Musculoskeletal ultrasound in Paediatric Rheumatology: a retrospective analysis

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ABSTRACT

Objectives: Musculoskeletal Ultrasound (MSK-US) has become increasingly important in the diagnosis and follow-up of children with rheumatic diseases. We describe the experience of a large Portuguese centre and study the added value of MSK-US in the clinical assessment of paediatric rheumatic diseases.

Material and methods: Patients were observed by assistant Rheumatologists, a clinical diagnosis was assigned and MSK-US requested. 330 MSK-US exams were performed to 222 children with rheumatic inflammatory diseases. The children's ages were between 1 and 18 years (mean=11.7±4.7 years) and 67.6% were female. Synovial membrane proliferation, intra-articular effusion, cartilage abnormalities, erosions and periarticular affections were searched in each joint. Clinical and ultrasonography data were compared.

Results: MSK-US detected synovitis in 100 of 194 exams (51.5%) of patients with that clinical information and in 36 of 136 exams (26.5%) of patients who presented other clinical findings. In those in which MSK-US did not confirm the clinical information of synovitis (94; 48.5%), we detected tenosynovitis/tendinopathy in 13 cases (13.8%) and synovial cyst in four (4.3%). The remaining patients had no ultrasonography changes and MSK-US helped to exclude synovitis. The sensitivity for arthritis clinical assessment was good (73.5%), with modest specificity (51.5%), an accuracy of 60.6% and precision of 51.5%. Ultrasonography synovitis was mostly found in the knee (37.5%), followed by the ankle (22.8%) and hip (10.3%).

Overall, 39 exams showed ultrasonographic tenosynovitis/tendinopathy, 15 of which had the same clinical diagnosis. Tenosynovitis/tendinopathy was mostly found in the ankle (59.0%) and knee (23.1%) areas.

Conclusions: MSK-US is an important aid to clinical evaluation, allowing both the detection and exclusion of joint pathology in children, contributing to a better assessment.

Keywords: Paediatric; Tenosynovitis; Ultrasound; Rheumatology; Synovitis;

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INTRODUCTION

Musculoskeletal ultrasound (MSK-US) has become increasingly important in the diagnosis and follow-up of both adults and children with rheumatic diseases in the last 20 years[1,2].

It is a non-invasive exam which not only helps the diagnosis and assessment of the disease, but it also assists in treatment decisions. Additionally, it allows ultrasound-guided procedures. Undervaluation of arthritis may lead to delayed diagnosis and treatment, or suboptimal suppression of joint inflammation with anti-rheumatic therapy. The issue of subclinical arthritis is particularly relevant in Juvenile Idiopathic Arthritis (JIA), but also applies to many other inflammatory rheumatic diseases affecting children. MSK-US seems to represent a reliable measure of JIA disease activity[3].

MSK-US has a number of advantages over other imaging methods, including non-invasiveness, radiation-free, relative low cost, availability, ability to scan multiple joints at one time, repeatability and good patient acceptance. Another advantage of US is that it can be coupled with the clinical approach to the patient in the standard rheumatology setting. Specifically considering children, the innocuous nature of MSK-US and the fact that it can be done swiftly along with clinical observation makes it a useful imaging technique in current medical practice.

In more advanced stages of JIA, gadolinium-enhanced Magnetic Resonance Imaging (MRI) seems to be

superior when evaluating synovial proliferation, articular cartilage, loculated effusions, menisci and ligaments[4]. Nevertheless, considering cartilage thickness, no significant joint size-related differences were found between MRI and MSK-US[5]. This gives weight to the usage of ultrasonography in children for evaluating articular changes, as MSK-US is a more accessible exam than MRI.

There are a small number of articles regarding the use of MSK-US in children, and as far as we know, no Portuguese study was published in this area of knowledge. In our work we discuss the experience in a large centre of MSK-US in the study of rheumatic conditions in children, comparing clinical observation with MSK-US assessment.

