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Original Article

Evaluation of enthesitis in patients with juvenile idiopathic arthritis by power color and spectral Doppler ultrasonography

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Abstract

Objective: Ultrasonography in patients with juvenile idiopathic arthritis (JIA) could potentially be useful for evaluation of enthesitis. The aim of this study was to evaluate enthesitis in patients with JIA quantitatively by power color and spectral Doppler ultrasonography by determining color fraction (CF) and resistive index (RI).

Methods: A cross-sectional single-center study was performed in 15 (61 entheseal sites) patients with JIA with clinical enthesitis. A total of 9 age and sex matched healthy controls (53 entheseal sites) were also examined and compared. Entheseal sites (quadriceps tendon, patellar tendon, tendo-Achilles, medial and lateral epicondyles of humerus) were examined on USG B mode for tendon thickening, hypo- and hyper-echogenicity, enthesophytes, and cortical erosions/irregularities by power Doppler ultrasound for the presence of Doppler signal and by power color Doppler and spectral Doppler ultrasonography to derive CF and RI respectively.

Results: The mean thickness of entheseal site in patients and controls were 3.55±0.82 mm and 2.8±0.37 mm, respectively ($p<0.001$). The power Doppler signal was present in 93.4% of patients ($p<0.001$). The pooled data of all entheseal sites revealed a significantly higher CF in patients (0.08±0.03) than in controls (0.006±0.008) ($p<0.001$). The mean RI in patients (0.61±0.09) was significantly lower than that in controls (0.92±0.12) ($p<0.001$). The cut-off of RI (0.7) and CF (0.029) determined by receiver operating curve analysis revealed a diagnostic accuracy of 94.7% and 96.5%, respectively.

Conclusion: Evaluation of enthesitis by determining CF and RI via power color Doppler and spectral Doppler is possible in JIA patients.

Keywords: Juvenile idiopathic arthritis, enthesitis, Doppler, resistive index, color fraction, ultrasonography

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Introduction

Enthesitis in patients with juvenile idiopathic arthritis (JIA) is often assessed by clinical examination and conventional radiography (1). Palpation detects local tenderness and swelling at the enthesis site but has low specificity, as similar findings have been reported in normal children (2, 3) and overuse injuries, apophysitis, and fibromyalgia (4). Conventional radiography detects only late manifestations like erosions, enthesophytes, and calcifications (5).

Magnetic resonance imaging, considered the gold standard for diagnosing arthritis, lacks sensitivity and specificity for detecting peripheral enthesitis (6).

Ultrasonography (USG) has emerged as a more sensitive, specific, and reproducible modality and helps in identifying subclinical enthesitis. USG based semi-quantitative scoring systems have been used for assessment of enthesitis in adults (4, 7-9). Power color Doppler has also been used for semi-quantitative assessment of enthesitis in adults and children (10-13). Assessment of enthesitis by quantitative parameters, color fraction (CF), and resistive index (RI) determined by power color and spectral Doppler USG has not been reported till date. Hence, this pilot study was planned with a primary objective to evaluate enthesitis quantitatively by power color and spectral Doppler USG in patients with JIA and a secondary objective to determine a cut-off value of CF and RI for diagnosis of enthesitis. We also assessed B mode ultrasound and power Doppler findings in our patients.

Methods

Place of study

This descriptive, cross-sectional study was conducted in the Department of Pediatrics and Radiodiagnosis of a tertiary care hospital from January 2016 through June 2017.

Enrollment and sample size

Absence of any previous study on determination of CF and RI in enthesitis precluded sample size calculation.

A total of 114 patients with JIA (diagnosed according to the International League of Associations for Rheumatology revised criteria) attending the Pediatric Rheumatology Clinic were clinically examined for the presence of enthesitis, after stopping intake of any non-steroidal anti-inflammatory drugs (NSAIDs) 7 days before examination to avoid any confounding effect on suppressing tenderness and pain.

