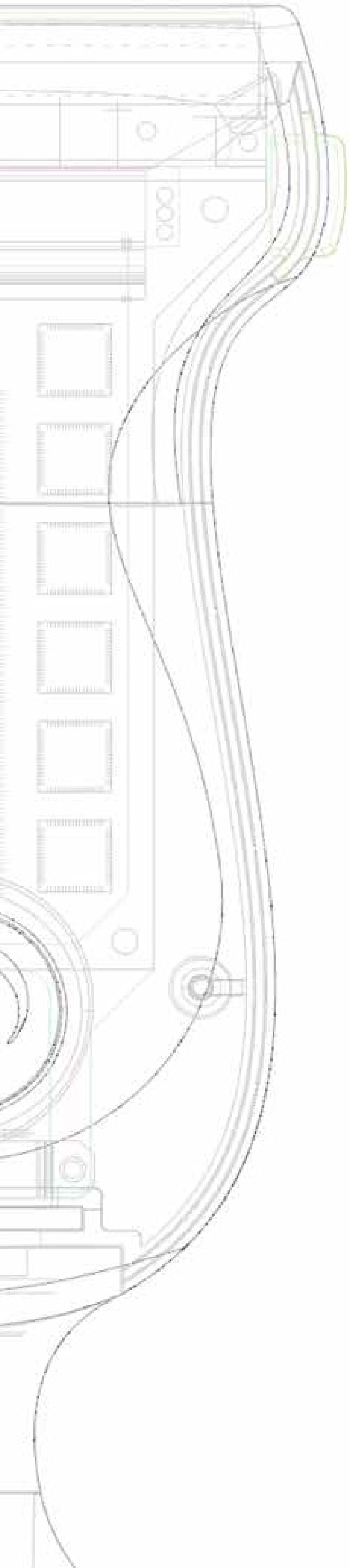
White Paper



Very-High Frequency transducers

A universe under the millimeter

Courtesy of:
Prof. Luca Maria Sconfienza, Dr. Romain Gastaldi,
Prof. Emilio Filippucci, Dr. Edoardo Cipolletta,
Dr. Eugenio M. De Miguel,
Dr. Ekaterina Privalova and Dr. Paolo Minafra

esaote

Clinical Background

Ultrasound (US) is a fantastic technique for imaging the musculoskeletal system, because is a unique clinical examination, offering the user advantages of real-time performance, superb tissue imaging and a wide choice of advanced new clinical investigations. US can be used to scan joints, muscles, or tendons.

In the past years there have been incredible advancements in technologies related to US devices. This is particularly due to the refinement and introduction of probes with frequencies exceeding 20MHz, the implementation of intelligent algorithms able to optimize contrast and automatically achieve a gain, associated with powerful denoising, thus offering very high resolution even for the tiniest anatomical structures.

The use of latest-generation probes makes it possible to see things never seen before, thus bringing radiologists forward in terms of anatomical knowledge (greater knowledge of tiny structures), reporting (even more details to be evaluated) and increased confidence in the identification of pathologies.

Very-High Frequency transducers

As a historic specialist in Very-High Frequency probe manufacturing, Esaote offers a collection of Very-High Frequency (VHF) transducers, where the elevated frequency range expands the horizon for clinical applications especially for MSK, Rheumatology and other potential clinical regions such as Dermatology, Aesthetic and Sport Medicine.

A genuine technological breakthrough in very superficial explorations, the LMX 4-20, Esaote's brand-new HD Single Crystal probe, operating up to 25MHz, reveals unprecedented clarity in the minutest details without compromising the deeper areas. Applied to this high-density element per multi-layer matrix structure array, XCrystal Technology, enables unparalleled sharp and clear imaging to achieve excellence in superficial ultrasound examinations and becomes Esaote's gold standard in terms of linear probes.

The SL 3116 transducer delivers outstanding image quality for temporal arterial maximum resolution, with up to 25MHz of frequency, ideal also for cartilage and skin studies.

The maximum resolution, up to 24 MHz, of the L 8-24 probe provides outstanding image quality for very superficial scans (fingers, wrists, elbows).

The extreme sensitivity of Esaote Power Doppler technology, with a frequency of 16,7 MHz, is designed for the detection of low flow in small and superficial vessels. This improved vascular image quality positively impacts diagnosis and therapy planning, with great interest particularly in rheumatologic conditions, for the detection of vascularity in synovial proliferations and in rheumatological inflammatory diseases, as well as for tendon neovascularization in patients with chronic achillodynia. Esaote has developed an adaptive algorithm that effectively separates flow signals from overlaying tissue motion artefacts and background noise. microV is the latest technology by Esaote, with a high degree of sensitivity even for very small vessels and slow flows, which enables hemodynamic evaluation with high sensitivity and high spatial resolution (Fig. 1).

