Trapeziometacarpal imaging: from radiographs to ultrasonography

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Authors: V. M. Créteur¹, S. Pather², A. Madani³; ¹Brussels/BE, ²Bruxelles/BE, ³Mons/BE
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Learning objectives

Describe the Anatomy and Pathology of the Trapeziometacarpal Joint (TMJ) using simple imaging modalities, such as Radiography and Ultrasonography

Background

The TMJ, connecting the Trapezium to the first Metacarpal, plays a major role in prehension and opposition activities of the human hand. Flexion, extension, adduction and abduction of this masterfully engineered joint allow full 3D motion of the thumb (Fig1) [1]. High mobility means also high constraints, both of these being supported by muscles and ligaments. Although osteoarthritis is the most frequent degenerative disease affecting the TMJ after knee and hip, multiple other circumstances may cause radial sided wrist pain. Differential diagnosis includes Abductor Pollicis Longus and Extensor Pollicis Brevis tendinopathy (known as De Quervain tenosynovitis), intersection syndrome, fractures of trapezium, scaphoïd or distal radius, thumb ulnar collateral ligament injury, neuropathy of the superficial terminal branch of the radial nerve (known as Wartenberg disease), ganglion cyst or carpal tunnel syndrome [2,3]. Therefore, Imaging is frequently required. Standard radiographs are mandatory but Ultrasonography, performed with a high-frequency (17-5 MHz) probe, allows static and dynamic visualization of bone surfaces, joint and soft tissues, and thus represents a simple, useful and cheap complementary modality [4]

Images for this section:
**Fig. 1:** Diagram (right) showing the full range of forces allowing 3D thumb mobility (left). The particular position of first metacarpal, special shape of TMJ as well as combination of adduction, abduction, extension and flexion movements allow thumb opposition, with a range of 45-50° in adduction-abduction and 50-90° in extension-flexion.
Findings and procedure details

**TMJ Anatomy**

The special "double-saddle-shaped" of the TMJ results from the asymmetric fitting of the metacarpal articular surface of the Trapezium, -concave in frontal plane and convex in sagittal plane-, with the trapezial articular surface of the first Metacarpal, - convex in frontal plane and concave in sagittal plane [5]. This highly mobile joint has a cartilaginous coating more developed on its volar side than on its dorsal side and a flexible capsule reinforced by three major ligaments (dorsal, volar and intermetacarpal ligaments) [6]. Five intrinsic (Abductor Pollicis Brevis, Adductor Pollicis, first dorsal Interosseous, Flexor Pollicis Brevis, Opponent) and four extrinsic (Abductor Pollicis Longus, Extensor Pollicis Brevis, Extensor Pollicis Longus, Flexor Pollicis Longus) muscles activate the TMJ and the thumb [7]. TMJ and muscles innervation is rich, depending on radial nerve (TMJ, Abductor Pollicis Longus, Extensor Pollicis Brevis and Longus), median nerve (TMJ, Flexor Pollicis Brevis and Longus, Abductor Pollicis Brevis, Opponent Pollicis) and ulnar nerve (Flexor Pollicis Brevis, Adductor Pollicis, first dorsal Interosseous)[8].

**TMJ Imaging**

TMJ radiographs should include (Fig2)

1. On face and lateral Kapandji views
2. Carpal tunnel view

TMJ ultrasonograms should include (Fig3-10)

1. Palmar and dorsal, longitudinal and transversal views of the joint and the bone surfaces (Fig3)
2. Longitudinal and transversal views of the 3 major TMJ ligaments and volar cartilages (Fig4,5,6,7)
3. Longitudinal and transversal views of intrinsic and extrinsic muscles (Fig8,9,10)

**TMJ Pathology**

Among all TMJ pathologies, osteoarthritis, fracture of the trapezium ridge, abnormal laxity, trapeziectomy and prosthesis are common situations that may remain asymptomatic for a long period of time or may present with unspecific clinical manifestations. Therefore, imaging investigations are often required.
TMJ Osteoarthritis

Radiography is the first imaging step, especially for osteoarthritis, using the Dell's or Eaton-Littler's classifications. Dell's radiological criteria are based on the severity of joint narrowing and first metacarpal subluxation, while Eaton and Littler's are based on the length of osteophytes [9]. In DELL’s classification, Stage 1 corresponds to slight narrowing of joint and subchondral sclerosis; in Stage 2, there is a moderate narrowing and sclerosis, with slight subluxation of first metacarpal (< one third trapezial diameter) and small osteophyte, while in Stage 3, there is important narrowing, sclerosis and osteophytosis, with subluxation of first metacarpal (# one third trapezial diameter). In Stage 4, there is total disappearance of joint, flattening of Trapezium, and peritrapezial osteoarthritis.

