Arthritis of the Thumb and Digits: Current Concepts

Richard A. Bernstein, MD

Abstract
Osteoarthritis of the hand continues to be a problem in an aging population and affects the proximal and distal interphalangeal, metacarpophalangeal, and carpometacarpal joints in the hands. Heberden nodes develop in the distal interphalangeal joints and typically present as a deformed and enlarged joint and can cause pain. Surgery rarely is necessary because functional difficulties are uncommon; however, there may be problems if the metacarpophalangeal and proximal interphalangeal joints are involved because cartilage destruction generates pain and causes weakness and motion loss. Implant arthroplasty typically can improve pain but does not reliably improve range of motion, and complication and revision rates are substantial. Arthrodesis continues as a treatment for digital osteoarthritis, but the surgeon must balance the risks of complications with the benefits of improved patient outcomes.

The opposable thumb, which is critical for hand dexterity and strength, can be severely disabled by basal joint arthritis. The complex architecture of the basal joint continues to be defined by its relationship to the surrounding bony and ligamentous anatomy and its effect on the trapeziometacarpal joint. Nonsurgical treatment may be beneficial, but surgical options, including arthroscopy, ostectomy, and arthroplasty, should be considered if nonsurgical management fails. Prosthetic arthroplasty has a historically poor record; therefore, trapeziectomy remains the hallmark of current reconstructive techniques. Ligament reconstruction and tendon interposition arthroplasty are the most commonly performed surgical procedures, but hematoma distraction arthroplasty and various methods of suspensionplasty also are currently used.

Osteoarthritis is a common condition that affects the wrist, thumb, and digits. As the population ages, degenerative changes are likely to present as symptoms, including aches, pain, cosmetic deformity, joint instability, weakness, and dysfunction. This chapter focuses on the effect of degenerative changes on the digits and the thumb. Osteoarthritis and degenerative arthritis are terms applied to age-related or progressive degenerative conditions that affect the articular cartilage and subchondral bone. In most instances, degeneration is progressive and related to age. Post-traumatic osteoarthritis can occur after simple or complex trauma that damages the articular surface or affects the underlying bony architecture of the hand and may subject the articular surface to abnormal biomechanical forces. Inflammatory, postinfectious, genetic, metabolic, and mechanical processes also cause osteoarthritis.

The diagnosis of osteoarthritis generally is straightforward based on the patient’s history, physical examination findings, and radiographic confirmation. Clinical signs include joint enlargement, loss of motion, pain, inflammation, deformity, and instability. Radiographs, if necessary, can confirm a diagnosis and help differentiate osteoarthritis from other inflammatory arthropathies.
**Carpometacarpal Joint Osteoarthritis**

An opposable thumb separates humans from other animals, and the basal joint helps position the thumb for prehension. The ability to grasp and oppose occurs primarily at the carpometacarpal (CMC) joint; consequently, it requires tremendous joint stability. For the hand to function, the thumb must be mobile and strong enough to oppose the lesser four digits; this stability of the thumb occurs primarily at the trapeziometacarpal joint. Because the thumb is in constant use during activity, osteoarthritis of the basal joint is common and has been predicted to occur in the general population at a rate of up to 22%. A study by Armstrong et al reported a 25% radiographic incidence of basal joint arthritis in women and an 8% radiographic incidence in men. Basal joint arthritis tends to predominate in women (female-to-male ratio is 7:1), and symptoms tend to increase with age.

Heberden and Bouchard nodes classically present as enlargements overlying the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints, respectively. In most instances, the “bumps” are relatively asymptomatic, and patients often present for an evaluation of an enlarged or angular cosmetic deformity. Occasionally, the underlying arthrosis can cause local irritation, and the escape of synovial fluid can form mucous cysts. If small, these cysts may be relatively asymptomatic; however, as they enlarge, they can affect the germinal matrix and cause ridging of the nail plate. Further enlargement is painful and can cause spontaneous cyst rupture. Because the cyst is contiguous with the DIP joint, a ruptured or inappropriately self-incised mucous cyst may lead to septic arthritis.

Patients generally can tolerate limited motion and stiffness in the DIP joint. A greater arc of digital motion occurs at the metacarpophalangeal (MCP) and PIP joints. Loss of motion in the PIP and MCP joints becomes more problematic and affects activities of daily living. Similarly for the thumb, osteoarthritis of the interphalangeal joint may be relatively asymptomatic, but if involvement occurs at the MCP joint, the effect on function increases. The spectrum of the normal arc of motion of the MCP joint is large, but if secondary hyperextension deformity occurs, pinch strength is affected, with a subsequent loss of the stabilizing effect of the volar plate and further weakness, instability, and pain.

Although most patients with osteoarthritis of the hand are relatively asymptomatic, patients with symptoms usually can be treated using nonsurgical measures, activity modifications, and over-the-counter anti-inflammatory drugs. Corticosteroids are commonly used in patients with recalcitrant symptoms, but their long-term effects are unknown. There have been no prospective, randomized trials evaluating the efficacy of corticosteroids in the digits; however, one trial studied the long-term efficacy of corticosteroid use in the basal joint. Heyworth et al randomized 60 patients with CMC joint osteoarthritis to receive either a placebo, corticosteroid, or hylan injection, with 1-week spacing between injections. Group 1 received two hylan injections, group 2 received a placebo injection and a corticosteroid injection, and group 3 received two placebo injections. The visual analog pain scale and range of motion were used for patient evaluation. At 2-week follow-up, all of the patients reported improvement in their symptoms. At 4 weeks, patients who received a corticosteroid injection had a 68% success rate; however, at 26 weeks, the hylan group surpassed the corticosteroid group, with 68% of patients reporting symptomatic improvement, but the findings did not reach statistical significance. The authors suggested that “hyaline injections should be considered in the management of basal joint arthritis of the thumb,” and, anecdotally, many clinicians continue to use corticosteroids to treat basal joint osteoarthritis.

