EURO-MUSCULUS/USPRM Dynamic Ultrasound Protocols for Wrist and Hand

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This feature is a unique combination of text (voice) and video that more clearly presents and explains procedures in musculoskeletal medicine. These videos will be available on the journal's Website. We hope that this feature will change and enhance the learning experience.

Walter R. Frontera, MD, PhD
Editor-in-Chief

Abstract: In this dynamic protocol, ultrasound evaluation of the wrist and hand is described using various maneuvers for relevant conditions. Scanning videos are coupled with real-time patient examination videos. The authors believe that this practical guide—prepared by the international consensus of several experts—will help musculoskeletal physicians perform a better and uniform/standard examination approach.

Key Words: Finger, Ultrasonography, Tendon, Maneuver, Physical and Rehabilitation Medicine

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The utility of musculoskeletal ultrasound (US) has already become a routine in the daily clinical practice of physiatrists. As an extension of basic/static scanning, dynamic assessment is a critical advantage of this examination technique. However, protocols for implementing this method in the wrist and hand do not exist in the literature. Like the previous basic scanning protocols in physical and rehabilitation medicine,[1–3] an international group of experts (European Musculoskeletal Ultrasound Study Group in Physical and Rehabilitation Medicine [EURO-MUSCULUS] and Ultrasound Study Group of the International Society of Physical and Rehabilitation Medicine [USPRM]) also prepared this guide for dynamic assessment of wrist and hand disorders.

DORSAL ASPECT OF THE WRIST

Radiocarpal Joint

Technique

The patient should sit face-to-face with the examiner keeping the hand in palm-down position, resting on an examination bed or the patient's ipsilateral knee, while the forearm is pronated and the elbow is semiflexed at approximately 90 degrees. The transducer is placed along the long-axis of the wrist. Bony prominences serve as anatomic landmarks for both orientation and evaluation of the joint stability. The authors also suggest placing a support underneath the patient's wrist or positioning the wrist over the edge of the examination bed/table, that is, to have mild volar flexion.

Clinical Indications

Radiocarpal Joint Effusion

Dynamic scanning allows better visualization of the radiocarpal joint effusion. With the patient's hand in a palm-down position, the wrist joint is slowly bent (dorsal/palmar) while resting on the examination table. This dynamic assessment is commonly performed in the long-axis view, at the level of the lunate bone. During the maneuver, it is possible to observe that the radiocarpal joint recess is stretched with palmar flexion and compressed while the wrist is dorsally flexed (Figs. 1A–C and Video 1, http://links.lww.com/PHM/B597). Of note, mild effusion/synovial hypertrophy can be missed during static scanning of the wrist in neutral position or dorsal flexion. Likewise, differentiating between synovial proliferation and effusion can also be challenging with only static imaging. Furthermore, loose bodies (e.g., cartilage or bony fragments) inside the joint can be better identified during dynamic scanning. As such, using these passive wrist flexion/extension maneuvers will potentially help elucidate the presence of all previously mentioned conditions (Video 2, http://links.lww.com/PHM/B598).

Triangular Fibrocartilage Complex Injuries

For dynamic examination of the triangular fibrocartilage complex, the probe is placed over the extensor carpi ulnaris tendon along its long-axis. The radioulnar deviation allows evaluation of the fibrocartilage disc with its attachment site to the distal radius and of the meniscus homolog (Figs. 1D, E and Video 3,