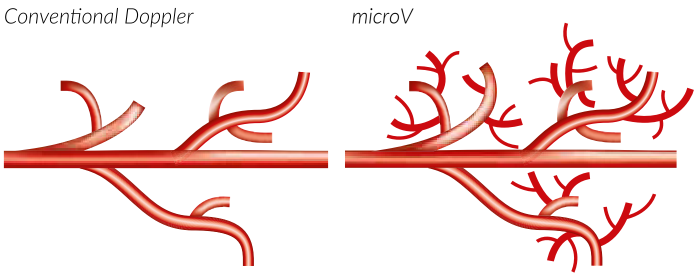


Fig. 1: Image representing sensitivity in terms of vascularisation visualisation between Power Doppler Technique and microV technology.

XCrystal Technology

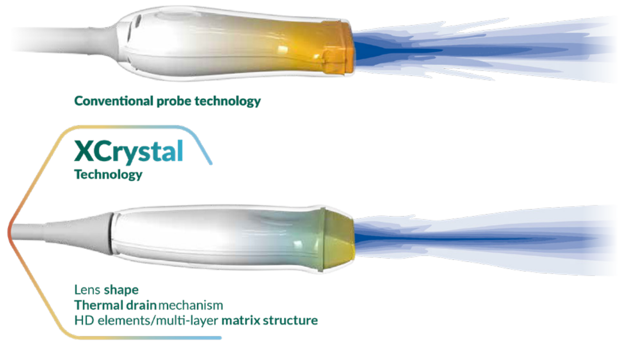


Fig. 2: Probes schema comparing conventional and XCrystal technology.

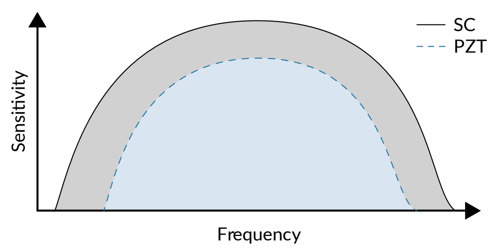


Fig. 3: Sensitivity graph comparing the usage of a single crystal array versus a PZT technology array.

Esaote-developed XCrystal technology dramatically increases sensitivity and penetration, to provide sharper images and homogeneity. Esaote, a benchmark for high-performance probe manufacturing, has designed a new generation of transducers to channel the ClearWave Architecture supported by MyLab™X90, and to deliver top-class resolution imaging. The ergonomic shape designed by Esaote engineering provides true comfort in everyday use.

“This new probe is excellent in detecting very thin, soft tissue foreign bodies and associated complications in difficult areas.”

Prof. Luca Maria Sconfienza
Head of Unit of Diagnostic and Interventional Radiology,
IRCCS Ospedale Galeazzi -Sant’Ambrogio, Milan, Italy;
Professor of Radiology, University of Milan, Italy

Advanced MSK – Septic tenosynovitis related to retained sea urchin sting

A female patient, 34 years old, with unremarkable medical history reported the symptoms of left forefoot stinging pain and second toe swelling and redness immediately after a vacation on the beach.

Ultrasound was used to investigate the second toe of the left foot, which was very swollen and painful, especially on the volar side, and revealed a thick hypoechoic layer (see asterisks) surrounding the flexor tendons (FT), with minimal to no fluid. Although the known history of the patient did not include any inflammatory conditions (DP=distal phalanx; IP=intermediate phalanx), diagnosis was a productive tenosynovitis, typical in patients with inflammatory conditions or during infections.

Power Doppler (Figure 2) and microV (Figure 3) tools showed impressive hypervascularization of tenosynovitis and superficial soft tissues.
Power Doppler is extremely efficient in correctly depicting hypervascularity, while it is less able to show tiny vessels.

Conversely, microV shows a slightly less massive vascularization, while improving the visibility of very tiny vessels, clearly visible in the tendon sheath (see the arrowheads). So far, the clinical picture was oriented towards a condition of septic tenosynovitis, which is however quite uncommon in a young, healthy woman.

The examination was therefore directed to the forefoot, where the patient reported a stinging pain at a specific point. In that area ultrasound has revealed only diffuse swelling of the forefoot fat pad.

Subsequently, with a more thorough evaluation, the presence of a very thin, linear structure surrounded by hypoechoic rim was pointed out. (Figure 4, arrows)
This finding was consistent with a foreign body surrounded by granulation tissue. Only at this point, the patient recalled having felt mild pain while walking in the sea, in an area highly populated by sea urchins.
After one week, the patient underwent surgery, which confirmed the final diagnosis of septic tenosynovitis related to a retained sea urchin sting.

