Arthroplasty of the Basal Joint of the Thumb

LONG-TERM FOLLOW-UP AFTER LIGAMENT RECONSTRUCTION WITH TENDON INTERPOSITION*†

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ABSTRACT: Twenty-four thumbs of twenty-two patients were evaluated at an average of nine years (range, eight to eleven years) after a ligament reconstruction-tendon interposition arthroplasty for osteoarthritis at the base of the thumb. The same group had also been examined two and six years postoperatively. The procedure had been performed as a primary operation in twenty-one thumbs and as a revision of a failed implant arthroplasty in three. Twenty-one (95 per cent) of the twenty-two patients had excellent relief of pain and were satisfied with the outcome. The average grip strength increased ten kilograms (p < 0.005), reflecting a 93 per cent improvement compared with the preoperative values. Similarly, the average tip pinch strength steadily improved, with an increase at the most recent examination of nearly one kilogram (p < 0.005) (65 per cent improvement). Improvements in the average key pinch strength, however, were first noted at the six-year follow-up examination and then tapered slightly; the most recent values reflected an average gain of 34 per cent but were not significantly different from the preoperative values. The tip of twenty-two (92 per cent) of the twenty-four thumbs was able to touch the base of the little finger, and the most recent average web angle (40 degrees) was unchanged from the value at the two-year follow-up examination. Stress radiographs showed an average subluxation of the metacarpal base of 11 per cent at nine years compared with 7 and 8 per cent at two and six years, respectively. Similarly, these radiographs demonstrated an average loss of height of the arthroplasty space of 13 per cent at nine years compared with 11 per cent at both of the earlier follow-up examinations. This modest deterioration of radiographic parameters was not predictive of an unsatisfactory outcome. The ligament reconstruction-tendon interposition arthroplasty provided a stable and functional reconstruction of the thumb, resulting in excellent relief of pain and a significant increase in strength for as long as eleven years after the procedure.

The goals of operative treatment for painful osteoarthritis at the basal articulation of the thumb are relief of pain and restoration of stability. Unfortunately, problems such as wear of synthetic implants, recurrent pain and instability, and loss of strength have often been noted after long-term follow-up1,2,3,11,15,16,26,28,30. In 1986, we reported early favorable results after ligament reconstruction-tendon interposition arthroplasty was done to address these problems5. Our early belief that this operative procedure would be efficacious in the reconstruction of the osteoarthritic basal joint was based on favorable reported experiences with ligament reconstruction for unstable joints without degenerative change14 and in conjunction with silicone implant arthroplasty15. Greater insight into the fundamental role of attrition of the palmar oblique (beak) ligament in the pathophysiology of osteoarthritis of the basal joint has further supported the concept that ligament reconstruction is fundamental to the maintenance of a stable, pain-free, mobile basal joint24,25.

More than 200 of these procedures have been performed at the University of Rochester since the early 1980’s, and we have closely followed the first twenty-five consecutive operations, in order to assess the long-term performance. Longitudinal analysis of this group has allowed the investigation of the durability of this reconstructive option with time. The retrospective review of this population of patients at an average of two, six, and nine years after the operation forms the basis of this report.

Materials and Methods

We have used ligament reconstruction-tendon interposition arthroplasty as the primary operative treatment for symptomatic osteoarthritis of the carpometacarpal joint of the thumb since 1979. One of the original twenty-three patients could not be located after the two-year follow-up report4. One patient had a cerebral vascular
accident one year before the nine-year follow-up examination, precluding the measurement of strength data at this interval. Two patients had had a bilateral procedure. Thus, this series comprised twenty-two patients (nineteen women and three men), with longitudinal analysis of twenty-four (96 per cent) of the original twenty-five thumbs provided at average follow-up intervals of two years (range, one to four years), six years (range, four to eight years), and nine years (range, eight to eleven years). The preoperative diagnosis for all of the patients was osteoarthritis, and pain and weakness in the basal joint had been a source of disability both at work and during recreational activities. None of the patients had responded satisfactorily to non-operative treatment with oral administration of anti-inflammatory medication, application of a splint, and strengthening exercises for the thenar muscles. Twelve of the treated thumbs were on the dominant hand. The average age at the time of the operation was fifty-six years (range, thirty-six to sixty-seven years). Two patients were punchpress operators; three were assembly-line workers; two were dental hygienists; two were secretaries; and one each was a school-bus driver, a waitress, and a pianist at the time of the operation. Ten patients were retired at the time of the operation, and seven of these played golf, gardened, or participated in other recreational activities.

