denote lower scores for males.
§Age is the effect of being over 60 years compared to being under 60 years.

months (Table 2). The decrease in pain, as measured by VAS, also improved significantly at each 3-month interval up to the 9-month follow-up, reaching an average pain score of 1.3 (range, 0.7−1.8). Pain scores at 12 months (Table 3) were clustered at the bottom end of the scale, with 84% of the patients having a pain score of 2 or less and 36% reporting no pain. Two patients with a VAS pain score of 6, 1 with a VAS score of 3, and 1 with a VAS score of 4 at the 12-month follow-up were subsequently treated for FCR tendinitis with a corticosteroid injection. Their symptoms had resolved at a subsequent review after the study period.

Opposition, as measured by the Kapandji score, declined significantly at 3 months, to 7.7 (range, 7.3−8.1); however, the score recovered to the preoperative score at 6 months (Table 4). There was no further significant improvement in the Kapandji score at 9 or 12 months. Palmar abduction improved significantly at 3 months and further improved at 9 months compared to the preoperative range, but did not improve further. Radial abduction improved significantly from the preoperative range at 6 months and did not improve thereafter. Power grip strength was reduced at 3 months but significantly exceeded the preoperative strength at 6 months, with a further significant increase at 9 months. Key pinch strength was significantly reduced at 3 months and recovered to the preoperative strength at 6 months. The key pinch strength measurements at 9 and 12 months were not significantly different compared to the preoperative strength. Tip pinch strength was significantly reduced 3 months after surgery and significantly increased between 3 to 6 months and between 6 and 9 months, but was only significantly improved compared to the preoperative strength at 12 months.

There was no evidence that the patients with STT arthritis did not improve at the same rate as those without STT arthritis, and none of the patients with a 12-month VAS of 4 or greater had radiological evidence of STT osteoarthritis. Complications were noted in 5 patients, with 4 cases of FCR tendinitis and 1 case of De Quervain's tenosynovitis at the 12-month follow-up. All complications had resolved with a corticosteroid injection after the completion of this study.

DISCUSSION

A recent Cochrane report noted that though surgery for TMC joint arthritis can successfully alleviate pain and improve physical function and quality of life, no procedure demonstrated a benefit or superiority over any of the other techniques reported, including trapeziectomy with or without LRTI, interposition arthroplasty, joint resurfacing, arthrodesis, and Swanson joint resurfacing.[28] The study designs or methodologies in the studies reviewed were not of sufficient quality to allow a comparative evaluation. Thus, although the various surgical options used can alleviate the pain symptoms and help patients regain function, the surgical technique used for the treatment of TMC joint arthritis may be influenced by radiological and patient factors, but also by the experience of the surgeon and influence from surgical mentors.

In a survey, Brunton and Wilgis[29] determined that 68% of respondents treated advanced TMC joint osteoarthritis by trapeziectomy and ligament reconstruction, and 72% used either the whole or a part of the FCR for the ligament reconstruction. Similar findings were reported by Yuan et al[30] in 2017, supporting the popularity of trapeziectomy and LRTI. Cadaveric studies by Koff et al[31] suggest that ligament reconstruction results in notable improvements in joint kinematics compared to trapeziectomy alone.

In this study, we treated all the patients with trapeziectomy and LRTI using the technique described by Burton and Pellegrini,[11] though other techniques using the FCR have been described.[26,32,33]

The purpose of this study was not to contrast the results of the Burton and Pellegrini[11] technique with those of other techniques, but to prospectively document the recovery after surgery using validated and commonly used outcome measures, and to use this to counsel patients about to undergo the procedure. Other prospective studies have reported on the recovery during the first 12 months after trapeziectomy and LRTI. Ulrich-Vinther et al,[17] using the abductor pollicis longus tendon, and Vadstrup et al,[18] using the Weilby[32] technique, reported on 112 and 106 patients, respectively, but did not include functional scores or patient-reported outcome measures. Vermeulen et al,[34] also using the Weilby[32] technique, reported on 20 patients, but the pain was evaluated at the final review using a questionnaire and not a VAS. The chronological changes in pain were not documented. Using the technique described by Burton and Pellegrini,[11] Nylén et al[35] reported on objective outcome measures before surgery and at a final follow-up. No functional scores or patient-reported outcome measures were reported. Similarly, Guzzini et al[15] only reported the subjective and objective outcome measures of 36 patients before surgery and at a 12-month review.