All patients were examined for enthesitis at the insertion of quadriceps tendon (superior pole of patella), infra-patellar ligament (tibial tuberosity), tendo-Achilles, plantar fascia, and the origin of wrist flexors-pronators (medial epicondyle) and wrist extensors (lateral epicondyle of the humerus). Initial examination of a total of 1,368 entheseal sites done by the first author identified 20 patients (70 entheseal sites) with suspected enthesitis. These were further verified by the corresponding and second authors independently for the presence of swelling and tenderness. Five patients (9 entheseal sites) were excluded. Finally, 15 patients (61 entheseal sites) were enrolled in the study, along with 9 age and sex matched healthy controls (53 entheseal sites).

Patients with a history of trauma or avulsion injuries, localized tissue or bone infection, or vascular abnormalities of the knee, ankle, foot, and elbow joint areas were excluded.

Written informed consent was obtained from parents or guardians of all enrolled patients and controls. Ethical clearance was obtained from the Ethics Committee of Dr Ram Manohar Lohia Hospital, New Delhi (Approval Date: October 26, 2015; Approval Number: No-4907).

Main Points

- Quantitative parameters to evaluate enthesitis have not been studied earlier in patients with JIA.
- It is possible to evaluate enthesitis in patients with JIA quantitatively by estimating CF and RI by power Doppler and spectral Doppler ultrasonography.
- Cut-off values of RI (0.07) and CF (0.029) offer a very high diagnostic accuracy for enthesitis.

Data collection

The following were recorded in a proforma: (i) Site and number of inflamed enthesis; (ii) Number of active joints; (iii) Pain severity - assessed on a visual analog scale of 10 where 0 indicated no pain and 10 maximum pain; (iv) Patient or parent assessment of general wellbeing, (v) Physician assessment of disease activity - both measured on a 10 cm visual analog scale where 0 indicated very well and 10 indicated very poor; (vi) Erythrocyte sedimentation rate (ESR) estimated by Westergren's method and normalized to a 0-10 scale according to the formula: (ESR mm/hr-20)/10; (vii) Juvenile Arthritis Disease Activity Score-27 (JADAS-27) calculated as a linear sum of the scores of physician global assessment of disease activity, active joint count, parent/patient assessment of general wellbeing, normalized ESR and ranged from 0-57; (viii) C-reactive protein - measured by rapid latex agglutination test.

The patients and controls were subjected to B mode, power Doppler, and spectral Doppler USG evaluation on a PHILIPS HD 11 ultrasound system (Phillips Ultrasound, Washington 98021, USA) using a 5-12 MHz linear array transducer. Ultrasounds were done within 2 days of enrollment, while NSAID was still stopped and after that restarted. The examination of each enthesis took around 20-30 minutes. The ultrasonographer was kept blind to the patients and controls.

B mode ultrasound evaluation

Enthesitis on ultrasound was defined by Outcome Measure in Rheumatology in Clinical Trials (OMERACT) criteria: (a) tendon thickening (in mm), (b) presence of hypo-echogenicity of the tendon, (c) presence of hyper-echogenicity of the tendon, (d) presence of enthesophytes, (e) presence of cortical erosions or irregularities, (f) color Doppler signal defined as Doppler activity 2 mm near the bony cortex, different from the reflecting surface artifact or nutrition vessel signal (11, 12).

Quadriceps tendon and patellar ligament insertion were examined in the supine position with the knee in 30º flexion, Achilles tendon and plantar fascia were examined in the prone position with feet hanging at the edge of the table in a neutral position, medial epicondyle with the arm in full extension, lateral epicondyle with mid flexion of elbow and pronation of the forearm. Each site was scanned in the longitudinal and transverse planes. Entheseal thickness was measured at the point of maximum thickness on the bony insertion (7).

Power Doppler was done to assess vascularity and calculate CF. The power Doppler settings were kept the same for all entheseal sites and all participants with a gain setting just below the noise level, using the set up for low flow: Nyquist limit ±0.14 m/s and MHz Doppler frequency. With this set up all the color pixels corresponded to motion of blood flow. The entheseal site was visualized for abnormal vascularization and assessed semi-quantitatively. Abnormal vascularization of the entheseal insertion into the cortical bone was defined if a power Doppler signal was detected and then scored as 0-absent, 1-minimal (1 color spot), 2-moderate (2 color spots), or 3-severe (≥3 color spots) (10).