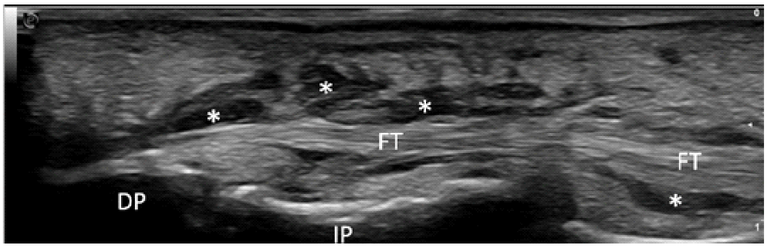


Fig. 1: B-Mode modality.

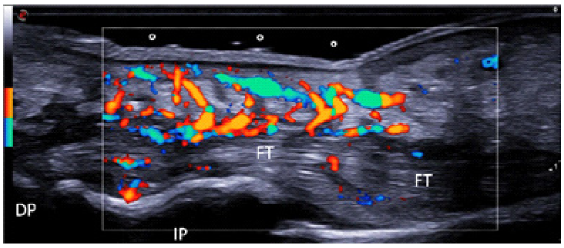


Fig. 2: Power Doppler technology.

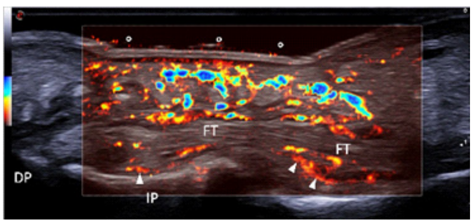


Fig. 3: microV advanced tool.

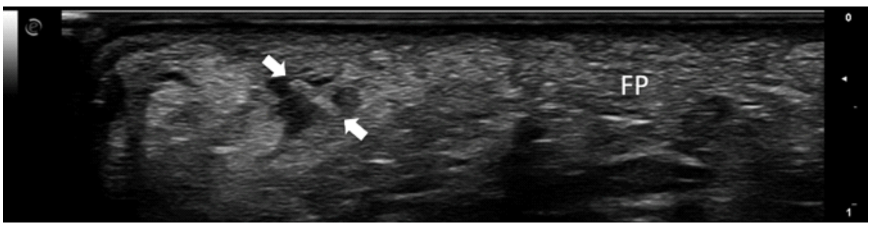
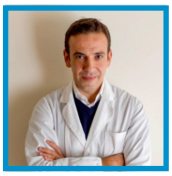


Fig. 4: B-Mode examination - VPan activated.

“Studying the microvascularity of the patellar tendon in chronic tendinopathy is essential for understanding its underlying mechanisms and developing effective therapeutic strategies.”



Dr. Paolo Minafra
MSK Radiologist Health Director, Affidea Modena, Italy

Sport Medicine - Significance of Ultrasound Study in Patellar Tendon Chronic Tendinopathy: Defining Microvascularization

Patellar tendon chronic tendinopathy, commonly known as jumper’s knee, is a prevalent and debilitating condition that affects athletes and active individuals. It is characterized by pain and functional limitations in the patellar tendon, which connects the patella (kneecap) to the shinbone. To effectively manage and treat this condition, it is crucial to employ advanced diagnostic tools like ultrasound to assess the extent of damage and understand the underlying mechanisms contributing to it. One critical aspect of ultrasound evaluation in patellar tendon tendinopathy is the assessment of microvascularization within the tendon.

Microvascularization refers to the presence and density of tiny blood vessels (capillaries) within the patellar tendon. In healthy tendons, these capillaries are relatively sparse. However, in tendinopathy, there is often an increase in microvascularization. This phenomenon is called neovascularization and indicates tissue degeneration, inflammation, and healing processes within the tendon. Regrettably, these newly formed blood vessels are inherently ineffective, unable to transport the oxygen and nutrients needed to alleviate the existing oxygen deficiency. Stabilizing these neovascular structures may present an enticing prospective method for addressing tendinopathy in the future.

In the context of patellar tendon tendinopathy, ultrasound is particularly useful for assessing microvascularization. Here’s why it’s essential:
1. Early Detection: Ultrasound can detect neovascularization in its early stages, allowing healthcare professionals to identify the condition before it progresses further. Early detection is crucial for initiating timely interventions and preventing long-term damage.
2. Treatment Planning: The degree of microvascularization within the tendon can help healthcare providers tailor treatment plans to each patient’s specific needs. For example, a patient with extensive neovascularization may require more aggressive interventions, such as platelet-rich plasma (PRP) therapy or shockwave therapy, alongside traditional treatments like physiotherapy.
3. Monitoring Progress: Regular ultrasound assessments can track the progression or regression of neovascularization during treatment. This helps clinicians gauge the effectiveness of interventions and make adjustments as necessary.
4. Patient Education: Visualizing microvascularization through ultrasound images can enhance patient understanding of their condition. It visually represents the injury’s severity and motivates patients to adhere to treatment plans.
5. Research and Development: Studying microvascularization through ultrasound aids researchers in advancing our understanding of tendinopathy. This knowledge can lead to the development of more effective treatments and prevention strategies.