We observed that patients will notice a significant decrease in pain, measured by VAS, and significant improvements in DASH and PRWE at 3 months. Further significant improvements in these measures will occur at 6 and 9 months, after which no further improvement will occur. In total, 80% of the patients can expect little or no pain (VAS scores 0−2). Only 2 patients in our cohort complained of notable pain (VAS score 6) at 12 months, and both had tendinitis of the FCR tendon that resolved after treatment with corticosteroid injections administered after the 12-month study period. There were no differences in outcomes in patients with preoperative radiological evidence of STT arthritis.

The minimal clinically important difference (MCID) is the smallest change or difference in any outcome measure score that is associated with a clinically relevant change. For the DASH, it has been suggested that a change in score of 15 represents a clinically relevant change in patient function.[36,37] For the PRWE, the MCID has been reported to be in the range of 11.5 to 14.[38,39] Our results show that the MCID for DASH occurred between the 3- and 6-month period and the MCID for PRWE occurred both in the first 3-month period after surgery and between the 3- and 6-month period.

Although normal function varies with the specific needs of each individual, Hunsaker et al[40] reported a normative value of 10.1 for the DASH score. In our cohort, the mean DASH score at 9 months was 15.5 (standard deviation, 10.5−20.5). Although not quite reaching the normative value for DASH as quoted by Hunsaker et al,[40] at 9 months the 95% confidence interval was within 1 standard deviation. In the first 12 months after LRTI, the outcome, as measured by DASH and PRWE, reaches a plateau after 9 months. Patients can expect to attain 37% of their eventual measured DASH score at 3 months and 82% at 6 months. Alternatively, patients can expect to attain 46% of their eventual measured PRWE score at 3 months and 79% at 6 months. Gervis and Wells[41] also noted that there was a sufficient return of pinch strength at 12 months to allow winding a clock with a strong spring.

Several studies have reported significant improvements in power grip, key pinch, and tip pinch strengths after trapeziectomy.[16−18,34] We found that grip strength was reduced 3 months after surgery but was significantly better than the preoperative strength at 6 months and further increased significantly at 9 months. Patients can expect their grip strength to exceed their preoperative strength by 15% at 6 months after surgery and by 30% at 9 months. There was no further increase at 12 months. Tip pinch strength significantly exceeded the preoperative strength by 20% at 9 months. Although the mean key pinch strength at 9 and 12 months exceeded the preoperative strength, the increase was not significant (Table 4). The power grip, key pinch, and tip pinch strengths may be improved by a supervised hand therapy program, though previous studies did not report the use of a strengthening program.[16−18,34]

In our patient cohort, the mean power grip, key pinch, and tip pinch strengths at 12 months for men (n = 10) were 33.8 kg (range, 27.4−40.1 kg), 6.2 kg (range, 4.9−7.4 kg) and 6.3 kg (range, 5.2−7.5 kg), respectively, and for women (n = 45) were 20.7 kg (range, 18.4−22.9 kg), 4.2 kg (range, 3.7−4.7 kg), and 3.9 kg (range, 3.4−4.4 kg), respectively. However, these mean strength measures were reduced compared to the normative values for men and women, measured from right and left hands, in the 60- to 64- year age group.[42−44]

Barakat et al[45] determined that the mean normative values of thumb movement in a cohort of volunteers with a mean age of 26 years, of which 63% were women, was palmar abduction of 61°, radial

abduction of 63°, and a Kapandji score of 9. Follow-up of the patients in our study showed that radial and palmar abduction increased significantly compared to the preoperative ranges at 6 months and 9 months, respectively. Opposition, measured by determination of the Kapandji score, exceeded the preoperative mobility from 6 months, but not significantly. Patients with osteoarthritis of the TMC joint have reduced preoperative mobility scores, and while trapeziectomy and LRTI in our study did not restore the thumb mobility to normative values, there were modest improvements in palmar and radial abduction after surgery.