To analyze CF, the image with the maximum color activity was selected for analysis. The digitally stored Doppler image in Digital Imaging and Communications in Medicine format was transferred to a processing program (Adobe Photoshop version CS6, Adobe Inc, San Jose, CA, USA). The entheseal site was traced indicating the region of interest (ROI). Using a color recognition function, the number of color pixels and total pixels in ROI were counted, and CF was derived by dividing color pixels by the total number of pixels.

Spectral Doppler ultrasound to calculate RI

Using the color Doppler as guidance, the pulsed Doppler was placed over an artery supplying the entheseal site. The ultrasound unit traced the Doppler spectrum electronically and identified the cardiac cycles, peak systolic blood flow, and end-diastolic blood flow. RI was then calculated as (peak systolic flow minus end-diastolic flow)/peak systolic flow (14, 15). The maximum value of RI was taken as 1. When spectral Doppler measurements could not be performed owing to lack of detectable vascularization in the examining enthesis, RI was taken as 1. In an inflamed tissue, the vascular resistance decreases and tissue perfusion increases. Hence in an inflamed area, CF was expected to increase and RI to decrease (14-16).

Intra and inter-observer reliability to determine CF and RI in inflamed tissue (synovium) in patients with JIA have been addressed in a previous study from the same center (17).

Statistical analysis

Statistical analysis was performed by the Statistical Package for the Social Sciences software for Windows version 17.0 (SPSS Inc.; Chicago, IL,

Table 1. USG B mode and PDUS findings in patients (n=15) and controls (n=9).

	Patients-Enthesis (n=61)		Controls-Enthesis (n=53)		
Parameter	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	p
Presence of hypo-echogenicity of the tendon	5	8.1	0	0	0.024
Presence of hyper-echogenicity of the tendon	0	0	0	0	-
Presence of enthesophytes	0	0	0	0	-
Presence of cortical erosions or irregularities	3	4.9	0	0	0.08
Presence of PDUS signal	57	93.4	0	0	<0.001
PDUS signal 1 color spot	41	67.2	0	0	<0.001
PDUS signal 2 color spot	16	26.2	0	0	<0.001

PDUS: power Doppler ultrasound signal; USG: ultrasonography.

Table 2. Entheseal thickness in patients and controls at individual tendon sites.

	Patients			Controls			
Site	No of enthesis	Mean±SD (mm)	Range (mm)	No of enthesis	Mean±SD (mm)	Range (mm)	p
Quadriceps	13	4.01±0.93	3-5.5	18	2.99±0.37	2.21-3.72	0.0002
Tendo-Achilles	21	2.88±0.31	2.4-3.8	16	2.65±0.37	2.04-2.99	0.021
Patellar tendon	24	3.96±0.66	2.8-5.2	18	2.84±0.34	2.18-3.81	<0.001

SD: standard deviation.

USA). Continuous variables were presented as mean±standard deviation (SD) and categorical variables as absolute numbers and percentages. Data were checked for normality before statistical analysis. The comparison of normally distributed continuous variables between the groups was performed using student's t test. Nominal and categorical data between groups were compared using the chi-squared test or Fisher's exact test as appropriate. The Mann-Whitney U test was used for those variables that were not normally distributed. A receiver operating characteristics (ROC) analysis was done to determine optimal cut-off values for RI and CF for all enthesis pooled together. ROC curve analysis was aimed to minimize the number of false positives and false negatives, thereby maximizing the sensitivity and specificity. In an ROC curve, if the test generates a straight line, it does not yield any predictive information, whereas a test that discriminates well between 2 groups will have a high rate of true positives and low false positive results yielding an elliptical curve. A point on this elliptical curve nearest to the upper left corner would be an excellent first choice of cut-off value. This was how the cut-off values for CF and RI were calculated with an area under the curve. After deriving the cut-off value, the sensitivity, specificity, positive predictive value, and negative predictive value were calculated using a 2×2 contingency table to determine CF and RI's diagnostic accuracy. For all statistical tests, a p-value less than 0.05 was taken to indicate a significant difference.