The procedure was done in three thumbs as a revision of a failed silicone implant arthroplasty that had been performed in conjunction with complete excision of the trapezium. Over-all, six thumbs had partial excision of the distal aspect of the trapezium and eighteen had complete excision. A complete trapeziectomy was performed instead of a partial one when either scaphotrapezial osteoarthritis or an adduction (first-web-space) contracture was observed.

One-half of the width of the flexor carpi radialis tendon was used for ligament reconstruction in twenty-two thumbs; one-half of the abductor pollicis longus tendon was used in the remaining two thumbs, as the flexor carpi radialis tendon was found to be inadequate. In eight thumbs in which there was more than 30 degrees of passive hyperextension of the metacarpophalangeal joint, stabilization of this joint was performed at the same time as the arthroplasty of the basal joint. The metacarpophalangeal joint was fixed in 10 degrees of flexion with a Kirschner wire in four of these thumbs, a volar capsulodesis was performed in one, and an arthrodesis was performed in three. If unaddressed, such hyperextensibility at the metacarpophalangeal joint may lead to attrition of the ligament reconstruction, and a characteristic zigzag longitudinal collapse deformity may occur secondary to subluxation of the base of the first metacarpal.

Eighteen patients had a coexistent condition, including compression of the median or ulnar nerve at the level of the wrist and de Quervain tenosynovitis. Six of these patients had a carpal tunnel release, four had a release of the Guyon canal, and eight had a release of the compartment of the first extensor tendon at the time of the ligament reconstruction.

All patients were examined, independent of the operating surgeon (R. I. B.), at an average of two, six, and nine years. Each patient was evaluated with a standardized questionnaire for the assessment of subjective functional performance and relief of pain; a physical examination; and radiographs, including stress radiographs (as described by Eaton and Littler), an antero-posterior (Robert) radiograph made with the hand in forced pronation, and a lateral radiograph. The questionnaire inquired whether the patient had pain with changes in weather, activities of daily living, or forceful use of the hand involving lateral or chuck pinch during such activities as brushing the teeth, sewing or needlepoint, turning a key, opening the door of an automobile, opening a jar, or picking up a book. Occupational status was also determined.

The physical examination included evaluation of the operative site for sensory nerve dysfunction. The stability of the basal joint was assessed on the basis of the presence of a prominence or so-called shoulder sign at the radial base of the thumb from dorsal subluxation of the metacarpal on the trapezium when flexion stress was applied to the metacarpal of the thumb with simultaneous axial loading. Active functional flexion of the ray of the thumb from the abducted position was indicated by the ability to touch the tip of the thumb to the palmar base of the little finger. The dynamometer was used to quantitate grip strength, and a pinch meter was used to determine key and tip pinch strengths. The average preoperative grip, key pinch, and tip pinch strengths were 14.6, 4.8, and 2.9 kilograms, respectively. Comparison of the preoperative values and the values at each follow-up interval allowed longitudinal analysis of changes in strength. The strength of wrist flexion at each interval was assessed on the basis of whether the patient could resist the examiner's attempt to extend the flexed wrist to neutral.

Radiographs of each thumb were made at approximately three months after the operation and at each follow-up interval. The stress radiograph consisted of an antero-posterior radiograph of both thumbs with the radial margins of each distal phalanx pressed together (Fig. 1). Restoration of the web space of the thumb was assessed on the basis of the thumb-index intermetacarpal angle with the thumb in maximum palmar abduction, as measured on the antero-posterior (Robert) radiograph. The stability of the arthroplasty was assessed according to the percentage of subluxation of the base of the metacarpal relative to the scaphoid, and proximal migration of the metacarpal was measured as the percentage of diminution in the height of the arthroplasty space compared with the height on early postoperative radiographs. The antero-posterior and lateral radiographs were used to evaluate the meta-
carpal-halangeal joint of each thumb for degenerative change.

Statistical analysis was performed with the unpaired Student t test.

Operative Technique

In this procedure, as originally described in 1983, one-half of the width of the flexor carpi radialis tendon was used to reconstruct the palmar oblique ligament, to suspend and resurface the metacarpal of the thumb, and to fill the new arthroplasty space created by either partial or complete excision of the trapezium (Fig. 2).