The basal joint of the thumb has anatomically developed to allow a large arc of motion that includes opposition and prehension and, consequently, the ability to accommodate a variety of activities. The basal joint has been described as a biconcave saddle joint that allows a tremendous range of motion but lacks substantial osseous stability. In the AP plane, the trapezium is concave, and the lateral plane is convex with the base of the metacarpal with the corresponding opposite architecture. The anatomy of the articular surfaces allows multiplanar motion; although it is semiconstrained, it is relatively incongruent. The pressure generated at the basal joint can be extreme. Cooney and Chao noted that 6 to 13 kg of pressure occurs at the basal joint of the thumb, and, with pinch, there is a 12-fold increase of force at the tip of the thumb. Because of the lack of substantial osseous stability, the ligamentous support of the thumb is critical for function. Bettinger et al identified 17 separate ligaments that surround the CMC joint; however, according to Van Buren et al, the four main stabilizers of the CMC joint are the dorsal oblique ligament, the palmar oblique ligament, the anterior volar (beak) ligament, and...
the intermetacarpal ligament. In a dissection of 17 cadavers, Colman et al concluded that the dorsoradial ligament is more important than the anterior oblique ligament, although statistical significance was seen only in lateral pinch. In their in vitro trial, increased translation was 1.3 mm versus 0.6 mm, and increased rotation was 4.1° versus 2.4° for the dorsoradial ligament and the anterior oblique ligament, respectively. In a series using cadaver dissection, Edmunds described a unique area of bony stability with the beak of the thumb metacarpal in a corresponding recess of the trapezium, which allows the metacarpal to “lock” into the trapezium. This bony stability combined with the ligamentous architecture of the thumb, specifically the dorsal ligament complex, converts a lax joint in rest to a stable joint. Edmunds also postulated that the intermetacarpal ligament between the thumb and index metacarpals provides substantial stabilizing force. The third layer of support includes the intrinsic and extrinsic muscles. Primarily, the volar intrinsic muscles stabilize the joint, the abductor pollicis brevis (APB) abducts at the CMC joint, and the opponens pollicis allows rotation. Extrinsicly, the flexor pollicis brevis, adductor pollicis brevis, and flexor pollicis longus compress the joint and afford dynamic stability during opposition and pinch.

When at rest, the trapeziometacarpal joint may be relatively lax, but stability may be increased with a screw-home torque rotation, especially in opposition. If a dynamic force is exerted across the basal joint of the thumb, the volar beak ligament becomes taut in the hitchhiker position and stability increases. The dorsal ligament complex, composed of the dorsoradial, posterior, and oblique ligaments, is the most important ligamentous stabilizer of the thumb. Disruption of the dorsoradial ligament results in complete instability of the thumb.

The topography and progression of articualr surface degeneration has been well established through multiple studies using cadavers. Pellegrini et al evaluated the contact patterns of 23 cadaver forearms. The joints were loaded to simulate lateral pinch, and pressure-sensitive films were used to evaluate the contact pressures in different functional positions. During flexion and adduction, the palmar aspect of the trapeziometacarpal joint received the primary load; however, if dynamic pinch was simulated, there was enlargement of the dorsal contact pattern and physiologic translation of the metacarpal on the trapezium. If the volar oblique ligament was detached, a similar dorsal translation contact area was found. The authors concluded that wear in the trapeziometacarpal joint was based on loss of the volar beak ligament.

The theory of basal joint arthritis involves progressive changes based on degeneration of the volar beak ligament. If intact, the ligament provides stability in translation; however, as demonstrated through cadaver dissections, degeneration causes increased shear across the CMC joint. The loss of stability and the increasing shear forces contribute to degeneration of the articular cartilage, which begins primarily along the volar surfaces of the metacarpal and trapezium and progresses dorsally. The mechanical action of pinch further exacerbates these contact pressures and contributes to subsequent articular cartilage degeneration. Edmunds postulated that osteoarthritis of the CMC joint occurs as a result of the compressive and rotational shear forces across the volar aspect of the trapezial area contribute to degeneration.

Another theory of basal joint arthritis involves joint impingement. It suggests that degeneration occurs secondary to the mechanical forces across the basal joint during thumb opposition and pinch, which places the metacarpal and the trapezium in an incongruous position. This mechanical action increases compressive force across the dorsoradial aspect of the trapezium and contributes to dorsoradial cartilage breakdown that progresses volarly.

Secondary changes occur in the longitudinal arch of the thumb because of changes in the CMC joint. Often, adduction contracture occurs at the first metacarpal and narrows the first web space. To compensate for the narrowed web space and inability to adequately adduct the thumb, secondary hyperextension can occur at the MCP joint. Initially, the volar plate elongates, but with time, hyperextension worsens and causes abnormal loading of the dorsal aspect of the metacarpal head, which leads to MCP joint arthroses.