Results

Of the 15 enrolled patients, 10 had Enthesitis Related Arthritis (66.7%), and 5 had undifferentiated JIA (33.3%). The mean age of patients and controls was 12.87±1.89 years and 13.44±2.24 years, respectively (range 10-18 years in both). The mean age of onset of disease was 9.53±2.42 years (range 6-16 years), and the mean duration of disease was 3.33±1.63 years (range 1-6 years). The mean value of physician global assessment score was 6.47±1.55 (range 4-9), patient general wellbeing score 6.67±1.59 (range 4-9), JADAS-27 score 18.67±3.95 (range 9-25), and C-reactive protein levels were 4.72±6.13mg/dL (n<1). All the patients had active disease. Current treatment included methotrexate in all patients, sulfasalazine in 10, biological in 1, and low-dose steroids in 5 patients. Of the 61 entheseal sites examined in patients, 13 were quadriceps tendon enthesis, 21 tendo-Achilles, 24 patellar tendons, and 3 elbow flexors whereas in controls, 18 each were quadriceps and patellar tendon enthesis, 16 tendo-Achilles, and 1 elbow flexor.

The USG B mode findings are shown in Table 1 and 2. The mean entheseal thickness of all enthesis pooled in JIA patients was 3.55±0.82 mm (range 2.4-5.5 mm) as compared with 2.8±0.37 mm (range 1.89-3.81 mm) in the control group, and the difference was statistically significant (p<0.001). Similarly, significantly higher entheseal thickness in patients were observed at each tendon site (Table 2). The patients and controls were divided into age groups of 3 years each. In each group, the mean entheseal thickness was significantly higher in patients [10-12 years, patients, (n=21), 3.06±0.36 mm vs controls (n=19), 2.54±0.51 mm; 13-15 years, patients, (n=38), 3.74±0.85 mm vs controls (n=30), 2.9 ±0.14 mm; 16-18 years, patients, (n=3), 4.9±0.14 mm vs controls (n=4), 3.56±0.36 mm]; 5 out of the 61 entheseal sites (8.1%) revealed hypo-echogenicity with loss of fibrillary pattern; and 3 had cortical erosion, which were not found in any of the controls. None of the patients had hyper-echogenicity or enthesophytes (Table 1). No entheseal thickness value is available in literature beyond which thickened enthesis can be considered abnormal in children. Entheseal thickness has been shown to increase with age in healthy controls (10). In pediatric practice, it is usual to consider a value beyond ±2SD of the mean as abnormal for parameters like weight, height, etc. Following the same corollary, the cut-off value of entheseal thickness in our study would be 3.54 mm (0.37×2+2.80). Analysis of the patients' data revealed that 27 entheseal sites were more than 3.54 mm in thickness, and

Table 3. Resistive index and color fraction in patients and controls.

	Patients		Controls		
Parameter	Mean±SD	Range	Mean±SD	Range	p
Total pixels	3364.23±706.55	1,883-4,899	3179.93±737.77	2,167-4,890	0.021
Color pixels	258.84±105.03	0-499	18.25±23.76	0-81	<0.0001
Color fraction	0.08±0.03	0-0.11	0.006±0.008	0-0.03	<0.0001
Resistive Index	0.61±0.09	0.482-1	0.90±0.12	0.618-1	<0.0001

SD: standard deviation.