This study was limited by size and was underpowered for subgroup analyses of the effects of sex and age. The analyzed results were performed on the basis of means and may not reflect individual responses. Additionally, the study period is limited to the first 12 months after surgery, and the response after surgery beyond this period cannot be inferred.

Preoperative counseling can better prepare patients for their expected recovery and can decrease negative outcomes, such as pain and anxiety after surgery.[46–48] The objective and patient-reported outcome measures from this study can be used to counsel patients before trapeziectomy and LRTI.

ACKNOWLEDGMENTS

We thank Certified Hand Therapists Kerry White, Bernadette Kelly, and Leanne Graham.

REFERENCES

1. Armstrong AL, Hunter JB, Davis TRC. The prevalence of degenerative arthritis of the base of the thumb in post-menopausal women. *J Hand Surg Br*. 1994;19(3):340–341.
2. Amadio PC, Millender LH, Smith RJ. Silicone spacer or tendon spacer for trapezium resection arthroplasty—comparison of results. *J Hand Surg Am*. 1982;7(3):237–244.
3. Atroshi I, Axelsson G. Extensor carpi radialis longus tendon arthroplasty in the treatment of primary trapeziometacarpal arthrosis. *J Hand Surg Am*. 1997;22(3):419–427.
4. Avisar E, Elvey M, Wasrbrout Z, Aghasi M. Long-term follow-up of trapeziectomy with abductor pollicis longus tendon interposition arthroplasty for osteoarthritis of the thumb carpometacarpal joint. *J Orthop*. 2013;10(2):59–64.
5. Davis TR, Brady O, Barton NJ, Lunn PG, Burke FD. Trapeziectomy alone, with tendon interposition or with ligament reconstruction? *J Hand Surg Br*. 1997;22(6):689–694.
6. Dell PC, Brushart TM, Smith RJ. Treatment of trapeziometacarpal arthritis: results of resection arthroplasty. *J Hand Surg Am*. 1978;3(3):243–249.
7. Eaton RG, Glickel SZ, Littler JW. Tendon interposition arthroplasty for degenerative arthritis of the trapeziometacarpal joint of the thumb. *J Hand Surg Am*. 1985;10(5):645–654.
8. Froimson AI. Tendon arthroplasty of the trapeziometacarpal joint. *Clin Orthop Relat Res*. 1970;70:191–199.
9. Menon J, Schoene HR, Hohl JC. Trapeziometacarpal arthritis-results of tendon interpositional arthroplasty. *J Hand Surg Am*. 1981;6(5):442–446.
10. Wong TC, Ip FK. A modified technique of interpositional arthroplasty in treating the basal joint arthritis of the thumb in a chinese population. *Hand Surg*. 2009;14:83–87.
11. Burton RI, Pellegrini VD Jr. Surgical management of basal Joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty. *J Hand Surg Am*. 1986;11(3):324–332.
12. Tomaino MM, Pellegrini VD, Burton RI. Arthroplasty of the basal joint of the thumb. Long-term follow-up after ligament reconstruction with tendon interposition. *J Bone Joint Surg Am*. 1995;77(3):346–355.
13. Yeoman TFM, Stone O, Jenkins PJ, McEachan JE. The long-term outcome of simple trapeziectomy. *J Hand Surg Eur*. 2019;44(2):146–150.
14. Belcher HJ, Nicholl JE. A comparison of trapeziectomy with and without ligament reconstruction and tendon interposition. *J Hand Surg Br*. 2000;25(4):350–356.
15. Guzzini M, Perugia D, Proietti L, et al. Suspension arthroplasty versus interposition arthroplasty in the treatment of trapeziometacarpal osteoarthritis: a clinical and magnetic resonance imaging study. *Int Orthop*. 2019;43(3):647–651.
16. Miura T, Osuka K, Itoh S, Nakagawa T, Kawano H, Nakamura K. Early functional improvement after a modified ligament reconstruction tendon interposition arthroplasty for thumb basal joint arthritis. *Hand Surg*. 2008;13(3):153–158.
17. Ulrich-Vinther M, Puggaard H, Lange B. Prospective 1-year follow-up study comparing joint prosthesis with tendon interposition arthroplasty in treatment of trapeziometacarpal osteoarthritis. *J Hand Surg Am*. 2008;33(8):1369–1377.
18. Vadstrup LS, Schou L, Boeckstyns ME. Basal joint osteoarthritis of the thumb treated with Weilby arthroplasty: a prospective study on the early postoperative course of 106 consecutive cases. *J Hand Surg Eur*. 2009;34(4):503–505.
19. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med*. 1996;29(6):602–608.
20. De Smet L. Responsiveness of the DASH score in surgically treated basal joint arthritis of the thumb: preliminary results. *Clin Rheumatol*. 2004;23(3):223–224.
21. MacDermid JC, Turgeon T, Richards RS, Beadle M, Roth JH. Patient rating of wrist pain and disability: a reliable and valid measurement tool. *J Orthop Trauma*. 1998;12:577–586.
22. Kapandji A. Clinical test of apposition and counter-apposition of the thumb. Article in French. *Ann Chir Main*. 1986;5:67–73.
23. Schmidt RT, Toews JV. Grip strength as measured by the Jamar dynamometer. *Arch Phys Med Rehabil*. 1970;51(6):321–327.
24. Hook WE, Stanley JK. Assessment of thumb to index pulp to pulp pinch grip strengths. *J Hand Surg Br*. 1986;11(1):91–92.
25. Scott J, Huskisson EC. Graphic representation of pain. *Pain*. 1976;2(2):175–184.
26. Eaton RG, Littler JW. Ligament reconstruction for the painful thumb carpometacarpal joint. *J Bone Joint Surg Am*. 1973;55(8):1655–1666.
27. Mulders MAM, Kleipool SC, Dingemans SA, et al. Normative data for the patient-rated wrist evaluation questionnaire. *J Hand Ther*. 2018;31(3):287–294.
28. Wajon A, Vinycomb T, Carr E, Edmunds I, Ada L. Surgery for thumb (trapeziometacarpal joint) osteoarthritis. *Cochrane Database Syst Rev*. 2015;2015(2):CD004631.
29. Brunton LM, Wilgis EF. A survey to determine current practice patterns in the surgical treatment of advanced thumb carpometacarpal osteoarthrosis. *Hand (N Y)*. 2010;5(4):415–422.
30. Yuan F, Aliu O, Chung K. Evidence-based practice in the surgical treatment of thumb carpometacarpal joint arthritis. *J Hand Surg Am*. 2017;42(2):104–112.e1.
31. Koff MF, Zhao KD, Mierisch CM, Chen MY, An KN, Cooney WP. Joint kinematics after thumb carpometacarpal joint reconstruction: an

