Osteoarthritis of the thumb trapeziometacarpal joint

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Summary
Trapeziometacarpal osteoarthritis is a very common condition, with radiological changes prevalent in 30% of post-menopausal women but a large number being asymptomatic. A lack of bony constraints and laxity of the supporting ligaments, particularly the "beak" ligament is consistently implicated in disease progression. The severity can be staged according to the radiological appearance, which does provides a conceptual framework for rationale of treatment. Fortunately, roles for both conservative and surgical options currently exist to successfully treat joint pain and restore joint stability. The surgical options range from ligament reconstruction or osteotomy for early painful laxity, through to trapeziectomy, arthrodesis and arthroplasty for more severe osteoarthritis. The success of ligament reconstruction tendon interposition arthroplasty in treating trapeziometacarpal arthritis has withstood the test of time. Trapeziometacarpal joint replacement ranges from elastomeric spacers and true total joint replacement to the more current hemiarthroplasty designs with varying results. A better understanding of surgical outcomes for advanced arthritis requires long-term prospective outcome studies while the pursuit for an ideal trapeziometacarpal arthroplasty continues.

Epidemiology
As the humans climbed the evolutionary ladder, the refinement to a dominant prehensile digit to perform myriad functions and movements led to compromise of the stability at the base of thumb. Recession of the palmar metacarpal beak facilitated rotational movements of the thumb ray and the "residual" beak ligament assumed the task of stabilizing the metacarpal in lateral pinch. Ironically these attritional changes in the same ligament integral to diverse mobility of thumb appear to be responsible for the pervasive problem of osteoarthritis of the trapeziometacarpal joint (TMJ) in the contemporary hand.

Although the thumb TMJ is the second most common hand joint afflicted by osteoarthritis (following the distal interphalangeal joints), it is the most common site for which surgery is sought because of the profound impact on hand function, strength and dexterity and disabling symptoms. About 1 in 4 women (in fact, 30% of post-menopausal women) and 1 in 12 men eventually have radiological changes of osteoarthritis at the TMJ, but again the vast majority are asymptomatic. The overwhelming female predilection is attributable to anatomic (a smaller less congruous shallow saddle joint, flat trapezial facet),...
hereditary (dysplastic joint surfaces) and hormonal factors (increased ligament laxity) all resulting in greater joint contact pressure. To date there is no longitudinal natural history study suggesting that TMJ arthritis is caused by certain repetitive work practices. However there is a strong association between excessive joint laxity and the development of premature joint degenerative changes.

Anatomy and biomechanics

The TMJ is a uniquely structured biconcave-convex saddle joint in comparison to the hinge-type joints that dominate the hand. It consists of four articulations: trapeziometacarpal (TM), trapeziotrapezoid (TT), scaphotrapezial (ST) and trapezium-index metacarpal (TIM) articulations. North and Eaton observed that radiographic disease most commonly affects TM and ST joints lying along the longitudinal compression axis of the thumb and typically spares the TT and TIM articulations. The disparate radii of curvature result in large loads being transmitted across small surface areas through much of the range of motion. It has been calculated, using three-dimensional analysis, that during simple pinch of 1 kg force at the finger tips, the joint compression force at the TMJ is 12 kg and increasing to as much as 120 kg during strong grasp.

The paucity of bony constraints and intrinsic osseous stability forces the TMJ to rely on static ligamentous constraints to limit metacarpal base translation, which subjects the joint to abnormal pressure loads. The trapezium endures both axial and cantilever stress loads, particularly during lateral pinch and grasp maneuvers. 

Bettinger et al. in arthroscopic studies on complex ligamentous anatomy of TMJ described 16 ligaments that stabilize the joint (Fig. 1) (Table 1).

Current research, based on biochemical and histologic analysis, continues to describe the “beak ligament” as being the primary restraint to dorso-radial subluxation. The intracapsular “beak ligament” is so named because its obliquely oriented fibers originate just ulnar to the volar styloid process of the first metacarpal base (beak) which may include the anterior oblique ligament (AOL), first intermetacarpal ligament, and ulnar collateral ligament and insert onto the palmar tubercle on the central apex of the trapezium.