In patients with digital osteoarthritis, symptoms are localized to an enlarged joint, whereas patients with basal joint osteoarthritis typically report pain at the volar aspect of the palm toward the thenar eminence. Patients describe pain with grip as vague and an achy discomfort in the thenar eminence. Although some patients present with a ganglion cyst, which likely is related to underlying osteoarthritis causing increased fluid production, complaints of clinical cosmetic deformity usually are rare.
Examination
On clinical examination, a prominence at the dorsoradial base of the CMC joint is noted. Tenderness elicited using direct palpation, a grind test (axial load and metacarpal rotation), a crank test (axial load and flexion/extension), and a pinch test (MCP joint hyperextension collapse), and relief of pain using joint distraction may help diagnose basal joint osteoarthritis. In early stages or in younger patients, generalized ligamentous laxity (more common in women than men) can occur, and pain can result from changes caused by instability of the basal joint. The pattern of articular wear suggests that CMC joint instability may progress to frank arthroses. The joint, therefore, should be examined for instability. In early cases, degenerative changes in the cartilage may not yet have occurred, but excessive laxity at the CMC joint and pain with the aforementioned clinical diagnostic maneuvers may be present. The younger patient should be examined in the upper extremity for signs of generalized ligamentous laxity, including digital hyperextension at the MCP joint, hyperflexion of the thumb to the forearm, and recurvatum of the elbow.

Diagnosis
The diagnosis of CMC joint osteoarthritis is primarily clinical, although radiographs may be helpful in assessing the degree of deformity. Eaton and Littler\(^\text{14}\) classified four stages of joint degeneration. Stage I reflects a joint with a normal appearance. Stage II demonstrates joint space narrowing and osteophytes less than 2 mm in size. Stage III is characterized by sclerosis, subchondral cysts, and osteophytes greater than 2 mm in size. Stage IV represents pantrapezial arthritis, and clinical changes can be seen across the trapeziometacarpal joint (Figure 1). Although staging may help describe the radiographic appearance, it does not necessarily correspond to the degree of patient symptomatology or the degree of response to nonsurgical treatment algorithms.

The differential diagnosis of radial wrist pain includes de Quervain tenosynovitis, radial sensory neuritis, radiocarpal osteoarthritis, and arthritis of the scaphotrapezial trapezoid joint. In most cases, the diagnosis can be differentiated by a thorough physical examination and radiographic verification. In some cases, however, it may be difficult to differentiate tenosynovitis in the first dorsal compartment from basal joint changes. The Finkelstein test that is used to evaluate de Quervain tenosynovitis often may be painful and uncomfortable for a patient who also has basal joint osteoarthritis. It is important, however, for the clinician to differentiate these diagnoses, and, occasionally, the use of a diagnostic injection may be helpful to manage pain during the differential diagnosis.

Nonsurgical Treatment
Nonsurgical treatment can be effective for most patients.\(^\text{18}\) Patient education and activity modifications often can resolve inflammatory symptoms. Often, patients are not aware of activities that may precipitate or exacerbate arthritic inflammation. The use of over-the-counter or prescription anti-inflammatory drugs is common, but no level I studies demonstrate their long-term effectiveness. A study by Swigart et al\(^\text{19}\) reported on 114 patients (130 thumbs) with CMC joint arthritis who were treated with long opponens splinting. Seventy-six percent of the patients with stage I or II disease reported early pain relief, and 54% were satisfied with their outcomes at 6 months. Fifty-four percent of the patients with stage III or IV disease reported improvement in their symptoms. Most patients reported enough symptomatic relief to allow for continued activity; however, 19% of the patients progressed to surgery.

Physical therapy also is used. Ultrasound, iontophoresis, and thenar cone muscle strengthening have been advocated in conjunction with splinting.\(^\text{20}\)

Surgical Treatment
Although most patients respond to nonsurgical treatment, indications for surgery include recalcitrant pain, loss of function, weakness, and symptoms refractory to nonsurgical measures. The goals of surgical treatment are pain relief, improved pinch and grip strength, improved range of motion, stability, a low complication rate, and long-term efficacy. For symptomatic patients, radiographic staging can help guide surgical treatment options, which include first metacarpal osteotomy, ligament reconstruction, or arthroscopic débridement.\(^\text{14}\) If the basal joint has more advanced osteoarthritis, surgical options include arthroscopy,\(^\text{21-27}\) trapeziectomy/arthroplasty (HDA),\(^\text{28-32}\) trapeziectomy with stage I or II disease reported early pain relief, and 54% were satisfied with their outcomes at 6 months. Fifty-four percent of the patients with stage III or IV disease reported improvement in their symptoms. Most patients reported enough symptomatic relief to allow for continued activity; however, 19% of the patients progressed to surgery.

Physical therapy also is used. Ultrasound, iontophoresis, and thenar cone muscle strengthening have been advocated in conjunction with splinting.\(^\text{20}\)

Surgical Treatment
Although most patients respond to nonsurgical treatment, indications for surgery include recalcitrant pain, loss of function, weakness, and symptoms refractory to nonsurgical measures. The goals of surgical treatment are pain relief, improved pinch and grip strength, improved range of motion, stability, a low complication rate, and long-term efficacy. For symptomatic patients, radiographic staging can help guide surgical treatment options, which include first metacarpal osteotomy, ligament reconstruction, or arthroscopic débridement.\(^\text{14}\) If the basal joint has more advanced osteoarthritis, surgical options include arthroscopy,\(^\text{21-27}\) trapeziectomy/arthroplasty (HDA),\(^\text{28-32}\) trapeziectomy with stage I or II disease reported early pain relief, and 54% were satisfied with their outcomes at 6 months. Fifty-four percent of the patients with stage III or IV disease reported improvement in their symptoms. Most patients reported enough symptomatic relief to allow for continued activity; however, 19% of the patients progressed to surgery.

