Painful Basal Joint Arthritis of the Thumb

Part I: Anatomy, Pathophysiology, and Diagnosis

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ABSTRACT
Pathology at the base of the thumb can often be confusing. Numerous tendons, nerves, bones, and joints are all in close proximity and may cause pain and loss of function to the thumb. A systematic approach to this area, identifying abnormal anatomy or lesions of these structures, is presented along with the characteristic features of the examination of the pathologic basal joint. The importance of obtaining a careful medical history with regard to possible causes and symptoms is presented. Concurrent conditions, which are present in a large percentage of patients, are discussed. Radiographic views for diagnosis and staging will be demonstrated.

The carpometacarpal joint of the thumb is one of the most mobile joints in the body, providing a stable base for the thumb to move in multiple planes. Bony stability has been sacrificed for this increase in mobility, however. The carpometacarpal joint is prone to ligament damage, from either trauma or attrition, which can lead to pain and arthritis.

Treatment has evolved from understanding the normal joint anatomy. Examination of the painful thumb should be systematic and comprehensive. Many disorders can be confused with carpometacarpal arthritis. Ancillary studies such as radiology should be used as an adjunct to the clinical examination.

It is the purpose of this paper to review the pertinent works regarding the anatomy and pathophysiology of the basal joint of the thumb, and the diagnosis of associated arthritis.

ANATOMY
The thumb is positioned in a different plane than that of the other four digits (Figure 1). This has been an evolutionary change that has allowed humans greater prehensile activity. In 1752,

Figure 1. Radial view of the hand.

Figure 2. Thumb flexion.
ulnar four metacarpals (Figure 2). Extension, also called radial abduction, is the opposite motion, moving away from the palm in a parallel plane (Figure 3). Abduction (Figure 4) moves the thumb away from the palm in a perpendicular direction, while adduction (Figure 5) moves the thumb toward the palm, nearly parallel to the axis of the second ray. Opposition is a complex motion that results in the pulp surface of the thumb becoming diametrically opposed to the pulp surface of one or more of the other remaining digits for the purposes of prehension.

The trapezium articulates with the base of the first metacarpal distally, the scaphoid proximally, the base of the second metacarpal distally and ulnarily, and the trapezoid proximally and ulnarily (Figure 6). The joint between the first metacarpal and the trapezium has widely been described as a biconcave or saddle joint, a term originally used by Fick. In a cadaveric study by Napier, articular congruity was only apparent when the thumb was brought into an adducted posture (Figure 7). Kuczynski and Zancolli et al investigated the surface anatomy. Kuczynski found a ridge on the distal articular surface of the trapezium that ran anterolaterally from the base of the second metacarpal bone, where it was most pronounced, and traveled at an angle to the greatest diameter of the trapezium (Figure 8). This ridge was most pronounced ulnarily and flattened as it moved radially. A groove transverse to the ridge was also present, which allowed 90° of rotation of the base of the first metacarpal as it moved from end to end along the ridge. The groove divides the surface of the trapezium into anterolateral and posteromedial portions. The anterolateral portion is the larger of the two and is flatter. Zancolli et al described this portion of the trapezium as spherical. Both reports agreed that this flat/spherical portion is where rotation takes place. The base of the metacarpal nearly matches the opposing surface of the trapezium (Figure 9).

While intrinsic and extrinsic muscles do provide some dynamic stability, it is mainly the capsular ligaments that stabilize the joint. Napier credited

Figure 3. Thumb extension.

Figure 4. Thumb abduction.

Figure 5. Thumb adduction.
Haines with the first description of these ligaments. The anterior oblique ligament was given primary importance and has been proved by other authors to be the stabilizing ligament of the first carpectacarpal joint.\textsuperscript{5,7-16}