in vitro comparison of various constructs. *J Hand Surg Am*. 2007;32(5):688–696.
32. Weilby A. Surgical treatment of osteoarthritis of the carpo-metacarpal joint of the thumb. *Acta Orthop Scand*. 1971;42(5):439–440.
33. Kleinman WB, Eckenrode JF. Tendon suspension sling arthroplasty for thumb trapeziometacarpal arthritis. *J Hand Surg Am*. 1991;16(6):983–991.
34. Vermeulen GM, Brink SM, Sluiter J, Elias SG, Hovius SE, Moojen TM. Ligament reconstruction arthroplasty for primary thumb carpometacarpal osteoarthritis (Weilby technique): prospective cohort study. *J Hand Surg Am*. 2009;34(8):1393–1401.
35. Nylén S, Johnson A, Rosenquist AM. Trapeziectomy and ligament reconstruction for osteoarthrosis of the base of the thumb. A prospective study of 100 operations. *J Hand Surg Br*. 1993;18(5):616–619.
36. Beaton DE, Davis AM, Hudak P, Mcconnell S. The DASH (Disabilities of the Arm, Shoulder and Hand) outcome measure: what do we know about it now? *Br J Hand Ther*. 2001;6(4):109–118.
37. Beaton DE, van Eerd D, Smith P, et al. Minimal change is sensitive, less specific to recovery: a diagnostic testing approach to interpretability. *J Clin Epidemiol*. 2011;64(5):487–496.
38. Walenkamp MM, de Muinck Keizer RJ, Goslings JC, Vos LM, Rosenwasser MP, Schep NW. The minimum clinically important difference of the patient-rated wrist evaluation score for patients with distal radius fractures. *Clin Orthop Relat Res*. 2015;473(10):3235–3241.
39. Sorensen AA, Howard D, Tan WH, Ketchersid J, Calfee RP. Minimal clinically important differences of 3 patient-rated outcomes instruments. *J Hand Surg Am*. 2013;38(4):641–649.
40. Hunsaker FG, Cioffi DA, Amadio PC, Wright JG, Caughlin B. The American Academy of Orthopaedic Surgeons outcomes instruments: normative values from the general population. *J Bone Joint Surg Am*. 2002;84(2):208–215.
41. Gervis WH, Wells TA. A review of excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint after twenty-five years. *J Bone Joint Surg Br*. 1973;55(1):56–57.
42. Massy-Westropp N, Rankin W, Ahern M, Krishnan J, Hearn TC. Measuring grip strength in normal adults: reference ranges and a comparison of electronic and hydraulic instruments. *J Hand Surg Am*. 2004;29(3):514–519.
43. Angst F, Drerup S, Werle S, Herren DB, Simmen BR, Goldhahn J. Prediction of grip and key pinch strength in 978 healthy subjects. *BMC Musculoskelet Disord*. 2010;11:94.
44. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. *Arch Phys Med Rehabil*. 1985;66(2):69–74.
45. Barakat M, Field J, Taylor J. The range of movement of the thumb. *Hand (N Y)*. 2013;8(2):179–182.
46. Edwards PK, Mears SC, Lowry Barnes C. Preoperative education for hip and knee replacement: never stop learning. *Curr Rev Musculoskelet Med*. 2017;10(3):356–364.
47. Powell R, Scott NW, Manyande A, et al. Psychological preparation and postoperative outcomes for adults undergoing surgery under general anaesthesia. *Cochrane Database Syst Rev*. 2016;5(5):CD008646.
48. Shuldham C. A review of the impact of pre-operative education on recovery from surgery. *Int J Nurs Stud*. 1999;36(2):171–177.