In managing patellar tendon chronic tendinopathy, ultrasound is pivotal in evaluating microvascularization within the tendon. This assessment aspect offers valuable insights into the extent of damage, the inflammatory response, and the healing processes occurring within the tendon. By defining microvascularization, healthcare professionals can make informed decisions about treatment strategies, monitor progress, and improve patient outcomes. As our understanding of tendinopathy continues to evolve, the importance of ultrasound in assessing microvascularization cannot be overstated, making it an indispensable tool in the field of sports medicine.

19-year-old professional football player reported a chronic patellar tendon tendinopathy at the proximal attachment. Ultrasound examination, performed with Esaote’s high frequency linear probe operating between 8 and 24 MHz, has clearly revealed an intratendinous fissure and multiple calcifications. (Figure 1)
The investigation has been supported using Power Doppler technology to better assess the tendon’s vascularization.
(Figure 2)
To conclude, with the patient in orthostatic conditions, tendon behavior has been evaluated by both Power Doppler and microV to define the best treatment to be followed. (Figure 3 & 4)

[References from 1 to 8]

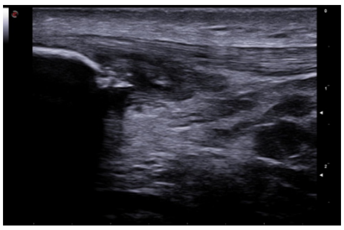


Fig 1: B-Mode modality.

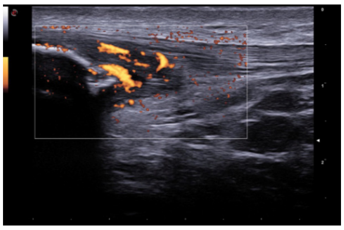


Fig. 2: Power Doppler technology.

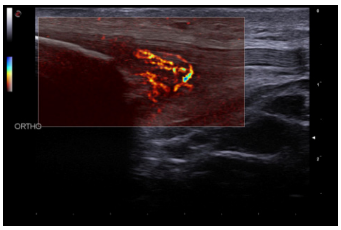


Fig. 3: microV technology - orthostatic conditions.

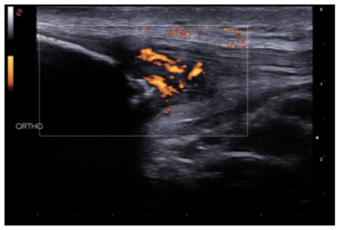


Fig. 4: Power Doppler technology - orthostatic conditions.

"Going from deep/intermediate articulations to superficial ones without losing the quality of the image is fundamental to speed up and facilitate our clinical workflow."

Dr. Romain Gastaldi
Medical Doctor (ou M.D.) Rheumatologist, Department of Rheumatology,
Université Grenoble-Alpes & CHU Grenoble-Alpes, France

Advanced MSK – Gout diagnosis from nearfield joints to deeper areas

Ultrasound examination was performed with Esaote's newest very high-frequency linear probe, operating between 4 and 25 MHz, that allowed to diagnosticate a severe case of gout between the metacarpus and the phalanges of the finger.

The improved sensitivity of the image, due to the perfectly balanced contrast of the image, has shown, perfectly visible, the double-contours sign on the metacarpophalangeal (MCP) joint, a clear indication of gouty pathology. (Figure 1)

Moreover, Power Doppler tool (Figure 2), due to its high sensitivity and few artifacts, has confirmed the diagnosis of inflammatory synovitis with a high reliability.

Finally, comparison with an image of the same area of a healthy joint (Figure 3) leaves no room for doubt versus gouty joint (Figure 4).

Proceeding the examination moving to the ankle joint, the significant contrast makes it possible to visualize well tissue structures such as synovitis or liquid effusions.

The large frequency band of this new probe allows to study also the deeper areas with great clearity, quite uncommon when talking about VHF probes. Therefore, the bottom of the joint spacing (over 3 cm of depth) is clearly visible, thus giving the possibility to eventually guide a puncture gesture of the articular effusion. (Figure 5)

In figure 6, the very high contrast resolution of this transducer makes it possible to clearly see intra-articular hyperechoic spots with a snowstorm appearance of the synovial fluid, a fairly common index of gouty pathology.

Focusing again on a deeper structure, in particular at the femoral condyle level, sign of the double contour with excellent definition are clearly highlighted by the ultrasound image. (Figure 7)

Figure 8 depicts the calcaneal tendon and provides a very precise visualization of the tendon fibers. A so defined image allows to identify, close to the enthesis, a probable gouty tophus that occupies part of the tendon area, that could not be as easily appreciated with other probes.

In conclusion, the unparalleled level of detail imaging of this new VHF probe and its broad spectrum of action allows to diagnosticate easily cases of gout in different districts with high reliability.