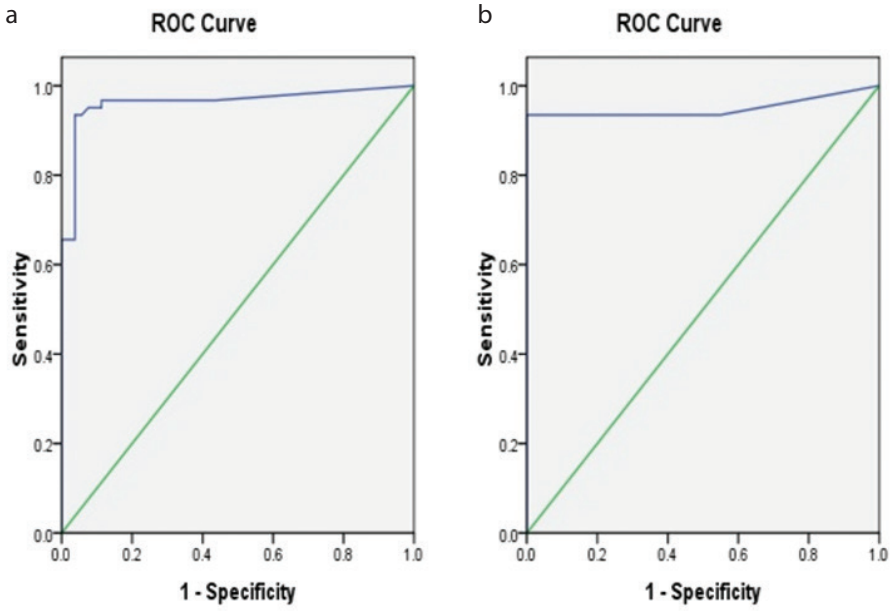

Figure 1. a, b. Receiver operating characteristic (ROC) curve for all the enthesis pooled together to obtain a perfect separation between 2 groups (normal vs diseased). Resistive Index - area under the ROC curve (AUC) 0.963 (95% CI: 0.926-1.00) (a). Color fraction - area under the ROC curve (AUC) 0.949 (95% CI: 0.900-0.993) (b).

of these 2 had hypo-echogenicity, and 1 had cortical erosions. Thus only 32 (52.45%) entheseal sites in patients showed changes in USG B mode (27 thickened enthesis + 3 hypo-echogenicity + 2 cortical erosion).

On power Doppler, the ultrasound flow signal was observed in 57 patients and none in controls, which was statistically significant (p<0.001). It was minimal (1 color spot) in 41 sites and moderate (2 color spots) in 16 sites. Four patients with hypo-echogenicity and 1 with cortical erosion on B mode had a power Doppler signal of moderate grade (2 color spots) (Table 1).

The mean RI in patients (0.61±0.09, range 0.482-1) was significantly lower than that in controls (0.90±0.12, range 0.618-1) (p<0.001). Similarly, CF was significantly higher in patients (0.08±0.03, range 0-0.11) than in controls (0.006±0.008, range 0-0.03) (p<0.001) (Table 3). On further comparison of individual entheseal sites, i.e., quadriceps tendon, tendo-Achilles, and patellar tendon, similar results were obtained. CF of 0 and RI of 1 were found in 2 entheseal sites, indicating the absence of inflammation in 2 sites. Thus, 59 out of the 61 entheseal sites (96.6%) showed signs of inflammation on power Doppler and spectral Doppler USG. Correlation between RI, CF and JADAS-27 was not found significant.

By ROC curve analysis, a cut-off for RI and CF, for all the entheses pooled together, was determined to give the maximum possible sensitivity and specificity. The cut-off determined for RI was 0.7 (AUC_SD: 0.963±0.19, 95% CI: 0.926-1.00) (Figure 1) for which the sensitivity, specificity, negative predictive value, and positive predictive value was 93.4%, 96.2%, 92.7%, and 96.6%, respectively with an overall diagnostic accuracy of 94.7%.

Similarly, for CF the cut-off determined was 0.029 (AUC_SD: 0.949±0.025, 95% CI: 0.900-0.993) (Figure 1). The sensitivity, specificity, negative predictive value, and positive predictive value for this cut-off was 93.4%, 96.2%, 93%, and 100%, respectively, with an overall diagnostic accuracy of 96.5%.

Discussion

OMERACT criteria for a diagnosis of enthesitis in rheumatoid arthritis have been developed on gray scale B mode and power Doppler USG. As per these criteria, the present study in patients with JIA revealed a significantly higher thickness of enthesis than that seen in controls, similar to the finding reported in a study on gluteus medius enthesis (18). Cortical erosions were found in a few patients only and enthesophytes in none probably owing to shorter duration of the disease (3.3 years). Mild to moderate power Doppler signal was seen in 93.4% of the enrolled entheseal sites and none in controls compared with 9.4% and 37% in 2 previous studies (10, 18). Such wide variations could probably be due to different objectives and design of each study.

