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Symptomatic Ankle and Mid-foot; Clinical and Ultrasound Evaluation.

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Abstract

Background: Gait and other daily activities depend on proper ankle and foot function. In many rheumatic and musculoskeletal conditions, the ankle is a frequently affected joint in both young and older populations, leading to pain, restricted mobility, and a lower quality of life. The difficulty in accessing the ankle and foot anatomically and the lack of adequate training in clinical assessment methods are two factors that contribute to this problem. Although traditional radiography is currently the preferred imaging method in everyday clinical practice for determining ankle involvement, it does not allow for the evaluation of soft tissues. Additional different diagnostic modalities such as magnetic resonance imaging, computed tomography and imaging diagnostic ultrasonography may offer more comprehensive data on soft tissue and bone structures. To diagnose and evaluate patients with different auto-immune rheumatic and degenerative illnesses, ultrasound is particularly well-suited for examining soft tissue components of different joints. Conclusions: Ultrasonography is considered a reliable method for diagnosing and predicting functional disability and managing ankle pathologies. Longitudinal studies are needed to confirm these findings.

Keywords: Ultrasound, ankle, foot.

1. Introduction

Whenever ankle pain occurs, anatomic structures that are affected by the condition can be identified using ultrasonography as a medical imaging method, explain the etiology of the pain, and detect subclinical disorders in asymptomatic ankles (1).

2. Anatomy of the ankle:

The distal tibia, distal fibula, and talus constitute the joint structures of the hinged synovial ankle joint. Flexion to the planter plane and flexion to the dorsal plane of the foot are principal main ankle movements. The synergistic articulations between the other tarsal bones and the subtalar joint enable an enormous range of motion, including plantar flexion, dorsiflexion, abduction, adduction, eversion, and inversion, (2).

The tibio_fibular ligaments (inferior-posterior and inferior-anterior), transverse ligaments, and inter_osseous membrane are supporting ligaments of the ankle joint. They provide a significant function in supporting weight and stability but provide a small role in mobility (3). Additionally, deltoid ligament (also known as the medial_ligament) and collateral lateral ligament (also known as anterior, posterior, and calcaneofibular ligaments) support the ankle joint, respectively (4). (Figure 1)

The articular edges of the bones are connected to the fibrous capsule that surrounds the joint. The front capsule is fragile, whereas the posterior capsule is reinforced by robust collateral ligaments (6). The retinacula are fibrous bands that wrap, cover, and stabilize the tendons in the anterior, medial, and lateral directions. It acts as a series of pullies to provide muscular tendons with a smooth gliding surface, thereby preventing tendon bowstringing (7).

Plantar flexion is primarily accomplished by gastrocnemius and soleus. The digitorum flexor longus, and hallucis flexor longus are main plantar flexors. These muscles have the ability to enter the foot behind the lateral malleoli and medial malleoli. The fibularis tertius, extensor hallucis longus, extensor digitorum longus, and tibialis anterior which straddle the ankle in the anterior area, cause flexion of the foot in the dorsal plane. The primary plantar flexors of foot, tibialis anterior, and tibialis posterior, which also serve as dorsiflexors, enable ankle inversion. The plantar flexors, fibularis longus and fibularis brevis, as well as the dorsiflexor fibularis tertius, are responsible for the eversion of the foot (8).

The peroneal (fibular) artery and tibial (posterior and anterior tibial arteries) make up the ankle's blood supply (9). The roots from the spinal cord L4 to S2 provide nerve supply to the ankle. The sural nerve, the tibial nerve, deep fibular (or peroneal) nerve all supply branches to ankle joint as well (10).

3. Anatomy of the foot:

The hindfoot, midfoot, and forefoot are three classical foot divisions.

The Midfoot starts at the transverse tarsal joint and ends at the TMT joint, where the metatarsals start. Compared with the hindfoot, the midfoot has a few more joints, although these joints are not mobile. The navicular, cuboid, and three cuneiforms (medial, middle, and lateral) comprise five midfoot bones (11).