Although we were satisfied with the results of ligament reconstruction-tendon interposition arthroplasty as it was originally described, the operative technique has evolved to facilitate the technical performance of the procedure and to eliminate potential complications. We now routinely excise the entire trapezium, as this provides broader exposure of the flexor carpi radialis tendon and facilitates its use in ligament reconstruction. In addition, removal of the entire trapezium minimizes the likelihood of osseous impingement between the metacarpal of the thumb and the trapezial remnant and decreases the risk that unrecognized scaphotrapezial osteoarthrosis could result in persistent postoperative pain. In younger patients with isolated trapeziometacarpal osteoarthrosis, in whom arthrodesis is still a useful salvage procedure if the ligament reconstruction attenuates with time, a hemitrapeziectomy is preferred in order to preserve bone stock.

Routine use of the entire width of the flexor carpi radialis tendon constitutes a second change in the procedure as originally described. Use of the entire width not only facilitates the harvest of the tendon more proximally in the forearm but also provides a bulkier piece of tissue for both ligament reconstruction and interposition into the arthroplasty space.

The trapeziometacarpal joint is exposed with a modified triradiate incision. The longitudinal limb extends along the metacarpal of the thumb and around the volar palmar aspect at the base of the thenar cone, and a small dorsal limb is necessary to facilitate safe exposure and mobilization of the radial artery. Superficial dissection in the region of the basal joint must be performed carefully to avoid injury to the many branches of the radial sensory nerve. The radial artery is a helpful landmark because it lies directly over the scaphotrapezial joint. Small arteries arising from its deeper and distal surface and extending toward the trapezium must be carefully dissected and ligated or coagulated. The capsule overlying the surface of the trapezium is exposed and opened longitudinally, and its edges are tagged to facilitate closure at the conclusion of the arthroplasty.

With traction applied to the thumb, the carpometacarpal, scaphotrapezial, and scaphotrapezoidal joints are inspected, and the articular surface at the base of the metacarpal of the thumb is removed with a power sagittal saw directed perpendicular to the long axis of the metacarpal so as to leave the insertion of the abductor pollicis longus tendon intact. Either the entire trapezium or its distal half is excised, depending on the extent of scaphotrapezial osteoarthrosis and narrowing of the
A cut is made with the saw to a depth of three-quarters of the full thickness of the trapezium, parallel to the course of the flexor carpi radialis tendon. A small sharp osteotome is placed into the space that was created and is twisted, breaking the trapezium at its deeper surface without damage to the underlying flexor carpi radialis tendon. After the trapezium is removed, an oblique hole is developed through the dorsal cortex of the metacarpal of the thumb one centimeter distal to its resected base in the plane of the nail and is extended through the medullary canal into the trapezium fossa. Gouges of increasing size or a small blunt-tipped power burr is used to make and enlarge the initial hole, and a series of curets are used to remove bone selectively from the distal margin of the hole to prevent infraction of the dorsal bridge of bone between the hole and the base of the metacarpal. The diameter of the resulting hole is most often approximately six millimeters. The flexor carpi radialis tendon can be seen in the depths of the future arthroplasty space created by the excision of the trapezium as it passes to its insertion on the base of the metacarpal of the index finger. Care should be taken at this point to resect any osteophytes on the radial surface of the trapezoid or on the volar ulnar aspect of the metacarpal of the thumb to facilitate adequate abduction of the latter before the ligament reconstruction. If such osteophytes are not removed, impingement will prevent maximum restoration of the web space.

One-half of the flexor carpi radialis tendon is harvested from its junction with the muscle to its insertion on the volar aspect of the base of the metacarpal of the index finger. This is done with a series of transverse incisions rather than with a single longitudinal incision. A curved hemostat is placed beneath the tendon, and the tendon is pulled gently from the depths of the space formerly filled by the trapezium, to bring it into the operative site. The tendon is then mobilized to its insertion on the metacarpal of the index finger. The tendon should be kept in a moist sponge soaked with saline solution while small rents in the volar aspect of the capsule in the depths of the arthroplasty space are repaired with 4-0 non-absorbable suture material. In addition, a 4-0 suture is placed through the volar aspect of the capsule, distal to the scaphoid, so that it can be used later to secure the interposition material. A 30-gauge monofilament wire is then passed through the hole in the metacarpal of the thumb and out through its base. It is tied tightly around the distal edge of the flexor carpi radialis tendon with a single throw and is used as a tendon-passer. In this manner, the tendon is delivered through the base of the metacarpal of the thumb to exit through the dorsal hole. This passage is facilitated by use of a twisting motion while the tendon is pulled and by keeping the tendon moist. Before the tendon is sutured in any way, longitudinal traction is applied to the metacarpal of the thumb to bring the base of the metacarpal to the same level as that of the metacarpal of the index finger; this preserves the space formerly occupied by the