However, the moderate interobserver agreement of these classifications systems is recently stressed by Spaans et al, leading to controversies in the use of such radiological quotations [10]. In TMJ osteoarthritis, like in other wrist and hand locations, or in rheumatoid disease, Ultrasonography represents an interesting imaging modality, because it may show superficial irregularities of cortical bones, synovial thickening or inflammation, osteophytes and/or erosions (Fig11-14)[11]. In addition, conflict between osteophytes, muscles, tendons or vessels around pathological TMJ may be nicely demonstrated by dynamic Ultrasonography (Fig14).

TMJ fractures

Trapezial fractures represent 3 to 5% of all carpal fractures, and trapezial fracture is more frequent at ridge than at body. Diagnosis of such fracture is often delayed, because standard radiographs may not demonstrate them, especially if localized at trapezial ridge. Although CT is recommanded in this situation of a suspected trapezium fracture, Ultrasonography may also show ridge fracture, as recently published by Botchu and Bianchi (Fig15)[12].

TMJ ligaments strain or tear

As much as 16 ligaments have been described around the TMJ, but three of them seem to be very important (volar, dorsal and intermetacarpal ligaments). Although their respective role in the stabilization of TMJ remains controversial, abnormal laxity of volar ligament, resulting for example from traumatic TMJ strain, first metacarpal fracture (Bennett's fracture) or trapezium fracture, may represent a predisposing factor in the development of TMJ osteoarthritis. Ultrasonography is a reliable technique to demonstrate normal and abnormal ligament.
**TMJ Volar ligament**

This ligament, also called Anterior Oblique Ligament (AOL), is composed by a deep part (dAOL), in relation with the capsule, and a superficial part (sAOL), in relation with the Abductor Pollicis Brevis muscle (Fig 4) [6, 13].

During palmar abduction-extension stress test, Ultrasonography may document an abnormal laxity of AOL: during this test, a volar translation of first metacarpal relative to trapezium cortex should be ≤ 1mm. Tear or rupture of the volar ligament, occurs more frequently on the metacarpal side of the joint (Fig 5) [14].

**TMJ Dorsal and intermetacarpal ligaments**

Two other ligaments may also be demonstrated by Ultrasonography: the dorsal ligament, also called dorsoradial ligament (DRL), and the intermetacarpal ligament (ML) (Fig 6, 7). The dorsoradial ligament (DRL) links the dorsoradial tubercle of the Trapezium to the dorsal edge of first metacarpal basis, close to the Abductor Pollicis Longus tendon. Dynamic stress test in flexion-adduction toughs the ligament (Fig 6). The intermetacarpal ligament (ML) links the dorsoradial aspect of second metacarpal base to the volar-ulnar aspect of first metacarpal base, close to the Extensor Carpi Radialis Longus tendon insertion. As a result of this peculiar disposition, only the dorsal side of ML could be visualized by Ultrasonogram (Fig 7).

**Trapeziectomy**

When medical treatment of trapeziometacarpal osteoarthritis fails, surgical treatment may be proposed. Among a large variety of surgical procedures, trapeziectomy remains the technique of reference. The trapeziectomy includes an arthrotomy, a partial or complete removal of trapezium bone, and a capsular suture (Fig 16). The trapeziectomy may be associated or not with a ligamentoplasty, and combined or not with an artificial filling of the trapeziectomy space, such as an implant or a prosthesis. In a recent publication, Putterie et al. evaluate clinically and ultrasonographically total trapeziectomy two years post-surgery. This study brings important new information about the nature of the interposed tissue in the trapezial space and about the state of thenar musculature after trapeziectomy (Fig 17, 18) [15].