A predominant palmar pattern of articular surface destruction has been associated with beak ligament attrition (known to occur before cartilaginous destruction) and gross ligament detachment from the native position, which has led to the popularity of ligament reconstruction. Biochemical analysis of the arthritic hyaline cartilage reveals a

<table>
<thead>
<tr>
<th>Table 1 Major ligaments of the trapeziometacarpal joint.</th>
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<tbody>
<tr>
<td>Deep anterior oblique</td>
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<tr>
<td>Superficial anterior oblique</td>
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<tr>
<td>Dorso-radial</td>
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<tr>
<td>Ulnar collateral</td>
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<tr>
<td>Intermetacarpal</td>
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<tr>
<td>Dorsal intermetacarpal</td>
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Figure 1 Anatomy and ligaments of the trapezio-metacarpal joint. (a) Volar and (b) Dorsal views. APL = Abductor pollicis longus, AOL = Anterior oblique (Beak) ligament, UCL = Ulnar collateral ligament, MC = Metacarpal; IML = Intermetacarpal ligament, DRL = Dorso-radial ligament, POL = posterior oblique ligament.
selective loss of glycosaminoglycan from the extracellular matrix and sparing of the collagenous network in the palmar region, where osteoarthritic disease first originates.\(^7\)

Six other ligaments play contributing roles in TMJ stability. The superficial AOL is longer than the deep AOL and provides the laxity necessary for pronation. The dorsoradial ligament assisted by intermetacarpal ligament; is the shortest and thickest ligament of the TM joint and the first to become taut during dorsoradial subluxation\(^6\) however, its significance in providing TM stability has been debated.\(^6\) The dorsal intermetacarpal ligament may also help restrain the first metacarpal from collapsing proximally after trapezial excision.

**Mechanisms underlying the development of trapeziometacarpal osteoarthritis**

**Articular configuration**

The articular surface of the trapezium is divided into two slightly concave surfaces, volar and dorsal by an oblique bony ridge. The subtle differences in the curvature of the TMJ surfaces result in there being no position in which they fit together well allowing the joint to sublux during pinch and grasp unless adequately restrained by the surrounding soft tissue structures.

**Ligamentous tension**

The mechanism of ligament laxity was identified in cadaveric studies by Pellegrini\(^7\) as one of the key factors underlying the development of TMJ osteoarthritis by allowing excessive shear forces at the joint, altering contact wear patterns.

**Muscular activity**

With incompetence of the volar oblique ligament, dorsal subluxation of the base of the metacarpal progresses unchecked, and two thenar muscles with potential to counter this are abductor pollicis brevis and opponens pollicis. Because the distal aspect of the first metacarpal is dynamically tethered to the second metacarpal by the adductor pollicis muscle, subluxation of its base where the adductor pollicis longus (APL) inserts causes an adducted posture of the first metacarpal. This leads to progressive functional deficit as activities like spreading the hand and palm around jar lids is compromised. Continued efforts to perform these activities lead to the thumb assuming a collapsed deformity of flexion at the TMJ, hyperextension at the metacarpophalangeal (MCP) joint and reciprocal flexion at the interphalangeal (IP) joint.

**Changes to contact wear patterns**

Early work by Pellegrini\(^7\) determined that the volar compartment is the major area of joint contact during lateral pinch in the normal joint. Dynamic testing of 20 cadaveric forearm specimens revealed that positioning the TMJ in 30° flexion unloaded the volar compartment, moving the centre of contact pressure dorsally. Thus, suggesting that limiting the amount of joint subluxation, metacarpal pronation, and/or hyperextension will alter the joint contact wear patterns, and may have a role in delaying the development of TMJ osteoarthritis.

**Diagnosis**

**Clinical presentation**

Diagnosis is based on clinical findings such as pain, dropping objects, oedema, instability, limited range of motion, and joint deformities. Typical patients include postmenopausal women with disabling pain at the thumb base, often radiating to the thenar eminence or MCP joint, men with a history of repetitive occupational joint use or trauma and young women with generalized ligamentous laxity and joint hypermobility.\(^8\) Carpal tunnel syndrome, De Quervain’s disease, and trigger finger are frequently encountered in patients with TMJ osteoarthritis, as a result of synovial thickening and wrist ganglia attributable to capsular defects. Stiffness is usually not a feature of early disease. Osteophytes may, however, lead to limited motion, eventually resulting in a dorsally fixed and subluxed joint that is adducted, with limited palmar abduction and compensatory MCP joint hyperextension.\(^9\) Provocative tests that elicit pain in the TMJ have been described and include the axial compression adduction test, axial compression rotation test (grind test), and the distraction test. The critical determination at the MP joint is the degree of hyperextension during thumb pinch because hyperextension collapse would need to be addressed along with surgical reconstruction of the TMJ.

