Surgical management of basal joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty

Palmar oblique ligament reconstruction combined with tendon interposition (LRTI) arthroplasty with part of the flexor carpi radialis tendon was developed for advanced osteoarthritis of the thumb basal joint. Twenty-five procedures are reviewed with an average follow-up of 2 years, ranging from 1 to 4½ years. LRTI arthroplasty more consistently improved pinch strength, increased grip strength endurance, and restored thumb web space than did silicone implant arthroplasty. Proximal metacarpal migration averaged only 11% of the initial arthroplasty space versus nearly 50% loss of height with silicone implants. Subluxation averaged only 7% of the width of the thumb metacarpal base relative to the scaphoid versus subluxation of 35% of the base of the implant with silicone arthroplasty. Excellent results were achieved in 23 thumbs or 92% of cases. No deterioration of function or stability has been noted over time, and no revisional procedures have been necessary. On the basis of these encouraging early results, LRTI arthroplasty has become our preferred surgical treatment for advanced basal joint osteoarthritis of the thumb. (J HAND SURG 11A:324-32, 1986.)

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Problems with instability, material wear and cold flow, and foreign-body synovitis with silicone trapezium implants provided the impetus to develop an alternative surgical approach to basal joint osteoarthritis of the thumb (Part I). Palmar oblique ligament reconstruction has been shown to be essential for maintaining metacarpal joint stability.1, 2, 21, 29 Experience with silicone implant wear in the basal joint with recurrent synovitis and destructive bone changes has led us to favor the concept of soft tissue interposition arthroplasty. Previous reports of natural tissue interposition after trapezium removal are notable for persistent looseness and proximal metacarpal migration with possible impingement on the scaphoid.30-34 This is reminiscent of the early experience with simple trapezium excision as reported by Weilby,36 Gervis,37-38 and Marini.39 Accordingly, our current approach to the osteoarthritic basal joint at the University of Rochester combines a sling ligament reconstruction with tendon...
The flexor carpi radialis (FCR) tendon is used for this purpose because of its insertion at the base of the thumb. The procedure simulates the vascular oblique ligament and its convenient groove of the trapezium. Retrospective review was made of 240 patients with silicone basal joint arthroplasties. As reported in Part I, the LRTI arthroplasty has been our principal treatment for advanced basal joint osteoarthritis. This procedure has not been used in the series because of concern over the weak-forcerotic metacarpal and degenerative changes of the FCR tendon secondary to the inflammatory process. Of the first 25 patients followed an average of 2 years with a range of 1 to 4½ years. One was bilateral LRTI arthroplasty; thus 24 patients were included in the series. Five patients had their previous silicone arthroplasties in the contralateral thumb. In some, the LRTI procedure was performed in the failed silicone implant arthroplasty. Partial resection of the basal joint was performed in six cases. Complete resection of the basal joint in 19 cases, as needed, either by web space contracture or pantrapezial arthroplasties, most commonly scaphotrapezial. The characteristics of patients undergoing operative treatment for basal joint arthritis have been previously described (Part I). Consistent with this profile, 85% of patients in this group were women with an average of 5½ years at the time of operation (Table I). Indications for surgery were pain refractory to conservative measures and progressive dysfunction affecting activities of daily living and occupational performance. Distal joint stabilization for longitudinal col lateral deformities and adjacent procedures for coxarthrosis were performed as indicated (Part I, II, and III).

All patients were seen in follow-up examination by the author independent of the operating surgeon. Standard anteroposterior and lateral x-ray films and anteroposterior stress views were obtained on all patients. Evaluation included pain relief, pinch and grip strength, and evidence of proximal metacarpal migration and arthroplasty instability as demonstrated by longitudinal analysis of stress x-ray films. Settling of the trapezial space was quantitated as a percentage diminution height of the arthroplasty “space” compared with the initial postoperative x-ray film. Arthroplasty instability was calculated as the percentage subluxation of the metacarpal base relative to the scaphoid.

### Table I. LRTI procedures in osteoarthritic thumbs

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of patients</th>
<th>No. of thumbs</th>
<th>As revision</th>
<th>Bilateral</th>
<th>Sex M F</th>
<th>Average age (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRTI Arthroplasty</td>
<td>24</td>
<td>25</td>
<td>4</td>
<td>1 (5)*</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>

*Number of patients having had basal joint operative procedures of different types on each side.

