

MR Derived Synovial Volume Reflects Disease Regression in Children with JRA

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Introduction:

Juvenile rheumatoid arthritis (JRA), the most common type of arthritis affecting 100,000 children in the United States is an auto-immune disease that attacks the synovium (tissue that lines the joint). As a result of the inflammation the synovium hypertrophies causing joints to swell producing pain and stiffness [1]. This study was designed to evaluate the synovial volume in children with JRA after three visits with the initial visit before treatment. To establish the effective means of using MR as surrogate marker of disease progression, the synovial volume was compared with the clinical and laboratory scores of disease activity.



Figure 1: One slice (#4) out of 12 slices and ROI of synovial volume A. during enrollment (synovial volume - 50 cc) B. after 3 months (39 cc) C. after 12 months (20 cc) for a 12 year old girl.

Materials and Methods:

Twenty children (14 girls and 6 boys) (mean age \pm sd was 10 ± 3 y.o., range 6-15 y.o. at enrollment) with JRA were enrolled in this study and were scanned during three visits (initial scan, 3 months and 1 year). Subjects had different JRA subtypes and duration of disease ranging from 3 months to 12 months. Treatments during the course of the study included non-steroidal anti-inflammatory drugs (NSAID's), methotrexate, etanercept, and intra-articular corticosteroids. Treatment started after the initial MR imaging session.

T1-weighted spin echo MR images of the sagittal plane of the knee were obtained using a GE LX 1.5T scanner (GE Medical systems, Milwaukee, WI) using a quadrature transmit/receive extremity coil (IGC Medical Advances, Milwaukee, WI) before and after the intravenous administration of contrast agent (Magnevist[®] - 0.2 ml /kg of body weight). The sagittal images were acquired with TR/TE of 300/9 msec, 4 mm slice thickness, 90° flip angle, NEX = 2, matrix of 256 x 256, 14 x 14 cm field of view, bandwidth of 31 MHz, with a total acquisition time of 2.5 min.

The sagittal post contrast enhanced T1-weighted images exhibited contrast enhancement in blood vessels and in the inflamed synovium. The region of interest (ROI) was defined using CCHIPS (a semi-automated software program developed with IDL (RSI, Boulder, CO)) [2] to segment the synovium in the image excluding the higher intensity blood vessels. A "K-means clustering" algorithm [3] was used to segment the image signal intensity into four populations. The population with the highest signal intensity was the "considered" enhanced synovium. Each slice was examined and voxels that were enhancing but not synovium (physes, lymph nodes, and blood vessels) were excluded. Synovial volume was calculated as the product of the total number of voxels within the ROI and the volume of each voxel. The ROI marked in blue in Figure 1 shows the decrease in synovial volume in the same patient obtained over one year.

Results and Discussion:

Synovial volume was compared with various clinical scores – Childhood Health Assessment Questionnaire Disability Index (CHAQ-D), Physician Global Assessment (PhGA), Parent Global Assessment (PaGA), Total Active Joints (TAJ), Total Knee Score (TKS) and lab scores – Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). TKS was calculated as the sum of swelling (S), tenderness (T) and limit of motion (L) in the knee. The correlation (ρ) of the clinical scores with synovial volume at enrollment: TKS ($\rho = 0.666$, $p = 0.001$) and CHAQ-D ($\rho = 0.626$, $p = 0.003$), at 3 months: TKS ($\rho = 0.518$, $p = 0.019$) and PaGA ($\rho = 0.446$, $p = 0.048$) and at 12 months: TKS ($\rho = 0.471$, $p = 0.036$) were significant. The correlation of the lab scores with synovial volume at enrollment: CRP ($\rho = 0.745$, $p < 0.001$) and ESR ($\rho = 0.721$, $p < 0.001$), and at 3 months: CRP ($\rho = 0.540$; $p = 0.014$) were also significant. There was no significant correlation between the lab scores and synovial volume at 12 months. Correlation between both the lab and clinical scores are shown in Figure 2a. The correlations for the other parameters with synovial volume were not significant. The clinical scores, laboratory scores and synovial volume were highly correlated with time after therapy and decreased with time as shown in Figure 2b.

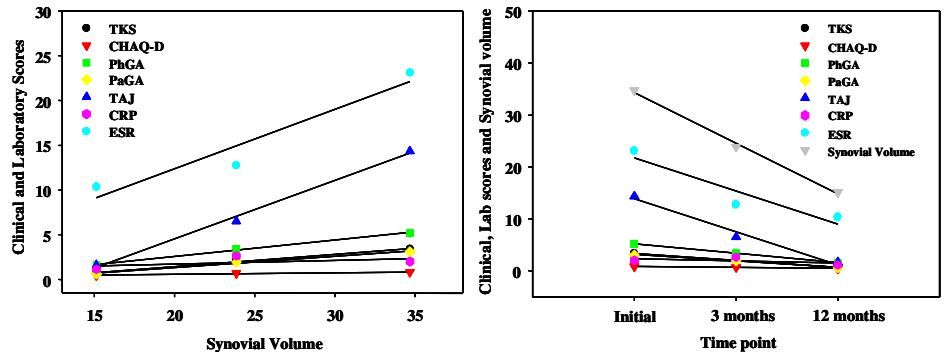


Figure 2: A. Correlation of clinical and laboratory scores vs. synovial volume. B. Correlation of clinical scores, lab scores and synovial volume vs. time (enrollment, 3 months, 12 months).

Conclusion: The MR derived synovial volume, in the most involved knee in children with JRA, clinical and laboratory parameters decreased with time following therapy reflecting diminution in disease activity. There was a strong correlation of the MR derived synovial volume with clinical and laboratory scores at enrollment especially the total knee score as assessed by the rheumatologist.

References: 1. <http://www.clevelandclinic.org/health/health-info/docs/3100/3133.asp?index=10370>, 2. http://www.irc.cchmc.org/cchips_main.htm 3. Hartigan JA, Clustering Algorithms, New York: Wiley, 1975.