**Diagnostic radiographic assessment and staging**

Radiographs of the thumb in three planes and the special basal joint stress views are helpful in confirming the diagnosis. Further evidence of painful laxity of the TMJ can be obtained from an Eaton and Littler stress radiograph. This radiograph consists of a PA 30° oblique view centred on both thumbs (the plane of the thumb nails is parallel to the X-ray plate), which is taken when the patient's thumb tips are touching and being pushed against each other. This stresses the TMJ causing radial subluxation. If the TMJ is lax then, on these radiographs, 50% of the articular surface of the base of the thumb metacarpal lies radial to the trapezial articular surface. An additional view, the pinch lateral, can also be obtained preoperatively to allow later comparison with longitudinal follow up radiographs. The best AP view to show the four trapezial articular facets and often the trapezio-metacarpal osteophyte next to the index metacarpal, is the Robert pronated view (Fig. 2). This is obtained by fully pronating the forearm and internally rotating the shoulder, thus allowing the dorsal surface of the thumb to be placed next to the X-ray plate.\(^9\)

Historically, several staging systems have been created to correlate radiographic evidence of TM arthritis with clinical symptomatology. Eaton and Glickel’s staging system presented in 1987\(^10\) (originally described in 1973 by Eaton & Littler) for roentgenographic appearances is extensively used to define the severity of disease into four stages.
A stage V has recently been suggested to account for pantrapezial arthritis. Therapeutically, the real value of this classification is to recognize painful laxity of the TMJ and help to differentiate between patients with isolated ST arthritis and those with TMJ arthritis. Approximately 90% of patients with osteoarthritis at the base of the thumb have isolated TMJ osteoarthritis whereas the remaining 10% have osteoarthritis involving both the TMJ and the articulation between the trapezium, the trapezoid and the scaphoid (STT joint).

**Staging of osteoarthritis of the first carpometacarpal joint, as described by Eaton and Glickel**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>I</td>
<td>Normal articular contours; joint space may be widened due to effusion or ligamentous laxity.</td>
</tr>
<tr>
<td>II</td>
<td>Joint space is slightly narrowed but articular contours maintained and there is minimal sclerosis of the subchondral bone. Joint debris and osteophytes &lt; 2 mm. ST joint is normal.</td>
</tr>
<tr>
<td>III</td>
<td>Markedly narrowed or obliterated joint space with cystic changes, sclerotic bone, and osteophytes &gt; 2 mm in size. Varying degrees of subluxation, and the ST joint not affected.</td>
</tr>
<tr>
<td>IV</td>
<td>Complete obliteration of the joint space with signs of pantrapezial arthritis. Large osteophytes with marked subchondral sclerosis are present along with osteoarthritic changes of the ST joint.</td>
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**Management**

**Non-surgical treatment**

The first line of treatment of TMJ osteoarthritis is non-surgical and includes rest, splinting, anti-inflammatory drugs, steroid injections, physiotherapy, and patient education, usually offered on a 3-month trial.

(i) **Splintage and hand therapy**

As heavy stresses are placed on the TMJ, particularly during pinching or grasping, splintage can be useful. A variety of thermoplastic splinting options exist; from a small short opponens splint which supports the TMJ and MCP joint, to a much larger long opponens splint, which includes both the MCP joint and the wrist.

Therapists may be able to provide advice on avoiding activities that may lead to thumb metacarpal adduction and on maintaining the first web space and strengthening the thenar muscles.

(ii) **Intra-articular steroid injections**

The beneficial effects of steroids in osteoarthritic joints compared with placebo have been shown to be short-lasting and confined to three weeks only. A recent randomised controlled trial showed that no clinical benefit was gained from intra-articular TMJ steroid injection in moderate to severe osteoarthritis compared with placebo injection. Day et al., in a prospective analysis of a single intraarticular steroid injection followed by 3 weeks of splinting in 30 thumbs demonstrated 40% substantial relief regardless of radiographic stage. Eighty per cent of Eaton stage I patients experienced pain relief at 18 months; only 25% of stage IV patients and approximately 35% of stages II and III patients had sustained relief. These findings suggest that patients with Eaton stage I disease can be successfully treated with a steroid/splinting regimen, but as osteophytes develop and joint narrowing progresses (stages II and III), results become less predictable.

Repeated steroid injections should be avoided, as they can further weaken the joint capsule. Furthermore, due to potential complications including fat necrosis, depigmentation and radial nerve neuritis, steroid injection therapy should be used judiciously in the management of this condition.

(iii) **Adaptations**

Education about techniques of joint protection can assist in controlling symptoms and delay the need for surgical intervention. These may include use of assistive devices (e.g., tap turners), use of splints or instruction in ways to change their technique for performance of specific tasks (e.g., lifting with two hands).

