White Paper

High-frequency ultrasound in the musculoskeletal system: hand and finger pathology

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Clinical background

The anatomy of the hand and fingers consists of many small structures within a confined space. This makes imaging assessments challenging, as high spatial resolution is required for proper evaluation.
Of all the different imaging techniques, ultrasound is considered the gold standard for assessing small, superficial structures. In addition, Doppler evaluation, dynamic maneuvers, and bilateral comparison provide further diagnostic information. However, some structures, such as the palmar digital nerves, have a very small caliber (ranging from 0.7 to 1.5 mm), making them difficult to evaluate with standard ultrasound probes.
For this reason, high-frequency ultrasound probes with exceptional spatial resolution are required.
A hockey-stick probe, equipped with a high-frequency linear array transducer, provides high-resolution, detailed images of superficial structures. Its enhanced maneuverability in tight spaces and over irregular surfaces makes it ideal for imaging small joints in the musculoskeletal system. Its small footprint allows for optimal contact with tiny anatomical areas, such as the fingers.

IHX 6-25: redefining superficial imaging

Esaote is renowned for its pioneering work in Very-High Frequency Sonography (VHFS), offering a wide portfolio of transducers designed for a variety of clinical applications, with a strong focus on musculoskeletal imaging.
A key example of this innovation is the IHX 6-25, a very-high-frequency hockey stick probe operating at up to 25 MHz. It delivers exceptional spatial resolution for superficial imaging and, thanks to its refined ergonomic design, simplifies needle guidance, supporting highly precise interventional procedures with millimeter-level accuracy.
Esaote's renowned Doppler technologies, including Power Doppler and microV, provide outstanding sensitivity. They capture high-quality blood flow information from the smallest and slowest microvascular networks. This significant improvement is particularly valuable for diagnosing musculoskeletal disorders, where it is essential to detect the presence of synovitis and tenosynovitis and to evaluate the vascularization of soft tissue growths.

XCrystal technology

The XCrystal technology developed by Esaote dramatically increases sensitivity and penetration to provide sharper images and greater homogeneity. A benchmark for high-performance probe manufacturing, Esaote has designed a new generation of transducers that channel the ClearWave Architecture to deliver top-class resolution imaging. Its ergonomic design, created by Esaote engineers, provides true comfort for everyday use.

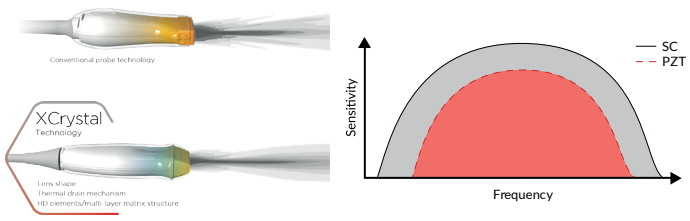

Figure 1. Probes scheme comparing conventional and XCrystal technology and sensitivity graph comparing the usage of a single crystal array versus a PZT technology array.

Figure 2. Ultrasound examination of the hand using the IHX 6-25 Esaote high-frequency hockey stick probe.

Figure 3. Esaote high-frequency hockey stick probe, IHX 6-25, operating at up to 25 MHz.

Palmar fibromatosis

Palmar aponeurosis is a strong thickening of the central portion of the deep fascia of the palm and covers the underlying neurovascular structures, tendons, and intrinsic muscles of the hand.
Palmar fibromatosis, also known as Dupuytren's disease or Dupuytren's contracture, is a benign fibroproliferative disorder in which subcutaneous fibrous nodules arise within the palmar fascia of the hand. These nodules may eventually form cords and bands that progress to the characteristic flexion contracture caused by fibrous adhesion to the underlying tendon sheath.

On ultrasound, palmar aponeurosis appears as a thin echogenic structure overlying the flexor tendons. Palmar fibromatosis most commonly appears as hypoechoic nodules located directly superficial to the flexor tendons, with an epicenter at the distal metacarpal, most commonly the fourth digit.

Case 1

A 57-year-old man presented with a palpable nodular thickening in the palm of his right hand, along the fourth metacarpal bone.
High-resolution ultrasound was performed using the IHX 6-25 Esaote high-frequency hockey stick probe.
In the region of interest, a hypoechoic nodule overlying the flexor tendons of the ring finger was identified at the level of the fourth metacarpal bone (Figure 4).