Surgical technique

The procedure, as described in 1983 by Eaton and Littler and Eaton et al., is similar to the technique described by Eaton and Littler. A portion of the FCR tendon for ligament reconstruction is combined with trapezial excision and tendon interposition arthroplasty. Either the distal one half or the entire trapezium is excised as determined by the extent of pantrapezial joint involvement and the amount of thumb web contracture to be corrected. The entire trapezium is removed if degenerative changes in the scaphotrapezial joint are noted preoperatively or at the time of operation. Similarly, severe thumb web contracture is treated with excision of the trapezium. Great care must be taken during trapezial excision to not damage the FCR tendon that is enclosed on three sides by the body and tuberosity of the trapezium. The trapezial fossa may be deepened as for silicone implant arthroplasty by partial trapezial excision. The base of the thumb metacarpal is then excised perpendicular to its long axis to include the diseased articular surface, and a hole is placed in the base of the radial cortex with a 6 mm gouge passing through the medullary canal into the trapezial fossa (Fig. 1). The longitudinal radial half one of the distally based 10 to 12 cm of the FCR tendon is harvested through a series of short transverse incisions along the forearm. The tendon must be split all the way to its insertion on the index metacarpal and passed into the dorsoradial wound through the trapezial fossa (Fig. 2). Two nonabsorbable sutures are placed in the deep capsule for subsequent use. The metacarpal is seated in an ulnar direction toward the fixed unit and stabilized in the abducted position with a longitudinal Kirschner wire (Fig. 3). Care is taken to apply traction to the metacarpal during fixation to preserve the arthroplasty space in which the trapezium formerly existed. The leading free end of the
Table II. LRTI and silicone results in osteoarthritic thumbs

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of thumbs</th>
<th>ROM*</th>
<th>Web angle</th>
<th>Aggregate strength† differential</th>
<th>Subluxation‡</th>
<th>Wear cold flow§</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRTI arthroplasty</td>
<td>25</td>
<td>7</td>
<td>40.5°</td>
<td>+19%</td>
<td>7%</td>
<td>11%</td>
</tr>
<tr>
<td>Silicone implants</td>
<td>average</td>
<td>32</td>
<td>6</td>
<td>35°</td>
<td>-3.8%</td>
<td>35%</td>
</tr>
</tbody>
</table>

*Number of thumbs that failed to reach palmar flexion crease at the base of the small finger.
†Average change in preoperative to postoperative sum of key pinch, tip pinch, and grip strength measurements.
‡Average radial displacement expressed as percentage of width of prosthesis or metacarpal base.
§Average loss of vertical height expressed as percentage of initial postoperative implant height or fascial arthroplasty space.

Table III. Osteoarthritis—grip and pinch strength determinations (kg) for LRTI arthroplasty

<table>
<thead>
<tr>
<th>Key pinch</th>
<th>Tip pinch</th>
<th>Grip</th>
<th>Average overall differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>M F</td>
<td>M F</td>
<td>M F</td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>5.5 4.39 4.0 2.58 23.7 12.47</td>
<td>+19%</td>
<td></td>
</tr>
<tr>
<td>Postoperative</td>
<td>6.7 4.53 5.17 2.68 33.7 15.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FCR is then passed from its intact distal insertion proximal to the base of the ulnar metacarpal cortex into the medullary canal and out the hole in the radial metacarpal cortex. The tendon slip is then pulled tight and sutured to the lateral periosteum of the metacarpal and then back to itself to resurface the base of the metacarpal. The remainder of the tendon is folded to act as a spacer and sutured to itself and the deep palmar capsule with one of the previously placed sutures (Fig. 4). The second deep capsular suture is utilized to complete a two-layered purse string lateral capsular closure over and including the tendon arthroplasty spacer.

A critical and essential concept is the distal orientation of this tendon slip from the base of the thumb metacarpal to its intact insertion on the base of the index metacarpal. This creates a supporting ligamentous sling beneath the ulnar cortex of the thumb metacarpal, which discourages both proximal migration and radial subluxation of the thumb ray (Fig. 5).