**Surgical management**

Surgical reconstruction is indicated when non-operative treatment measures have failed to relieve pain and improve thumb function. So although staging can help preoperative planning, patient education and prognostication, the ultimate determinant of accurate diagnosis of the extent of...
Table 2 Treatment options for osteoarthritis of the trapeziometacarpal joint.

<table>
<thead>
<tr>
<th>Conservative</th>
<th>Operative</th>
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<tbody>
<tr>
<td>NSAIDS</td>
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<tr>
<td>Intra-articular steroid injection</td>
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<tr>
<td>Splints</td>
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<tr>
<td><strong>Operative</strong></td>
<td></td>
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<tr>
<td>○ Ligament reconstructions</td>
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<tr>
<td>○ Trapezial resection procedures</td>
<td></td>
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<tr>
<td>Partial trapezium resection and tendon interposition</td>
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<tr>
<td>Complete trapezium resection</td>
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<tr>
<td>■ Resection arthroplasty</td>
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<tr>
<td>■ Distraction Resection arthroplasty</td>
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<tr>
<td>■ Tendon interposition</td>
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<tr>
<td>■ Ligament reconstruction and tendon interposition</td>
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<tr>
<td>■ Ligament reconstruction</td>
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<td>○ Implant arthroplasty</td>
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<tr>
<td>Hemiarthroplasty</td>
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<td>■ Trapezial stemmed component</td>
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<tr>
<td>Ashworth–Blatt</td>
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<tr>
<td>■ Metacarpal stemmed component</td>
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<td>Kessler</td>
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<td>Swanson titanium</td>
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<tr>
<td>Interposition arthroplasty</td>
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<td>Swanson silicone</td>
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<td>Eaton</td>
<td></td>
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<tr>
<td>Niebauer</td>
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<td>Proplast</td>
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<td>Goretex</td>
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<tr>
<td>Spherical Interposition arthroplasty</td>
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<tr>
<td>Total joint arthroplasty</td>
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<td>Cafniere</td>
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<td>Braun</td>
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<td>Mayo</td>
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<td>Steffee</td>
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<td>Nahigian</td>
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<td>Ledoux</td>
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<tr>
<td>○ Metacarpal Osteotomy</td>
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<tr>
<td>○ Arthrodesis</td>
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Disease and reconstructive procedures is the intraoperative assessment by surgeon. This is because of the poor correlation between radiographic findings and clinical symptomatology and variation in reliability of the Eaton classification system with reported intra-observer and inter-observer reliability varying from 0.529 to 0.657 (Table 2).

The choice of operative procedure is tailored to the individual patient, with factors being the patient's age and functional demands, including occupation and activities, and the extent and stage of disease. Currently, the most accepted treatments are variations of the trapezial resection suspension arthroplasty introduced by Eaton and Littler. Fundamentally, the specific procedure selected will depend on the presence of cartilage erosion at TMJ and ST joint (i.e. stage I vs. Stage II–IV).

**(A) Stage I disease**

There are no clear objective criteria that define the need for surgical intervention at stage I (Painful laxity of TMJ joint) with no radiographic evidence of degenerative disease ("prearthritic stage"). Extra-articular reconstruction procedures have been described which aim to relieve pain, improve stability and attempt to prevent the progression of osteoarthritis. These include volar ligament reconstruction (Eaton) using flexor carpi radialis (FCR) and others using ECRL and APL. Alternatively, a metacarpal osteotomy may be performed as an effective biomechanical alternative to ligament reconstruction to redistribute TMJ contact area and load.

**Ligament reconstruction.** Stabilization of the TMJ joint by isolated reconstruction of the beak ligament should only be performed in Stage I disease. However, for long-term success, the articular surfaces must be eburnation-free which can be best assessed intraoperatively.

The most commonly used is modified technique described by Eaton and Littler using 50% of the width of the FCR tendon. Through a palmar approach, half of the FCR tendon is harvested through either a proximal extension of the incision or through a series of short transverse incisions. After capsulotomy, the articular surfaces are inspected and the tendon split longitudinally for 8–10 cm from its insertion proximally detaching the radial half. The strip of FCR tendon is then passed through a tunnel drilled in the base of the thumb metacarpal, from its dorsal surface to its ulnar rim; any subluxation of the TMJ is reduced by abducting the thumb which then is stabilized with a Kirchner wire. The strip is then pulled tight and sutured to the periosteum on the dorsal surface of the thumb metacarpal at the exit site of the intraosseous tunnel. The residual length of the tendon strip is then passed over the palmar surface of the TMJ, around the intact portion of the FCR tendon and back on to the palmar capsule where it is sutured to itself.