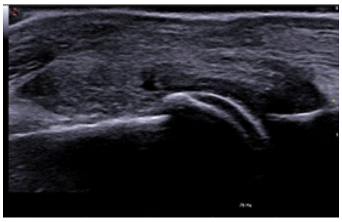


Fig. 1: B-Mode modality: MCP2 Gouty Arthritis.

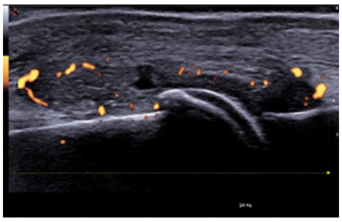


Fig. 2: Power Doppler modality: MCP2 Gouty Arthritis.

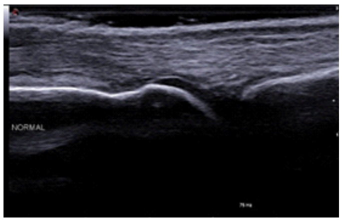


Fig. 3: B-Mode modality: MTP Healthy.

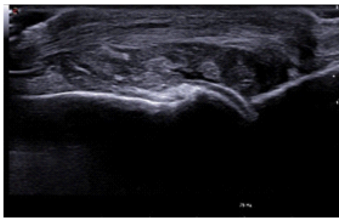


Fig. 4: B-Mode modality: MTP Gouty Arthritis.

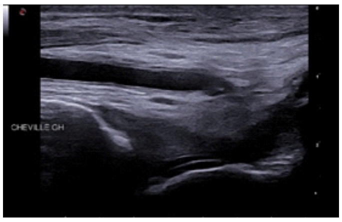


Fig. 5: B-Mode modality: Ankle Gouty Arthritis.

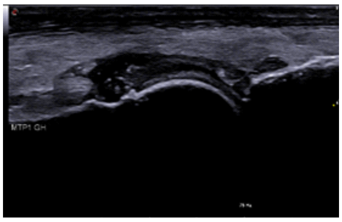


Fig. 6: B-Mode modality: MTP 1 Gouty Arthritis.

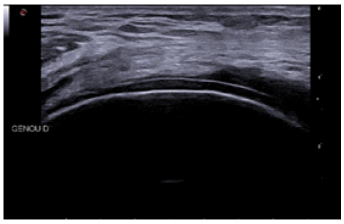


Fig. 7: B-Mode modality: Femoral condyle Gouty Arthritis.

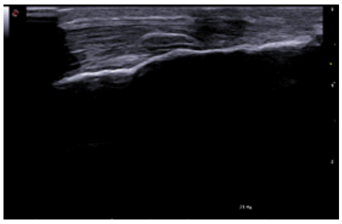


Fig. 8: B-Mode modality: Calcaneal tendon Gouty Arthritis.

“For a precise diagnosis and tailored treatment of metacarpal head’s diseases, high-frequency high- resolution US imaging is certainly essential.”


Prof. Emilio Filippucci
MD, PhD. Rheumatology Department, Marche Polyclinic University, Carlo Urbani Hospital, Jesi (Ancona), Italy

Dr. Edoardo Cipolletta
MD. Rheumatology Unit, Department of Clinical and Molecular Sciences, Polytechnic University of Marche, Ancona, Italy;
Academic Rheumatology, University of Nottingham, Nottingham, UK

Rheumathology - A shining dot in the metacarpal head’s hyaline cartilage

Calcium pyrophosphate deposition (CPPD) disease is a common arthropathy due to the deposition of calcium pyrophosphate (CPP) crystals in articular and periarticular tissues[9]. Although CPPD has been estimated to affect 4-7% of the adult populations in Europe and the United States[10], it is often underdiagnosed. Its clinical heterogeneity, ranging from acute inflammatory mono-arthritis “pseudo-gout” to chronic polyarticular arthritis “pseudo-rheumatoid arthritis”, gave CPPD disease the nickname of the “great mimicker”[11]. Musculoskeletal ultrasound (US) is gaining popularity among rheumatologists, as it is a non-invasive, radiation-free imaging modality that is relatively easy to set up in a clinic setting. Although US is often regarded as being operator dependent with associated reproducibility issues, the use of consensus-based scoring system along with standardized definition of elementary MSUS findings in rheumatoid arthritis has been shown to improve its performance and reliability as an outcome measurement tool[12]. In addition, recent technical developments such as the use of very-high frequency probe (>20 MHz) allow to obtain detailed imaging of many structural and inflammatory abnormalities. For instance, high-frequency high-resolution probes enable a superb visualisation of the metacarpal head’s hyaline cartilage, that has been poorly investigable by previous generation of US probes (Figures 1 and 2).

