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Ultrasonographic findings in juvenile idiopathic arthritis

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Abstract
While encountering several obstacles, musculoskeletal US stands as a widely- recognized valuable method in the field of pediatric medicine, as shown by the findings of multiple surveys conducted among pediatric rheumatologists. The majority of participants found musculoskeletal US to be highly relevant in detecting subclinical synovitis while improving the classification of cases developing different subtypes of JIA. It is also useful in guiding intraarticular corticosteroid injections along with identifying early articular damage. Furthermore, several joints were identified as particularly suitable for examination with musculoskeletal US, including the midfoot, ankle, hip, wrist, as well as the hands and feet small joints.

Keywords: Musculoskeletal ultrasound, Juvenile idiopathic arthritis, synovitis

Introduction
Juvenile idiopathic arthritis (JIA) involves a diverse collection of different disease subtypes. It is characterized by the development of arthritis among individuals younger then sixteen years old, with no clear etiology, along with clinical manifestation persisting for a minimum of six weeks [1]. The International League of Associations for Rheumatology (ILAR) classifies Juvenile Idiopathic Arthritis (JIA) into seven clinical subtypes. These subtypes include oligoarthritis (o-JIA), which can be persistent or extended; polyarthritis (p-JIA), which can be rheumatoid factor-positive or negative; psoriatic arthritis; systemic JIA (s-JIA); enthesitis-related arthritis (ERA); and undifferentiated arthritis [2].
Regardless of their variations, all types of JIA are characterized by persistent inflammation of the synovial membrane, which may result in the deterioration of cartilage as well as bone, in addition to significant physical disability and a detrimental effect on one's quality of life (3). The emergence of powerful and costly drugs in recent times has highlighted the need of identifying cases exhibiting a high risk for erosive damage at an early stage, as well as those developing a less severe conditions, enabling physicians to determine the most suitable treatment at abd fir the best period. As a result, researchers began searching for precise methods to effectively record and track synovial inflammation [3, 4].
Musculoskeletal ultrasound (MSUS) has become a recommended method for assessing treatment response while detecting subclinical synovitis in rheumatoid arthritis [5]. This technique is also gaining importance, particularly in children's assessment. MSUS is increasingly employed for cases developing JIA to confirm suspected clinical findings, identify subclinical synovitis, visualise specific anatomical structures, along with guiding interventional procedures such as joint injections [6]. Studies have shown that MSUS is more effective than a clinical examination in detecting synovitis in JIA [7] It has proven to be a valuable tool in evaluating JIA since it could identify inflammatory lesions before permanent joint damage occurs in addition to monitoring disease progression and treatment response, thus potentially influencing suitable treatment [8].

Technical Aspects: MSUS often utilizes B mode or grey scale (GS) evaluation as a structural indication, such as for synovial hypertrophy, effusion, along with tendinopathy. Power Doppler Ultrasound (PDUS) is utilized as a sensitive measure of vascular flow,

which indicates inflammation. Doppler modalities are presently regarded as essential components of the global US evaluation of cases developing rheumatic conditions. Their capacity to identify pathogenic flow inside musculoskeletal soft tissues allows them to demonstrate the existence of local active inflammation [9]. PDUS is capable of identifying indirect synovial hyper vascularization symptoms along with related articular inflammatory alterations. The PDUS signal is strongly associated with the local clinical evaluation of disease activity in many joints, involving the knee, shoulder, elbow, metatarsophalangeal, as well as interphalangeal joints, among cases developing JIA and other arthritis types [10].

Ultrasonographic findings

Joint effusion: Effusion often appears as a fluid collection with clear boundaries surrounding the joint, as observed in Figure (1). Recognizng this characteristic may aid in differentiating effusion from the anechoic articular cartilage appearance in a youngster. If a complex intra-articular collection is seen, it may be distinguished from synovial hypertrophy by manually manipulating the joint. An effusion should be compressible and able to be displaced [11].

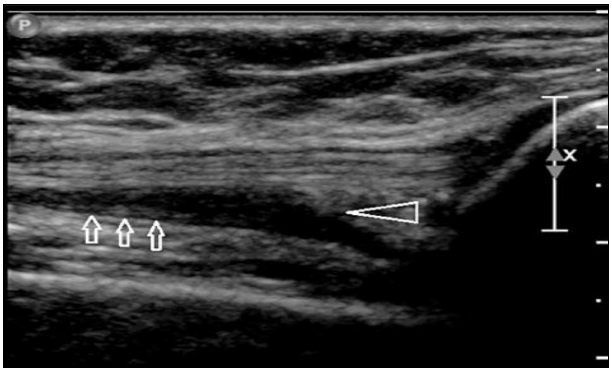

Fig 1: An anechoic collection with angular borders, indicating a mild to moderate joint effusion, is seen in the knee's suprapatellar recess (white arrowhead). The presence of thickened, hypoechoic synovium is also observed around the effusion (shown by white arrows) [12]

Tenosynovitis

In cases with JIA, the tendon sheaths around the affected joints could be involved as well, resulting in thickened tendon sheath, inflammation, along with the presence of fluid inside the sheath. Tenosynovitis is characterized by the thickening of the tendon sheath, thus appearing as hypoechoic or anechoic area on US imaging. This thickening may be seen in two different planes and may or may not be accompanied by a Doppler signal [11].