Physical therapy also is used. Ultrasound, iontophoresis, and thenar cone muscle strengthening have been advocated in conjunction with splinting.\(^\text{20}\)

Surgical Treatment
Although most patients respond to nonsurgical treatment, indications for surgery include recalcitrant pain, loss of function, weakness, and symptoms refractory to nonsurgical measures. The goals of surgical treatment are pain relief, improved pinch and grip strength, improved range of motion, stability, a low complication rate, and long-term efficacy. For symptomatic patients, radiographic staging can help guide surgical treatment options, which include first metacarpal osteotomy, ligament reconstruction, or arthroscopic débridement.\(^\text{14}\) If the basal joint has more advanced osteoarthritis, surgical options include arthroscopy,\(^\text{21-27}\) trapeziectomy/arthroplasty (HDA),\(^\text{28-32}\) trapeziectomy
with tendon interposition or ligament reconstruction and tendon interposition (LRTI) arthroplasty, silicone arthroplasty, prosthetic hemiarthroplasty or total joint implant of the trapeziometacarpal joint, and trapeziometacarpal arthrodesis.

First Metacarpal Osteotomy

More normal cartilage is preserved toward the dorsal aspect of the CMC joint. Pellegrini et al. evaluated stress distribution across the basal joint and theorized that a transfer of force distribution dorsally could be advantageous. The amount of arthrosis at the trapeziometacarpal joint in 20 cadaver specimens was assessed with pressure-sensitive film. The primary contact area and peak pressure area were evaluated before and after osteotomy was performed. The authors found that a 30° extension osteotomy shifted the contact stress from a volar to a more dorsal area; however, it did not substantially change the contact stress area in specimens that had already demonstrated substantial osteoarthritis. Although the procedure appeared to work clinically, the authors concluded there was no clear biomechanical rationale.

Tomaino retrospectively reported the results of metacarpal osteotomy in 12 patients after a mean 2.1-year follow-up (range, 6 to 46 months). The osteotomies typically healed at 7 weeks, and 11 of 12 patients were satisfied. Although the author believed the rationale for success was unclear, grip and pinch strength were restored, and the dorsal shift of contact pressures improved symptoms. The author, however, cautioned against using the procedure in patients with substantial ligamentous laxity.

Ligament Reconstruction

Ligament reconstruction techniques for the basal joint using the flexor oblique ligament and creates a new ligament at the volar aspect of the joint where there previously was a meniscal capsule. Complementing the work of Napier, the authors postulated that the anterior oblique or beak ligament of the metacarpal is the key structure in basal joint stability. Instability was classified into four stages: synovitis (stage I), one-third subluxation of the joint (stage II), greater than one-third subluxation of the joint (stage III), and advanced arthritis (stage IV). Using a longitudinal approach along the volar aspect of the metacarpal and trapezium, the FCR tendon and the volar aspect of the metacarpal is the key structure in basal joint stability. Instability was classified into four stages: synovitis (stage I), one-third subluxation of the joint (stage II), greater than one-third subluxation of the joint (stage III), and advanced arthritis (stage IV). Using a longitudinal approach along the volar aspect of the metacarpal and trapezium, the FCR tendon is then advanced through a “gouge hole” in the base of the thumb metacarpal to stabilize the CMC joint. Eaton and Littler reported on 18 patients with an unstable basal joint of multiple etiologies; when the procedure was performed before arthritic changes were present, patients reported restoration of strength and mobility as well as diminished pain.

Arthroscopy

Arthroscopy offers the greatest theoretic advantages for a painful CMC joint because it is a minimally invasive procedure that can be used to remove loose bodies, débride the joint, and perform a hemitrapeziectomy or thermal capsulorrhaphy. Badia combined arthroscopic débridement, synovectomy, thermal shrinkage, and metacarpal osteotomy and obtained satisfactory results in 41 of 43 patients. Using an arthroscopic approach, Culp and Rekant reported 22% improvement in pinch strength with 2 to 4 mm of subsidence. Adams et al. interposed acellular dermal allograft and reported partial or complete satisfaction in 94% of the patients. Using a procedure that combined arthroscopic hemitrapeziectomy and thermal capsular plication, Hofmeister et al. reported 100% satisfaction with a mean 1.8 mm of subsidence in 18 patients at 7.6-year follow-up, and Edwards and Ramsey reported that 19 of 23 patients were satisfied with their treatment using the same procedures. The long-term follow-up of these cohorts and prospective randomized studies would be valuable in the assessment of efficacy, longevity, and safety.

HDA/Trapeziectomy

HDA was initially reported by Gervis in 1949 and recently has seen a resurgence in interest. Although HDA was used successfully by Gervis, it lost favor because surgeons believed that a suspensionplasty was necessary for success. Theoretically, HDA works by removing the pain generator (specifically, the arthritic trapeziometacarpal joint).

Davis randomized 183 thumbs to trapeziectomy alone, trapeziectomy with palmaris longus interposition, or trapeziectomy with LRTI arthroplasty using 50% of the FCR tendon. Kirschner wires (K-wires) were placed for 4 weeks, and the thumbs were splinted for 6 weeks. The author reported no subluxation or dislocation at 1-year follow-up. Pain relief was achieved in 82% of the thumbs, and 68% had sufficient strength. Davis reported no substantial difference in results among the three procedures; however, a separate study by Sandvall
et al\textsuperscript{29} reported substantial differences in surgical time and complexity for each procedure. Gangopadhyay et al\textsuperscript{30} provided a median 5-year follow-up of the same cohort of patients; 78% of the patients reported good or better results with a maintenance of grip strength. Although key and pinch strength deteriorated compared with results from the 1-year follow-up, there were no statistically significant differences among the three cohorts.