**Metacarpal extension Osteotomy.** Pellegrini and others have shown that incompetence of the beak ligament increases the volar shear stresses and lead to cartilage breakdown volarly. Extension osteotomy described by Wilson in 1973, has been shown to shift contact stresses dorsally and may give symptomatic relief in Stage I or minimal Stage II disease but not in advanced Stage III and IV arthritis. In a review of 41 thumbs at a mean of seven years, Hobby et al. found that 80% had achieved good or excellent pain relief. It has been proposed as best suited to high demand young individuals, as it is a more durable procedure than an arthroplasty and less restriction of motion than arthrodesis. However, it is not widely used and its outcome has never been compared with that of other procedures.

When there is no laxity at an early stage, denervation has been shown to give immediate and satisfactory relief from pain, and can be used as palliative treatment in association with conservative measures.

**(B) Early stage II**

Although degenerative changes are clearly present in stage II, there is a spectrum of severity. Some authors feel that cases with no significant joint irregularity are amenable to treatment with volar ligament reconstruction alone.
If progression of arthritis does occur, revision with interpositional arthroplasty can be added. Others recommend dorsal closing wedge metacarpal osteotomy to unload the volar TM joint (Fig. 3a and b).

(C) Late stage II and stage III disease
Surgical treatment of established TMJ arthritis has evolved over the last 6 decades since Gervis\textsuperscript{17} reported trapezial excision in 1949, with the addition of soft-tissue interposition by Froimson\textsuperscript{18} in 1970 and finally the addition of ligament reconstruction by Burton and Pellegrini in 1986.\textsuperscript{19}

People with Eaton Stage III osteoarthritis show advanced degenerative changes and significantly greater trapezoidal tilt than people with Eaton Stage I or II. If disease is confined to TMJ, the bulk of the trapezium may be left in place and the joint space resurfaced with autogenous tendon but if the ST joint is also involved, both diseased articulations must be addressed. Procedures include metacarpal osteotomy, trapeziectomy with or without LRTI, interpositional arthroplasty, TMJ replacement or trapeziometacarpal arthrodesis.

(a) Trapezial resection procedures
(i) Excisional arthroplasty. Gervis first described Trapezial excision in 1949\textsuperscript{17} who was so influenced by it that he underwent the procedure himself. This may be appropriate for cases of advanced Stage II to Stage IV disease or in the low demand older patients. The arthritic articulations are removed, which theoretically treats the source of pain; however, the instability persists, leading to weakness and a significant proximal migration of the first metacarpal with shortening of the thumb.

All procedures that involve excision of the trapezium can be performed for patients with isolated TMJ osteoarthritis or combined TMJ and SST joint osteoarthritis. In an assessment of 34 simple trapezial excisions at 5-year follow-up, Varley et al.\textsuperscript{20} reported only 47% were completely pain-free.

(ii) Interpositional arthroplasty. Froimson in 1970 first described Caroll’s concept of using a rolled up piece of FCR (“anchovy” spacer) inserted into the cavity left after trapeziectomy without ligament reconstruction.\textsuperscript{18} This technique was then adapted using the APL tendon, lyophilized homologous dura mater and fascia lata as interpositional material. Although these procedures initially appeared to considerably decrease thumb shortening, it was subsequently noted that, over time, thumb length was lost due to the metacarpal settling into the interpositional material, and that no significant improvement in function was actually obtained.

Swanson, in the mid-1960s, pioneered the use of silicone as an interpositional implant material. Alternative interpositional arthroplasties include procedures which excise either all or part of the trapezium, and interpose the space with materials such as costochondral allograft (Trumble) or expanded polytetrafluoroethylene (Gore-Tex) and polypropylene (Marlex) by Muermans and Coenen.\textsuperscript{21}

(iii) Ligament reconstruction and tendon interposition. For disease limited to TM articulation, the technique used most commonly is the ligament reconstruction and tendon interposition arthroplasty (LRTI) described by Burton and Pellegrini in 1986 using half of the width of the FCR tendon to support the base of the thumb metacarpal after excision of the trapezium.\textsuperscript{22}

The strip of the FCR tendon, with its insertion preserved, is passed through a drill hole in the base of the thumb (articular surface previously resected) and sutured to the periosteaum on the dorsal aspect of the base of the thumb metacarpal. The remaining length of the FCR is then rolled up into an ‘anchovy’ and placed into the trapezial void (Fig. 3c). The ligament reconstruction is protected with a Kirschner wire and a short arm thumb-spica cast for 4 weeks. Thereafter range-of-motion exercises are begun.