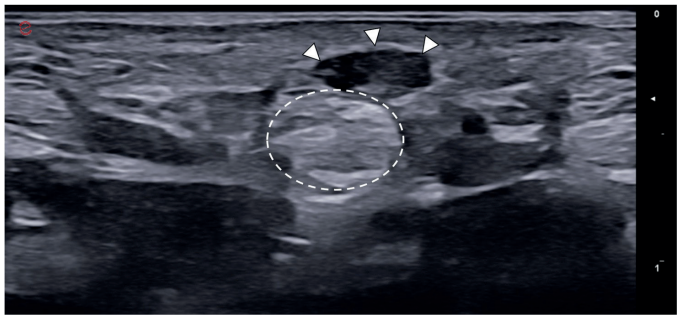

Figure 4. Short axis. Above the flexor tendons of the ring finger (dashed circle), a focal hypoechoic nodule (arrowheads) is observed, which is consistent with nodular palmar fibromatosis (Dupuytren's disease).

The long-axis view confirmed continuity with palmar aponeurosis (Figure 5).

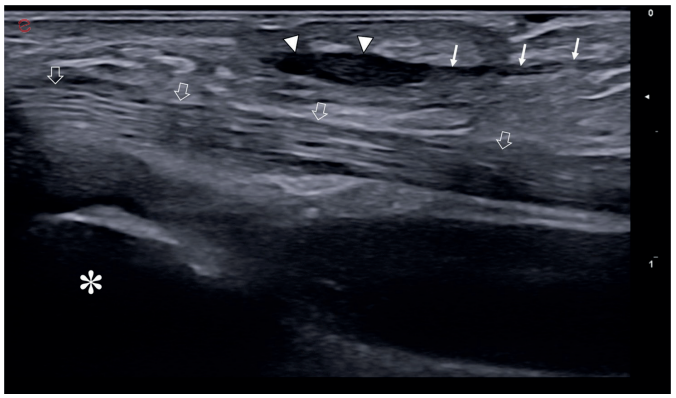

Figure 5. Long axis. Along the palmar aponeurosis (white arrows), a focal hypoechoic thickening (arrowheads) is observed, which corresponds to palmar fibromatosis (Dupuytren's disease). Flexor tendons (void arrows). Fourth metacarpal bone (asterisk).

Trigger finger

The annular pulleys of the fingers form a complex system that provides a fulcrum for flexion and extension movements by maintaining the flexor tendons in close vicinity to the bone.
From the second to the fifth finger, there are five annular pulleys:

- A1 extends from the palmar plate of the metacarpophalangeal (MCP) joint to the base of the proximal phalanx.
- A2 extends from the base of the proximal phalanx to the junction between the proximal two-thirds and distal one-third of the proximal phalanx.
- A3 is small and located over the proximal interphalangeal (PIP) joint.
- A4 is located in the middle third of the middle phalanx.
- A5 lies over the distal interphalangeal (DIP) joint.

In the thumb, the flexor digital sheath contains two annular pulleys:

- A1, located at the level of the MCP joint.
- A2, at the head of the proximal phalanx.

Trigger finger or trigger thumb refers to the difficulty in flexing or extending the affected digit. The digit may become temporarily locked in a flexed position and suddenly release with a painful snapping sensation when extended.

Trigger finger results from a mismatch between the volume of the flexor tendon and its sheath, typically due to fibrocartilaginous thickening of the pulley (typically A1).

On ultrasound, the normal A1 pulley appears as a thin, ring-like hypoechoic structure in a transverse scan and as a linear, hypoechoic band overlying the flexor tendon in a longitudinal scan.

In trigger finger, the A1 pulley is usually thickened and more hypoechoic compared with the contralateral side, sometimes with increased Doppler vascularity. Associated findings may include flexor tendon thickening with heterogeneous echotexture (tendinopathy) and peritendinous fluid (tenosynovitis).

