dGEMRIC in Osteoarthritis: Comparison with Radiography

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INTRODUCTION

dGEMRIC has been proposed as a technique for imaging the molecular status of cartilage. No study to date has compared dGEMRIC to standard metrics of evaluation in osteoarthritis [OA] of the knee. The goal of the current study was to compare dGEMRIC to radiography and to assess the practicality of acquiring 3D dGEMRIC to evaluate cartilage biochemical status across the entire knee joint.

METHODS

dGEMRIC and radiography were compared in 11 patients. dGEMRIC was performed at 1.5T on a GE MRI system. A double dose of Magnevist (Berlex, NJ) was administered by intravenous injection after which patients were asked to walk for 10 minutes. T1 images were obtained starting 90 min later. Three 2D single slice dGEMRIC images were obtained in each knee, one sagittal image in the medial compartment, one in the lateral, and an axial. T1-weighed images were acquired using an FSE IR sequence with 5 inversion delays ranging from 50-1680ms, TR/TE = 1800/14ms. Slices were 3mm thick with an in-plane resolution of 275µm. The scan time was 15 min per single slice 2D acquisition. T1 maps were generated with Matlab (The MathWorks, Natick, MA) using a pixel-by-pixel 3-parameter T1-fit. AP knee x-rays were obtained in the semi-flexed position with fluoroscopic confirmation of tibial rim alignment, centering of the tibial spines in the condylar notch, and with correction for magnification. Medial, lateral, and patellofemoral compartments were graded (0-3) separately using the OARSI atlas.

For comparison between dGEMRIC status and the radiographic score of a compartment, the dGEMRIC index was averaged over central zones of the femoral condyle and tibial plateau in sagittal views. In axial views, the dGEMRIC index was averaged over all patellar cartilage. In all, 31 compartments were compared.

Due to the heterogeneity seen in the dGEMRIC scans of the patients with OA, 2D scans were felt to be insufficient for follow-up due to difficulties in placement of the section on subsequent scans. Therefore, 2D and 3D dGEMRIC images were compared in 3 other volunteers. 2D images were acquired as described above. 3D dGEMRIC images were acquired with an inversion recovery prepared 3D T1-weighted spoiled gradient echo sequence with five inversion delays ranging from 27-1650 ms, TR/TE = 9.1/4.5 ms, flip angle 20º, readout BW= 50 kHz, FOV 140 mm, matrix 512x512, slice thickness 3mm, 30-34 slices. In this sequence slice encoding was done in the inner loop and phase encoding was done in an outer loop. The inversion preparation was applied once before each slice loop so all slice encodes were collected during a single TI period. Total scan time for all inversion delays in the 3D series varied with number of slices, 28-35min.

RESULTS

Figure 1 shows the distribution of dGEMRIC in the different radiographic score groups. The dotted lines represent the ranges in which dGEMRIC has been considered high (above 500 ms), mid (400-500 ms) and low (below 400 ms) [Williams *et al* ISMRM 2003, #447]. In this population of OA patients, the mean dGEMRIC of the central areas was in the mid to low range of dGEMRIC scores previously reported. All dGEMRIC in compartments of radiographically narrowed joint space (scores 2 and 3) were in the low range, with one exception. This outlier represented a compartment with an area of totally denuded cartilage with surrounding thick cartilage that had high dGEMRIC (Figure 2a). There were a number of radiographically normal (Score = 0) compartments that had low dGEMRIC values. These were in the radiographically "uninvolved" compartments of knees scored K/L 3 and 4. (The mid-range dGEMRIC values were found in knees scored K/L 0-4.) In some cases they represented compartments with thick cartilage, and in others cases with focal narrowing not apparent on radiography (Figures 2b, 2c). Figure 3a shows an example of striking heterogeneity of dGEMRIC that motivates the need for evaluation of the entire knee. Figure 3b shows that 2D and 3D dGEMRIC sequences measure the same T1s *in vivo* within the margin of error (10%) previously reported for 2D repeatability [Williams *et al* ISMRM 2003, #447].

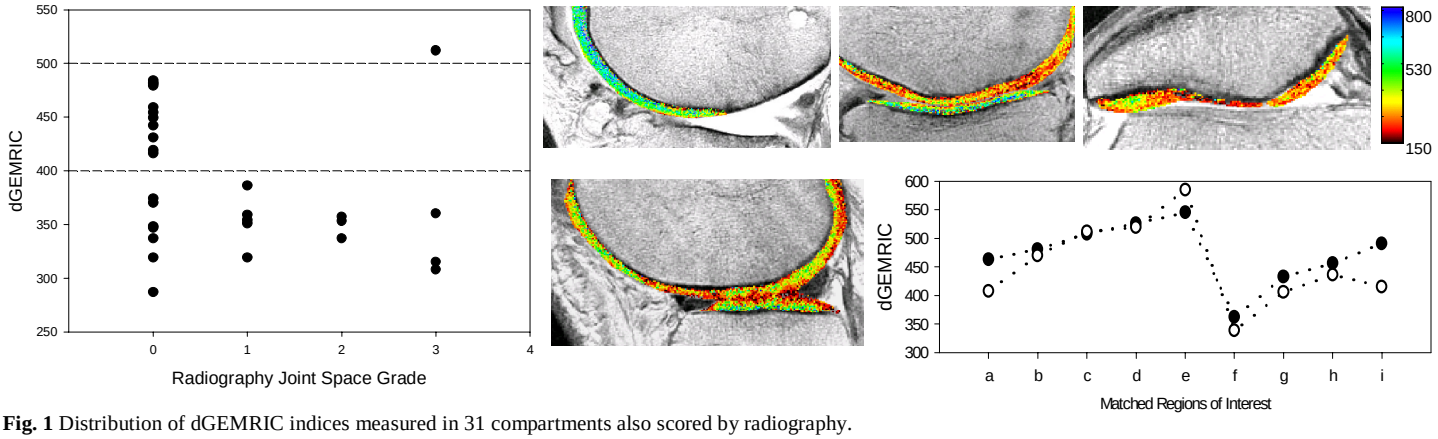

Fig. 1 Distribution of dGEMRIC indices measured in 31 compartments also scored by radiography.

Fig. 2 (images top row) a(left), dGEMRIC image of compartment that scored 3 by radiography with thick cartilage of high dGEMRIC index adjacent to area completely denuded of cartilage. **b(center),** Relatively low dGEMRIC index seen throughout compartment normal by radiography. **c(right),** Focal narrowing and biochemical degeneration seen on dGEMRIC images in radiographically normal compartment.

Fig. 3 (bottom row) a(left), dGEMRIC image illustrating high degree of heterogeneity observed within some compartments. **b(right),** dGEMRIC index measured by 2D (solid dot) and 3D (open dot) sequences vary less than 10% across 9 small ROIs across comparable sections.

CONCLUSION

The dynamic range of dGEMRIC in this population of OA patients is high, varying from below 300 ms to near 500 ms, although generally in the mid to low range of values previously seen in asymptomatic individuals. The low dGEMRIC values in many radiographically "uninvolved" compartments of knees graded K/L 3 or 4 suggest substantial biochemical abnormalities in compartments that x-ray have indicated have no disease. This finding also indicates that future clinical trials may be better served by enrolling patients earlier in the disease process in order to better monitor disease progression. The level of heterogeneity observed within and across slices is motivation for 3D acquisitions that were found to be feasible and comparable to the 2D acquisitions.