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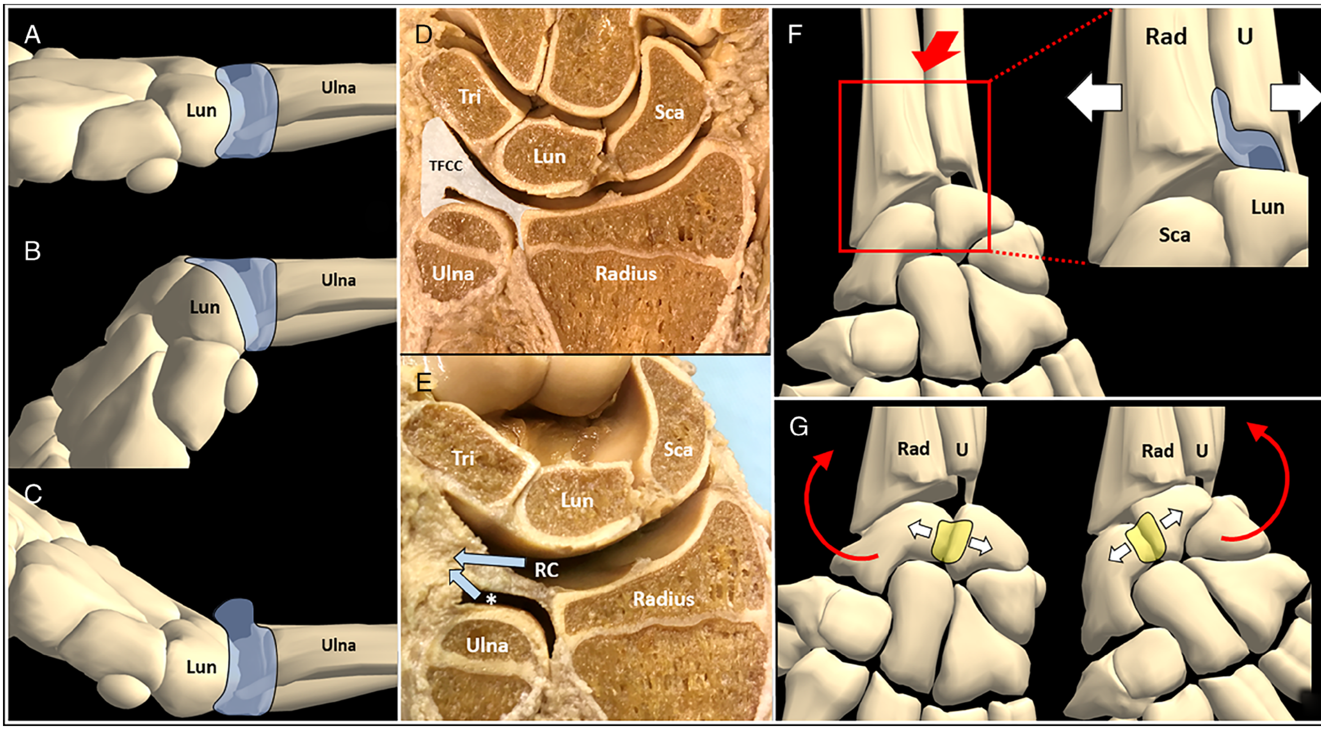

FIGURE 1. Schematic drawings and cadaveric specimens show the dynamic assessment of the radiocarpal synovial cavity (light blue) during flexion/extension of the wrist (A–C), of the triangular fibrocartilage complex located at the level of the ulnocarpal space during radial/ulnar deviation of the wrist (D, E), the distal radioulnar joint (light blue) during the squeeze maneuver (red arrow) of the distal forearm (F), and of the dorsal scapholunate ligament (yellow) during stress movements (red arrows) of the wrist (G). lun, lunate; rad, radius; RC, radiocarpal joint; sca, scaphoid; tri, triquetrum; u, ulna. Blue arrows, flow of the synovial fluid; white arrows, articular diastasis; white asterisk, distal radioulnar joint recess.

http://links.lww.com/PHM/B599). Using ulnar and radial deviations, the stress test can reveal fluid being penetrated within the triangular fibrocartilage complex as an apparent cleft opening toward its inside (indicating a tear; Videos 4 and 5, http://links.lww.com/PHM/B600, http://links.lww.com/PHM/B601). The fluid can also derive from the radiocarpal joint and/or the distal radioulnar joint (Fig. 1E). In some cases, a larger gap can also be observed between the proximal carpal bones and the ulna during radial deviation.[4,5]