Because it has been shown that the thickness of enthesis increased with age, no single cut-off value could be considered applicable in the pediatric age group (10). It would be more appropriate to have age related cut-off values of entheseal thickness beyond which an enthesis could be considered to be abnormally thickened. To obtain such age related cut-off values, normative data for each age would have to be developed, which is a challenging task. Hence, an objective parameter that does not change with age would be ideal for patients of pediatric age groups. Power Doppler and spectral Doppler USG provide parameters that would not be influenced by age. These are total pixels, color pixels, CF, and RI. The total pixels would reflect the entheseal volume, and color pixels and CF would reflect the vascularity of entheseal sites. The RI reflects the velocity of blood flow in the selected vascularized site. In an inflamed tissue, CF is expected to increase and RI to decrease (14).

Our study revealed a significantly lower RI (0.61±0.09) in patients than in controls (0.90±0.12), and significantly higher CF in patients (0.08±0.03) than in controls (0.006±0.008) for all enthesis pooled together. The cut-off value for RI was 0.7, which had a diagnostic accuracy of 94.7%. Similarly, the cut-off value for CF was 0.029, with a diagnostic accuracy of 96.5%. Although not powered for subgroup analysis, similar results were obtained on comparison of individual entheseal sites-quadriceps, tendo-Achilles, and patellar tendon insertion sites. The absence of any previous study on CF and RI in enthesitis precluded a comparison of results.

Enthesitis could be detected by all 3 modes, i.e., B mode, power Doppler, and spectral Doppler ultrasonography. Although the study was not designed to compare the 3 modes, analysis of data revealed that B mode, power Doppler, and spectral Doppler USG detected inflammation in 32/61, 57/61, and 59/61 enthesis, respectively. Moreover, power Doppler and spectral Doppler could evaluate the enthesitis quantitatively, hence these modes had an advantage. CF value above 0.029 and RI below 0.7 would suggest enthesitis.

No correlation of JADAS-27 with CF and RI was observed in our study subjects. It could have been due to the fact that JADAS-27, as a disease activity score, does not include any score for enthesitis.

The major limitations of our study included a small sample size that could negatively impact the generalizability of results and a lack of comparison of entheseal thickness for each tendon at each age.

Ultrsonographic evaluation of children's enthesis can be challenging - be it B mode, power Doppler, or spectral Doppler and requires an experienced sonographer. The enthesis contains relatively few vessels, and the sonographer has to detect blood flow in entheseal vessels carefully avoiding nutrient and cartilage vessels.

To conclude, our study has shown that enthesitis could be evaluated quantitatively by determining CF and RI using power Doppler and spectral Doppler USG, with excellent diagnostic accuracy of RI below 0.7 and CF above 0.029. This study could form the basis for more extensive studies to validate the cut-off values for RI and CF in all enthesis pooled together and individual enthesis for early diagnosis or evaluation of response to treatment.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Dr Ram Manohar Lohia Hospital, New Delhi (Approval Date: October 26, 2015; Approval Number: No-4907).

Informed Consent: Written Informed consent was obtained from the parents or guardians of the patients who participated in this study.