Case 2

A 46-year-old woman complained of her right thumb intermittently locking in a flexed position, especially in the morning.
An ultrasound examination of the flexor pollicis longus tendon and pulley system was performed using the IHX 6-25 Esaote high-frequency hockey stick probe. The left side was evaluated for comparison.
A markedly thickening of the right A1 pulley was observed in a short-axis evaluation at the level of the metacarpophalangeal joint compared with the contralateral side (Figure 6).

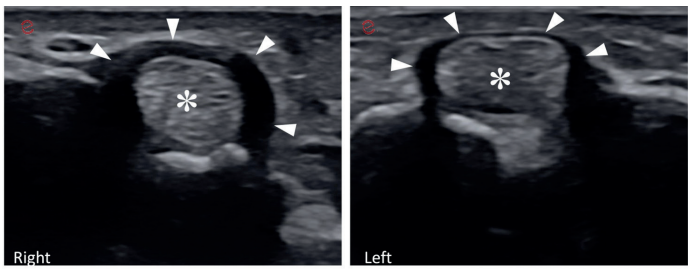

Figure 6. Short axis of annular pulley A1 of the right and left thumbs. A1 is represented as a ring-like, hypoechoic structure surrounding the tendon of the flexor pollicis longus (asterisk). A substantial thickening of the right A1 pulley is observed when compared with the left side.

Palmar digital nerves

The palmar digital nerves are the terminal sensory branches of the median and ulnar nerves that run along the radial and ulnar sides of each finger. Due to their small caliber and superficial location just beneath the skin, they are susceptible to injury due to finger lacerations.

A traumatic neuroma is the result of abnormal nerve regeneration following surgery or injury. After a peripheral nerve lesion, regeneration is triggered by mechanical trauma, which begins with axonal sprouting from the proximal end of the injured nerve.

Clinically, a neuroma can be either asymptomatic or symptomatic. When symptomatic, the most prominent complaint is pain, which is usually accompanied by altered sensation in the affected nerve's distribution. The classic clinical presentation is the combination of tenderness over the scar and sensory changes in the corresponding nerve territory. Patients with chronic pain may report a deep, aching, or throbbing sensation, though severe and persistent pain is relatively uncommon.

Case 3

A 53-year-old woman presented with persistent paresthesia and numbness in her left ring finger on the radial side. She reported having experienced a penetrating trauma one year earlier.

A high-resolution ultrasound of the digital nerve was performed using the Esaote high-frequency hockey stick probe (IHX 6-25).
A well-defined, hypoechoic, fusiform swelling was identified along the radial digital nerve of the ring finger, near the metacarpophalangeal joint. The lesion was continuous with the proximal and distal nerve segments, consistent with a post-traumatic neuroma in continuity (Figure 7-9).
Color Doppler imaging showed no internal vascularity.

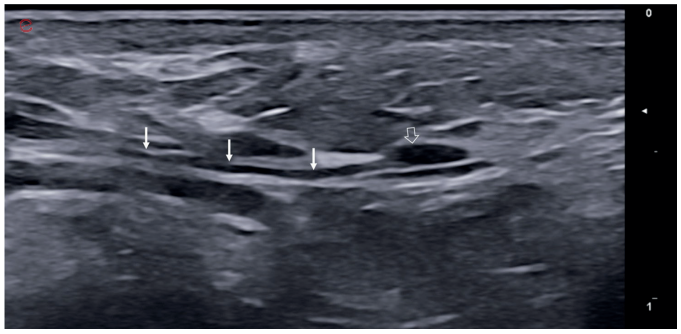

Figure 7. Long axis: radial digital nerve of the ring finger (white arrows). Focal enlargement of the nerve, hypoechoic (void arrow), consistent with a neuroma.

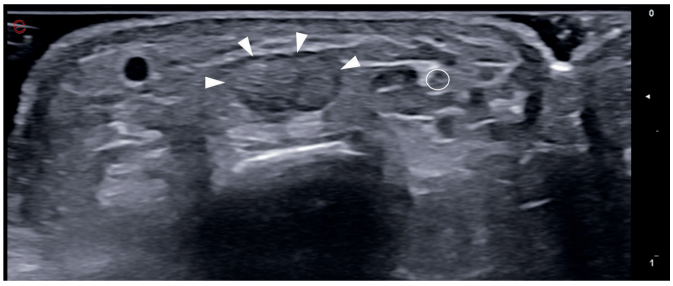

Figure 8. Short axis: the radial digital nerve appears normal (circle) with a fascicular echotexture and a honeycomb appearance. Flexor tendons (arrowheads).