Distal Radioulnar Joint Instability

For dynamic assessment, the examiner applies a squeezing force to the interosseous membrane at midforearm level, placing the thumb on the dorsal aspect while the remaining fingers are placed on the volar aspect of the forearm.[6] At the same time, the physician uses his other hand to place the US probe in short-axis view over the distal forearm, visualizing the Lister's tubercle on one side and the apex of the ulnar styloid on the other side of the US screen (Video 6, http://links.lww.com/PHM/B602). When abnormal, the diastasis is associated with the distraction of the previously mentioned bony landmarks (Fig. 1F and Video 7, http://links.lww.com/PHM/B603). The contralateral side can, for sure, be used as the reference.[5] Distal radioulnar joint instability can be congenital (in patients with laxity of the capsuloligamentous structures), or be related to chronic overloads of the wrist, or can be posttraumatic. Particularly, in patients with posttraumatic instability (a high-grade instability), during the dynamic maneuver and the squeezing phase of the technique, the diastasis of bones is associated with a bulging of the dorsal aspect of the synovial membrane—due to dynamic flow of the intra-articular effusion.

Carpal Bones and Ligaments

Technique

The patient sits in front of the examiner with the palm-down, the forearm pronated, and the elbow flexed at approximately 90 degrees. The palmar and dorsal aspects are used to visualize the bony surfaces of the radius, ulna, and carpal bones, and the ligaments that interconnect the above structures. Initially, the transducer is positioned on the Lister's tubercle when scanning from the dorsal aspect and then it is advanced distally toward the fingers. Smooth surfaces of the individual carpal bones can be identified, forming the proximal and distal rows, together with the intrinsic and extrinsic ligaments.

Systematic scanning from the palmar side starts at the distal wrist crease. Moving the transducer distally, the scaphoid tubercle and the pisiform bone can be observed bridging the carpal tunnel. Two important bony landmarks can be observed when advancing the probe further toward the fingers: the trapezium tubercle and the hook of the hamate. Relocating the probe along the fingers, individual metacarpal bones can also be identified.

Ultrasound allows a comprehensive assessment of the extrinsic and intrinsic wrist ligaments as hyperechoic bands connecting the individual bones.[7] It is essential to direct the sound beam as perpendicular as possible to avoid anisotropy artifact that can otherwise be misinterpreted as a pathology (e.g., edema, tear). A ligament tear is suspected if the fibers are discontinuous or the ligament is absent. In addition, corresponding cortical irregularity and/or ligament thinning should also caution the examiner. Herein, dynamic examination will allow for better visualization of the ligament stability (Videos 8 and 9, http://links.lww.com/PHM/B604, http://links.lww.com/PHM/B605).[8] One can either apply stress to the joint to generate tension on the ligaments or directly compress with the probe. Separation of the (torn) ends or penetration of the overlying superficial tissues toward the joint would be the relevant findings for instability and/or rupture. For sure, dynamic testing may also reveal an impingement due to ligament tear/instability.[9]

Clinical Indications

Scapholunate Ligament Dysfunction

The transducer is first placed in the short-axis view over the radiocarpal joint on the distal forearm (dorsal side). While the probe is being moved distally, the two bony structures on the screen will represent scaphoid and lunate. A V-shaped hypoechoic area is apparent between these two bones, while the gap (hypoechoic area) in the scapholunate joint is filled with the dorsal portion of the scapholunate ligament. The ligament can be stressed dynamically by moving the patient's wrist into ulnar deviation and any increase in the width between the two bones can be checked (Fig. 1G) for scapholunate dissociation.[10] Aside from their diastasis, common sonographic findings also include penetration of synovial fluid through a focal gap of the ligament (Video 10, http://links.lww.com/PHM/B606) and abnormal movements of a small bony fragment in case of posttraumatic avulsion. Alternative maneuvers to mechanically stress the ligament—that is, (de)tensioning—would be opening/closing the fist and palmar/dorsal flexions of the wrist.