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**Fig. 2**

Schematic representation of the ligament reconstruction-tendon interposition arthroplasty. The forces in function producing proximal migration and radial subluxation of the metacarpal are neutralized by the ligament reconstruction, as indicated in the vector diagram. a = ligament reconstruction, b = metacarpal resurfacing, and c = tendon arthroplasty spacer.
trapezium. In addition, the metacarpal of the thumb is abducted as much as the first web space will allow, to restore the breadth of the first web space fully. A 0.054-inch (0.137-centimeter) smooth Kirschner wire is directed through the metacarpal of the thumb into the carpus ulnar to the scaphoid so as not to interfere with the ligament reconstruction and the tendon interposition. This stabilizes the position of the thumb before completion of the arthroplasty.

The flexor carpi radialis tendon is pulled tightly to remove all slack and is sutured to the periosteum, where it exits through the hole in the bone dorsally. The tendon is folded across the base of the metacarpal of the thumb, so that the metacarpal is effectively resurfaced to prevent extrusion of the interposition material into the medullary canal. The tendon is then sutured to itself (Fig. 2). At this point, the ligament-reconstruction component of the arthroplasty is completed, and the residual length of remaining flexor carpi radialis tendon is fashioned into an anchovy shape with use of a Keith needle over which the length of the tendon is folded onto itself like an accordion. The four corners of the "anchovy" are then sutured together, and a second Keith needle is placed through this interposition mass, parallel to the first needle. The previously placed suture in the volar aspect of the capsule is used to thread both limbs through the two Keith needles so that the "anchovy" can be resected into the arthroplasty space and secured with ligation of this suture. The dorsal aspect of the capsule is carefully repaired in a two-layer closure over the interposition material; the surface of this material and the superficial portion of the reconstructed ligament can be incorporated into the repair if necessary. Last, the extensor pollicis brevis tendon is tenodesed to the shaft of the metacarpal, proximal to the metacarpophalangeal joint, to remove the hyperextension deforming force from the proximal phalanx.

When the ligament reconstruction-tendon interposition arthroplasty is performed, it is important that the stability of the metacarpophalangeal joint of the thumb be ensured. If there is more than 30 degrees of valgus instability or more than 30 degrees of hyperextension instability to passive stress, arthodesis or stabilization of the joint by capsulodesis should be done. We recommend that the former procedure be done, in approximately 10 degrees of flexion, because of the durability of an arthodesis and the minimum resulting disability. If hyperextension instability is less than 30 degrees, a Kirschner wire is used for temporary stabilization for four weeks. Failure to stabilize the unstable metacarpophalangeal joint will result in collapse of the thumb with longitudinal pinch. Hyperextension of the metacarpophalangeal joint causes adduction of the metacarpal of the thumb with pinch, which increases stresses on the ligament reconstruction. When the metacarpophalangeal joint of the thumb must be stabilized, we prefer to do this after the trapezium has been excised and the flexor carpi radialis tendon has been harvested but before the new ligament is sutured in place, so that the manipulation that is necessary to perform the procedure up to this point is not done in the presence of a previously stabilized metacarpophalangeal joint. We normally perform an arthodesis with two crossed Kirschner wires and, when we do, we do not perform the extensor pollicis brevis tenodesis.