Detailed dissections from the Mayo Clinic have delineated more than the two capsular ligaments originally described.\textsuperscript{15,16} A total of five major ligaments, both intracapsular and extracapsular, have been shown to exist (Figure 10). These studies have also confirmed the work of Pellegrini\textsuperscript{11,12} in showing that the anterior or palmar oblique ligament serves to limit translation of the metacarpal on the trapeziuim with the ligament becoming taut in extension, abduction, and pronation. This ligament originates from the palmar (anterior) tubercle of the trapeziuim and inserts into the palmar tubercle of the first metacarpal base. Four other ligaments were described: ulnar collateral ligament, first intermetacarpal ligament, posterior oblique ligament, and dorsoradial ligament. All except the dorsoradial ligament were found to be secondary stabilizers, forming a "force nucleus" at the base of the first metacarpal and preventing radial translation. A ligaement-sectioning study showed that when the anterior ligament structures of the basal joint were divided, the center position of the metacarpal base shifted significantly, increasing dorsovolar laxity.\textsuperscript{16} Pellegrini's work confirms this pathologic joint translation with similar ligament incompetence.\textsuperscript{11}

Cooney and Chao\textsuperscript{17} have investigated the biomechanical forces that act on the thumb joints during normal hand function. For the interphalangeal, metacarpophalangeal, and carpectacarpal joints, there is a force multiplication of 3, 5.4, and 12, respectively. These forces, generated by both the intrinsic and extrinsic thumb muscles, are mainly compressive in nature and depend on a competent ligament support system. The co-
pressive forces may be converted to shear forces if the ligaments are disrupted, which is deleterious to articular cartilage.

**PATHOPHYSIOLOGY**

The essential lesion for articular cartilage destruction is attenuation or detachment of the palmar oblique ligament.\(^5\)\(^6\)\(^8\)\(^9\)\(^10\)\(^11\)\(^12\)\(^13\)\(^14\)\(^15\) Translation of the basal joint was found to occur with flexion and axial rotation, which occurs during pinch and opposition movements. A direct correlation was found between ligament integrity and the status of the articular surfaces. Degeneration of the palmar lip cartilage was always associated with attritional detachment of the palmar oblique ligament (Figure 11).

Cadavers in which end-stage arthroses of the basal joints were dissected\(^12\) conclusively showed severe loss of cartilage in the palmar compartment with nonprogressive chondromalacia on the dorsal articular surfaces. Dorsal chondromalacia of the first carpometacarpal joint was found to have a male predominance of 2:1, with attritional changes in the palmar oblique ligament in fewer than 50%.

Conversely, palmar chondromalacia was always found with palmar oblique ligament attenuation or detachment, and did progress to eburnation proportional to changes in the ligament. Palmar compartment changes showed a female prevalence of 9:1. The cartilage loss was always more severe on the trapezial side of the joint. It was the author's\(^12\) conclusion that changes in the palmar compartment were progressive and were related to incompetence of the palmar oblique ligament.

Pellegrini further investigated the wear patterns in the carpometacarpal joint.\(^13\) He found that the eburnation began at the site of the ligamentous detachment and spread dorsally on the metacarpal, while alterations on the trapezial side began at the central palmar slope and spread centrifugally. While changes were always more severe by a ratio of 3:1 on the trapezium in early cases, the ratio dropped to 1:1 in advanced cases.

Biochemical and ultrastructural analyses were performed in an attempt to reconcile whether mechanical wear or synovial inflammatory mediators are responsible for articular cartilage loss.\(^18\) Gross ultrastructural and biochemical profiles of arthritic postmortem and surgically removed joints were nearly identical. Loss of glycosaminoglycans exceeded that of hydroxyproline from areas of diseased cartilage. This suggested early mucopolysaccharide loss followed by late erosion of the collagen substructure. This wear pattern in the volar compartment was thought to be caused by shear forces that came about by lax or torn ligaments, which caused selec-

**Figure 11.** Arrowhead denotes degenerated palmer lip cartilage. Star shows a large dorsal osteophyte.

tive biochemical destruction in an abnormal mechanical environment. Disruption of the surface layer of the cartilage, the lamina splendens, may allow the chondrocytes to be exposed to synovial mediators, which may lead to cartilage degradation.

**DIAGNOSIS**

**Medical History**

When the orthopedist is diagnosing a lesion in the basal joint, it is important to ask the patient if there has been any prior trauma to the thumb, or if any systemic illness exists. There are two types of fracture that can predispose the patient to arthrosis of the first carpometacarpal joint. The first type would involve the articular base of the metacarpal and is commonly known as a Rolando or Bennett fracture. If these injuries are left to heal in a malunited position, increased shear forces on the cartilaginous surfaces can lead to premature degeneration. The second, less common type of fracture would be that involving the surface of the trapezial. Both of these types of injury are predecessors of traumatic arthrosis.