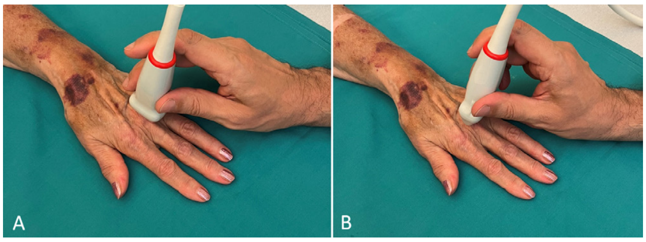


Fig. 1: Dorsal longitudinal (A) and transverse (B) scans for the metacarpophalangeal joint using a very high frequency probe (i.e., 12-25 MHz linear probe SL3116 using a MyLab™X75 Esaote Spa).

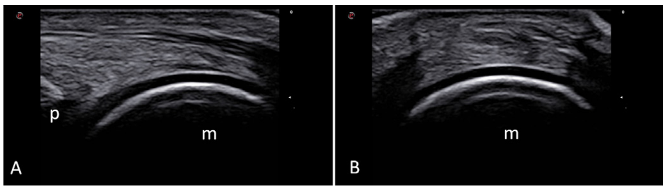


Fig. 2: Healthy subject. Normal sonographic features of metacarpal head hyaline cartilage appearing in dorsal longitudinal (A) and transverse (B) views as a subtle anechoic layer delimited by two hyperechoic acoustic interfaces: the chondro-synovial otherwise called superficial margin which is physiologically thinner than the osteo-chondral otherwise called deep margin.

We present a case of a 72-year-old woman who was referred with an acute mono-arthritis of the right wrist. Her medical history was notable for a traumatic fracture of the distal epiphysis of the right radius 4 years ago and a similar episode of acute monoarthritis affecting the right metacarpophalangeal joint of the third finger (the dominant hand) about a year ago. On physical examination, clear signs of synovitis of the right wrist were observed. An US examination of the right wrist revealed an “active” synovitis of the radiocarpal and intercarpal joints with intense Power Doppler signal. Additionally, a calcification was identified within the triangular ligament of the wrist, though interpretation was challenging due to the prior wrist fracture (post-traumatic calcification vs. calcification secondary to systemic pathology i.e., CPPD). To address this diagnostic challenge, we conducted a multi-site US evaluation of the joints involved in the patient’s clinical history. In particular, the US assessment of the right metacarpophalangeal joint of the third finger allowed the detection of the findings showed in Figure 3.

In this case, a targeted US scanning protocol focusing on the right metacarpophalangeal joint of the third finger allowed us to confirm the diagnosis of CPPD disease. This aligns with a previous study, where a targeted US scanning protocol of two joints bilaterally (knees and wrists) plus the target joint (in this case, the right metacarpophalangeal joint) yielded excellent diagnostic sensitivity and specificity for crystal arthritis in patients with acute mono/oligoarthritis[12].
The study on US findings in metacarpophalangeal joints of CPPD patients becomes highly relevant in this context. A previous study has reported various patterns of CPPD involvement at metacarpophalangeal joints. Capsuloligamentous, intra-cartilaginous, and intra-articular deposits, and the pseudo double contour sign were identified.
The wide spectrum of CPPD at metacarpophalangeal joints underscores the complexity of CPPD and emphasizes the need for detailed imaging assessments like high-frequency high-resolution US imaging to differentiate and diagnose the specific type of crystal deposition disease[13].
In recent years, high-frequency high-resolution US imaging has enabled an in-depth visualisation of superficial small targets (less than 1 mm). The thickness of metacarpal head’s hyaline cartilage ranges from 0.4 to 1.0 mm[14,15]. High-frequency high-resolution US imaging provides a clear and detailed understanding of the exact nature of US abnormalities and their extent.

Ultrasound allows for a rapid and detailed assessment of the metacarpal head. In the present case, the use of high-frequency high-resolution US imaging can be crucial for accurate diagnosis and tailored treatment, which is particularly relevant when clinical symptoms and history alone may not provide a definitive answer.

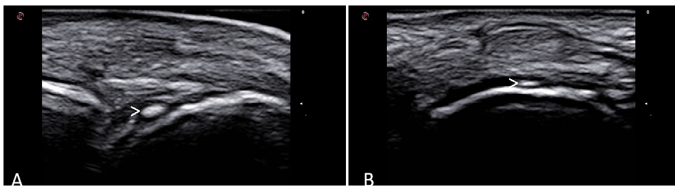


Fig. 3: Calcium pyrophosphate deposition (CPPD) disease. Same views of the previous image. The arrowheads show a crystal-clear hyperechoic spot not generating acoustic shadow within the hyaline cartilage layer.

“The Esaote L 8-24 probe helps me to differentiate between pathological and physiological anatomical structures in a very precise way.”