MATERIAL AND METHODS

We performed a retrospective analysis of 330 MSK-US exams performed to 222 children with rheumatic complaints in our department in the last 11 years (2001--2011). The children's ages were between 1 and 18 years (mean= 11.7±4.7 years) and 67.6% were female. They were observed in the Paediatric Rheumatology outpatient clinic by consultant Rheumatologists, with training and expertise in Paediatric Rheumatology and more than a decade of practice. The great majority of ultrasonographic exams were performed non--blinded in the same day as clinical observation by one of two rheumatologists with more than 15 years of ultrasound experience, using Diasus (Dynamic Imaging) ultrasonograph equipped with 3 linear probes (5-10 MHz, 8-16 MHz and 10-22 MHz) and Logiq E9 (General Electric Medical Systems, Milwaukee, WI), equipped with an 8–15 MHz volumetric probe (4D16L) and 2 linear probes (ML6-15 and L8-18i).

We compared the clinical information accompanying the MSK-US request (inflammatory arthritis, swollen joint, tender joint, tenosynovitis/tendinitis or others) with the ultrasonographic findings. Synovial membrane proliferation, intra-articular effusion, cartilage abnormalities, erosions and soft tissue affections (tendinopathy, tenosynovitis, and bursitis) were searched at each joint[6]. Each joint was scanned in both the longitudinal and transversal view using grey-scale. Overall, the following joints were scanned: hand distal and proximal interphalangeal, metacarpophalangeal, wrist, elbow, shoulder, sternoclavicular, sacrococígeal, hip, knee, ankle, metatarsophalangeal and feet proximal interphalangeal.

Continuous variables are summarized by mean, standard deviation and range. Categorical (dichotomous) variables such as synovitis or tenosynovitis are shown as absolute numbers or summarized as frequency (in percentage). The performance of clinical evaluation compared with MSK-US was made with determination of sensitivity, specificity, accuracy and precision. Clinical and ultrasonographic data were evaluated using Chi-Square test and Spearmans rank correlation coefficient; p values < 0.05 were considered to be statistically significant.

RESULTS

We analyzed a total of 330 exams in 222 children. In most children (70.3%) only one MSK-US exam was done per observation.

MSK-US detected synovitis in 100 of 194 exams (51.5%) of patients who had the clinical information of arthritis. In contrast, synovitis was found in 36 of 136 exams (26.5%) of patients with other clinical diagnosis: tendinitis, tenosynovitis, joint pain or other (Figure 1). Using Chi-Square, there is a statistically significant difference between the total number of ultrasound-confirmed synovitis and the total number of clinically diagnosed arthritis ($p<0.0001$). Nevertheless, if we compare the number of clinical arthritis with the number of ultrasonographic synovitis for each individual joint, there is a significant correlation ($r=0,88$; $p=0,002$).

In 48.5% of patients with arthritis at observation, MSK-US did not support the clinical findings. In these patients with clinical, but not ultrasonographic synovitis (n=94), we detected tenosynovitis/tendinopathy in 13 cases (13.8%) and the presence of synovial cyst in 4 (4.3%). The 77 remaining patients had no ultrasonographic changes whatsoever.

Ultrasonographic synovitis was mostly found in the knee (37.5%), followed by the ankle (22.8%) and hip (10.3%). (Table I) If we consider the relative frequency of synovitis, the elbow (72.7%), shoulder (55.6%), knee (50.5%) and foot joints (50.0%) were the anatomical areas where MSK-US mostly confirmed the clinical findings.

Compared to MSK-US, the overall sensitivity for arthritis clinical assessment was 73.5%, with a 51.5% specificity. There was a 60.6% accuracy and 51.5% precision (Table II).