Traumatic arthritis does not have any age predilection. The time of injury to when the patient presents for symptoms of pain is unpredictable. When the degree of joint incongruity is mild and the soft-tissue restraints about the carpometacarpal joint are intact, arthritis may be mild and may not require treatment. The degree of joint incongruity and the radiographic appearance do not always correlate with pain and functional loss. In a biomechanical study by Cullen et al.,\(^19\) Bennett fractures that were artificially created and recessed 2 mm, maintaining the integrity of the palmar beak ligament, were found to shift the area of contact stress dorsally and to load a larger surface area. The conclusion from this study was that
<table>
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<th>Stage</th>
<th>Eaton and Littler&lt;sup&gt;25&lt;/sup&gt;</th>
<th>Burton&lt;sup&gt;34&lt;/sup&gt;</th>
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<tr>
<td>I</td>
<td>Normal joint contours with (&lt;1/3) joint subluxation</td>
<td>Ligamentous laxity. Pain present with heavy/repetitive use. Joint hypermobile. Roentgenograms negative. Stress view shows subluxation.</td>
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<tr>
<td>II</td>
<td>Small bone or calcific fragments (&lt;2) mm. Instability apparent on stress views. (\geq 1/3) joint subluxation.</td>
<td>Osteoarthritis. Instability and crepitus on examination. Roentgenograms show cartilage loss, especially at dorsoradial facet of the carpometacarpal joint. Pantrapezial osteoarthritis. Arthritis affects at least one other articulation of the trapezium.</td>
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<tr>
<td>III</td>
<td>Bone fragments (\geq 2) mm. Cartilage space narrowing. (\geq 1/3) joint subluxation.</td>
<td>Metacarpophalangeal joint problems. Includes all stage II and III with pain, arthritis, or instability at the metacarpophalangeal joint of the thumb.</td>
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<tr>
<td>IV</td>
<td>Advanced arthritic changes. Marked cartilage space loss and osteophytes of carpometacarpal joint.</td>
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An articular step-off of 2 mm may not, in itself, lead to posttraumatic changes; rather, reduction of the metacarpal subluxation and restoration of the palmar beak ligament may be the important factors in preventing arthritis.

Inflammatory arthritis, such as rheumatoid arthritis, is another predisposing condition. A panus of inflammatory tissue forms at the joint margins and covers the surface of the joint. This diseased synovium elicits mediators which, over time, chemically degrades the articular cartilage. Joint laxity that occurs as a sequelae of the inflammation aggravates the joint destruction.

Inflammatory arthropathies do not commonly target the basal joint initially. The most common site of upper extremity involvement in the rheumatoid population is the distal radioulnar joint.<sup>20</sup> About 35% of these patients will have involvement of the basal joint.<sup>21</sup> This population generally puts low demands on their hands and they may not seek treatment for the thumb. A recent study showed that patients with rheumatoid arthritis who came to operation for disabling basal joint arthritis all had relatively minor systemic involvement.<sup>22</sup>

The third major disorder category that may lead to basal joint arthritis is idiopathic or osteoarthritis. This is the most common cause for symptoms.<sup>23-34</sup> There have been no conclusive environmental or genetic factors that lead to the expression of this disease. Eliciting the cause of the symptomatic basal joint is important, since each entity may present concurrent conditions that also warrant consideration at the time of evaluation.

**Presentation**

The most common patient is a postmenopausal woman who does not give any history of trauma or systemic illness.<sup>22-27,29,30,32-36</sup> There does not appear to be any predilection for involvement of either the dominant or the nondominant thumb.<sup>22,29,30,32,34</sup> In a study by Aune,<sup>37</sup> 96 women over the age of 40 years were evaluated. He found that 21 had degenerative changes present radiographically. Only half of these patients were even mildly symptomatic when questioned. The same author studied 22 patients with unilateral symptoms and found similar changes in the opposite asymptomatic thumb.