Dr. Eugenio M. De Miguel
MD, Rheumatology Department,
Hospital Universitario La Paz, Madrid, Spain

Rheumatology - Swelling of soft tissue in the index finger of the right hand

A female patient, 52 years old, with cutaneous psoriasis but no history of arthritis, has reported pain in the right finger for the last four months. This pain has increased in the last four weeks, with the addition of rigidity, mainly in the morning and after rest, and a partial limitation in full flexion.

Clinical examination showed no swelling in the writ or metacarpophalangeal joints but showed, after pressure, tenderness on the level of the third right metacarpophalangeal joint in the palmar aspect.

Ultrasound examination, performed with Esaote’s high-frequency linear probe operating between 8 and 24 MHz, on the index finger of the right hand, revealed slight hypoechoic thickening of the A1 pulley (Figures 1 to 3) with a visible increase in the thickening of the flexor tendon if compared to the adjacent ones.

Investigations of the cross-section of the index finger showed a significant increase in thickness, particularly in the A2 pulley (Figure 4, see white arrow), with a doppler signal of grade 2 inside the pulley and in the sheath of the own digital flexor, as well as a hypoechoic distension of the flexor sheath.

Ultrasound’s diagnosis was psoriatic arthritis and, in particular, the functional enthesitis of the A1 pulley plus the tendosynovitis of the digital flexor of the middle finger.

Since the patient revealed no other evidence of joint problems, an intra-sheath ultrasound-guided infiltration was performed.

Follow-up at three and six months showed the disappearance of both Doppler signal and tendosynovitis, except for a slight maintenance of the thickening of the A1 pulley, observable in B-Mode.

High-frequency ultrasounds allowed us to diagnose pulley enthesitis, probably related to the associated tendosynovitis of the patient. Recognizing the involvement of the pulley is certainly of interest because it helped us to confirm the association with psoriatic etiology.

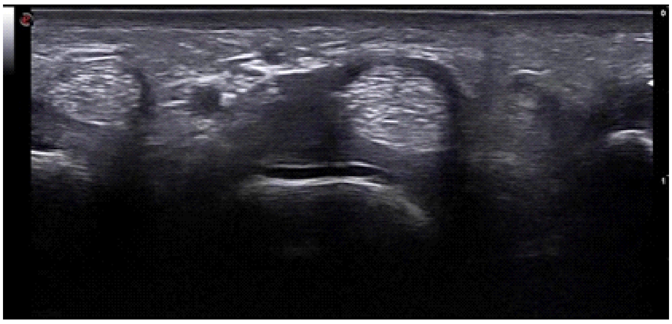


Fig. 1: B-Mode modality - thickening of A1 pulley.

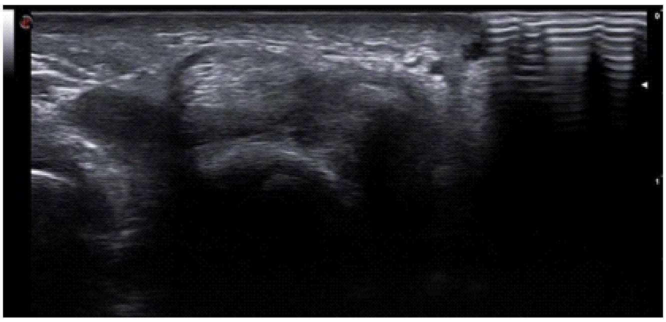


Fig. 2: B-Mode modality - thickening of A1 pulley.

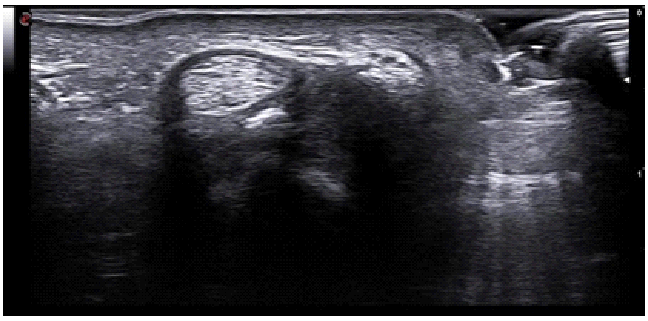


Figure 3 – B- Mode modality - thickening of A1 pulley.

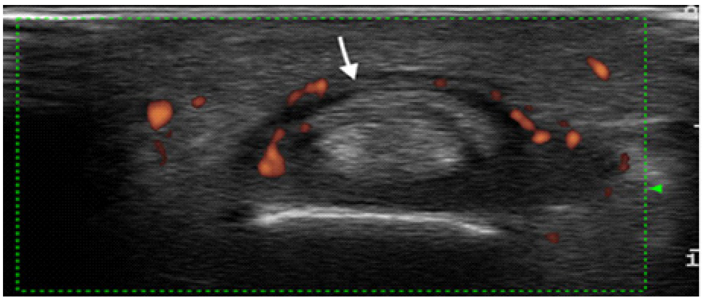


Figure 4 – Power Doppler Technology - A2 pulley.