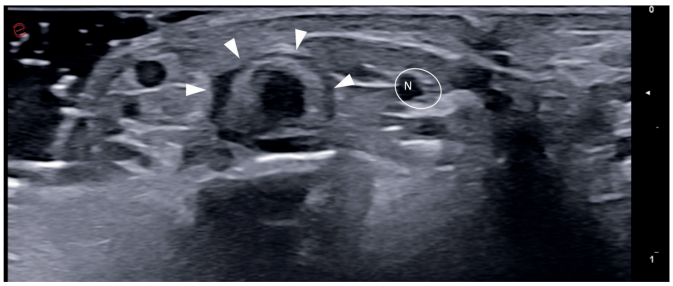

Figure 9. Short axis: at the level of the lesion, the nerve is enlarged (circle) with a focal, eccentric hypoechoic area (N), which corresponds to a neuroma in continuity. Flexor tendons (arrowheads).

Case 4

A 36-year-old man presented with focal pain and sensory changes on the radial side of his right index finger. Six months earlier, he had undergone an A3 pulley release on the same finger.

A high-resolution ultrasound with the Esaote hockey stick probe (IHX 6-25) revealed swelling and thickening of the A3 pulley, with fibrotic scar tissue formation (Figure 10).

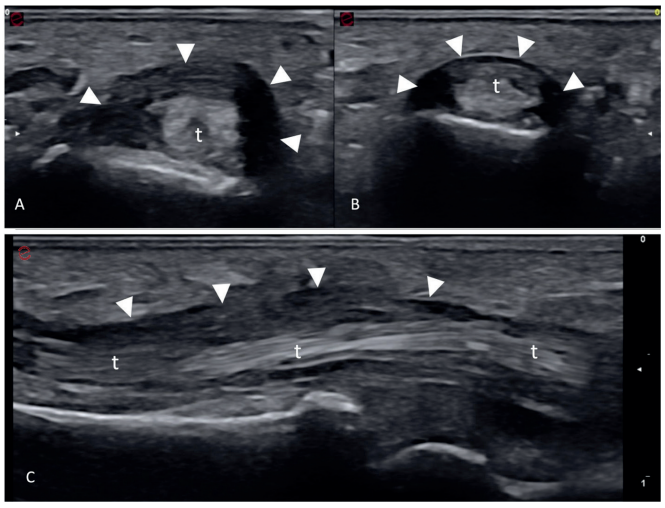

Figure 10. Short axis: right A3 pulley of the index (A). Comparing to the other side (B), the A3 pulley is significantly thicker on the right. The long-axis view of the thickened A3 pulley (C) shows scar formation (arrowheads). Flexor tendons (t). Pulley (arrowheads).

The radial digital nerve was focally enlarged and hypoechoic adjacent to the pulley, remaining in continuity with its proximal and distal segments. Color Doppler imaging showed no vascular signal (Figures 11 and 12).

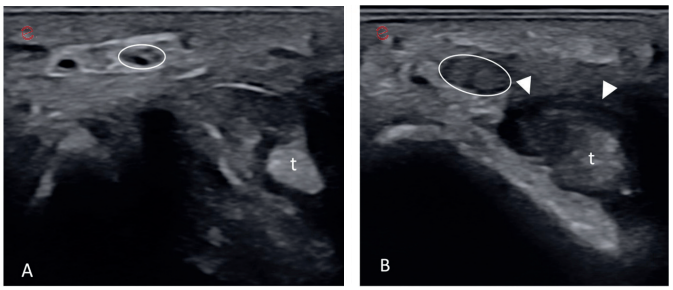

Figure 11. Short axis. The digital nerve (circle) proximal to the A3 pulley (A) has a normal caliber and fascicular echotexture. At the level of the A3 pulley, the nerve (arrowheads) is globally thickened and hypoechoic, with loss of the fascicular pattern. Flexor tendons (t).