Potential concerns of HDA include metacarpal subsidence, loss of pinch and grip strength, instability, pain, and an increased rate of revision surgery. Midterm results published by Gangopadhyay et al\textsuperscript{30}, however, demonstrate good early and midterm reliability of HDA. The mean preoperative pain level of the patients was 5 (range, 4 to 6), whereas the mean postoperative pain levels were 0 (range, 0 to 1) for the LRTI and HDA groups and 1 (range, 0 to 2) for the trapeziectomy with palmaris longus interposition group. There was no statistical significance in pain level among the groups.

Edwards and Ramsey\textsuperscript{22} reported results of a minimally invasive arthroscopic hemitrapeziectomy and shrinkage in 28 patients with stage III thumb CMC arthritis. Compared with the preoperative findings, at the 3-month follow-up, patients demonstrated improved Disabilities of the Arm, Shoulder and Hand (DASH) scores (61 to 10), improved visual analog pain scale scores (8.3 to 1.5), and grip and pinch improvement of 6.8 kg and 1.9 kg, respectively, with only 3 mm of proximal migration. Nineteen of 23 patients were pleased with their outcomes, and the authors reported unchanged results at a minimum 4-year follow-up.

**Trapeziectomy With Tendon Interposition/LRTI Arthroplasty**

The most common procedure performed for recalcitrant basal joint arthritis involves either a partial or a complete trapeziectomy with a tendon transfer or interposition. An arthroscopy is performed, and, based on the status of the scaphotrapezial joint, either a partial or an entire trapeziectomy is performed (Figure 2). A drill hole is made in the base of the metacarpal perpendicular to the nail to allow passage of the FCR tendon (Figure 3). A drill hole is made in the base of the metacarpal perpendicular to the nail to allow passage of the FCR tendon (Figure 3). The radial half of the FCR tendon is harvested, typically by making two transverse incisions in the forearm. The FCR tendon is passed through the drill hole (Figure 4), the thumb is positioned in space, and the transferred FCR tendon is secured at its exit point in the metacarpal using nonabsorbable sutures and then folded upon itself and secured at the dorsal ulnar aspect of the trapeziectomy site using nonabsorbable sutures (Figure 5). The remaining tendon is secured in an “anchovy” fashion and the capsule is closed in layers. K-wire fixation is not used. Sutures are removed 10 days postoperatively, and a thumb spica cast is used for 3 weeks, after which a removable splint is placed and therapy instituted.

Burton and Pellegrini\textsuperscript{2} reported the results of LRTI arthroplasty in 25 patients at a mean 2-year follow-up.
Excellent results were obtained in 92% of the patients, with improvement of pinch strength, grip strength, and endurance; however, proximal migration and subluxation averaged 11% and 7%, respectively. Tomaino et al provided 9-year follow-up results on the same cohort, in which excellent pain relief was obtained in 95% of the patients, and grip and tip pinch strength improved 93% and 65%, respectively. Although key pinch strength improved, it tapered to 34%. The web angle was maintained, but there was a 13% loss of arthroplasty height.

Over the past more than 30 years, LRTI arthroplasty has been modified by various surgeons. If only the trapezial metacarpal surface is involved, a hemitrapeziectomy is performed, leaving the scaphotrapezial articulation intact. Because loss of strength was not believed to be clinically important, many surgeons use the entire FCR tendon rather than only one-half of the tendon. Advocates of this modification suggest that the tendon bulk not only provides better suspension of the first metacarpal but also a greater biologic spacer to fill the trapezial void. The use of the entire FCR tendon allows it to be transected in the proximal forearm and delivered distally in one piece with less soft-tissue dissection. The abductor pollicis longus and extensor carpi radialis have been used as alternative tendons for basal joint stabilization. Palmaris longus and materials such as acellular dermal allograft have been used to fill the trapeziectomy space. Although some surgeons continue to use K-wire fixation, others, including this chapter’s author, do not. Some surgeons use the TightRope device (Arthrex) for suspensionplasty.

### Alternatives to Tendon Interposition

Alternatives to tendon interposition for the FCR also have been used. A study by Heyworth et al reported results of APB suspensionplasty in which the APB was transferred volar to the FCR tendon to serve as a suspensionplasty for the thumb metacarpal. The authors believed this tendon transfer would increase the abduction movement of the thumb and also provide stabilization at the base of the first metacarpal. The procedure was categorized as more of a tendon transfer than a ligament reconstruction. Of the 22 patients followed for a mean of 9 years, 95% rated the procedure as good to excellent, with a mean DASH score of 13.3. The authors reported that the procedure was safe and effective with a low complication rate and believed that this type of tendon transfer restored better function to the APB and opponens pollicis and helped the metacarpals resist subsidence. Three of the patients underwent MRI brain mapping; the results suggested activation of the APB as a dynamic tendon transfer.

Yao and Song reported results of prosthetic suspensionplasty using the TightRope device. Patients (mean age, 68 years) underwent partial or complete trapeziectomy and were followed for a minimum of 2 years. Using the TightRope device, the thumb metacarpal was suspended to the index metacarpal and both metacarpals were immobilized for 10 days. At follow-up, the mean QuickDASH score was 10, and pinch and grip strength were 86% and 96%, respectively, with a 74% maintenance of trapezial height. Complications included one patient with complex regional pain syndrome who sustained a metacarpal fracture at the device insertion site.

Kokkalis et al used acellular dermal allograft replacement in 89 patients (100 basal joints) with thumb CMC arthritis. The graft was used to suspend the metacarpal without supplemental K-wire fixation. The graft was wrapped around the FCR tendon at the volar aspect of the trapeziectomy site and brought through the metacarpal base (as described for FCR tendon transfer), and the remaining implant was placed in the trapeziectomy site. Pain levels (measured using the visual analog pain scale) decreased from 6.2 preoperatively to 0.7 postoperatively, and grip and pinch strength increased 16% and 19%, respectively. Subsidence was 31%, and no infections or foreign-body reactions were reported.