“Detailed imaging using high-frequency probes, accurate diagnosis and identification of the best treatment has finally been made possible.”

Dr. Ekaterina Privalova
Ultrasound diagnostic doctor, expert in the field of ultrasound diagnostics in cosmetology, Doctor of Medical Sciences, Moscow

Dermatology – Granulomatous inflammation in the face and neck due to injected drugs

A 57-year-old patient came to the clinic with complaints of widespread nodular seals in the jaw areas, the area at the corners of the lower jaw, as well as in the anterior and lateral surfaces of the neck. According to the patient, she had injected a wide range of drugs in the past year. Ultrasound examination of the soft tissues of the maxillary, parotid-masticatory areas, as well as the anterior and lateral surfaces of the neck, performed with Esaote’s high-frequency linear probe at 8 to 24 MHz, has revealed multiple formations of reduced echogenicity, with clear contours and heterogeneous echo structure due to the presence of hyperechogenic inclusions.
(Figure 1 & 2)

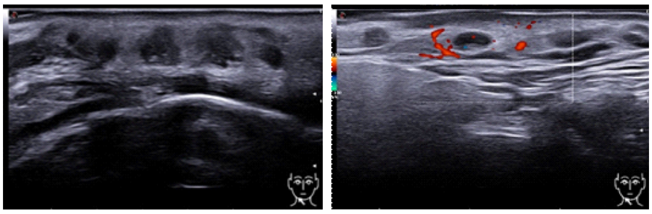


Fig. 1 & 2: Echogram of soft tissues of the right maxillary region in B-Mode (1) and Color Doppler Mode (2).

With Color Doppler, there is an increase in vascularization in the surrounding soft tissues, as well as the possibility of tracing single vascular structures in the lumen of the above formations.
(Figure 3 & 4)

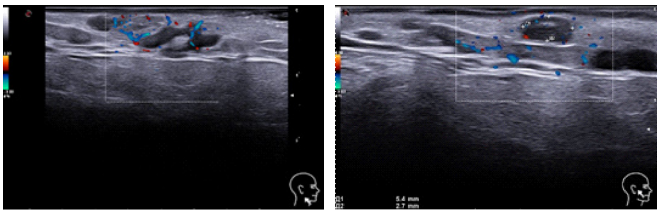


Fig. 3 & 4: Echogram of soft tissues of the right maxillary (3) and right zygomatic (4) in the CDK Mode.

Ultrasound’s diagnosis, subsequently confirmed by a histological examination, was of granulomatous changes (due to the injected drugs) plus the presence of an autoimmune process owed to fragments of foreign bodies. Conservative treatment was therefore selected, resulting in patient’ relief and clinical manifestations.

Dermatology – Surgical filler removal in the periorbital areas

A 34-year-old female patient reported swelling, soreness, and compaction of the suborbital areas. According to the patient, seven months previously she had undergone treatment of periorbital area contouring with an unknown drug (probably based on hyaluronic acid). Ultrasound examination of the soft tissues of the face in the chin area, performed with Esaote’s high-frequency linear probe at 8 to 24 MHz, revealed, symmetrically on both sides of the periorbital area, two zones of reduced echogenicity, heterogeneous echostructure, clear, uneven contours, and a size of 20.8 x 6.6 x 18 mm and 20.8 x 7.4 x 9 mm, on the right and left side, respectively.
(Figure 5 & 6)

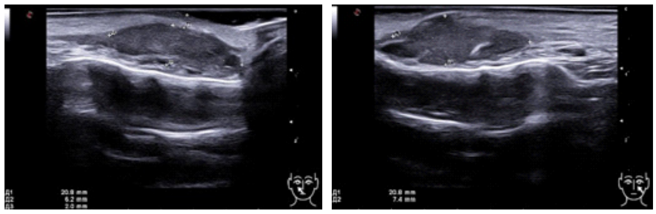


Fig. 5 & 6: Echograms of soft tissues of the suborbital areas in B-Mode, right (1) and left (2) sides.

In Doppler Modes (Color Doppler, Power Doppler and microV technologies), the two zones exhibited as actively vascularized both in the periphery and in the central parts. (Figures 7 & 8)

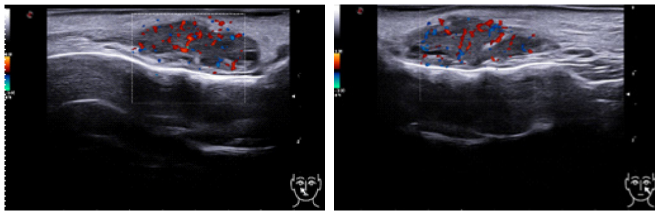


Fig. 7 & 8: Echograms of soft tissues of the subglacial areas in Color Doppler, right (3) and left (4) sides.

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