Scaphoid Fracture

The scaphoid bone should optimally be scanned in short/long-axis while the wrist is positioned in ulnar deviation. The typical finding for fracture is discontinuity of the bony cortex. Indirect signs are radiocarpal hemarthrosis and scapho-trapezium-trapezoid effusion.[11] Needless to say, nearby soft tissues changes, such as callus formation, can easily be detected by US examination.[12] The sonographer can also apply stress tests to check for the (in)stability of the fracture and/or callus. Dynamic maneuvers using passive movements can demonstrate fracture nonunion with apparent motion between the two bone fragments.[13]

Extensor Tendons

Technique

The patient sits in front of the examiner with the palm-down, the forearm pronated, and the elbow flexed at 90 degrees. The probe is placed at the level of the distal radioulnar joint over the Lister's tubercle, which is the bony landmark that separates the second and third compartment. Sliding the probe toward the ulnar/radial side, all six extensor compartments can be systematically evaluated. Dynamic scanning allows evaluation of tendon gliding beneath the extensor retinaculum and within the tendon sheaths (Fig. 2). Active/passive flexion and extension of the fingers will confirm integrity of the normal-appearing hyperechoic tendons from proximal to distal as necessary. Likewise, intersections syndromes—that is, either the first compartment crossing over the second proximally or the third one crossing over the second distally—can also/thoroughly be examined (Video 11, http://links.lww.com/PHM/B607).[14]

Clinical Indications

Extensor Retinaculum Impingement

During the active movement (e.g., flexion/extension of the fingers and radial/ulnar deviation of the wrist; Video 12, http://links.lww.com/PHM/B608), it is possible to identify the location of a mechanical conflict between the extensor tendons and the retinaculum (Fig. 2 and Video 13, http://links.lww.com/PHM/B609). In

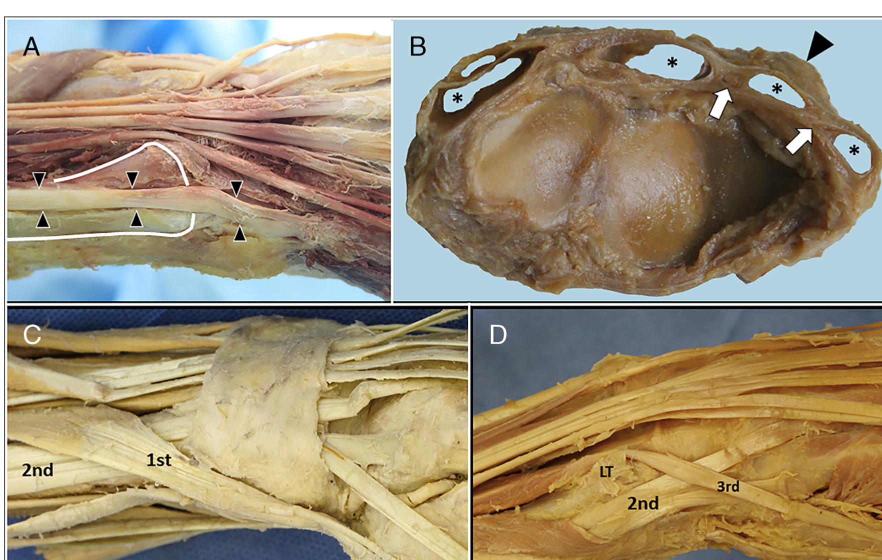

FIGURE 2. Cadaveric specimens show the anatomical location of the extensor carpi ulnaris tendon (black arrowheads) within the bony groove of the ulna (white lines; A), the fibrous sheaths (black asterisks) of the extensor tendons with a dorsal component (black arrowhead) and intercanal septa (white arrows; B) and the sites of proximal (C) and distal (D) intersection syndromes. 1st, first extensor compartment; 2nd, second extensor compartment; 3rd, third extensor compartment. LT, Lister's tubercle.