In its current form, LRTI has yielded favourable results with regard to pain, grip strength and satisfaction in both short and long-term follow-up studies. Although preservation of trapezial height is widely thought to be pertinent for thumb strength, recently studies have failed to show a correlation between thumb key and tip pinch strengths and the height of the pseudarthrosis formed after trapeziectomy alone or with the addition of tendon interposition or LRTI. LRTI has been preferred when compared with silicone implant.

Figure 3 (a) A lateral view shows the anticipated wedge of bone to be resected to afford an extension osteotomy and (b) completed osteotomy, (c) Trapeziectomy with ligament reconstruction and tendon interposition (LRTI) using flexor carpi radialis (FCR).
replacement arthroplasty and the Ashworth-Blatt interposition implant arthroplasty. However, it is not absolutely clear whether these ligament reconstructions produce a stronger thumb than that produced by simple excision of the trapezium without any additional reconstruction procedure, and also whether they shorten the rehabilitation time.

**Technical variations.** Numerous technical variations of LRTI have been described in the literature. Harvesting of the entire FCR versus one-half FCR has not been shown to produce any more morbidity, with respect to wrist strength or endurance. Other variations of LRTI centre on the use of different tendons, variations of tendon configurations, and/or interposition material. Thompson described suspension-plasty: a technical modification using the abductor pollicis longus (APL), rather than the FCR tendon and a different graft configuration. The technique involves detaching half of the APL at its musculotendinous junction, and leaving its dorsal attachment to the thumb metacarpal intact. The APL is then passed retrograde through the dorsal bone hole and out the articular surface hole. The APL tendon is then passed through a second oblique bone tunnel from the trapezial facet of the index metacarpal and heading dorso-ulnarly on the index metacarpal. Next, the APL is woven into the extensor carpi radialis brevis tendon for added stability.

Originally, this technique was intended for silicone arthroplasty salvage and only later became a primary procedure.

(iv) Partial trapeziectomy. An alternative to the LRTI procedure after trapeziectomy is resection of only part of the trapezium and interposition with autogenous or other tissue. It allows the remaining trapezium to act as a spacer and buttress and to address only the arthritic joint surface. Theoretically, this would improve stability and thumb strength and lead to less proximal migration of the thumb ray. This type of arthroplasty is appropriate for Stage II and III disease.

Partial trapeziectomy does not allow evaluation of the ST joint, and it makes treatment of ST osteoarthritis technically more demanding. It is important to inspect the scaphotrapezial surfaces at the time of surgery to determine whether single or double interposition is needed as ST joint arthritis has been shown to be more prevalent at operation (62%) than on preoperative radiographs (32%). Nonetheless, with the development and proficiency of arthroscopic procedures, performing a partial trapeziectomy is becoming more prevalent.

(b) Prosthetic TMJ arthroplasty. The goal besides eliminating painful articular joint surfaces is to establish a stable force column during pinch and grip. The force transfer from thumb tip pinch to TMJ is amplified by a factor of 17X. Stability of prosthetic joint articulation must be sufficient to prevent significant metacarpal base subluxation. Competency of innate soft tissue envelope may alone be insufficient and augmentation by local tissues may be necessary for stability.

Prosthetic joint replacement of the TMJ may be divided simply into three broad categories.

(1) Arthroplasties that resurface either trapezium or metacarpal base for strict TMJ arthritis only and (2) trapezium replacement arthroplasties for patients with pantrapezial arthritis, and (3) total joint replacement.

(1) Resurfacing arthroplasties. The Swanson convex condylar implant designed for the thumb metacarpal base was one of the first TMJ resurfacing arthroplasties available. Swanson subsequently preferred using these for advanced cases of rheumatoid arthritis. Swanson, in 1984, developed a titanium implant for the TMJ to address the problem of silicone wear particles. However it was reserved for low-demand patients due to high rates of loosening.

A solution to the problem associated with implant instability was reported independently by Kessler and Axer and Ashworth et al. Kessler devised a prosthesis in the form of a thin silicone disc, which is interposed between the trapezium and metacarpal. The Kessler implant achieved stability by the use of an intramedullary stem, which was Dacron coated and fitted into the metacarpal shaft. The device by Ashworth et al. was a neurosurgical burr hole cover that had been trimmed to fit the surface of the trapezium and had a short stem that was fitted into the body of the trapezium. Both of these were unsuccessful and were abandoned because of problems with synovitis and instability.

