Clinical Application of dGEMRIC for Detecting Early Arthritis in the Hip

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Methods

Control experiments were preformed to look at the kinetics of intravenous gadolinium enhancement of cartilage in hip joints. Asymptomatic volunteers were given IV injections and asked to walk for 15 minutes. Hip joints were scanned at multiple time points (up to 2 hours after contrast injection) using an IR sequence with TI set at 0.5 sec. Additionally, the stability of gadolinium enhanced T1 maps of hip articular cartilage in healthy volunteers were checked at 30, 60, 90 min after contrast injection using multiple IR sequences.

For the patient studies, all scans were performed using 1.5 T clinical scanners by Siemens or GE and a surface coil. Double dose (0.4 ml/kg) Magnevist (Gd-DTPA2-) was infused intravenously and subjects were required to walk prior to scans. T1 maps were obtained using multiple inversion recovery (IR) scans. In plain resolution was 400-600 microns with slice thickness of 2-4 mm. The repetition time was 1800 msec with inversion time ranging from 25-1680 msec. Five to 7 inversion time images were used to calculate the T1 maps. Custom software was used to detect and compensate for motion between sequential inversion time scans. T1 maps were also obtained using multislice fast spin echo (FSE) sequence. In plain resolution was 500 microns with slice thickness of 4 mm. The repetition time ranged from 300 to 2000 msec. Six repetition time images were used to calculate the T1 map.

Correlation between symptoms and degenerative changes as measured by T1 maps after gadolinium enhancement was studied in 22 patients with early degenerative changes. All of these hips had no prior operative procedures. When both hips were painful, only the more painful hip was included. All patients filled out a WOMAC questionnaire, which measures clinical symptoms of the hip joint. All patients had dGEMRIC scans of both hips using FSE sequence. Double dose intravenous contrast was used and patients were required to walk for ½ hr prior to scans. In addition, each patient had standing AP radiographs of the pelvis, from which minimal joint space measurements were made. Four coronal T1 maps were obtained, which spanned the weight bearing surface of the hip joint. The femoral and acetabular cartilage in the weight bearing zone was manually segmented to obtain an average T1 value for the weight bearing zone of each hip. The weight bearing zone T1 value and minimal joint space were correlated with sum score of the WOMAC pain domain. The intensity of pain was assessed by asking the patients to grade the level of pain from 0 to 4, which correspond to none, mild, moderate, severe, and extreme, with activities such as walking on flat surface, going up or down stairs, night pain, sitting or lying down, and standing up right. The total cumulative score ranged from 0 to 20, which corresponded to none to extreme for all five activities.

Results

Kinetic studies of hip joint articular cartilage enhancement, as measured by sequential IR images with TI set at 0.5 sec, showed that steady levels were achieved rapidly, within 30 minutes. Constant levels were maintained for an additional 60 minutes. These findings were verified by measuring T1 values of articular cartilage at 30, 60, and 90 minutes after contrast injection. In two volunteers, the gadolinium enhanced T1 value did not significantly change over 30 to 60 minute time period after contrast injection (0.60 ± 0.09 at 60 min to 0.52 ± 0.08 at 90 min; 0.61 ± 0.06 at 30 min to 0.62 ± 0.10 at 60 min, mean ± SD).

Correlation between early degenerative changes as assessed by dGEMRIC and clinical symptoms:

- T1 correlated (negatively) with the WOMAC pain score.
- The correlation coefficient was 0.60 and the slope was statistically different (p < 0.005) from zero.
- This is in contrast with minimal joint space data from the same hips, which showed a correlation coefficient of 0.30 and a slope not statistically different from zero.
- In eight patients, the contralateral hip was asymptomatic and anatomically normal. When the average T1 value of the weight bearing zone of these hips were used to normalize the T1 value of the painful contralateral hip, the correlation coefficient between dGEMRIC and the WOMAC pain score increased to 0.89 (r²=0.78) as seen in Fig. 1.

Discussion

Previously, the study of osteoarthritis progression has been difficult due to the insensitivity of traditional radiographic techniques in detecting early disease changes. We have applied dGEMRIC to study osteoarthritis development in hips. We have shown that the technique can be applied in a clinical setting. The gadolinium enhancement of cartilage appears to be stable for one hour from 30 to 60 minutes after intravenous contrast injection. Multislice scans of both hips can be obtained within this hour window using fast spin echo technique. Care must be taken to correct for patient motion between image slices when calculating the T1 value. Additionally, T1 values obtained using FSE sequences appear to be consistently higher than those obtained using IR sequences. This appears to be inherent to the pulse sequence used; therefore, T1 values obtained using FSE and IR sequences should not be compared directly. The T1 (dGEMRIC) value of articular cartilage in the weight bearing zone appears to correlate well with hip pain. When the inherent variability in articular cartilage charge density and gadolinium enhancement is controlled for by normalizing the T1 value of the symptomatic hip with values of the normal contralateral hip, the correlation between T1 values and pain is increased. This suggests that this technique should be more accurate when used to serially follow a patient in this subset. Another normalization (ie GdDTPA2- blood level) will be investigated to further improve the correlation between dGEMRIC and WOMAC pain score in all patients.

In summary, this study demonstrates that dGEMRIC is feasible in clinical studies of the hip, and that the dGEMRIC score correlates better with a clinical pain score than the standard radiographic measure of minimal joint space.