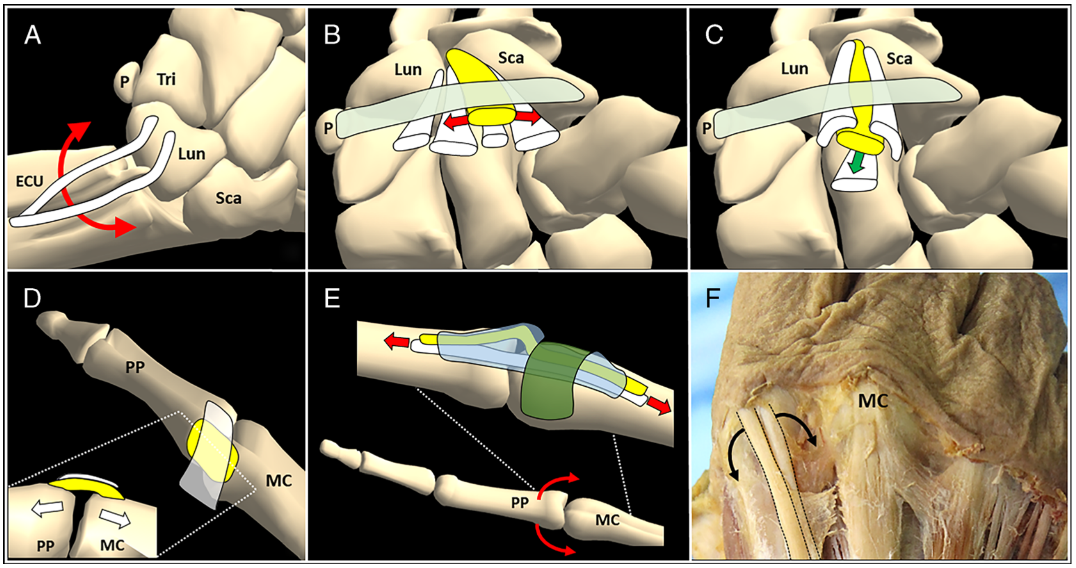

FIGURE 3. Schematic drawings and cadaveric specimens show the dynamic evaluation of the extensor carpi ulnaris tendon during pronation/supination (double red arrow) of the wrist/forearm (A), of the lateral gliding (red arrows) and torsional movements (green arrow) of the median nerve (yellow) within the carpal tunnel among the flexor tendons (white; B, C), of the UCL (yellow) of the thumb—beneath the adductor aponeurosis (white)—during the valgus stress test (D), of the gliding movements (thick red arrows) of flexor digitorum superficialis (yellow) and profundus (white) tendons within the synovial sheath (light blue) and beneath the A1 pulley (green) during flexion/extension (thin red arrows) of the finger (E), and of the extensor tendons (black dotted lines) of the finger while closing the hand into a fist (F). Lun, lunate; MC, metacarpal bone; p, pisiform; PP, proximal phalanx; sca, scaphoid; tri, triquetrum. Black arrows, shifting movements of the extensor tendons; light green, transverse carpal ligament; white arrows, articular diastasis.

some cases, the thickened retinaculum can mimic trigger finger symptoms whereby dynamic US examination would definitely be contributory.[15,16] Similar to other conditions, if a mass or bone fragment is present at this location, dynamic scanning can also explain the exact causal relationship between the pathology and the patient's complaint.

Subluxation of the Extensor Carpi Ulnaris Tendon

During forearm pronation and supination, scanning can be performed in the short-axis view where the tendon is located within its subsheath—separate from the common extensor retinaculum (Fig. 2 and Video 14, http://links.lww.com/PHM/B610). Extensor carpi ulnaris instability can be diagnosed if the tendon is slipping out of the ulnar groove in a volar-ulnar direction during supination and relocating during pronation of the forearm (Fig. 3A and Video 15, http://links.lww.com/PHM/B611). The dislocation can be accompanied by a click sound over the wrist's dorsoulnar aspect.[17] It is noteworthy that increased mobility of the tendon can also be a normal variation, for example, if it resides in a shallow groove.[18]

De Quervain Tenosynovitis

From the basic position over Lister's tubercle, the transducer is shifted radially to depict the first extensor compartment which harbors abductor pollicis longus and extensor pollicis brevis tendons. Sonographic findings of De Quervain tenosynovitis include thickening of the extensor retinaculum and/or tendons and their synovial sheath. Attention should also be paid during the US examination for septa that would cause further compartmentalization and/or extra terminal attachments of the tendons (Video 16, http://links.lww.com/PHM/B612). These conditions might predispose to De Quervain tenosynovitis because of increased friction. Dynamic US examination during thumb extension can reveal snapping phenomena pertaining to an uneven excursion of the extensor pollicis brevis subcompartment[19] or the gliding extensor pollicis brevis over the accessory abductor pollicis longus tendon.[20]