The postoperative regimen consists of immobilization in an above-the-elbow thumb-spica cast, hospitalization for intravenous administration of antibiotics and analgesics for forty-eight hours, and range-of-motion exercises for the fingers and the interphalangeal joint of the thumb. One month after the operation, we remove the hand dressing and cast, the sutures, and the Kirschner wire. If an arthodesis was performed on the metacarpophalangeal joint, we leave those Kirschner wires in place until the site of the arthrodesis is no longer tender or there is radiographic evidence of union, or both. An isoprene thumb-spica splint extending from the level of the interphalangeal joint of the thumb to the junction of the proximal and middle thirds of the forearm is applied. The patient removes this splint four times a day for a specific program of exercises consisting of active motion of the metacarpophalangeal joint (if it was not stabilized) and the interphalangeal joint and isometric setting exercises of the thenar. Isometric exercises of the thenar muscles involve positioning of the thumb in abduction, both in and out of the plane of the palm, followed by isometric contraction to resist gentle pressure that the therapist applies to the thumb with the aim of reversing the set position. Two months after the operation, active flexion-adduction exercises of the basal joint are begun. Weaning from the splint is begun at this time. Use of the splint is discontinued when the thenar strength has improved to a level that allows pain-free pinch and grip, as would be needed to perform activities of daily living; this typically occurs at approximately three months. Resistive lateral pinch and grip-strengthening is begun at three months, with gradual resumption of unrestricted activity as the return of strength allows (typically by four to six months after the operation). The first postoperative radiographs usually are made approximately three months after the operation unless earlier examination of the metacarpophalangeal joint was necessary after an arthodesis.

**Results**

The present study gave us an opportunity to follow a cohort of patients longitudinally for an average of nine years (range, eight to eleven years) after the arthroplasty. All but two of the patients had complete relief of pain and were satisfied with the thumb at each follow-up interval. While two patients noted slight discomfort with pinch, only one remained dissatisfied with the relief of pain and the function of the thumb throughout the entire follow-up period. Eleven of the twelve patients
who were employed at the time of the operation, including two punch-press operators, three assembly-line workers, two dental hygienists, two secretaries, a waitress, and a school-bus driver, had been able to return to their previous employment. The twelfth patient (the pianist) had retired, but she was satisfied with the results of the operation. Seven of the ten patients who were retired at the time of the operation and who had been very active in such recreational pursuits as golf and gardening continued to perform these activities postoperatively without restriction. Two patients noted a pulling sensation in the forearm along the course of the flexor carpi radialis tendon at the two-year follow-up examination and, notwithstanding full bilaterally symmetrical strength of wrist flexion as determined by manual testing, this was again noted at the nine-year evaluation. Neither patient had limitation of motion at the wrist. Bothersome paresthesias in the palmar radial aspect of the thumb along the incision were noted in two patients at the two-year follow-up examination, but these had completely resolved by the time of the six and nine-year examinations.

All twenty-two of the patients thought that the reconstructed thumb was more effective for activities involving pinching and gripping than it had been preoperatively. Each patient was able to open jars and automobile doors and to use keys. No patient had pain associated with changes in the weather.

The only dissatisfied patient at the two-year follow-up examination remained so at each subsequent evaluation; this patient was involved in Workers’ Compensation litigation. She complained of pain and weakness at the base of the thumb with activities involving pinching and gripping, despite longitudinal improvement in objective strength measurements. With the exception of this patient, who had left her job as a punch-press operator by the time of the six-year follow-up examination, the function of the thumb postoperatively did not necessitate a job change or retirement for any of the patients. In addition, subjective results were not influenced by the extent of the excision of the trapezium or diminished in the thumbs for which the ligament reconstruction-tendon interposition arthroplasty was performed for revision of a failed silicone arthroplasty.

On examination, there was no evidence of hypersensitivity at the site of the incision or dystrophic findings in any patient at any of the follow-up intervals. Transient mild reflex sympathetic dystrophy developed in one patient seven months after the operation, but the patient recovered fully after a vigorous supervised hand-therapy program. Among the sixteen thumbs in which the metacarpophalangeal joint was not stabilized, there was no evidence of deformity or of progression of metacarpophalangeal hyperextension. The eight thumbs in which an arthrodesis of the metacarpophalangeal joint or stabilization of the metacarpophalangeal joint with capsulodesis had been performed had no degenerative changes or recurrent instability. Axial stress with circumduction applied to the basal joint elicited pain without crepitation in only one patient, the one who was involved in Workers’ Compensation litigation. This patient continued to be dissatisfied with the function of the thumb despite a 100 per cent improvement in both grip and tip pinch strength compared with the preoperative values.

Mobility of the thumb improved between the two-year follow-up evaluation, at which time seven of twenty-five thumbs could not touch the base of the little finger, and the nine-year follow-up evaluation, when twenty-two of twenty-four thumbs could reach the base of the little finger and two could reach the crease of the proximal interphalangeal joint. For the thumbs that gained motion with time, there was no association between declining functional performance and evidence of metacarpal settling or subluxation on the stress radiographs.