Synovial hypertrophy/hyperemia

The presence of synovial membrane inflammation stands as a characteristic sign of JIA and may be readily seen with sonography. It appears as a complex, hypoechoic bulging of the synovium, typically accompanied by increased blood flow. The presence of more blood vessels in the hypertrophic synovium shows that the disease is currently active. When observing an increased periarticular blood flow on Doppler with no structural synovial abnormality on gray-scale sonography, the results need to be interpreted cautiously since the anatomical knowledge regarding normal blood arteries supplying the joints in children is still limited [11].

Enthesitis: Enthesitis is the primary characteristic of the ERA-JIA subgroup, as classified by ILAR for JIA. Clinically, it is characterized as pain at the point where a tendon, ligament, joint capsule, or fascia attaches to the bone. Diagnosing enthesitis in children may be difficult due to the unique distribution of fat, which can obscure anatomical landmarks, and the sometimes limited cooperation of very young children. A recent study examined the sensitivity of MSUS in detecting enthesitis among children developing JIA, comparing the effectiveness of physical examination as well as power Doppler (PD) MSUS in detecting enthesitis in five specific sites. These sites included the quadriceps tendon insertion, the proximal and distal patellar ligament insertion on the tibial tuberosity, the Achilles tendon insertion on the calcaneus' posterior surface, as well as the plantar fascia insertion. It addressed that MSUS can help identify peripheral enthesitis that may not be evident during a physical examination among both ERA along with non-ERA cases. Additionally, MSUS can significantly contribute to the accurate diagnosis and classification of JIA [13].

Bony erosion: The erosion of the bony epiphyses stands as a sign of advanced arthropathy, indicateing a late-stage degenerative deterioration. Distinguishing between pathological erosions and ossification centres is challenging among paediatric cases. Therefore, alternative imaging techniques such as MRI or conventional radiography (CR) are deemed the most reliable methods for identifying epiphyseal erosion. [14].

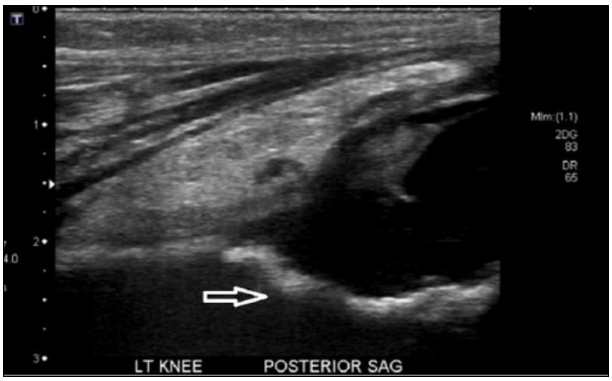

Fig 2: Shows an accumulation of fluid behind the knee, namely in the subperiosteal area, in a case developing a deteriorating suprapatellar fluid collection. Beneath the posterior accumulation, there are indications of cortical irregularity that imply bone erosion (white arrow) [12]

Thinning of articular cartilage

Chronic inflammation may result in a degenerative joint cartilage, characterized by blurring at the edges along with a reduction in cartilage thickness, ultimately causing a joint space narrowing. The articular cartilage thickness assessment with sonography is debatable. However, some studies have shown encouraging outcomes, particularly when assessing the distal femoral cartilage thickness at the intercondylar notch. Age as well as BMI are deemed variables, possibly influencing or distorting these readings [14].

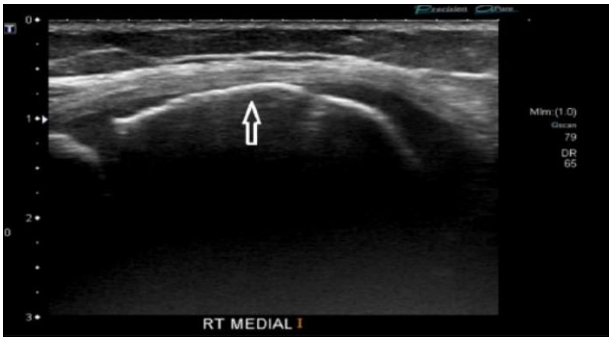

Fig 3: Illustrates the reduced articular cartilage thickness on the medial femoral condyle thigh within a case diagnosed with JIA. The normal cartilaginous interface (Shown by the white arrow) is visually absent [12]

Synovitis Classification [15, 16]

a. Based on grey scale mood individually [15]