The extensor pollicis brevis is transferred proximally to a bony insertion on the metacarpal shaft to dynamically augment metacarpal abduction and remove the hyperextension deforming force from the proximal phalanx at the metacarpophalangeal joint. Transfer of the abductor pollicis longus distally along the metacarpal shaft is usually not necessary.

The postoperative regimen consists of thumb spica cast immobilization for 4 weeks by pin removal, isoprene thumb spica splint, and commencement of active range of motion exercises. Initial ROM exercises emphasize metacarpal abduction and extension while avoiding adduction position, and (2) active flexion of metacarpophalangeal and interphalangeal joints as the metacarpal supported in abduction by the opposite hand. The splint is worn constantly for hand exercises and washing for 2 to 4 weeks after start of the exercise program. Thenar strength is emphasized starting at 6 weeks and must be maintained for 4 to 6 months. Pinch and grip strengthening is started at 8 weeks. Splinting is stopped when full pinch is attained and thenar strength is improved to a functional level. This is usually 8 to 12 weeks after surgery. Strength and function continue to improve for months after surgery.

Results

Subjective. Ninety-two percent of patients enjoyed excellent pain relief and were satisfied with the result. Two patients noted a sensation of pulling in the hand along the course of the FCR, but both demonstrated satisfactory tension in the remaining tendon and full strength of wrist flexion. There was no limitation of wrist motion in either patient. Subjectively, they were pleased with the LRTI procedure better withstood strenuous tasks than did those with silicone implants. Opening jar tops and car doors and using a key were well tolerated by these patients. Weather changes did not provoke basal joint symptoms. All patients with the LRTI arthroplasty returned to their previous employment, including punch press operators, an assembly line worker, a dental hygienist, a schoolbus driver, and a maker. Two professional pianists noted increased strength and endurance while performing, but experi-
Fig. 3. The metacarpal is stabilized with a longitudinal Kirschner wire into the fixed unit before ligament reconstruction is performed. The Kirschner wire holds the metacarpal in the fist projection, well reduced over the scaphoid and well distracted with ample arthroplasty “space,” with the thumb metacarpal base at the same level as that of the index metacarpal.

Fig. 4. Ligament reconstruction with the FCR tendon has been completed. The creation of the tendon interposition spacer uses a suture previously placed in the deep capsule.

sequent to the completion of this study, the patient’s Swanson implant fractured, became symptomatic, and was converted to the LRTI arthroplasty.

Objective. Two patients developed bothersome paresthesia in the palmar radial aspect of the thumb along the incision. None had any functional impairment with this complication. Dissection of the FCR tendon at the wrist adjacent to the palmar sensory branch of the median nerve and retraction of the terminal sensory branches of the radial nerve demand meticulous technique to avoid injury to these sensitive structures. One patient developed transient mild reflex sympathetic dystrophy 7 months after operation, but recovered com-
Fig. 5. Schematic representation of ligament reconstruction with tendon interposition arthroplasty. The forces in function producing proximal migration and radial subluxation of the metacarpal are neutralized by ligament reconstruction as indicated in the vector diagram. Key: a, ligament reconstruction; b, metacarpal resurfacing; c, tendon arthroplasty spacer.

completely on a vigorous supervised hand therapy program.

Seven of 25 thumbs or 28% could not touch the thumb tip to the base of the small finger, but all could reach the proximal interphalangeal joint crease (Table II). This mild restriction of motion is comparable to that seen with the ligament-stabilized Eaton silicone implants. The enhanced basal joint stability common to both of these procedures restricted extreme flexion of the thumb unit without any apparent compromise in functionally significant motion.

Postoperative index-thumb metacarpal web angle averaged 40.5° compared with 35° for the aggregate silicone implant group (Table II). Web space restoration in LRTI arthroplasty with partial distal trapezium excision (41.5°) was comparable to that with complete trapezium excision (40°). No meaningful statement can be made regarding the relative efficacy of partial versus complete trapezium excision in widening the thumb web because complete excision was preferentially used in cases of more severe web space contracture.