The restoration of the web space was well preserved. The average index-thumb metacarpal web angle was 41 degrees at the two, six, and nine-year follow-up evaluations compared with 28 degrees preoperatively. In addition, the restoration of the web space achieved with partial excision of the distal aspect of the trapezium (average, 43 degrees) was comparable with that achieved with complete excision of the trapezium (average, 40 degrees).

In 1986, we reported a 19 per cent improvement in aggregate grip and pinch strength following ligament reconstruction-tendon interposition arthroplasty compared with the preoperative values. Analysis of the data that composed that report with use of the same methodology as was used to analyze the data from the six-year and nine-year follow-up examinations demonstrates that grip and tip pinch strength continued to increase steadily for six years before it reached a plateau. The average grip strength at the nine-year follow-up examination was 24.6 kilograms compared with 14.6 kilograms preoperatively, reflecting a 93 per cent improvement. The average tip pinch strength at the nine-year follow-up examination was 3.8 kilograms compared with 2.9 kilograms preoperatively, reflecting a 65 per cent improvement. The gains in both types of strength had become significant (p < 0.05) by the time of the six-year follow-up examination (Table I). In contrast, the average key pinch strength at

<table>
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<th>AVERAGE STRENGTHS (IN KILOGRAMS)</th>
<th>Improvement between Preop. Value and Most Recent Value (Per cent)</th>
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<tr>
<td></td>
<td>Preop.</td>
<td>At 2 Yrs.</td>
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<tr>
<td>Grip</td>
<td>14.6</td>
<td>17.6</td>
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<tr>
<td>Key pinch</td>
<td>4.8</td>
<td>4.4</td>
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<tr>
<td>Tip pinch</td>
<td>2.9</td>
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*The change is significant compared with the preoperative value (p < 0.05).
the two-year follow-up examination was 4.4 kilograms compared with 4.8 kilograms preoperatively. It increased to an average value of 5.6 kilograms at the six-year follow-up but then declined to 4.9 kilograms at the nine-year follow-up, for an average over-all improvement of 34 per cent. This gain was not significant ($p \leq 0.09$) (Table I). There was no association between the decline in key pinch strength and radiographic evidence of settling or subluxation.

The improvements in grip and pinch strength at the nine-year follow-up examination were not influenced by the extent of the excision of the trapezium. At the nine-year evaluation, the average grip, key pinch, and tip pinch strengths of the thumbs that had had a complete trapeziectomy were 23.5, 4.7, and 3.6 kilograms, respectively, compared with 27.3, 5.7, and 4.2 kilograms for the thumbs that had had a hemitrapeziectomy. The differences were not significant ($p \leq 0.10$). In two of the three thumbs in which the ligament reconstruction-tendon interposition arthroplasty had been done for revision of a failed silicone implant arthroplasty, however, the grip and pinch strengths decreased to less than the preoperative values by the nine-year follow-up examination. The most recent average values for grip, key pinch, and tip pinch strengths were 25.7, 5.1, and 3.9 kilograms, respectively, for the twenty-one thumbs that had had a primary procedure, compared with 15.9, 3.9, and 2.7 kilograms for the three thumbs that had had a revision procedure. The differences were significant for the grip and key pinch strengths ($p < 0.05$) but not for the tip pinch strength.

The average subluxation of the base of the metacarpal, as seen on stress radiographs, was 11 per cent of the width of the base at the nine-year follow-up examination compared with 7 and 8 per cent at the two and six-year follow-up examinations, respectively. Similarly, the average loss of height of the arthroplasty space on the stress radiographs was 13 per cent at the nine-year follow-up examination compared with 11 per cent at each of the earlier follow-up examinations. Over-all, eleven thumbs had absolutely no subluxation or loss of height of the arthroplasty space between the two and nine-year follow-up examinations. Subluxation and loss of height of the arthroplasty space of more than 20 per cent occurred in only two patients; subluxation alone of more than 20 per cent, in three; and proximal migration alone of more than 20 per cent, in three. Metacarpal subluxation and settling in excess of 50 per cent occurred in only two of these thumbs. The radiographic values changed little between the two and nine-year follow-up examinations of these eight thumbs. One of the patients who had more than 50 per cent subluxation and settling was very satisfied with the functional result and the other was dissatisfied. Although the dissatisfied patient had pain and weakness, the improvements in grip, key, and tip pinch strengths at the nine-year follow-up examination compared with the preoperative values were approximately 100, 11, and 100 per cent, respectively. Two of the three thumbs in which the procedure had been revisional had a decline in radiographic parameters associated with decreases in grip and pinch strength, but neither of these two patients reported functional disability other than slight weakness with lateral pinch when they used a key. Therefore, only three of the eight thumbs in which the radiographic parameters declined had any subjective or objective decline in function. No thumb had evidence of scaphometacarpal impingement on the stress radiographs.