The talonavicular, calcaneocuboid, entocuneiform, and tarsometatarsal (TMT) joints make up the midfoot. The calcaneocuboid and talonavicular joints were combined to form the transverse tarsal joint. The foot is flexible when these two joints are parallel, but becomes rigid when their axes split. (12).

The deep (intrinsic) muscles in the foot are small muscle groups located deep within the foot. They support the stability of foot and toe movements. Extensor hallucis brevis and digitorum extensor brevis were found on dorsal aspect of the foot. The deep peroneal nerve innervates muscles. Their fundamental purpose is to assist with toe mobility (mainly extension). The four smaller toes and the great toe can be flexed with the help of these muscle-tendon units, which are situated deep within the plantar arch. They received innervation from the plantar nerve mainly the medial one.

The fibrous tissue of plantar fascia was robust. The tissue that extended to the bases of each of the five toes originated deep within the calcaneus plantar surface. This motion tightens plantar fascia and preserves the foot arches (medial and lateral longitudinal foot arches) by preserving space between the calcaneus and metatarsal heads. (13).

4. US scanning technique:

Different imaging methods as; magnetic resonance imaging, computed tomography and diagnostic musclo_skletal ultrasonography were used to analyze and visualize the ankle. However, US had additive benefits for examining the ankle soft tissues structures as tendons, capsule and ligaments, especially with dynamic assessment and real-time analysis, along with low cost-effectiveness and low radiation exposure (1). Additionally, Doppler imaging helps distinguish the intrasubstance tears of the tendinopathic tendon (14)

Anterior Ankle Evaluation

Evaluation of the anterior compartment of both ankle joints includes exploration of the peroneus tertius (PT), tibialis anterior (TA), anterior retinaculum, extensor digitorum longus (EDL) tendons, anterior tibial artery, and extensor hallucis longus (EHL) tendons, and deep fibular nerve, which are inconstant (15). For proper visualization of anterior compartment area of both ankle joints, the patient was placed lying in supine posture, flexing both knee joints, and foot sole was facing the examining table. (Figure 2)

Medial compartment

The medial compartment region of the ankle joint encompasses the flexor digitorum longus (FDL) tendons, medial retinaculum, subcutaneous medial malleolar bursa, neurovascular bundle, medial collateral tibiotalar or deltoid ligament, tibialis posterior (TP), and flexor hallucis longus (FHL).

Patient was positioned supine with the hip in flexion and adduction positions, the knee in semi-flexion position, and the outer side of foot lying on examining table to properly examine the medial compartment (15). (Figure 3)

Lateral compartment

The sub-cutaneous lateral malleolar bursa, Peroneus Quartus (PQ), peroneus longus (PL), peroneus brevis (PB), additional peroneal retinacula (superior and inferior), and lateral collateral ligaments are all located in lateral compartment region of both ankle joints (16).

With the patient's knee flexed, thigh extended, and inner-most part of foot lying on examining table, this ankle area was evaluated. Inversion is more helpful when examining the anterior talofibular ligament, while researches of the calcaneo_fibular ligament were easier if foot in dorsiflextion postion (17). (Figure 4)

Posterior compartment:

The Achilles tendon, plantar muscle tendon, retrocalcaneal bursae, and Kager's triangle are anatomical components of posterior compartment region. The patient was relaxed in a prone posture with his toes facing examination table's surface. As a result, the foot is fully extended, and the Achilles tendon will be under the most tension. Later, dynamic investigations and Doppler scanning were used to identify hypervascularization symptoms. This part of the evaluation is carried out with both feet hanging over the edge of examination table, and the Achilles tendon at the back of the ankle is slightly relaxed and not in tension because excessive strain in the tendon can compromise small intra-tendinous vessels (18). (Figure 5)

Plantar region of Heel and Plantar Fascia:

While the patient was lying on his or her back with the affected leg extended. Physicians should stand in a way that allows them to passively move the foot while applying stress to the plantar fascia to check its patency. The front edge of the probe extends into the medial longitudinal plane, and its posterior edge is placed above the anterior medial calcaneal tubercle in the anatomical sagittal plane (19). (Figure 6)

5. Structure-wise Pathologies and Ultrasound Findings:

Tenosynovitis and synovitis

The location of the affected joints and occurrence of synovitis are important diagnostic indicators of inflammatory or auto-immune arthropathies. It could be challenging in distinguishing clinical symptomatic synovitis from minmal or early onset inflammatory arthritis. Early rheumatoid arthritis and spondylarthritis frequently present with synovitis and tenosynovitis (16).

Intraarticular tissues that were abnormally anechoic, thickened or hypoechoic, non-displaceable, and poorly compressible are characteristics of synovitis on grayscale ultrasonography. Articular cartilage is disturbed as synovial proliferation advances, and erosions might be visualized at the osteo_chondral junction (20).

Inflammatory tenosynovitis is not a particular lesion; it is characterized by thicker tissue that is anechoic or might be hypo-echoic, with or without inflammatory exudate in the tendon's surrounding sheath. When synovial enlargement was present, Power Doppler ultrasound or color Doppler ultrasound should be used to determine vascular supply, and consequently, inflammatory changes of different tissue (17). (Figure 7)

Tendon pathologies:

Tendinosis: Tendinosis is often detected by ultrasound, which typically reveals distortion of the usual normal fibrillar tissues, along with wider areas between the hyper-echoic fibrillar tissues. The tendon appeared to be hypoechoic and thick. A thicker tendon with diffuse or dispersed echogenic foci that exhibits distal acoustic shadowing is a symptom of calcific tendinosis.

Tenosynovitis: With or without tendinitis, acute tenosynovitis manifests as an anechoic effusion in the tendon sheath (17).

Tendon tears

In a complete ripping, retraction of the proximal and distal ends was observed. Partial tears manifest as partial disturbance of the tendon fibrillar echotexture (19). (Figure 8)

Bursitis:

Ultrasonography is considered as an important diagnostic method for the identification and assessment of bursitis. It is comparable to MRI in terms of specificity and sensitivity for the evaluation of bursal disease, particularly in superficially localized bursae (21).

On ultrasonography, normal bursae are typically seldom or never discernible. Bursa expansion with increased fluid within it, which in some cases might be anechoic, is a key ultrasonographic indicator of bursitis. At other times, increased echogenicity might be seen because of debris, blood from recent trauma, or pus from an illness (19). (Figure 9)

Enthesitis

Enthesitis is a clinical characteristic of seronegative spondyloarthropathy, particularly psoriatic arthritis, and is less commonly present in other different inflammatory and autoimmune diseases, as rheumatoid arthritis and systemic lupus. Ultrasound can show Doppler activity in the peri-ethereal region, in addition to echo-texture abnormalities (such as tendon thickening and lack of fibrillar echotexture) at the enthesis sites. Transverse and longitudinal scans with extended and relaxed tendons should be included in the endoscopic ultrasound evaluation. Flexed muscles may make grayscale irregularities easier to observe, but they may also cause tension that weakens the Doppler activity signal. However, there is debate on which enthesis should be examined by ultrasonography when seronegative spondyloarthropathy is suspected, and it is usually recommended to include posterior Achilles tendon and select the knee tendons as quadriceps and patellar ligaments and enthesis of plantar fascia (18).