**Trapezial implants and prostheses**

In case of trapezial implant or prosthesis, the radiological aspects will depend on the interposed material. If the material is non opaque, plain radiographs will not
demonstrate them, as opposed to Ultrasonography. In addition, Ultrasonography may also demonstrate instability of a trapezial Pi2 implant (Fig.19-22). Although Radiography is mandatory in survey of prostheses, Ultrasonography may depict soft tissue complications such as synovitis resulting, for example, from foreign body reactions to silicone components in some TMJ prosthesis. These reactions may develop between 6 months and 9 years after surgery. Although Radiography is usually sufficient to diagnose siliconitis (multiple carpal cystic-like lesions), and MRI often required in order to evaluate of the extent of synovitis and differentiate it from degenerative cysts, one should be aware, when doing an Ultrasonography, of this silicone complication, especially when the implant is not known, when the implant has been removed, or in the presence of persisting swelling and tenderness after surgery [16, 17].

**TMJ infiltrations**

Ultrasonography may be also accurately and safely used for intra-articular injections for medical treatment of TMJ osteoarthritis. This method, recently described by H. Guérini et al[1], demonstrates three advantages of a transmuscular palmar approach of the TMJ under Ultrasonography. These advantages are the absence of contrast material, easy technique avoiding osteophytes and adequate intrarticular injection of medication, using the "duck sign" demonstrated on Fig.11 [18].

**Images for this section:**
**Fig. 1:** Diagram (right) showing the full range of forces allowing 3D thumb mobility (left). The particular position of first metacarpal, special shape of TMJ as well as combination of adduction, abduction, extension and flexion movements allow thumb opposition, with a range of 45-50° in adduction-abduction and 50-90° in extension-flexion.

**Fig. 2:** TMJ Radiography Three views are realized: Kapandji on face (left), lateral (middle) and carpal tunnel (right). The trapezial concavity in frontal plane (yellow signs) and convexity in sagittal plane (blue signs) as well as the trapezial ridge (white signs) are clearly visible on these pictures. Top clinical views indicate X-ray localization technique.
Fig. 3: TMJ Ultrasonography Longitudinal palmar (top), longitudinal dorsal (middle) and transversal palmar (bottom) sonograms demonstrate the regular hyperechoic bone surfaces (left) with corresponding clinical views showing probe’s positioning (right). Red arrow = radial artery in the snuff box White arrow = trapezial ridge TRAP, T = trapezium M1 = first metacarpal
**Fig. 4:** Palmar TMJ ligament (AOL, beak) Ultrasonography Schema (modified from Cardoso et al ref 6) (left), clinical view with probe position (top right) and sonogram (bottom right). This ligament, localized between volar trapezium (T) and first metacarpal base (M1), that is taught during extension-abduction stress test (see also video), is identified as a linear hyperechoic band (A) slightly thicker in its mid-portion (0.98mm) than in its metacarpal or trapezial sides (respectively 0.70mm and 0.65mm). The superficial part of the ligament (sAOL on schema, plain arrow on sonogram) covers its deep part (dAOL on schema, dotted arrow on sonogram) which appears as a hyperechoic triangle in continuity with articular capsule.
Fig. 5: Palmar Ultrasonograms of TMJ (left) and schema (right) illustrate the palmar ligament (Anterior Oblique Ligament-AOL), at rest (top left) and during abduction-extension stress test (bottom left). Superficial AOL (sAOL) is in contact with Abductor Pollicis Brevis (APB), while deep AOL (dAOL) is in contact with joint capsule. During stress test, the mean volar translation of first metacarpal relative to trapezium cortex should be # 1mm; here the translation reaches 3 mm. A hypoechoic zone, compatible with a rupture, is delineated on the metacarpal side of the ligament (thin white arrow)
Fig. 6: Dorsal TMJ ligament (DRL) Ultrasonography Schema (modified from Cardoso et al ref 6) (left), clinical view with probe position (top right) and sonogram (bottom right). This ligament, localized between dorsal trapezium (T) and first metacarpal base (M1), is taught during flexion-adduction stress test (see also video). Normal ligament (yellow arrows) has regular straight borders and often appears hypoechoic because of anisotropy
Fig. 7: Intermetacarpal TMJ ligament (ML) Ultrasonography Schema (modified from Cardoso et al ref 6) (left), clinical view with probe position (top right) and sonogram (bottom right). This ligament runs obliquely from dorsal aspect of second metacarpal (M2) to volar aspect of first metacarpal (M1) and is taught during extension of the hand and thumb abduction-flexion. This ligament is only visible on sonogram at the dorsal base of second metacarpal (green arrows), close to Extensor Carpi Radialis Brevis insertion (ECRL) AR = radial artery.