Considering each joint, we calculated sensitivity,

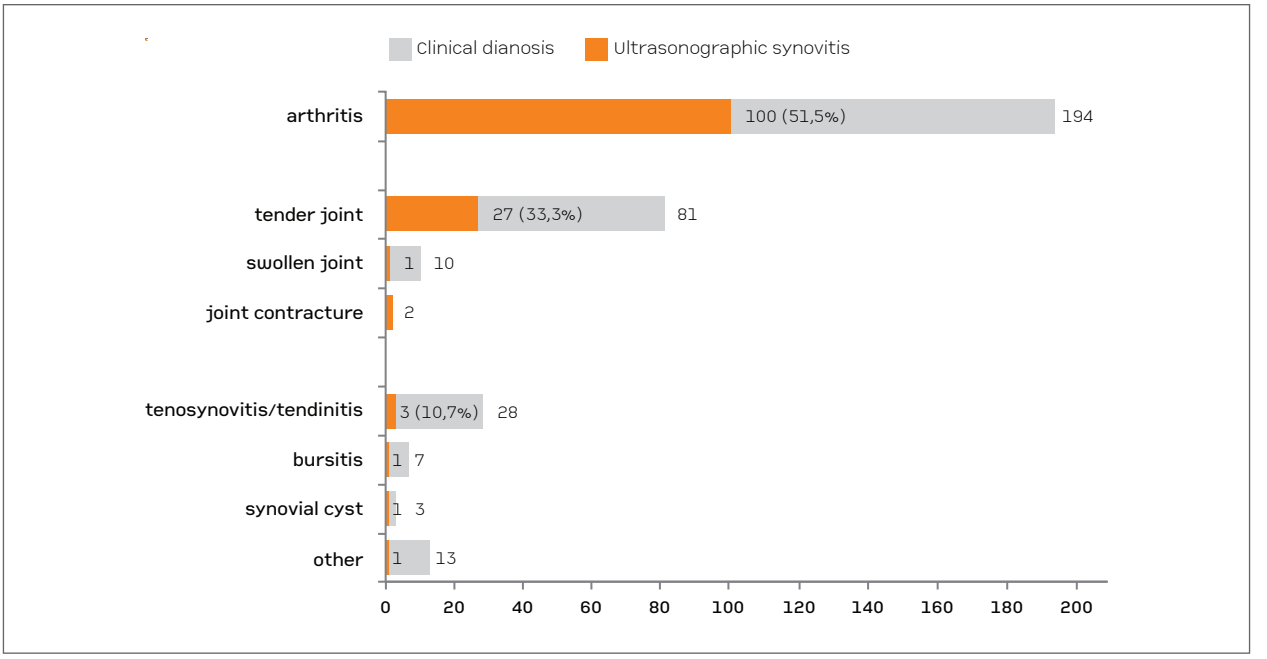

FIGURE 1. Number and percentage of ultrasonographic synovitis per clinical diagnosis

specificity, accuracy and precision for clinical arthritis compared to MSK-US. The shoulder, wrist, ankle and feet joints have the highest sensitivity when using clinical evaluation (Table II). Hip, knee and hand joints also present sensitivity over 70%. As for specificity the elbow and hip present the best values. The most accurate clinical assessment for synovitis was in the wrist and feet joints, although both hip and ankle clinical evaluations proved to have an accuracy above 70%. Precision was highest in assessment of the elbow, wrist and feet joints.

Overall, 39 exams showed ultrasonographic tenosynovitis/tendinopathy, 15 (38.5%) of which had the same clinical diagnosis associated. In the remaining 24 exams, 14 (35.9%) had clinical arthritis, 7 (17.9%) had joint pain and 3 (7.7%) had clinical information of bursitis. Of 26 patients with clinical tenosynovitis/tendinitis only 15 (57.7%) had ultrasonographic tenosynovitis/tendinopathy. There is a statistically significative difference between MSK-US and clinical evaluation at detecting tenosynovitis/tendinopathy ($p< 0.0001$).