JOURNAL CME QUESTIONS

Functional Recovery Following Trapeziectomy and Ligament Reconstruction and Tendon Interposition: A Prospective Longitudinal Study

1. Following ligament reconstruction with tendon interposition (LRTI), thumb opposition measured by Kapandji score worsens after surgery but recovers to preoperative mobility by which of the following?

a. 6 weeks
b. 3 months
c. 6 months
d. 9 months
e. 12 months

2. In this study, visual analog scale (VAS) pain scores for the thumb improved postoperatively and reach a plateau at which of the following?

a. 6 weeks
b. 3 months
c. 6 months
d. 9 months
e. 12 months

3. In this study, what percentage of patients experienced little to no pain (VAS score 0-2) by 12 months?

a. 20%
b. 40%
c. 60%
d. 80%
e. 95%

4. In this study, the final grip measurements at 12 months after LRTI demonstrated which of the following?

a. Minor loss of strength compared to preoperative values.
b. No improvement from preoperative values.
c. Improvement from preoperative values but still less strength on average compared to normative values for this patient population.
d. Improvement from preoperative values and equivalent strength on average compared to normative values for this patient population.
e. Improvement from preoperative values and greater strength on average compared to normative values for this patient population.

To take the online test and receive CME credit, go to https://www.jhandsurg.org/cme/home.