Vascularization at cortical bone insertion is a defining feature associated with inflammatory enthesitis found on power Doppler ultrasound. Because nearby inflammatory bursitis and calcifications of tendons are frequently visualized on ultrasonography at various places of enthesitis, nearby tissues should be additionally assessed (22). (Figure 10)

Bone erosions

According to the two perpendicular planes' visible intra-articular irregularities of the bone terrain, bone erosion is a significant characteristic of both rheumatoid arthritis and spondyloarthropathies and can be detected with ultrasonography. Cortical abnormalities of at least 2 mm in width can be accurately identified using ultrasound, as cracks on the surface of the bone are linked to inflammatory arthritis. Ultrasonography is more useful for detecting bone degradation in the fingers and foot joints than in bones with poor ultrasound glazing, such as the wrist and tarsal bones (22). Differentiating between normal cortical cracks without inflammation and bone erosion is crucial. Minor pathologies (2 mm) or pathologies located in the palm of the metacarpal bones and phalanges, as nourishing blood supply travel through bone and vascular pathways, are often the cause of false positive ultrasound results. Pseudo-erosions created by osteophyte formation arranged in forceps like formations, which were more evident in psoriatic arthropathy and is considered challenging in observing the cortical plan of bones, are another cause of false-positive results (23). (Figure 11)

Ligamentous disorders:

The following ultrasonographic findings were used to identify ligamentous disorders (24).

In an acute sprain, the ligament grows larger and loses normal fibrillar echogenicity. It also displayed anechoic zones that transversed or replaced the ends of the ligament, anechoic bands that followed its superficial border, signifying a rupture of the bony insertion, and inflammatory exudate as edema of the subcutaneous soft structures with lymphatic engorgement.

There were three levels of ligamentous injuries:

*First degree injuries: Ultrasonography revealed a distended ligament with a hypo-echoic presentation according to the intervening inflammatory edema and a hypo-echoic finding highlighting the superficial component of the ligament as the ligament has a smooth contour and is continuous.

* Second degree injuries: Regular echotexture seems altered. A slight ligament discontinuity can be observed, and the ligament is swollen, uneven, and irregularly shaped.

*Injuries of third degree: ultrasonography allows for the detection of a full-thickness lesion, with potential fiber retraction and hemorrhagic collection filling the void.

6- Role of the US in foot joints and ankle in different diseases:

Rheumatoid arthritis:

Synovial thickening is most frequently found on the inner side of PIP and dorsal metacarpo-phalangeal joints in patients suffering from RA. The palmar and dorsal regions of the foot and ankle should be evaluated to assess for symptoms of tenosynovitis, arthritis and enthesitis, even if the diagnosis is in doubt (25).

Established rheumatoid arthritis may also have para-tendinosis, which is characterized by the absence of the covering layer on the extensor tendon above the metacarpo-phalangeal joints and concomitant alterations to the extensor tendon, including increased diameter, decreased fibrillar echogenicity, and higher Doppler activity (26). (Figure 12)

US scores:

Ultrasound results: To evaluate small joints, a highly resolution modality with an increased frequency probe (7.5–18 MHz) could be used. The most popular scoring system, semi-quantitative GS, derived in the B-mode, categorizes expansion of the synovium either absent, minimal (small hypo-echoic or anechoic area presented in capsule of the joint), moderate (elevation of the capsule), severe or marked (distension of the capsule), or marked (marked distension of the capsule) (27).

Performance of Backhaus score GS/PD 7-joint in rheumatoid arthritis patients receiving various medications was demonstrated to be equivalent to clinical and laboratory findings. Bone degradation after one year was indicated by higher scores. It is noteworthy that the Backhaus approach was sensitive enough to show a decrease in bone erosion among individuals who changed their biological treatments (28).

Inflammatory response and angiogenesis are categorized on the semi-quantitative power Doppler signal scale either: absent (existent), minimal (1 power Doppler signal), moderate (2 or more power Doppler signals, implying less than 50% of intra-articular flow), and severe or marked (greater than 50% of intra-articular flow). Additionally, Carotti et al. demonstrated that rheumatoid arthritis synovitis (higher values) could be distinguished from normal participants using the resistive index (RI), which assesses various alterations in the microvessels of joints of the hands and wrists (29). The OMERACT criteria are used to define bone erosion, which is then categorized as present or missing (30).