The six thumbs that had had a hemitrapeziectomy had, on the average, subluxation and settling of the metacarpal of 4 and 8 per cent, respectively, compared with 12 and 16 per cent for the eighteen thumbs that had had a complete trapeziectomy. However, these differences were not significant ($p \leq 0.15$). Although it appeared as though salvage of part of the trapezium had some effect on settling, there was no association between improved functional results and partial excision of the trapezium. The three thumbs in which the procedure had been done for revision of a failed silicone implant arthroplasty had, on the average, subluxation and settling of 21 and 35 per cent, respectively, compared with 9 and 11 per cent for the twenty-one thumbs in which the procedure was not revisional; these differences were not significant either ($p < 0.12$).

None of the ligament reconstruction-tendon interposition arthroplasties had been revised at the time of writing and, despite subjective functional impairment and associated radiographic deterioration of the thumb, a revision operation has not been planned for the one patient who was dissatisfied.

**Discussion**

Although reciprocal concave surfaces on the base of the metacarpal of the thumb and the distal articular surface of the trapezium afford exceptional mobility of the basal joint, there is minimum osseous constraint and contact stresses within the joint are large²°. The primary contact area during functional activities involving flexion and adduction of the thumb, such as lateral pinch and grip, involves the palmar surfaces of the trapezium and the metacarpal²°. Study of postmortem material has provided evidence of this palmar pattern of wear of the joint surface in close association with degeneration of the palmar oblique ligament from the articular margin of the metacarpal²⁴. Indeed, a mechanism for osteoarthrosis of the basal joint predicated on incompetence of this so-called beak ligament (referred to as such because of its origin from the volar ulnar beak of the base of the metacarpal) is substantiated not only by postmortem findings but also by the clinical observation that symptomatic relief and prevention of osteoarthritis follow ligament reconstruction in thumbs with abnormal trapeziometacarpal laxity²⁴.

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A number of operative procedures have been employed to treat the changes characteristic of stage II, III, and IV osteoarthrosis of the basal joint stage 1-3,7,8,10,11,13,16,22,26,29,31. While stage-1 disease involves synovitis of the carpo-metacarpal joint and pathological laxity without eburnation of the cartilage and narrowing of the joint space, stages II and III are characterized by attrition of the beak ligament, loss of cartilage, narrowing of the joint space, and formation of osteophytes and loose bodies that are less than and greater than two millimeters in diameter, respectively 14. Stage IV represents the end stage — that is, pantrapezial osteoarthrosis 14. While excision of the trapezium makes it possible to avoid the limited motion associated with an arthrodesis and the material wear associated with implant arthroplasty, weakness and instability limit the long-term functional results in the absence of ligament reconstruction 10,18,22.

This observation stimulated the addition of fascial or tendon interposition by Froimson 15 in 1970, in an effort to reduce settling of the metacarpal of the thumb and to improve pinch strength. Long-term follow-up, however, still revealed a decline in pinch strength and shortening of the thumb 10.

The more recent combination of reconstruction of the beak ligament with tendon interposition arthroplasty reflects the consolidation of three fundamental principles: excision of the trapezium to remove osteoarthrotic joint surfaces, reconstruction of the palmar oblique ligament to restore stability of the metacarpal of the thumb and to prevent axial shortening, and fascial interposition to reduce the likelihood of impingement of neighboring osseous surfaces on one another. In our 1986 report 16, we expressed cautious optimism regarding ligament reconstruction-tendon interposition arthroplasty on the basis of favorable functional results and radiographic stability at an average of two years. The longitudinal analysis at the average follow-up intervals of six and nine years validates our continued enthusiasm for this procedure.

Grip and tip pinch strengths steadily improved for six years before leveling off, reflecting over-all improvement in function of the hand secondary to gains with regard to the web space, mobility, and stability. Despite smaller objective improvements in key pinch strength, functional activities requiring lateral pinch — that is, resistive flexion and adduction of the thumb against the post of the index finger as well as grip strength needed to open jars, turn door handles, use keys, pick up objects, and so on — have been performed well by 95 per cent (twenty-one) of our twenty-two patients.