### Subsidence

Subsidence is an ongoing issue in the treatment of basal joint arthritis. In the early history of LRTI arthroplasty, the FCR tendon transfer theoretically acted as a suspensionplasty and maintained the height of the thumb metacarpal. There was concern, however, that after the trapezium was excised, metacarpal height would be lost. First metacarpal height has been postulated to preserve thumb strength with use; therefore, loss of height could theoretically affect the biomechanics of the extrinsic and intrinsic musculotendinous units controlling the thumb. Theoretically, subsidence may cause abutment of the metacarpal against either the scaphoid or the proximal part of a hemitrapeziectomy, resulting in recurrent arthroses at the scaphometacarpal joint. Most long-term studies have presented data on either maintenance or loss of metacarpal height through assessment of the trapezial space and whether metacarpal height...
is maintained after trapeziectomy and ligament reconstruction.36 Kriegs-Au et al38 reported that patient satisfaction remained high even with a 70% loss of trapezial height. Yang and Weiland39 suggested that proximal metacarpal migration does not correlate with functional outcome, and advocates and supporters of HDA clinically demonstrated that outcomes may be independent of suspensionplasty.30

Silicone Arthroplasty
In a retrospective presentation of their experience with silicone arthroplasty over an 8-year period, Pellegrini and Burton2,12 reviewed 90 arthroplasties performed in 71 patients. In the 72 procedures available for follow-up, 59 involved osteoarthritis and 13 rheumatoid arthritis. Although there was a 75% patient satisfaction rate, seven patients required revision surgery. In those patients requiring revision surgery, the authors reported prosthetic fractures, subluxation, scaphotrapezial arthrosis, and silicone synovitis as the etiologies for failure. The authors questioned whether a silicone implant could, by its inherent nature, provide pain relief if the underlying problem was ligamentous laxity.12 In addition, the forces across the CMC joint were believed to put silicone interposition implants at risk. Eaton,35 while investigating the importance of the palmar oblique ligament as the stabilizing factor for basal joint arthritis, expressed concern about cold-flow problems in silicone wrist implants, which could affect the trapeziometacarpal joint.

Prosthetic Arthroplasty
Although prosthetic arthroplasty is a standard of care for arthritis of the hip and knee, results of prosthetic arthroplasty in the CMC joint have been poor. Silicone, Artelon (Artelon Inc.), ceramic, hemiarthroplasty, and total arthroplasty generally have poor long-term results. Martinez de Aragon et al41 reported the results of 54 prosthetic pyrocarbon arthroplasties used to treat 49 patients with arthritis of the trapeziometacarpal joint of the thumb, 44 of whom had osteoarthritis. Follow-up at 22 months revealed 10 patients with metacarpal subluxations and 15 patients in whom revision surgery was required. Overall patient satisfaction was 81%. Goddard,44 however, reported a survivorship of 93%, a revision rate of 7%, and a 4% incidence of radiographic loosening in 227 ARPE prostheses (Biomet) in 207 patients with a mean follow-up of 7.8 years (range, 1 to 16 years). Early complications included four early dislocations, six patients with loosening, one trapezial fracture, and five patients with documented wear.

Trapeziometacarpal Arthrodesis
An alternative to arthroplasty is trapeziometacarpal fusion of the basal joint. Because fusion theoretically maintains the height of the CMC joint and relieves arthritic CMC joint pain, it has been postulated that fusion may be a better treatment option for young patients who require greater strength.30,61 Rizzo et al47 reported on a retrospective review of trapeziometacarpal arthrodesis performed in 114 patients (126 fusions) with osteoarthritis. A variety of fixation methods, including K-wires, tension-band wires, plates, and screws were used. Most patients were women with a median age of 52 years (range, 32 to 77 years). At 11-year follow-up, the mean visual analog pain scale score improved from 6.6 preoperatively to 0.4 postoperatively, and mean grip strength improved from 14 kg to 23 kg. No changes were reported with palmar radial abduction or at the MCP or interphalangeal joints. Ninety patients required a supplemental bone graft. Despite the generally successful subjective clinical outcomes, there were 17 nonunions (13.5%) that were independent of concomitant bone grafting. Nine of these thumbs underwent revision surgeries, six of which were repeat fusions and three of which were suspensionplasty. At final follow-up, associated findings included 39 patients (31%) with scaphotrapeziotrapezoid joint arthritis (pantrapezial arthrosis) and 16 patients (13%) with MCP joint arthritis.

In a nonrandomized, surgeon-preference trial, Mureau et al48 retrospectively compared 32 trapeziometacarpal fusions with 24 LRTI arthroplasties. Female-to-male patient ratio was 6:1, with a mean age of 62 years. The LRTI group demonstrated less pain, better thumb mobility, greater patient satisfaction, better thumb opposition, and better range of motion compared with the fusion group. There was no difference between tip, key, and grip strength. Although the authors found proximal migration in the LRTI group, they concluded that it was not related to patients’ symptoms at the time of final evaluation. Complications occurred in 27% of the LRTI group and 39% of the fusion group, with a 28% rate of pseudarthroses in the fusion group. Hartigan et al49 also compared LRTI arthroplasties with trapeziometacarpal fusions and obtained similar satisfaction rates of 90%.