Dorsal Wrist Ganglion

Ganglia are common pathologies at the dorsal wrist where dynamic US evaluation helps determine their origins, for example, joint, nearby tendon sheath. In particular, the articular ganglion shows limited excursion due to its connection with the dorsal joint recess and, in the latter case, the ganglion displays consensual gliding with the extensor tendon.[21] Similarly, as ganglia can expand between the extensor compartments, their relationship can promptly be uncovered to explain the complaint(s) of the patient (e.g., snapping ganglion during ulnar/radial deviation of the wrist).[22] Last, the examiner can also assess the ganglion cyst compressibility before considering an aspiration or planning for the appropriate technique (Video 17, http://links.lww.com/PHM/B613). Needless to say, hypo/anechoic-appearing accessory muscles of the hand should not be misdiagnosed as ganglia and dynamic imaging would again/also be contributory for such a differential diagnosis (Video 18, http://links.lww.com/PHM/B614).

VOLAR ASPECT OF THE WRIST

The patient sits opposite to the examiner with the hand in a palm-up position, resting on an examination bed or a pillow, the forearm supinated, and the elbow semiflexed at 90 degrees. The transducer is placed along the short-axis view on the volar aspect of the wrist to visualize the median and ulnar nerves and the flexor tendons. For sure, the palmar longitudinal window can also be used. During dynamic imaging, active/passive flexion and extension of the fingers is commonly performed whereby flexor tendons' integrity and gliding patterns are examined. In addition, structure/mobility of the median nerve as well as the palmar aponeurosis can also be evaluated.

Clinical Indications

Carpal Tunnel Syndrome

Median nerve mobility is likely to be reduced in patients with carpal tunnel syndrome.[23,24] Dynamic scanning on the short-axis view allows visualization of the mobility of the median nerve while the patient fully flexes the fingers (by slowly making a fist). The grade of its axial mobility at the carpal tunnel can be classified as follows: grade 0 (decreased) refers to minimal movement of the median nerve; grade 1 (slightly decreased) refers to freely moving median nerve in the transverse plane, which does not dive deep toward the flexor tendons; and grade 2 (normal) refers to freely moving median nerve between the flexor tendons (Video 19, http://links.lww.com/PHM/B615 and Figs. 3B, C).[25] Furthermore, dynamic scanning in the transverse plane (during finger flexion/extension) allows differentiation of tendinous structures from synovitis. Importantly, due to anatomical continuity between epimysium and the paraneural sheath, transverse displacement of the median nerve can also be reduced at the midforearm level in carpal tunnel syndrome patients.[26] Likewise, impaired longitudinal excursion of the nerve has also been reported in carpal tunnel syndrome.[27]

Accessory Muscles

Dynamic US examination can reveal accessory muscles that might compress the adjacent nerves (Video 20, http://links.lww.com/PHM/B616).[28] For instance, an anomalous muscle belly of the flexor digitorum superficialis of the index finger can be observed compressing the median nerve during finger flexion and extension.[29] Another common accessory muscle in the wrist and hand area is the abductor digiti minimi, which runs through the Guyon canal—causing ulnar nerve compression. When the patient abducts the little finger, increase in the muscle thickness as well as nerve impingement can be observed.[30] During the dynamic technique, an eventual intrusion of the lumbrical muscles can also be observed within the carpal tunnel (Video 21, http://links.lww.com/PHM/B617).

HAND AND FINGERS

The patient sits face-to-face with the examiner in different positions, depending on the hand/finger aspect studied. On the dorsal side, attachments of the extensor tendons can be visualized. Flexor tendons (Videos 22 and 23, http://links.lww.com/PHM/B618, http://links.lww.com/PHM/B619), annular pulley system, and volar plates can be evaluated on the volar side of the fingers. Each tendon needs to be scanned in short and long-axes—also followed until its insertion. Dynamic maneuvers, for example, passive/active finger flexion and extension, valgus/varus stress tests, and resisted flexion/extension can easily be performed. In certain cases (e.g., finger deformities), the examination inside a water basin can be beneficial to optimize the imaging quality.