Psoriatic arthritis:

Psoriatic arthritis exhibits erosion, hypertrophy of the synovium, inflammatory effusion inside the joints, and elevated Doppler power activity on grayscale US, which is comparable to the morphology of RA. Subjects with psoriatic arthropathy had more pronounced entheseal and tendinous involvement close to the synovial joints. Although there was no power Doppler activity signal across the hypertrophic tissues, active intra-articular synovitis was still possible (31).

The implementation of ultrasound has improved knowledge of dactylitis pathologies that go over the existence of inflammatory tenosynovitis of tendons or inflammation of synovium. In a new research on psoriatic arthritis patients with dactylitis, ultrasonography was used to identify joint synovitis in 40% of the affected digits. This condition was linked to an extended course of the condition and the asymptomatic "cold" subtype, which is defined by swelling but not pain or tenderness (32).

Ultrasound scores:

Entheseal lesions can be seen and signs of inflammation can be found using B-mode diagnostic ultra-sound in combination with a Doppler power activity signal (indicating blood supply). Agostino et al. created the following five-grade ultrasonography score for enthesitis:1, cortical junction vascularization with absent abnormal alterations in B mode; 2a, cortical junction vascularization with low echogenicity and distension in B mode; 3a, similar to 2a with adding erosions of cortical bone surfaces and/or entheseal micro-calcifications, and inflammation of the surrounding bursa; 2b, various abnormal alterations in B mode similar to that occured in stage 2a but with no abnormal vascularization; and 3b, alterations in B mode similar to in stage 3a, but lacking vascularization of different tissues (33).

Crystal deposits:

As contrast materials are not needed, sonography can reveal tophi deposition in various structures as joints, peri-articular soft tissues, and cartilage, as well as inflammatory synovitis, enhanced power Doppler signals and erosions of the articular surfaces. Recent research supports usefulness of US in detecting gout early and tracking the effectiveness of therapy (34).

The "double contour sign" is an amorphous echogenic line produced by urate deposition across the topmost layer of hyaline cartilage as seen with ultrasound technology. Patients suffering from acute attack of gout, patients had history of previous gout attack, and presenting with asymptomatic hyperuricemia; all showed this sign. Among patients suffering from gouty arthropathy, this observation found to be from twenty five to ninty five percent among these patients (35). (Figure 13)

A tophus typically has a hyperechoic heterogeneous center and an anechoic halo in the US. With a more centrally located hyperechoic synovial proliferation, the outermost anechoic findings corresponds to the fibro-vascular region observed in pathology examination. Occasionally, the tophus may be poorly defined and pass through several fascial planes. Sonolucent tophi are known to be soft tophi, whereas chronic tophi which not allowing imaging of the tissues beneath, known to be hard tophi (36). (Figure 14)

On ultrasonography, gouty synovitis shows mixed echogenicity, is primarily hyperechoic, and is frequently accompanied by enhanced vascularity. In contrast to the frond-like synovial enlargement observed in rheumatoid arthritis (37), it is more likely to be concentric.

A "snowstorm appearance" has been seen in some instances due to floating hyperechoic foci, which are most likely micro tophi. Bursitis, intratendinous deposits, entheseal inflammation, and sub-cutaneous nodules associated with gout are easily detected using ultrasound (38).

Intra-articualr inflammatory effusion is considered to be an early non-specific sign in subjects with gouty arthropathy. Diagnostic ultrasonography is the main imaging technique allowing for injection assistance during theraputic and diagnostic procedures, as intra-articular joint aspiration of effusion for the detection of gouty crystals. In addition to detecting the extra-articular structure implicated in the evaluation of acute gout, ultrasound may also provide needle guidance for fluid aspiration (35).

7.Conclusion:

The foot and ankle joints are commonly affected in various rheumatic diseases. Foot and ankle joints abnormalities have a specified effect on patients' functional mobility and disability, and they must be accurately evaluated using a variety of modalities. Ultrasonography is considered a reliable method for diagnosing and predicting functional disability and managing ankle pathologies. Longitudinal studies are needed to confirm these findings.

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