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References

1. Cassidy JT, Petty RE. Chronic arthritis in children. Cassidy JT, Petty RE, Laxer RM, Lindsley CB, editors. Text Book of Pediatric Rheumatology. 6th ed. Philadelphia: Elsevier Saunder; 2011.p.211-34. [Crossref]
2. Micu M, Fodor D. Concepts in monitoring enthesitis in patients with spondyloarthritis- role of musculoskeletal ultrasound. Med Ultrason 2016; 18: 82-9. [Crossref]
3. Havelka S, Hom V. Observations on the tidemark and calcified layer of articular cartilage. Archer CW, Caterson B, Benjamin M, Ralphs JR, ed. Biology of the Synovial Joint. Amsterdam: Harwood Academic Publishers; 1999.p. 331-46.
4. Mander M, Simpson JM, McLellan A, Walker D, Goodacre JA, Dick WC. Studies with an enthesis index as a method of clinical assessment in ankylosing spondylitis. Ann Rheum Dis 1987; 46: 197-202. [Crossref]
5. Resnick D, Niwayama G. Entheses and enthesopathy, anatomical, pathological and radio-logical correlation. Radiology 1983; 146: 1-9. [Crossref]
6. Mandl P, Neidermayer DS, Balint PV. Ultrasound for enthesitis: Handle with care. Ann Rheum Dis 2012; 71: 477-9. [Crossref]
7. Balint PV, Kane D, Wilson H, McInnes IB, Sturrock RD. Ultrasonography of entheseal insertions in the lower limb in spondyloarthropathy. Ann Rheum Dis 2002; 61: 905-10. [Crossref]
8. de Miguel E, Cobo T, Muñoz-Fernández S, Naredo E, Uson J, Acebes JC, et al. Validity of enthesis ultrasound assessment in spondylarthropathy. Ann Rheum Dis 2009; 68: 169-74 [Crossref]
9. Alcalde M, Acebes SC, Cruz M, Gonzalez-Hombradi L, Herroro-Beaumont G, Sanchez-Pernauto O. A sonographicenthesitis index of lower limbs is a valuable toolin assessment of ankylosingspondylitis. Ann Rhem Dis 2007; 66: 1015-9. [Crossref]
10. Jousse-Jollin S, Breton S, Cangeml C, Fenoll B, Bressolette L, de Parscau L, et al. Ultrasonography for detecting enthesitis in juvenile idiopathic arthritis. Arthritis Care Res 2011: 63; 849-55. [Crossref]
11. Gandjbakch F, Terselev L, Joshua F, Wakefield RJ, Naredo E, D'Agostino MA. Ultrasound in the evaluation of enthesis: Status and perspectives. Arthritis Res Ther 2011; 13: R188. [Crossref]
12. Wakefield RJ, Balint PV, Szkudlarek M, Filippucci C, Backhams M, D'Agostino MA, et al. Musculoskeletal ultrasound including definitions for ultrasonographic pathology. J Rheumatol 2005; 32: 2485-7.
13. Terslev L, Naredo E, Iagnocco A, Balint PV, Wakefiled RJ, Aegerter P, et al. Defining enthesitisin spondyloarthritis by ultrasound: Results of a Delphi process and of a reliability reading exercise. Arthritis Care Res 2014; 66: 741-8. [Crossref]
14. Terslev L, Torp-Pederson S, Qvistgaard E, Bliddal H. Spectral Doppler and Resistive Index - A promising tool in ultrasonographic evaluation of inflammation in rheumatoid arthritis. Acta Radiol 2003; 44: 645-52. [Crossref]
15. Ranjan S, Jahan A, Yadav TP, Sachdev N, Dewan V, Singh S. Evaluation of synovial inflammation in juvenile idiopathic arthritis by Power Color Doppler and Spectral Doppler ultrasonography. Indian J Pediatr 2013; 81: 29-35. [Crossref]
16. Bhagwani DK, Jahan A, Yadav TP, Dey S, Sachdev N. Diagnostic sensitivity and specificity of Spectral Color Doppler ultrasound indicies in juvenile idiopathic arthritis. Ann Ped Rheumat 2012; 1: 163-71. [Crossref]
17. Baikar T, Chhabra A, Yadav TP, Sachdev N, Dewan V. Power and spectral Doppler ultrasonography to evaluate response to intra-articular steroid injection in knee joints in juvenile idiopathic arthritis. Indian J Pediatr 2017; 84: 826-32. [Crossref]
18. Laurell L, Court-Payen M, Nielson S, Zak M, Thomsen C, Miguel-Perez M, et al. Ultrasonography and color Doppler of proximal gluteal enthesitis in juvenile idiopathic arthritis: A descriptive study. Pediatr Rheumatol Online J 2011; 9: 22. [Crossref]