Clinical Indications

Midcarpal Instability

Dynamic US evaluation can clarify the painful triquetral catch-up clunk, most commonly present with ulnar deviation. Examination is carried out both during pronation and supination. The patient performs radial and ulnar abduction, while the examiner holds the patient's fingers and follows the screen for clunks produced by translocation of the proximal carpal bones.[31]

Dupuytren Contracture

In some cases, dynamic techniques can help in the differential diagnosis of Dupuytren contracture,[32] including trigger finger, tenosynovitis, ganglion, dermoid cyst, and soft tissue masses.[33] In the early phase of Dupuytren contracture, the tendons are seen to move smoothly below the palmar fibromatosis (Video 24, http://links.lww.com/PHM/B620).[34] In later stages, the adhesion of the nodules to the tendons (due to their mutual cord-like attachments) can be visualized under dynamic imaging.[35]

Gamekeeper's Thumb (Skier's Thumb or Stener Lesion)

Dynamic stress can be applied to evaluate the integrity of the ulnar collateral ligament (UCL) of the metacarpophalangeal (MCP) joint of the thumb.[36] The palm-down position of the hand on the examination table will allow access to the radial aspect of the thumb, which is optimal for UCL imaging. Alternatively, the injured thumb grips a bottle while the examiner's free hand performs a valgus stress test (Video 25, http://links.lww.com/PHM/B621)—checking for an increase in the distance between the proximal phalanx and the first metacarpal bone (Fig. 3D). An intact UCL is best seen longitudinally on the radial side of the first MCP joint. Dynamic maneuver using valgus stress to the MCP joint can be applied to classify the injury into a nondisplaced UCL tear or a Stener lesion (Video 26, http://links.lww.com/PHM/B622). Normally, a limited joint gap opening and tensioning of the UCL are to be observed.[36] If painful, local anesthesia (e.g., vapor coolant spray) can be used during the test. Needless to say, these dynamic tests should be performed gently, that is, avoiding conversion of a nondisplaced injury into a Stener lesion.[37]

Trigger Finger

The patient is seated face-to-face with the examiner, keeping the affected hand in a palm-up position. Enough US gel (alternatively stand-off pad or water filled basin) can allow minimal probe pressure and maintain contact with the finger during dynamic scanning. The transducer is placed along the long-axis of the finger to visualize the flexor tendons as hyperechoic fibrillar bands superficial to the metacarpals/phalanges. Annular pulleys are seen as hypoechoic thickening of (the volar aspect of) the tendon sheath. Thickening and hypervascularization of the A1 pulley (most commonly) are the hallmarks of trigger fingers on sonography.[38] Herewith, dynamic examination during flexion/extension of the finger should be performed to evaluate the gliding of the tendon beneath the pulley system (Fig. 3E, Videos 27 and 28, http://links.lww.com/PHM/B623, http://links.lww.com/PHM/B624). This examination might give a better insight regarding the exact cause/site of triggering (not always at the A1 pulley level).[39,40] Aside from pulley swelling/thickening or effusion inside the synovial sheath, tendon thickening and abnormal tendon motions associated with friction patterns are other typical US findings (Video 29, http://links.lww.com/PHM/B625).[41] In some cases, triggering due to swelling of other pulleys can also be observed during dynamic imaging (Videos 30 and 31, http://links.lww.com/PHM/B626, http://links.lww.com/PHM/B627). Of note, differential diagnosis for trigger finger—for example, fibrous scar due to tendon rupture, tendon sheath tumors, ganglia, and exostoses—can be identified using (dynamic) US as well.[42]