Initially, pain at the thumb base may be activity related, but as the arthritis progresses, it becomes constant.<sup>37</sup> The person may decrease or change their activity pattern to avoid painful stress. The activities that seem to bring about discomfort can be classified into three main types, according to Burton.<sup>34</sup> The first is flexion and adduction of the thumb ray when it is used in tip-to-tip and tip-to-side pinch activities such as threading a needle. Axial compression of the thumb is the second type of motion. Finally, any type of power-grip maneuver can cause discomfort; opening a sealed jar or wringing out a washcloth. Pain on power grip appears to be one of the earliest symptoms reported.

In addition to pain, weakness or loss of motion are common complaints.<sup>38</sup> Patients may state that this is their primary complaint. These symptoms are a protective mechanism to prevent excess use of a damaged joint.

When arthritis alters the anatomy at the basal joint, the longitudinal arch of the thumb may collapse. In some patients, the metacarpal shaft assumes an adducted position with a loss of breadth of the first web space. With the metacarpal shaft fixed in adduction, grasp of large objects becomes difficult. This loss of the first web space can be one
of the most difficult coexistent deformities to treat. The hand then develops a hyperextension deformity of the metacarpophalangeal or the interphalangeal joint.

**Associated Conditions**

The most commonly reported associated disorders are carpal tunnel syndrome, metacarpal and basal joint contracture of the first metacarpal, tenosynovitis of the flexor pollicis longus and the first dorsal extensor compartment, and hyperextension instability of the thumb metacarpophalangeal and/or interphalangeal joints. The most prevalent of these disorders is carpal tunnel syndrome. In reviewing 246 basal joint arthroplasties, Florack et al found a 43% incidence of carpal tunnel syndrome. The prevalence of compression neuropathy was found to be higher in workmen's compensation patients, women, and patients with diabetes. It was recommended that patients who are contemplating surgery for basal joint arthritis undergo preoperative nerve conduction testing. The addition of a standard carpal tunnel release was not found to add any further time off work or difficulty with postoperative recovery.

Melone et al have postulated why this group of patients would be more prone to carpal tunnel syndrome. Carpal tunnel syndrome predominates in the same population as basal joint arthritis, and thus the two problems may coexist. The basal joint is in close proximity to the carpal canal and inflammation at one site may spread to a neighboring site. In addition, the skeletal changes that occur at the basal joint may affect the dimensions of the carpal tunnel, leading to reduced volume for the median nerve.

**Physical Examination**

When there is subluxation of the basal joint, the base of the first metacarpal will be dorsoradial to the trapezium, producing a “shoulder” deformity (Figure 12). The interval between the metacarpal base and the trapezium should be carefully palpated, since this often elicits pain. Eaton and Littler have noted that this pain can be specifically localized to the radial margin of the metacarpal base one-finger-breadth distal to the scaphoid tubercle. They described a “torque” test, in which there is pain on axial rotation of the distracted metacarpal in particular with the thumb metacarpophalangeal joint slightly flexed. Two other tests have also been described. When axial compression and gentle adduction of the first metacarpal are combined, the base of this bone can be felt to ride laterally against the examiner’s thumb with accompanying pain, instability, and crepitus. This test will elicit pain and often crepitus. Pinch and grip strength will often be decreased.

A positive Finkelstein sign can be found in both de Quervain’s and carpometacarpal arthritis. First-dorsal-compartment tenosynovitis has its point of maximal tenderness at the level of the radial styloid proximal to the first carpometacarpal joint. The torque test of Eaton and Littler, and the compression tests described by Burton, also help in differentiating these entities. Carpal tunnel syndrome may be part of the basal joint syndrome. Pain on the radial three and one-half digits, especially with a history of night pain and paresthesias, should alert the examiner to this diagnosis. Confirmation of the disorder can be obtained by appropriate nerve conduction studies. Flexor carpi radialis tendinitis may be difficult to detect. It may occur in association with inflammation of the basal joint. As the flexor carpi radialis inserts on the volar base of the second metacarpal, it travels through its own fibro-osseous tunnel, with the trapezium making up the bony floor. Ganglia that arise from the scaphotrapezial trapezoid (STT) joint may exit through this tunnel. Pain on resisted wrist flexion that is localized along the course of the flexor carpi radialis is a helpful diagnostic sign.