Radiographically, most of the thumbs remained stable with time after the ligament reconstruction-tendon interposition arthroplasty. Small over-all increases in metacarpal subluxation and proximal migration were due to large changes in a few patients; only eight of twenty-four thumbs had a decline in radiographic parameters of more than 20 per cent. The greatest ra-

Diographic changes occurred in the patient who was dissatisfied, but she had no decline in grip or pinch strength. Two of the three thumbs for which the procedure was revisional, however, had a decline in both the radiographic parameters and the grip and pinch strength. Although this association may indeed reflect attenuation or incompetence of the ligament reconstruction, there was no evidence of scaphometacarpal impingement either in these two thumbs or in any other thumb in the present series. Also, except in the dissatisfied patient who did not elect to have a revision, there was no association between radiographic decline and subjective functional impairment.

Neither complete nor partial excision of the trapezium was predictive of a poor subjective outcome, and objective criteria of strength and radiographic stability were comparable in the thumbs regardless of the extent of the excision. In contrast, as was mentioned, ligament reconstruction-tendon interposition arthroplasty for revision of a failed silicone implant arthroplasty did result in weaker and radiographically less stable thumbs but was not predictive of a poor subjective performance. While the differences in absolute strength and radiographic values between the primary and revisional arthroplasties did not achieve significance, the improvement from the preoperative status was significantly better after the primary operations. The small number of patients who had a revision operation precludes more definitive observations regarding any associated decline in objective results with time.

Recently, a number of variations on the ligament reconstruction-tendon interposition arthroplasty have been described. Suspensionplasty with use of the abductor pollicis longus tendon, as described by Thompson 17 in 1989, evolved as a salvage procedure for revision of failed silicone replacements of the trapezium. Although it was acknowledged that pinch strength was weaker than normal at the follow-up examination, all patients were able to complete normal daily tasks that they had not been able to perform preoperatively. Twenty-two of the twenty-four thumbs in which the suspensionplasty had been done had an excellent result and two had a satisfactory result at the time of the follow-up examination at six and a half years. Longer-term follow-up has not yet been reported. Similarly, Kleinman and Eckenrod 18 reported their early results with a flexor carpi radialis suspension sling arthroplasty for the reconstruction of forty thumbs with symptomatic pantrapezial osteoarthrosis of the basal joint. Although the average duration of follow-up was only twenty-one months, postoperative grip and pinch strengths failed to exceed the preoperative values appreciably. At the most recent assessment, only 85 per cent of their patients had an excellent or good subjective result. Radiographic follow-up was not reported.

In the present study, the availability of data, for each of the patients, from before the operation, from an aver-
age of two and six years after the operation, and from a long-term follow-up examination as many as eleven years after the operation has provided the opportunity to track the function of the thumb with time. In addition, it has obviated the potential pitfalls inherent in the comparison of postoperative results with the status of the contralateral, untreated extremity, which may be impaired by the osteoarthritic process as well. Indeed, with a 20 to 30 per cent prevalence of bilateral disease in most reported series, and an additional prevalence of more than 20 per cent of asymptomatic disease, the validity of such comparisons of strength with that of the so-called normal hand is questionable.

This long-term follow-up report shows convincingly that the function of the thumb continues to improve for as long as six years after a ligament reconstruction-tendon interposition arthroplasty, underscoring the protracted time that is necessary for maximum recovery of strength after the procedure. Such durable long-term performance contrasts markedly with experiences with prosthetic replacement of the trapezium and with excision of the trapezium with fascial interposition, after which stability and strength appear to decline with time.17,36.

In conclusion, ligament reconstruction-tendon interposition arthroplasty provides excellent relief of pain and a significant improvement in strength. The operative technique has evolved to include both routine excision of the entire trapezium and use of the full width of the flexor carpi radialis tendon. This not only ensures maximum restoration of the web space and eliminates potential postoperative pain secondary to unrecognized scaphotrapezial osteoarthrosis but also provides a bulkier piece of tendon for both ligament reconstruction and interposition into the arthroplasty space. Our observations of this original cohort of patients at two, six, and nine-year follow-up intervals suggest persistent integrity of the palmar oblique (beak) ligament reconstruction as an effective suspensionplasty of the metacarpal of the thumb. They also underscore the importance of duplicating normal anatomy to provide a stable, functional, and durable reconstruction of the thumb.

References