Pulley Rupture

Similar to the trigger finger examination, integrity of the pulley system can be evaluated promptly using US imaging. The annular pulleys are first recognized in their short-axis view (along the long-axis of the fingers) as tiny hypoechoic linear bands overlying the flexor tendons. The pulley system allows stabilization of the flexor tendons on the anterior phalangeal cortex. In cases of ruptures, either the pulley cannot be clearly/directly visualized or the characteristic/indirect finding of flexor tendon dislocation (away from the adjacent cortex) can be observed as "bowstringing." The patient can be asked to perform resisted flexion with his fingertip against the examiner to increase the diagnostic certainty whereby the tendons will normally remain adjacent to the underlying bony surface (Video 32, http://links.lww.com/PHM/B628). While maximal bowstringing over the proximal phalanx indicates an A2 pulley injury (Video 33, http://links.lww.com/PHM/B629), in A4 pulley injuries, the bowstringing is mostly pronounced at the middle phalanx level.[43]

Volar Plate Injuries

Dynamic studies can be used to determine the amount of soft tissue edema and mobility of the volar plate (Video 34, http://links.lww.com/PHM/B630). The unstable volar plate can be visualized during hyperextension—with increased mobility.[44] Dynamic testing should particularly be performed in posttraumatic conditions. The most common pathological US findings are (1) penetration of joint effusion within a focal gap of the volar plate (Video 35, http://links.lww.com/PHM/B631), (2) excessive excursion of the volar plate (chronic instability due to a previous trauma), and (3) aberrant movements of a small (bony) fragment in avulsions of the volar plate attachment on the base of the phalanx. Herewith, in some patients, a posttraumatic exuberant scar of the volar plate can lead to a mechanical conflict of the joint—easily depictable during dynamic imaging.

Proximal Interphalangeal and Distal Interphalangeal Joint Instability

Dynamic imaging under stress (valgus for ulnar and varus for radial ligaments) or with sagittal plane instability induced by hyperextension forces may be useful for assessing interphalangeal joint integrity (Video 36, http://links.lww.com/PHM/B632). Collateral ligament injuries range from sprains and partial-thickness tears with no or minimal loss of articular stability to complete tears with significant joint instability.[45] Sagittal plane instabilities of the proximal interphalangeal and distal interphalangeal joints can be associated with lesions of volar plates, collateral ligaments, or even bone fractures. Accordingly, during the US examination, it should be kept in mind that acute trauma can be associated with collateral ligament sprain, partial tear, or complete disruption. Various levels of valgus/varus instability can be determined using stress under dynamic scanning. Chronic instability of these joints is usually coupled with thickening of the collateral ligaments, fibrosis, formation of enthesophytes, or even avulsion fractures of the collateral ligaments.[46]

Clenched Fist—Human Bite Injury

This injury is frequently associated with complete or partial tears of the extensor tendons. Sonographic characteristics comprise soft tissue hypoechogenicity, consistent with edema and tendon disruption. Dynamic imaging during MCP joint active or passive flexion/extension can be confirmatory in ambiguous cases—showing the extent of the lesion.

Boxer's Knuckle

Dynamic US study in the axial plane, at the level of the distal metacarpal heads, can demonstrate partial/complete instability of the digital extensor tendons during flexion of the extended MCP joint against resistance (Video 37, http://links.lww.com/PHM/B633). The type of tendon instability is related to the seriousness of the sagittal band injury (Fig. 3F). The sagittal bands connect the extensor tendons to the collateral ligaments and the volar plates of the MCP joints. Subluxation may also be congenital (Video 38, http://links.lww.com/PHM/B634) or acquired (Video 39, http://links.lww.com/PHM/B635) because of degenerative/inflammatory changes of the sagittal band.

Insertional Tendinous Ruptures

During active/passive movements, the extensor/flexor tendon integrity can be assessed until its insertion at the base of the distal phalanx (Videos 35 and 40, http://links.lww.com/PHM/B631, http://links.lww.com/PHM/B636). From the dorsal aspect, the extensor tendon tear (Video 41, http://links.lww.com/PHM/B637) or the distal phalanx avulsion fracture (i.e., "Mallet finger") can be clearly exposed.[47] From the volar aspect, a partial or complete tear of the flexor digitorum superficialis/profundus tendon can be easily assessed during the dynamic US (Video 42, http://links.lww.com/PHM/B638). In addition, foreign bodies and their relationship with the tendons can be visualized as well (Video 43, http://links.lww.com/PHM/B639).[48]

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