Fig. 8: TMJ cartilages Ultrasonography: 3D graph from Primal Pictures 2012© (left) and palmar longitudinal sonogram (right) show one part of the palmar cartilages (green arrows). Dorsal cartilages are usually less visible on sonogram (compare with fig6).
**Fig. 9:** Intrinsic muscles (thenar muscles) Ultrasonography Clinical views with probe position (left) and sonograms (right) depict intrinsic muscles around TMJ. Five intrinsic muscles are originating from the hand and wrist and are responsible for fine motion of the thumb. The Abductor Pollicis Brevis, well demonstrated on palmar longitudinal view, covers the palmar side of TMJ. The other four intrinsic muscles are well seen on transversal view of thenar eminence. m1 = first metacarpal m2 = second metacarpal FCPs = superficial part of Flexor Pollicis Brevis FCPp = deep part of Flexor Pollicis Brevis OPP = opponent t = Flexor Pollicis Longus tendon ADD = Adductor Pollicis DI = first dorsal Interosseous
**Fig. 10:** Extrinsic muscles Ultrasonography The extrinsic muscles are long flexors and extensors that originate in the forearm. They are responsible for the powerful gripping force of the hand, and gross hand movements. Four of them are intended to the thumb; their tendons are easily demonstrated on transversal sonograms at dorsal wrist and thenar eminence (arrows) LA = Abductor Pollicis Longus tendon CE = Extensor Pollicis Brevis tendon LE = Extensor Pollicis Longus tendon FPL = Flexor Pollicis Longus tendon Lister = Lister tubercle

![Extrinsic muscles Ultrasonography](image)

**Fig. 11:** Lateral Kapandji Radiograph (left) and palmar Ultrasonogram (right) of normal TMJ. Cortical surfaces are regular and smooth. The joint is slightly opened ("duck sign") at rest on Radiograph and on Ultrasonogram (arrows), but normal AOL is demonstrated on Ultrasonogram. The "duck sign" is helpful when intrarticular TMJ injection is required

![Lateral Kapandji Radiograph](image)

**Fig. 12:** Lateral Kapandji Radiograph (left) and dorsal Ultrasonogram (right) of TMJ osteoarthritis (DELL2). Small osteophyte is demonstrated on both modalities (yellow arrows) as well as discrete dorsoradial subluxation of first metacarpal. Thickening of dorsal soft tissue on Radiograph corresponds to thickened and bulging DRL on Ultrasonogram (small green arrows)

![Lateral Kapandji Radiograph](image)
Fig. 13: Lateral Kapandji Radiograph (left) and palmar Ultrasonogram of TMJ osteoarthritis (DELL3). Big osteophytes are observed on both modalities (orange arrows) but capsular bulging and disappearance of AOL are depicted only on Ultrasonogram.

Fig. 14: Lateral Kapandji Radiograph (left), dorsal (top right) and palmar Doppler (bottom right) Ultrasonograms of TMJ osteoarthritis (DELL4). Trapezial flattening and scaphotrapezial osteoarthritis are better analyzed on Radiograph, but the relationship of a multiloculated unpainfull cyst with radial artery on dorsal TMJ (red arrow) and the
contact of big painful palmar osteophyte with APB (green arrow) are diagnosed with Ultrasonogram.

**Fig. 15:** Transversal Ultrasonogram (left) and axial Computed Tomography (right) demonstrate a fracture at the trapezial ridge (black arrowhead), close to the insertion of carpal retinaculum (white arrow). Trapezium is marked with an asterisk. Courtesy issued from Botch and Bianchi (ref12)