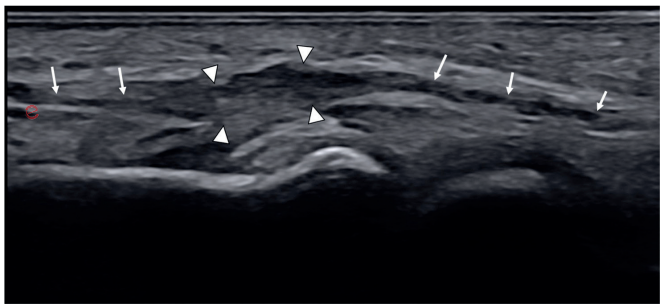

Figure 12. Long axis. Along the digital nerve (arrows), there is a focal hypoechoic lesion (arrowheads), which is in continuity with the nerve both proximally and distally, consistent with a neuroma in continuity.

The findings were consistent with a neuroma in continuity of the radial digital nerve of the index finger.
Additionally, compression of the neuroma with the probe elicited tingling sensations, consistent with a positive ultrasonographic Tinel sign.

De Quervain disease

De Quervain disease is a form of stenosing tenosynovitis involving the first dorsal compartment of the wrist, specifically the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons and their synovial sheath. These tendons course through an osteofibrous canal at the radial styloid, beneath the transverse fibers of the extensor retinaculum, which creates a fibro-osseous tunnel approximately 1 cm in length. Repetitive mechanical loading and microtrauma at this site may cause thickening of the extensor retinaculum, leading to narrowing of the first extensor compartment and subsequent irritation and inflammation of the APL and EPB tendons, which restrains normal gliding of the tendons within the sheath.

The condition occurs predominantly in women, with a female-to-male ratio of approximately 10:1, and most commonly affects individuals between 30 and 50 years of age. De Quervain disease is often linked to activities requiring repetitive wrist and hand motions in occupational, sport activity, or recreational settings. Postpartum women are particularly at risk due to frequent wrist flexion and extension combined with resisted thumb abduction during infant care, which has led to the colloquial terms “mommy wrist” or “baby wrist.”

The superficial position of APL and EPB tendons within the first extensor compartment, together with their easy accessibility for comparative and dynamic assessment, makes ultrasound the imaging modality of choice for evaluating this region.

Case 5

Ultrasound examination demonstrated thickening of the extensor retinaculum of the first dorsal compartment (Figure 13), which was highlighted during comparative assessment with the contralateral wrist (Figure 14).

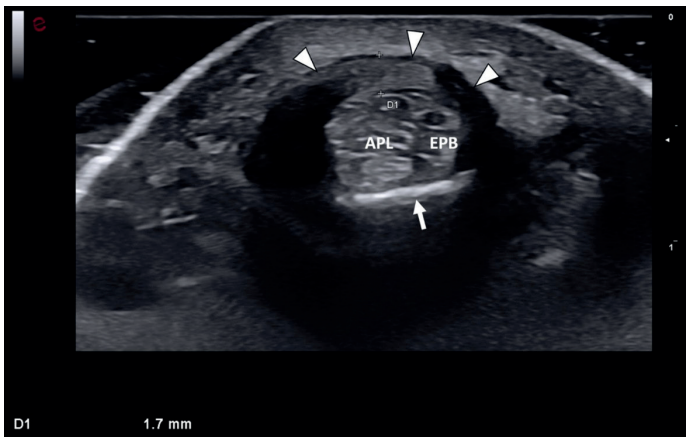

Figure 13. Short axis, left wrist. Markedly thickening of the retinaculum of the first compartment of the extensor tendons (arrowheads), which surrounds the tendon of the abductor pollicis longus (APL) and extensor pollicis brevis (EPB), creating a fibro-osseous tunnel at the level of the radius (arrow).

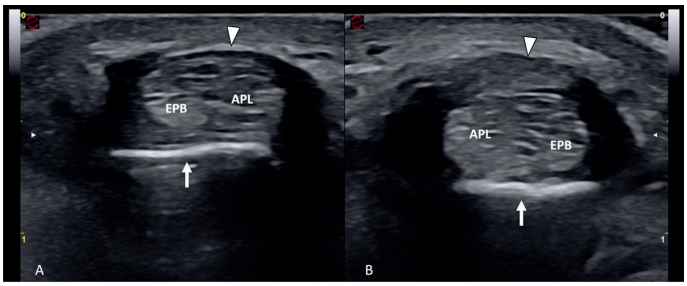

Figure 14. Short axis comparing the right wrist (A) and the left wrist (B). Comparative assessment of the contralateral wrist highlights asymmetric thickening of the retinaculum (arrowheads). Abductor pollicis longus tendon (APL), extensor pollicis brevis tendon (EPB), radius (arrow).