Sandvall et al50 reported on a comparison study of LRTI arthroplasty versus HDA. Patients were randomized based on surgeon preference with a total of 12 LRTI arthroplasties and
9 HDAs performed. Somewhat different than most studies on basal joint osteoarthritis, this study had a male-to-female patient ratio of 16:4. At a mean 24-month follow-up, there was no statistical difference in patient satisfaction; QuickDASH scores; range of motion; grip, tip, and pinch strength; or web space preservation. Proximal migration was similar in both groups, but the surgical time for the LRTI group was 54 minutes longer than the surgical time for the HDA group.

In two studies using the Cochrane database, the effects of seven different surgical techniques on 477 patients with trapeziometacarpal osteoarthritis were reviewed. Although the authors found fewer complication rates for trapexiectomy, the overall results with regard to pain, physical function, patient global assessment, and range of motion were equivalent.

**MCP Joint in CMC Osteoarthritis**

During the treatment of CMC osteoarthritis, it is imperative for the surgeon to evaluate and assess the MCP joint because many changes can develop at the MCP joint secondary to basal joint arthrosis. Adduction contracture limits mobility at the CMC joint, subsequently causing compensatory changes in the thumb axis. The adducted posture diminishes hand breadth and leads to compensatory changes at the MCP joint, including progressive laxity of the volar plate and hyperextension deformity. Eaton and Floyd proposed advancement and stabilization of the volar plate by decorticating the subsesamoid fossa area and advancing the sesamoid. At a mean 29-month follow-up, there were nine excellent results, three good results, and one fair result. Ten of the 13 patients demonstrated complete correction of the MCP joint extension, and with stabilization, there was a 50% increase in pinch strength.

The extent of the hyperextension deformity helps direct treatment. Typically, MCP hyperextension of less than 10° does not require treatment. If MCP hyperextension is between 10° and 20°, 6 weeks of K-wire fixation in 10° of flexion usually is sufficient. If the deformity is greater than 20°, volar plate advancement generally is advocated. For patients with long-standing deformity, cartilage wear and arthrosis may occur; therefore, MCP fusion is indicated, typically in a position between 20° and 25° of flexion.

Except for basal joint fusion procedures, subsidence and instability are reported complications of any procedure involving partial or entire trapexiectomy. Because the sensory branch of the radial nerve traverses the basal joint area, paresthesias along the radial sensory nerve distribution are common, and painful radial sensory neuromas may occur. Adduction contracture of the first web space limits the resting position of the hand and limits both abduction and opposition. If a substantial contracture occurs, it can be managed with a web space deepening or Z-plasty. Secondary arthrosis surrounding the basal joint can occur at the scaphotrapezial joint (in the case of hemicapexiectomy), the scaphotrapezoidal joint, and the articulation between the first and second metacarpal bases. It is important to be aware of any changes at the MCP joint and concomitantly address those changes during basal joint reconstruction.

Jones et al published results of a salvage procedure for failed LRTI arthroplasties. If one-half of the FCR tendon was available, the authors advocated the use of the FCR tendon remnant to reconstruct the basal joint. If one-half of the FCR tendon was not available, the authors proposed an extensor carpi radialis longus suspensionplasty. A 4-mm strip of the extensor carpi radialis longus was harvested. The tendon was passed in a dorsal to volar direction through the base of the second metacarpal and then through the base of the first metacarpal, typically being woven through the abductor pollicis longus tendon. The authors emphasized that any marginal osteophytes should be removed, and the construct should not be overtightened because it could cause impingement between the thumb and index metacarpal bases.

Reconstruction techniques for recalcitrant basal joint arthritis are highly effective if nonsurgical measures are unsuccessful. The key to consistent surgical success is resection of the distal aspect of the trapezium. Further prospective, randomized trials and longer-term results will help evaluate the long-term outcomes of the various surgical techniques. Because questions still remain, surgeons need to be cognizant of and concomitantly address any associated MCP pathology.

**PIP and MCP Joint Osteoarthritis**

Although osteoarthritis of the MCP and interphalangeal joints is common, it generally responds to nonsurgical treatment and does not frequently require surgical reconstruction. Patients typically have pain, deformity, and loss of motion or dexterity. Loss of motion appears to be the greatest patient complaint; unfortunately, it is the symptom least responsive to surgery. Nonsurgical measures, such as
anti-inflammatory drugs, activity modifications, and corticosteroid injections, usually improve symptoms. Both the MCP and PIP joints have an intricate and balanced relationship with the bony architecture, articular surface, collateral ligaments, volar plate, and the flexor/extensor tendon mechanism. Minor injuries to these joints quickly cause alterations in the joint biomechanics, and major injuries may rapidly cause permanent loss of motion and function. If symptoms persist, various surgical options are available.

In 1914, adipose tissue was interposed into an arthritic PIP joint. Vitallium and Lucite caps underwent trials in 1954, and Carroll and Taber reported on 20 patients who underwent resection arthroplasty. Multiple attempts at prosthetic implantation have been attempted. Brannon and Klein and other investigators reported on the use of constrained implants; however, the biomechanical force across the PIP joint caused failure within the implants. Swanson developed silicone implants in the 1960s, which caused a resurgence of interest in small-joint arthroplasty. In 1972, Swanson reported a mean 35° arc of motion with no complications in 148 silicone implants at 2- to 5-year follow-up. In a longer-term study, Swanson et al reported the results of 424 silicone implants, with pain relief in 98% of the patients but only a mean 10° gain in arc of motion. Long-term complications included a bone overgrowth incidence of 4.2%, a resorption rate of 1.2%, and a fracture rate of 5.2%.