Tenosynovitis/tendinopathy was mostly found in the ankle (59.0%) and knee (23.1%) areas (Table III). If we consider the relative frequency of tenosynovitis/tendinopathy, the ankle (28.4%) is still the most affected area.

MSK-US also identified erosions in 7 patients (2 of them had no ultrasonographic synovitis). Considering synovial cyst, there were 9 ultrasonographic findings, one third in patients with the same clinical diagnosis, four in patients with the clinical (but not ultrasonographic) diagnosis of arthritis and 2 in patients with popliteal pain.

DISCUSSION

The first publications using MSK-US in children with osteo-articular pathologies date back over 20 years[1,2]. MSK-US has seen a growing implementation in daily practice in the last decade in the field of Paediatric Rheumatology. Our work confirms the need of a wide implementation of MSK-US in Paediatric Rheumatology. In fact, it is an added value in the diagnosis and monitoring of children with rheumatic inflammatory conditions, confirming or denying synovitis and identifying other pathologies.

Our results are in agreement with a previous study[7] which also concluded that MSK-US is more accurate at detecting synovitis in children than clinical examination, allowing either confirmation or denial, or reclassification of diagnosis. Several other authors have reached the same conclusions when studying peripheral joints[8], ankles[9], knees[10-12] and hips[11,13,14]. Ove-

TABLE I. ULTRASONOGRAPHIC SYNOVITIS BY ANATOMICAL LOCATION

	Joints with US synovitis	Total joints scanned	Relative frequency	Absolute frequency
Knee	51	101	50.5 %	37.5 %
Ankle	31	81	38.3 %	22.8 %
Hip	14	49	28.6 %	10.3 %
Wrist	11	22	50.0 %	8.1 %
Elbow	8	11	72.7 %	5.9 %
MTP, PIP	8	16	50.0 %	5.9 %
MCP, PIP, DIP	7	39	17.9 %	5.1 %
Shoulder	5	9	55.6 %	3.7 %
Sternoclavicular	1	1	100.0 %	0.7 %
Sacrococígeal	0	1	0.0 %	0.0 %
TOTAL	136	330		100 %

(US – ultrasonographic, MCP – metacarpophalangeal, MTP – metatarsophalangeal, PIP – proximal interphalangeal, DIP – distal interphalangeal)
Relative frequency is the percentage of positive findings per anatomical area. Absolute frequency is the percentage of positive findings in an anatomical area compared with the total number of joints with US synovitis (136)

TABLE II. SENSITIVITY, SPECIFICITY, ACCURACY AND PRECISION OF CLINICAL EVALUATION OF ARTHRITIS COMPARED TO MSK-US, BY JOINT

Joint(s)	Sensitivity	Specificity	Accuracy	Precision	PPV	NPV	Youden's index
MCP, PIP, DIP	0.750	0.452	0.513	0.261	0.578	0.644	0.202
Wrist	0.923	0.600	0.783	0.750	0.698	0.886	0.523
Elbow	0.333	1.000	0.467	1.000	1.000	0.600	0.333
Shoulder	1.000	0.182	0.438	0.357	0.550	1.000	0.182
Hip	0.727	0.704	0.714	0.667	0.711	0.721	0.431
Knee	0.731	0.527	0.626	0.593	0.607	0.662	0.258
Ankle	0.900	0.596	0.707	0.563	0.690	0.856	0.496
MTP, PIP	1.000	0.500	0.889	0.875	0.667	1.000	0.500
OVERALL	0.735	0.515	0.606	0.515	0.602	0.660	0.250

(MCF – metacarpophalangeal, MTF – metatarsophalangeal, PIP – proximal interphalangeal, DIP – distal interphalangeal, PPV – Positive Predictive Value, NPV – Negative Predictive Value)

rall, for multiple joint assessments, MSK-US also proved to be an indispensable complement to clinical examination, allowing enhanced evaluation[7,8,15-17].