Grip and pinch strengths showed an overall improvement of 19% compared with preoperative values (Table II). This is in contrast to the results with silicone implants in which a loss of pinch strength was most frequently noted presumably secondary to implant instability and subluxation. Absolute strength values were at the low end or below the standard normal range and attest to the generally compromised state of most hands requiring operative intervention for basal joint disease.

Only the LRTI group had consistent although improvement in pinch strengths after surgery. Reoperative LRTI procedures also exhibited an increase in strength, but absolute values were below those achieved with primary LRTI. Most significant was the improved end range of thumbs in this group. Repetitive testing demonstrated a rapid decline in strength with each successive postoperative thumb and those after silicone arthroplasty. In contrast, thumbs having had procedures demonstrated sustained strength on testing without evidence for easy fatigability.

Radiographically, the LRTI arthroplasty was exceptionally stable with an average subluxation of the width of the metacarpal base with stress. In addition, proximal metacarpal migration with an average loss of 11% of the initial postoperative arthroplasty space (Figs. 6 and 7). This compares favorably with reports of proximal metacarpal migration in soft tissue interposition arthroplasty with implant reconstruction, and may be attributable to the ligamentous sling support of the thumb ray. Both of these values also compare favorably with those previously reported for subluxation (35%) and loss of height (49.5%) indicators of silicone implant instability and weakness of joint arthroplasty (Table II).

No LRTI arthroplasty procedures have required reoperation as of the time of submission of this report, and have demonstrated local synovitis.

Discussion

The concept of fascial or tendon interposition is in part on work done by Carroll and first reported Froimson in 1970 who used a rolled FCR "anchor" as a spacer for interposition arthroplasty of the thumb. Several authors have subsequently suggested the use of other tendons, fascia lata, and Gelfoam interpositional materials. Some reports have suggested that performance of tendinous interpositional arthroplasty without ligament reconstruction is comparable to that of silicone implant arthroplasty. Others have shown that the addition of fascial interpositional material does not significantly improve function over that achieved with simple arthroplasty. Reports of key pinch and pinch strengths after traditional tendon interposition arthroplasty have been varied, but often show values below the lower end of normal. Frequent strengths are reported relative to the opposite nonoperated side because of insufficient preoperative data. With
consistent although also exhibited an absolute value of primary LRTI arthroplasty. Improved endurative testing demonstrated a decrease in flexion after silicone rubber having had limited strength on a basis of fatiguability. Arthroplasty with coverage subluxations of the base with stress and metacarpal migration resulted in initial postoperative (7). This comparison of metacarpal arthroplasty without heavy hearting support of the basal bones also conventionally reported for height (49%), stability and wear were.

Figs. have requested this report, and this.

Intervention in the first reported FCR "interposition" and first report of interposition of the basal bone, and Gelfoam and. Some performance of tendons ligament reconstruction. Implant articulation the additional support not significantly with simple key pinch and an interpolation articulation show values.[13, 45].

Fig. 6. Stress x-ray films (A) before surgery and (B) 4 years after surgery after bilateral LRTI arthroplasty with partial distal trapezium excision. Note the sclerotic bone margins and preservation of the arthroplasty space. Patient is asymptomatic with good function and has returned to previous employment as an office supervisor.

Fig. 7. (A) Preoperative and (B) postoperative stress radiograph 3½ years after LRTI arthroplasty with complete trapezium excision. Again, note excellent preservation of the arthroplasty space and the sclerotic bone margins. Patient is asymptomatic with good function and enjoys golf as an avocation.

Evidence of bilateral disease of 20% to 30% in most surgical series and an additional prevalence of more than 20% with asymptomatic arthritis, the valvular strength determinations relative to the "normal" are doubtful. Longitudinal analysis of preoperative postoperative strength reflects most accurately the effect of the surgical procedure under discussion.