Arthritis within the STT joint may also be confused with carpometacarpal joint disorders. Often the pain is located volarly and proximally to what one would expect with disorders of the basal joint. Radiographs are also helpful in distinguishing between the two. While chronic scaphoid fractures and radial-sided carpal instability are not commonly confused with arthritic disorders of the thumb, surgeons should be careful during their examinations and history taking to elicit any prior complaints. Watson and Ball 44 had been instrumental in the diagnosis of advanced collapse of the scapholunate...
joint (SLAC wrist), as well as suggesting its association with carpal tunnel syndrome, largely due to the altered carpal canal dimensions.

**Radiographs**

Routine posteroanterior, lateral, and oblique views of the hand will not adequately image the thumb. It is necessary to have posteroanterior and lateral views in the plane of the thumb. Eaton and Littler have described a stress view of the basal joint to assess capsular laxity (Figure 13). By having both thumbs imaged on the same film, the degree of laxity of the involved joint is instantly apparent. The Bett's view is also helpful. This is an anteroposterior view of the trapezium and clearly demonstrates its articulations with the first metacarpal, trapezoid, scaphoid, and second metacarpal (Figure 14).

There have been few studies that have actually documented the correlation between anatomic and radiographic carpometacarpal arthrosis. North and Eaton have performed a cadaveric study in which only 46% of specimens showed actual multifaceted damage, while 73% showed these changes on roentgenographic films. All specimens in this study had changes within the first carpometacarpal joint. The major reason for this disparity was radiographic misinterpretation of the nature of the osteophytes near the trapezium-index metacarpal joint. Anatomic changes were found to be rare in the trapezium-trapezoid and the trapezium-index metacarpal joints.

**CLASSIFICATION**

Classification systems are popular in orthopedic surgery. They allow the surgeon to categorize stages of a disorder for both prognosis and treatment. Two such schemes have been widely used for basal joint arthritis. Neither classification scheme appears to be more widely used over the other. Eaton's system is based on radiographs. Burton's classification incorporates roentgenography and examination findings (Table).

**"Pre-Arthritis" of the Basal Joint**

There exists an entity of "pre-arthritis" of the basal articulation. At this stage there is pain and instability of the joint without radiographic changes. There does not appear to be any injury or predisposition that is associated with this prearthritic stage, other than its occurring in a younger age group. The patient experiences pain with use, despite normal radiographs. This pain is caused by ligamentous laxity, which produces a joint effusion. A careful physical examination, along with stress views, can confirm the diagnosis of carpometacarpal joint instability without articular changes. If the joint laxity can be diagnosed at this point, the ligaments can be reconstructed, thus saving the joint.

In 1973, Eaton and Littler published the first report for extra-articular ligament reconstruction of the first carpometacarpal joint with good results. Results deteriorated when joint changes were present. A follow-up report involving 50 ligamentous reconstructions with an average of 7 years after the procedure showed 95% excellent or good results when the patients had Eaton stage I or II joints. This study was also able to longitudinally observe patients for as long as 13 years and showed no articular degeneration after surgery. Lane and Scarangella confirmed the usefulness of the procedure and also extended its indications to

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**Figure 13.** An Eaton stress view of basal joints, showing clinical subluxation.

**Figure 14.** Bett's view, showing an outline of the trapezium. The arrows point to osteophytes at the carpometacarpal joint.
include treatment of Bennett fractures that had a volar fragment not amenable to fixation.

**SUMMARY**

Patients with thumb and hand pain should be questioned about how this pain limits vocational and avocational activities. Nerve compressions, tendinopathies, and neighboring joint lesions should be pursued. As outlined earlier by both Melone and Burton, neglecting associated pathologic conditions can be a reason for failure of what was seemingly an adequate procedure.

Radiography should be performed only after evaluating results of the medical history and physical examination. This test should be used to help confirm the clinician’s diagnosis, not to make it. The roentgenographic views should be those previously outlined. Using one of the standard classification schemes, one can be guided as to which treatment option may be best for the patient. The need for additional tests, such as nerve conduction studies and electromyography, should be based on examination criteria.

**REFERENCES**