(2) Interposition arthroplasty. Swanson silicone prosthesis: Swanson pioneered the design of a silicone spacer for the trapezial space and reported excellent results but later reports raised concerns regarding abrasive microparticles producing silicone synovitis, which could cause bone erosion with recurrent pain and swelling, weakness, implant dislocation, fracture of the implant, deformation (cold flow), osteolysis and immunologic alterations. Unfortunately, the silicone prostheses tended to sublux and dislocate. Modifications to the implant, such as a cannulated prosthesis to allow ligament attachment and prosthesis with pegs to slot into the scaphoid and metacarpal, were subsequently developed which effectively overcame the problems of instability.

This drew attention to the importance of correct implant seating and to the need for adequate capsular and ligamentous reconstruction. Although good long-term results with silicone implants have been reported, concern regarding silicone synovitis has led most surgeons to abandon this surgical option. Consequently silicone implants tend to be reserved for use in rheumatoid and elderly patients where demands are low.

Eaton designed a perforated implant so that a slip of tendon (e.g. a slip of APL) could be passed through the implant and anchored to an adjacent carpal bone for stability and prevent subluxation or dislocation. Another major design change was that the stem is conical in shape, allowing axial rotation of the thumb. Poppen and Niebauer in 1978 introduced a Dacron mesh coated intramedullary stem to promote bony ingrowth, and heavy Dacron ties extended from the prosthesis into either the flexor carpi radialis or the index metacarpal for fixation to prevent subluxation or dislocation of the prosthesis. Sotereanos et al. published the longest retrospective follow-up study regarding the Niebauer implant in 1993 citing pain relief in 94%. They also found that 83% of the implants showed subluxation 9 years postoperatively.

(3) Total joint replacement arthroplasty. TMJ prostheses most frequently used are “ball and socket” prostheses and may be classified according to their arc of mobility, or according to their mode of primary fixation (cemented,
non-cemented), and to their secondary fixation (hydroxyapatite).

De la Caffiniere in 1973 proposed a cemented prosthesis and others were described by Linscheid and Dobyns in 1979, Braun in 1982, and Ferrari and Steffee in 1986. Ledoux introduced a cementless prosthesis in 1990 and published his first report in 1994. The joint arthroplasty design of de la Caffeniierre (Francobal) is very similar to that used in total hip arthroplasty and consists of a polyethylene cup that was fixed into the trapezium and a cobalt-chromium stem that was fixed into the shaft of the first metacarpal.

The cemented total joint arthroplasties have presented difficulties, since the constrained, cemented, and articulated implants are all prone to loosening, failure, or dislocation and loss of motion secondary to fibrosis. Another major problem reported is perioperative complications (10%) due to the technically demanding nature of these arthroplasties and difficult revision. The cementless arthroplasty avoids the dislocations, weakness, and synovitis associated with silicone arthroplasties. It also avoids the weakness and instability associated with an interposition arthroplasty.

Designs based on a ball-and-socket principle have not been deemed suitable for replacement of the TMJ. The de la Caffiniere prosthesis has the longest follow up, and although some surgeons have reported good long-term results others have recorded high rates of loosening and dislocation, including the designer himself. A study comparing the de la Caffiniere cemented and the Ledoux uncemented joint replacements, both of which are constrained ball-and-socket joints with a fixed centre of rotation of the prosthesis in the axis of the first metacarpal, showed failure rates respectively of 34% at 5 years and 41% at 2 years. Both arthroplasties induce major constraints: their axes do not correspond to the physiological axis, the spherical design does not allow normal translation and the implants are fixed in cancellous bone this is unable to withstand the stress. Currently, prostheses with a less constrained design are being developed. The concerns with implant arthroplasty remain: addressing the pain source(s); tissue compatibility; durability; implant loosening; dislocation; wear; subsidence and revisability.