1. **None (Grade 0):** no No synovial hypertrophy regardless of the existence of fluid accumulation in the joimt.
2. **Minimal (Grade 1):** Synovial hypertrophy is evident and it may or may not be accompanied with fluid accumulation in the joint, reaching the horizontal line level, which connects bone surfaces.
3. **Moderate (Grade 2):** Synovial hypertrophy, which may or may not be accompanied with effusion that extends beyond the joint line. The synovial tissue's upper surface is either convex (curved downwards) or the hypertrophy extends beyond the joint line with the upper surface being flat.
4. **Severe (Grade 3):** Synovial hypertrophy, which may or may not be accompanied with effusion that extends beyond the joint line, with the upper surface being flat or convex (curved downwards).

b. By power Doppler mode individually [15]

1. **None (Grade 0):** Doppler activity is not detected.
2. **Minimal (Grade 1):** Around 3 single Doppler spots may be detected. Also, a single confluent spot could be observed in addition to 2 single spots, or 2 confluent spots may be evident.
3. **Moderate (Grade 2):** More Doppler activity in comparison to Grade 1 while being less than the total GS background by fifty percent.
4. **Severe (Grade 3):** More Doppler activity in comparison to Grade 2 (more than fifty percent of the background GS).

c. By EULAR-OMERACT combined scoring system for grading synovitis in rheumatoid arthritis [16]

1. **Normal joint (Grade 0):** SH is not evident in GS in addition to the absence of PD signal (In the synovium).
2. **Minimal synovitis (Grade 1):** Grade 1 SH in addition to PD signal of Grade 1 or less.
3. **Moderate synovitis (Grade 2):** Synocial hypertrophy of Grade 2 in addition to PD signal of Grade 2 or less or Grade 1 SH on GS ultrasound with a PD signal of Grade 2.
4. **Severe synovitis:** Either Grade 3 SH on GS ultrasound along with PD signal of Grade 3 or less, or Grade 1 or 2 SH on GS ultrasound with a PD signal of Grade 3.

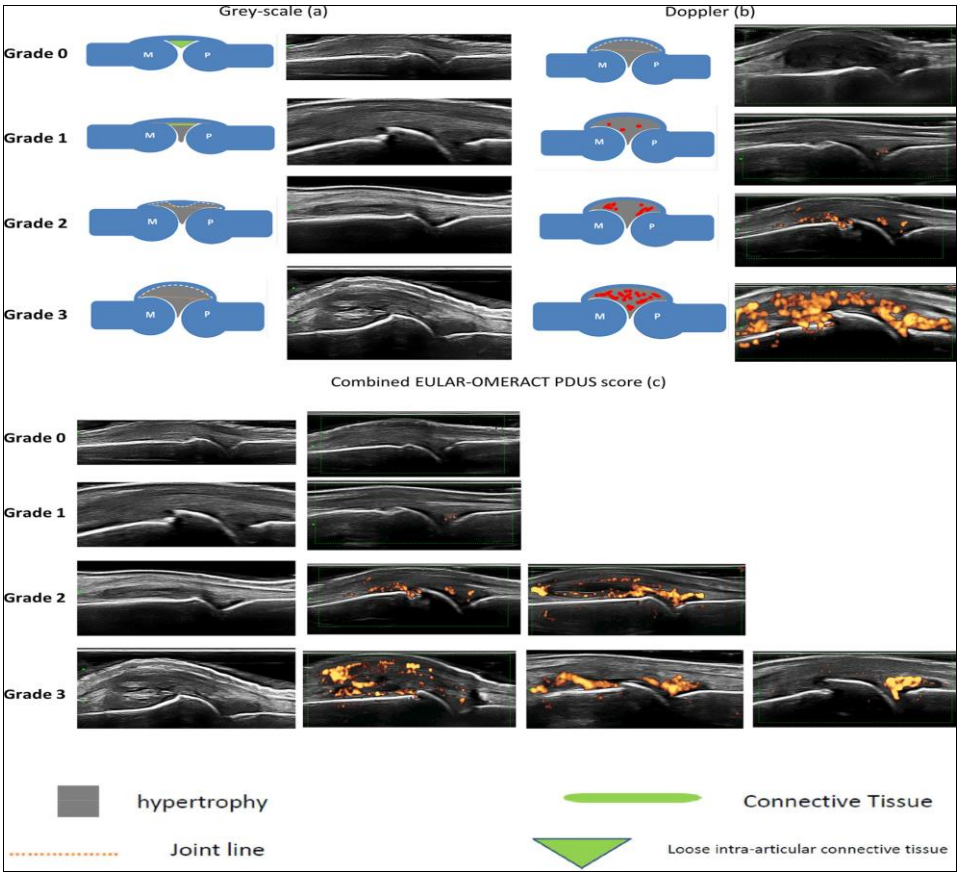

Fig 4: Illustrates synovitis by classification with US [16]. a. exhibits the schematic drawing of the hypoechoic SH individual grades for GS alone. b. exhibits the schematic drawing of the individual grades of Doppler activity c. exhibits the EULAR-OMERACT score for PDUS synovitis involving GS synovial hypertrophy in addition to PD signal

Conclusion

MSUS stands as a valuable method for evaluating JIA since it may detect inflammatory lesions before irreversible joint damage occurs. It also helps assess the disease progression while evaluating the treatment effectiveness, thus influencing proper therapeutic decisions.

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