**Fig. 16:** 3D graph from Primal Pictures 2012© (left), Photography of the resected Trapezium (middle) and early postoperative Radiograph of the hand. The trapeziectomy space appears "empty" between scaphoid and first metacarpal base
Fig. 17: Palmar Ultrasonograms (top) with corresponding Radiographs (bottom) in native TMJ and post trapeziectomy (arrow). A slight shortening of scapho (S) metacarpal (M1) distance is observed after trapeziectomy on both modalities. Asterisk shows some thinning of thenar muscles after trapeziectomy T = Trapezium M1 = first metacarpal S = scaphoid
**Fig. 18:** Palmar Ultrasonograms (left) and Radiography (right) after trapeziectomy. The trapeziectomy space is usually hyperechoic with a concave surface ("gullwing" sign; white arrows). Comparison between operated side (bottom left) and non-operated side (bottom right) in the same patient demonstrate similar thickness and echotexture of both APB, which is normal since APB does not have any insertions on Trapezium (red lines). Question mark on bottom left Ultrasonogram reminds that the patient did not mention any surgery at the time of sonographic examination, although trapeziectomy was confirmed in her medical chart.

**Fig. 19:** Four Radiographs demonstrating frequently used radiopaque implants and prostheses. In case of Pyrocarbone implant (Pi2), the trapeziectomy is associated with a trapezoid osteotomy to allow the placement of such "olive-like" implant. This material has no fixations: it is called a spacer. Pyrodisc implantation requires a trapeziectomy,
scaphoid and trapezoid osteotomies; the orthopedic material is fixed by ligamentoplasty through its central hole. In case of ARPE ® prosthesis, there is osteotomy of distal Trapezium and proximal first metacarpal. A sufficient thickness of residual Trapezium (at least 8 mm) is necessary to allow good implantation of the cup. In case of a OXALYS© prosthesis, same procedure. Notice that the proximal part of the prosthesis head is composed by silicone.

**Fig. 20:** On face and lateral Radiographs (right) and Ultrasonograms at rest (top left) show normal positioning of the Pi2 implant. This implant is radiopaque on X-ray and hyperechoic on sonogram. During even soft dynamic Ultrasonogram (bottom left), it is possible to demonstrate, like an olive pit, the palmar expulsion of the implant outside of its bed. This instability is very painful and sometimes remains irreducible.
**Fig. 21:** In case of a radiolucent implant, such as in Dacron anchovy, the Ultrasonogram may display the implant as a slightly rolled up, laminated and hyperechoic structure located inside the trapeziectomy space. On the right, a Photography of such an implant, courtesy from Vouillaumé et al in Chirurgie de la main 2003;22:197-202

![Image](image1.png)

**Fig. 22:** Longitudinal palmar Ultrasonogram (top) and Radiograph (bottom) are realized because of distal thumb pain five years after TMJ replacement with ARPE© prosthesis. Radiograph shows osseous resorption around the tip of the prosthesis tail (dotted black arrows). Ultrasonogram is tricky, because trapezial height is almost normal and cortical surfaces look quite regular. The only subtle finding that may raise the possibility of prosthesis is the linear reverberation echo localized at 4, 6 mm below the TMJ surface. This linear echo corresponds to the palmar side of the prosthesis cervix (red arrows).
Conclusion

In exploring wrist or thumb pain, tenderness or swelling, plain radiography remains mandatory. However, Ultrasonography may have significant clinical impact in detecting early osteoarthritis, volar ligament laxity or tear, occult trapezial ridge fracture, soft tissue or synovitis complications around orthopedic TMJ material, metallic or not. It can be used also for post-trapeziectomy evaluation and local TMJ medication infiltrations.

In addition, as Ultrasonography may be the first imaging step in radial sided wrist pain or thumb pain, or even in the evaluation of a suspected carpal tunnel syndrome, one should be aware of the diagnostic capabilities of Ultrasonography when realized with appropriate equipment and standardized methods.

Personal information

References

1. WP Cooney, MJ Lucca, RL Linscheid The kinesiology of the thumb trapeziometacarpal joint J Bone Joint surg Am 1981;63(9):1371-1381


5. EA.Zancolli The trapeziometacarpal joint: Tenotomy of the Accessory Tendons in Early Osteoarthritis Hands Clinics 2001;17(1):13-43


10. AJ Spaans, CM Laarhoven, AH Schuurman, LP van Minnen Interobserver Agreement of the Eaton-Littler Classification System and Treatment Strategy of Thumb Carpometacarpal Joint Osteoarthritis J Hand Surg Am 2011;36(9):1467-70