(c) Arthrodesis. Trapeziometacarpal arthrodesis has traditionally been the procedure chosen for younger, active people (often with a post-traumatic cause) who have high joint demands, requiring strong grip and pinch because of their occupation. It is indicated for people with Stage II–III osteoarthritis, i.e., without any ST joint involvement. While it provides stability, strength and pain relief, it does so at the expense of mobility and transfer of joint reaction forces to other joints. The techniques used include crossed Kirschner wires, cerclage wiring, cup-and-cone with a single oblique K-wire, tension band technique and plate and screw fixation has been used as one method of fixation. However, Forseth and Stern found that the hardware frequently needed removal (27%) and that patient satisfaction was lower than when Kirschner wires were used. The thumb is fused in a functional position of 20° of radial abduction and 40° of palmar abduction with the thumb tip resting on the middle phalanx of the index finger. Arthrodesis of the TMJ has become less popular because of its many drawbacks. The fixed first–second intermetacarpal abduction angle precludes one from laying the palm flat or from drawing five digits into cone shape to fit narrow openings. Any patient with a stiff MP joint, a zig-zag collapse deformity, an adduction deformity of the metacarpal or a pan-arthritis is not a candidate for this operation. Furthermore, arthrodesis usually requires a prolonged period of immobilization, and is technically demanding with a risk of non-union (5–50%).

Even the benefit in terms of strength has been questioned. Despite the significant loss of motion at the base of the thumb, and the inability to flatten the hand, minimal functional deficit has been reported. In a review of 52 thumbs, 85% were pain free at a mean follow-up of 4 years.

(D) Stage IV osteoarthritis

Until recently, the presence of stage IV disease implied that complete trapeziectomy with ligament reconstruction was necessary. Burton LRTI arthroplasty was the most popular technique used to accomplish this. Barron and Eaton described an alternative technique; double interposition arthroplasty. This technique retains much of the trapezium and resurfaces both the TM and ST joints, with the potential advantage of more predictable maintenance of thumb length. Alternatives procedures include trapeziectomy, trapeziectomy with LRTI, interpositional arthroplasties and TM and STT joint replacements. Interpositional arthroplasties for Stage IV osteoarthritis, such as the Swanson silicone implant arthroplasty and the Helal silicone rubber ball spacer remove the entire trapezium. A trapezium sparing double interposition joint replacement replaces both the TM and STT joints, and can be performed for Stage IV osteoarthritis.

Associated problems

Metacarpophalangeal joint hyperextension: Regardless of the technique chosen for basal joint reconstruction, secondary collapse deformity at the MCP joint should be addressed. Disease at the TMJ can cause dorsal subluxation of the base of the metacarpal leading to metacarpal flexion and adduction and secondary MCP joint hyperextension and can be a distinct source of pain and poor outcome. If the hyperextension deformity is less than 30°, and painless, then observation alone or placement of an oblique transarticular Kirschner wire with the joint in 30° of flexion for 4 weeks is appropriate. Alternatively or in conjunction with temporarily fixed flexion, the insertion of extensor pollicis brevis into the base of the proximal phalanx can be moved to metacarpal shaft. If hyperextension is greater than 30°, options include palmar capsulodesis or arthrodesis. The latter is especially useful for a very unstable MPJ with degenerative changes and/or ulnar collateral ligament insufficiency as well as for a joint that exhibits little flexion.

Complications

Although 80–90% of patients achieve a satisfactory result following a variety of surgical treatments, a minority complain of persistent pain and thumb weakness. The cause
for the persistent pain is a pre-existing condition other than TMJ osteoarthritis (in which case the characteristics of the persistent pain should be similar to the preoperative pain), or due to a complication of surgery. Both the dorsal sensory branch of the radial nerve and palmar cutaneous branch of median nerve are vulnerable to traction injury or laceration when dorsal and volar approaches are used as well as during harvesting of tendons. Damage to these can result in neuroma formation and complex regional pain syndrome.

**Practice points**

- TMJ arthritis is the second most common degenerative joint disease in the hand with more than 30% of postmenopausal women having characteristic radiological changes but the vast majority of these are asymptomatic.
- The beak ligament continues to be considered the primary stabilizer and is still implicated in the pathogenesis of TMJ arthritis.
- Current techniques that restore TMJ stability through ligamentous reconstruction such as the LRTI continue to produce consistently favorable results and have withstood the test of time.
- In Eaton stages 2–3 disease, the newer hemiarthroplasty designs may be an alternative to the traditional LRTI in patients with good bone stock.
- Silicone implant arthroplasty is generally reserved for low-demand patients with inflammatory arthritis or collagen vascular disease.
- Cemented total joint replacement of the TMJ is technically demanding and the results are not encouraging.

**Implications for research**

- Need for further studies to evaluate the long-term outcomes of the commonly used surgical procedures, in particular volar ligament reconstruction (without trapeziectomy) and LRTI.
- Randomized studies comparing techniques with common prognostic factors including stage with both objective and subjective outcome assessment and consistent timing of outcome measures.
- The development of an ideal trapezio-metacarpal joint arthroplasty design.

**References**