Other interesting finding of our work is that MSK--US could exclude synovitis in nearly half (48.5%) of the children with the clinical diagnosis of arthritis. It also excluded synovitis in two thirds of children with tender joints and in most children with apparent swollen joints. This emphasises the utility of MSK-US in identifying children without joint pathology, sparing unnecessary treatment and possible iatrogenesis.

We used an ultrasonograph without Power Doppler for most exams, because no other device was available at the time. Although Power Doppler is important in accessing information about joint active inflammation in children[18-20] a recently published study[15] compared both Power Doppler and grey-scale MSK-US, showing that there were more findings in children's joints using grey-scale than Power Doppler. Other authors[3] have reported that MSK-US parameters, not using Power Doppler, represent a reliable index of JIA disease activity, especially considering knee synovial thickness and knee effusion. Knee synovial thickness and effusion were always scanned in our patients.

TABLE III. MSK-US TENOSYNOVITIS/TENDINITIS BY ANATOMICAL AREA

	Joints with US tenosynovitis/tendinitis	Total joints scanned	Relative frequency	Absolute frequency
Ankle	23	81	28.4 %	59.0 %
Knee	9	101	8.9 %	23.1 %
MCP, PIP, DIP	4	39	10.3 %	10.2 %
Wrist	2	22	9.1 %	5.1 %
Shoulder	1	9	11.1 %	2.6 %
TOTAL	39	252		100.0 %

(US – ultrasonographic, MCP – metacarpophalangeal, PIP – proximal interphalangeal, DIP – distal interphalangeal)
Relative frequency is the percentage of positive findings per anatomical area. Absolute frequency is the percentage of positive findings in an anatomical area compared with the total number of joints with US tenosynovitis/tendinitis (39)

The most frequent locations for MSK-US synovitis in our study were the knees (37.5%) and the ankles (22.8%), while other authors studying only JIA children found the knees and wrists[16] and others established the feet as more prevalent[8]. However, we analysed also the relative frequency of synovitis and we found that the elbow (72.7%), shoulder (55.6%), knee (50.5%) and foot joints (50.0%) were the anatomical areas where MSK-US mostly confirmed the clinical findings. The small number of scanned shoulder and elbow joints makes these results to be confirmed by further studies. The hip (28.6%) and hand joints (17.9%) were the anatomical areas where MSK-US less corroborated clinical evaluation.

Our work also evaluated clinical assessment of tenosynovitis/tendinitis. There seems to be a remarkable discordance between clinical and MSK-US evaluation of tenosynovitis. In fact, most (61.5%) of the ultrasonographic diagnosis of tenosynovitis were found in patients with no clinical signs or symptoms of this affection. This may be due to subclinical tenosynovitis and illustrates the limitations of physical examination in children. The most common location for tenosynovitis was in the ankles (59.0%). Other studies concur with our results about tenosynovitis/tendinopathy and in fact they have very similar figures to ours[9,17].

If we consider MSK-US as the gold standard, we verified that clinical assessment in general had a good sensitivity but a modest specificity for synovitis detection. Despite having a correlation with ultrasonography findings and being fundamental in assessing children with rheumatic inflammatory conditions, clinical evaluation does not seem to be specific enough for synovitis detection, and lacks precision and accuracy. MSK-US, being a bedside, painless and radiation-free procedure has an added value and can help in decision making on the spot.

One limitation is that our work is a retrospective analysis, which requires cautious interpretation. An important aspect to note is that MSK-US was performed promptly in children observed in the Rheumatology clinic. The importance of this timing to exclude possible time-related differences between clinical observation and MSK-US examination has been underlined by other authors[3,7].

Globally, our results support the suggestion that MSK-US should be a screening procedure[7] for children with suspected joint pathology.

CONCLUSION

MSK-US is an important aid to clinical evaluation, allowing both the detection and exclusion of joint pathology in children, contributing to a better assessment and quality of care.

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