

Suitability of T1(Gd) as the "dGEMRIC Index" at 1.5T and 3.0T

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Introduction

dGEMRIC (delayed Gadolinium Enhanced MRI of Cartilage) is a technique for imaging the distribution of articular cartilage glycosaminoglycan (GAG) on the basis of the charged contrast agent Gd-DTPA²⁻ distributing in inverse relation to the concentration of the charged GAG molecules. T1 after penetration of Gd-DTPA²⁻, or T1(Gd), has been used as the dGEMRIC Index in a number of studies to demonstrate changes in cartilage biochemical status with physiologic and pathologic conditions or interventions [1-3]. However, $(1/T1(Gd) - 1/T1o)$, $\Delta R1$, should be more representative of Gd-DTPA²⁻ concentration, where T1o = T1 before contrast administration. If T1o is constant and/or large compared with T1(Gd), the two indices (T1o and $\Delta R1$) should provide comparable information in terms of dGEMRIC ranking. The aim of this study was to compare T1(Gd) with $\Delta R1$ in *in vivo* dGEMRIC evaluations at 1.5T and 3T.

Materials and Methods

Twenty volunteers, 11 asymptomatic and 9 with various prior knee complaints, participated. All studies were approved by the institutional review board, and all subjects gave their informed consent. A single 2D sagittal T1o image, 3mm thick, from the center of the medial condyle was acquired in each subject and compared to a matching medial section from a 3D dGEMRIC (T1(Gd)) acquisition. For dGEMRIC, subjects were imaged with a 3D inversion-prepared spoiled gradient echo sequence [4] 90-minutes after IV injection of a double-dose of Magnevist (Berlex, Wayne NJ). A sagittally oriented 3D slab with 32 3mm thick sections was centered on the knee joint. Both T1o and T1(Gd) were acquired with a 16cm FOV and 625 um in-plane resolution. T1 maps were generated using custom coded software and cartilage was manually segmented. A region of interest encompassing the central medial femoral cartilage was drawn on each image. All T1(Gd) values were corrected for BMI related contrast dose [5]. T1o, T1(Gd) (the metric previously used as the dGEMRIC Index), R1o (the pre-contrast relaxation rate, $1/T1o$), R1 (the post-contrast relaxation rate, $1/T1(Gd)$), and $\Delta R1$ ($1/T1(Gd) - 1/T1o$) were examined.

Results

Measured T1o and T1(Gd) are shown in Figure 1. Figure 2 shows the range of these values in the same subjects in the form $1/T1$ ($=R1$). Less separation between R1 and R1o is observed at 3T compared to 1.5 T suggesting that the effects of T1o on estimation of contrast agent concentration in the tissue may be more important at 3T than at 1.5T. The two parameters which might be used as a "dGEMRIC Index" are compared in Figure 3: T1(Gd), and $\Delta R1$ ($1/T1(Gd) - 1/T1o$). At 1.5T, the general ranking order of individuals for high to low dGEMRIC Index was relatively preserved across metrics; some cross-over occurs in the mid-range, however these are in individuals whose indices are close to each other. More cross-over is seen at 3T. In particular, individuals with low values of T1(Gd) showed $\Delta R1$ values closer to mid-range, suggesting that the low values of T1(Gd) were not only due to high Gd-DTPA²⁻ concentration.

Discussion

In the current study, taking T1o into account by computing the index $\Delta R1$ did not substantially alter dGEMRIC rankings of individuals at 1.5T. This suggests that taking T1o into account may not change the interpretation of individuals' dGEMRIC rankings from that based on T1(Gd) alone. The use of T1(Gd) as the dGEMRIC Index may be less appropriate at 3T as an index of Gd-DTPA²⁻ concentration. Less separation between $1/T1o$ and $1/T1(Gd)$ was observed at the higher field, presumably due to lower contrast agent relaxivity at 3T [6]. The fact that several individuals with low values of T1(Gd) were found to rank more towards the center of the $\Delta R1$ rankings suggests that the low values of T1(Gd) were not only due to high Gd-DTPA²⁻ concentration, but also due to lower T1o. In summary, the practice of using T1(Gd) as the dGEMRIC Index as a measure of Gd-DTPA²⁻ distribution may be less suitable at 3T than 1.5T. However, T1(Gd) as an index may prove to be clinically useful. Alternatively, further dGEMRIC studies could be performed at 1.5T, or at 3T with higher doses of Gd-DTPA²⁻ and/or concurrent measurement of T1o.

Figure 1

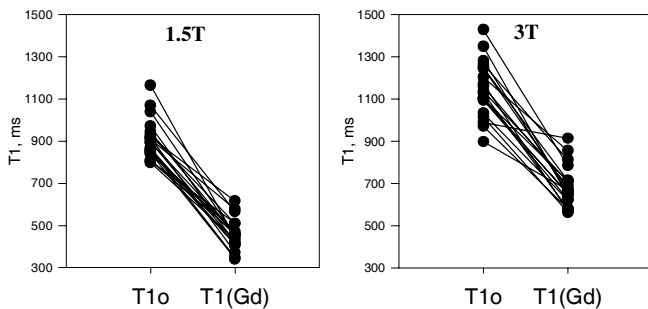


Figure 3

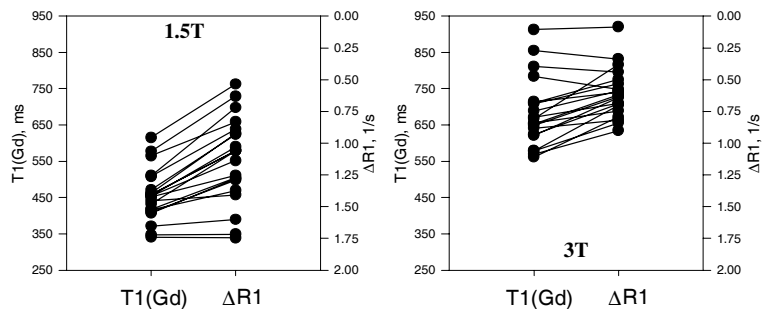
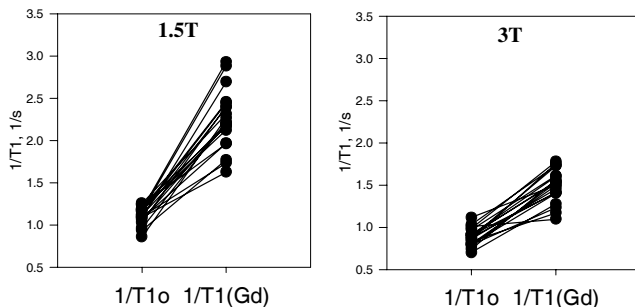


Figure 2



References

- [1] Cunningham T, et al. *J Bone Joint Surg Am.* Jul 2006;88(7):1540-1548.
- [2] Roos EM, et al. *Arthritis Rheum.* Nov 2005;52(11):3507-3514.
- [3] Williams A, et al. *Arthritis Rheum.* Nov 2005;52(11):3528-3535.
- [4] McKenzie CA, et al. *J Magn Reson Imaging.* Oct 2006;24(4):928-933.
- [5] Tiderius C, et al. *Osteoarthritis Cartilage.* Nov 2006;14(11):1091-1097.
- [6] Gillis A, et al. *Magn Reson Med.* Dec 2002;48(6):1068-1071.