Restoration of normal pinch strength is neither necessary nor expected after arthroplasty for basal joint disease in postmenopausal women. However, in a disease with pathologic laxity of the periarticular structures, reconstruction of these capsular and ligamentous supports would seem central to maximizing postoperative strength and function. During basal joint arthroplasty, resection of the trapezium and metacarpal base will destroy the insertion of the palmar oblique ligament and contribute to potential proximal and radial migration of the metacarpal. Proximal metacarpal migration effects further relative lengthening of this important ligament. Instability and compromised function are a
direct result. The purpose of ligament reconstruction combined with arthroplasty is to restore strength by restabilizing the basal joint while providing pain relief. Our data support this hypothesis and show the greatest improvement in daily function, return to employment, and key pinch strength in the group with ligament reconstruction combined, with tendon interposition arthroplasty. Grip strengths are more consistently improved than pinch strengths by nearly all arthroplasty procedures in our series (Part I), as in those of other authors.\textsuperscript{43, 45} This may be attributed to the pain relief afforded by the arthroplasty, which allows more optimal function of the hand as an integrated unit rather than from any direct increase in the contribution of the thumb to overall strength in power grip. In addition, LRTI arthroplasty was the only procedure that consistently improved grip strength endurance as demonstrated by rapid sequence testing.

We have combined ligament reconstruction with natural substance interposition arthroplasty. This procedure is mechanically designed to oppose effectively the adduction stress of the thumb metacarpal by virtue of the ligament orientation relative to the base of the metacarpal (Fig. 5). The line of ligament pull directly counteracts the radial displacement force vector of the base of the thumb metacarpal produced by flexion-adduction of the thumb unit. This prevents the common instability pattern as seen with silicone implant arthroplasty without ligament reconstruction. Our results also demonstrate preservation of the tendon spacer bulk. Although this may be explained by vascular ingrowth to form a viable fibrous tissue spacer, it is more likely that the ligamentous sling reconstruction contributes significantly to the maintenance of the arthroplasty "space." The distal orientation of the ligament from the radial base of the thumb metacarpal to its insertion on the base of the index metacarpal creates a sling beneath the ulnar metacarpal cortex that resists the compressive force vector directed along the axis of the thumb. This tendon sling prevents proximal metacarpal migration and resurfaces the metacarpal base of the thumb.

The advantages of natural tissue over silicone as a spacer arthroplasty in avoiding potential foreign-body synovitis are self-evident. In addition, since no implant is used, the complication of infection is less ominous and theoretically more easily treated.

The LRTI arthroplasty, however, is not without its shortcomings. The procedure is technically more demanding than silicone implant arthroplasty. The donor deficit incurred by harvesting one half of the FCR tendon is negligible, but can be amplified if the entire tendon is inadvertently divided. Injury to the palmar sensory branch of the median nerve near the tendon slip at the wrist crease must be avoided. Carpal settling onto the scaphoid has not been encountered to date. Scaphoid fracture is treated with total trapeziectomy excision; we now prefer over hemiresection as a primary procedure because of its added benefit of increasing carpal breadth. Postoperative rehabilitation after the procedure is prolonged and the maximal recovery is not realized for nearly 6 months. Patients undergoing silicone arthroplasty enjoy more painless stiffness during the initial months after surgery. This transient advantage of silicone implant is overshadowed by the instability and late material failure sometimes encountered with these devices.

Our contention is that LRTI arthroplasty produces better and longer lasting solution to the problem of joint osteoarthritis. However, the average follow-up period of this series is only 2 years, and as such it cannot be considered a definitive report. Our optimism concerning potential long-term results of this procedure is based on past reported experiences both with ligament reconstruction for early stage disease and in conjunction with silicone arthroplasty.\textsuperscript{1, 2, 23, 59, 61} Eaton et al.\textsuperscript{23} reported excellent long-term results of ligament reconstruction for early disease with preserved articulating surfaces. The Eaton implants with the recommended ligament reconstruction have demonstrated no progressive instability over time as reported in our series (part I). To illustrate this point, when a cannulated prosthesis was recently revised for silicone fragmentation and synovitis, the arthroplasty was found to be stable with functioning intact ligament reconstruction among silicone debris (Figs. 15 and 16, part I). The combination of palmar oblique ligament reconstruction with tendon interposition arthroplasty has been done in more than 5 years with excellent results and is currently our preferred treatment for advanced basal joint disease in the high-demand osteoarthritic thumb. It offers a prospect of lasting restoration of thumb function and alleviation of pain without the attendant risks and complications of silicone foreign-body implantation.

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