Distal to the retinaculum and tendons appeared markedly edematous with an increased cross-sectional area, more pronounced in the APL tendon, which showed a focal area of tendinosis (Figure 15).

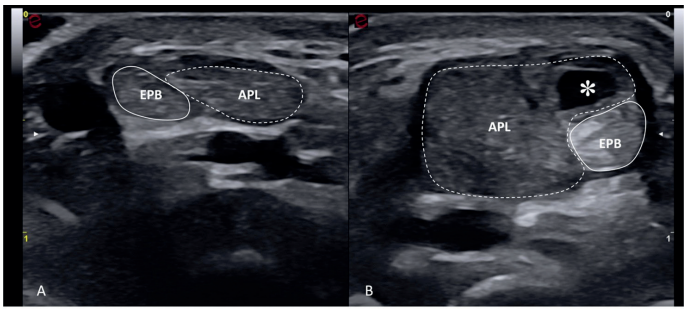

Figure 15. Short axis of the right wrist (A) and left wrist (B), distal to the retinaculum. On the left wrist there is a marked thickening of the abductor pollicis brevis tendon, with a focal hypoechoic area of focal tendon degeneration (asterisk). Extensor pollicis brevis (EPB) tendon.

Color Doppler imaging also revealed increased peritendinous hyperemia (Figure 16).

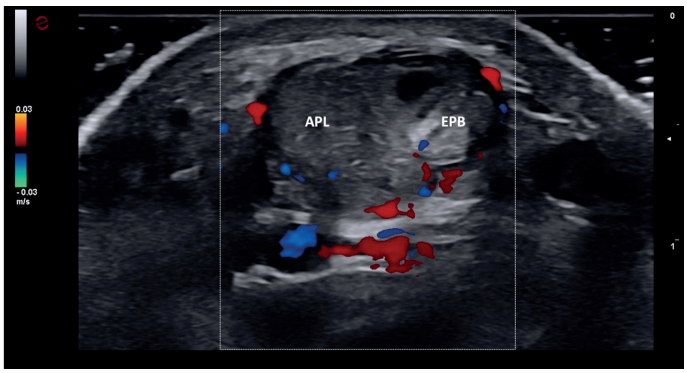

Figure 16. Short axis of the left wrist. Color Doppler evaluation shows increased peritendinous hyperaemia. Extensor pollicis brevis (EPB) tendon. Abductor pollicis longus (APL) tendon.

Conclusions

In conclusion, high-resolution ultrasound using very high-frequency linear probes, such as the IHX 6-25, has significantly advanced the assessment and management of a wide range of hand and finger pathologies.
The exceptional spatial resolution provided by these probes enables precise visualisation of minute anatomical structures, including the palmar aponeurosis, annular pulleys, digital nerves, and tendons. This level of detail is essential for accurate diagnosis, particularly in conditions such as Dupuytren's disease, De Quervain's disease, trigger finger, and traumatic neuroma.
The integration of advanced Doppler technologies and innovative transducer design, exemplified by Esaote's XCrystal technology, further enhances diagnostic confidence by allowing sensitive evaluation of microvascular changes and soft tissue alterations.
Dynamic and comparative assessments, as well as interventional guidance, are more effective, supporting clinicians in tailoring therapeutic strategies to individual patient needs.
The clinical cases presented demonstrate how high-resolution ultrasound not only facilitates the identification of structural abnormalities but also aids in differentiating pathological processes and monitoring treatment outcomes. As a result, ultrasound has established its role as the gold standard in musculoskeletal imaging of the hand, providing a non-invasive, reliable, and versatile tool for both diagnostic and interventional radiology.

Continued innovation in ultrasound technology promises to further improve the accuracy and utility of imaging in this complex anatomical region, ultimately benefiting patient care through earlier diagnosis, more precise interventions, and improved clinical outcomes.

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