Lin et al reviewed 36 patients (69 PIP joints) who had silicone arthroplasties performed using a volar approach. Lin et al reported that 67 of 69 digits were pain free. The mean extension deficit improved from −17° to 8°; however, there was no change in the overall total arc of motion. Complications included five implant fractures and three cases of implant malrotation.

Takigawa et al reviewed 70 silicone implants at a mean 6.5-year follow-up. Similar to Lin et al, there was improvement of the mean extension deficit from −32° to 18° but no change in overall total arc of motion. Pain relief was seen in 78% of the joints, and the results were classified as good for 25 joints, fair for 27 joints, and poor for 18 joints. Cystic changes were seen in 45% of the patients. Of the 11 implants that failed, 9 required revision surgery.

A resurgence in prosthetic arthroplasty occurred in the late 1990s because of the introduction of a series of bicondylar unconstrained implants. This newer generation of implants requires less bone resection and are not constrained by design. These advances diminish the mechanical force across the implant and implant-bone interface and retain the collateral ligaments, which provide greater inherent biologic support. The surface contour and bicondylar design of the implant are more anatomic and should, theoretically, provide a greater restoration of normal anatomy and a greater range of motion. Pyrolytic carbon also has been used in both the PIP and MCP joints, with better success in the MCP joint.

Cook et al reported the results of pyrolytic carbon arthroplasty on a mixed population with rheumatoid arthritis, osteoarthritis, trauma, and systemic lupus erythematosus. Range of motion improved 13°, but the failure rate was 2.1% per year, and the 5-year survival rate was 82%. Eighteen of 151 implants required revision surgery because of stiffness, loosening, subluxation, malposition, implant fracture, and/or dislocation.

Parker et al reported the results of a mixed population of 142 pyrocarbon MCP arthroplasties. In the osteoarthritis subgroup, range of motion improved from 44° to 58° with an 88% decrease in pain (measured using the visual analog pain scale) from 73.0 to 8.5. The complication rate for the osteoarthritis group was 20%, including one extensor lag and one ray amputation that the patient requested based on recalcitrant symptoms. All implants, however, demonstrated radiographic lucencies 1 year after implantation.

Branam et al retrospectively compared silicone PIP joint arthroplasty to pyrolytic carbon implants in patients with osteoarthritis. Twenty-two silicone implants with a follow-up of 45 months were compared with 19 pyrolytic carbon implants at a follow-up of 19 months. Range of motion, pain relief, and patient satisfaction were similar in both groups, but coronal plane correction was better with the pyrolytic carbon implants.

Similar to PIP arthroplasty, the studies of MCP replacement are limited and lack the support of evidence-based medicine. In general, MCP replacement has better results and fewer complications than PIP arthroplasty, but further studies are needed.

Although the trend appears to be toward surface replacement arthroplasty, Neral et al reported long-term results of silicone MCP arthroplasties in 30 patients (38 implants) over a 12-year period. Digital distribution included 15 index, 20 long, 1 ring, and 2 little fingers. Statistically significant improvement was noted in range of motion, DASH scores, and visual analog pain scores; however, preoperative measures

© 2015 AAOS Instructional Course Lectures, Volume 64
were not available for all patients. Eighty-five percent of the patients had complete pain relief, and there was no substantial difference between grip and key pinch strength in surgical versus nonsurgical hands. Despite suggestions that the index finger may be more prone to failure, similar outcomes were seen in the index and long fingers in this study. The mean satisfaction score was 3.8 of 4, with 100% of patients at least somewhat satisfied and 73% of those patients very satisfied. Eighty-seven percent of the patients said that they would proceed with surgery again. Radiographs showed 5° mean joint angulation and 2 mm mean subsidence compared with immediate postoperative radiographs. Revision surgery and implant breakage failure were 11%, with complications in 8 of 38 arthroplasties (21%). Implant breakage occurred in two long fingers, one index finger, and one little finger; revision surgery for instability was required in one long and one index finger.

Although pain-free restoration of motion is still the optimal goal, fusion remains the benchmark for treating osteoarthritis of the PIP joint because the procedure is long lasting after a solid fusion occurs. Stern et al. reviewed the results of PIP joint arthrodesis in 203 patients with both inflammatory arthritis and osteoarthritis. Union was achieved in 97% of the patients; four of the nine patients in whom bony union failed were asymptomatic.

Although both arthroplasty and arthrodesis improve pain in the short term, patients generally prefer arthroplasty because it retains range of motion. Despite implant breakage, silicone implant arthroplasty continues to be performed. The implants themselves have not greatly changed since Swanson’s original design and description, and they provide a reliable method for small-joint reconstruction. Although implant breakage and florid carpal synovitis have occurred in silicone wrist implants, proliferative silicone synovitis generally has not occurred in digital implants. Silicone digital implant complications include fracture, synovitis, stiffness, and instability; however, long-term results remain favorable.

Summary

Osteoarthritis commonly affects the thumb and adjacent digits and, in severe cases, causes substantial functional problems for patients. Most patients respond to nonsurgical measures, including splints and over-the-counter medications. Corticosteroids may be helpful, but there is a paucity of randomized controlled trials demonstrating its efficacy in arthritic conditions of the hand. Reconstructive techniques and arthroplasty are surgical alternatives with generally good patient satisfaction, but further long-term prospective randomized trials are needed to better define the best treatment methods.

References


14. Eaton RG, Littler JW: Replacement of the trapezium for arthritis of the basal articulations: A new technique with...


67. Jennings CD, Livingstone DP: Surface replacement arthroplasty of
the proximal interphalangeal joint using the PIP-SRA implant: Results, complications, and revisions. J Hand Surg Am 2008;33(9):1565e1-1565e11.


