Comparison of T2 Relaxation Time in Knee Cartilage using Quantitative DESS, CubeQuant and 2D-FSE

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Introduction

Osteoarthritis (OA) is a chronic disease of articular cartilage and other tissues of the joints. MRI is one of the most important imaging modalities for the detection of cartilaginous degeneration of the knee [1]. Assessment of T2 relaxation time has been proven to be useful in assessment of OA [2]. Two-dimensional fast spin-echo (2D-FSE) imaging is the technique most often used in clinical practice measurement of T2 relaxation times [3]. Three-dimensional quantitative double-echo steady-state (qDESS) imaging has shown to be useful in assessing the morphological changes in the knee cartilage. In qDESS imaging, two gradient echoes are acquired from two separate scans and the effect of T2 decay is separated from T1 relaxation and diffusion [4]. CubeQuant is a 3D T2 quantification method that is highly SNR efficient [5]. The purpose of our study was to evaluate whether the T2 measurements as acquired through qDESS and CubeQuant techniques have similar relaxation times in healthy participants compared to the T2 measurements acquired through the 2D-FSE (Cartigram) technique.

Material and Methods

10 healthy volunteers (5M, 5F, ages 24-47) were scanned using a Discovery MR750 3T scanner (GE Healthcare, Waukesha, WI) with a receive-only 16-channel knee coil (NeoCoil, Pewaukee, WI). A healthy volunteer is defined as having no: prior pain, swelling, clicking in the knee, diagnoses of arthritis, prior injuries and prior knee surgeries. We obtained written informed consent from all participants prior to the study. Imaging parameters are included in Table 1. Each volunteer was scanned on one knee by qDESS, CubeQuant and 2D-FSE techniques and for each technique, the medial femoral cartilage and the medial tibial cartilage of the knee were segmented, on a single slice, into 3 and 2 regions respectively (MFC-1 through MFC-3 and MTC-1 and MTC-2) (Figure 1), by a single observer and the T2 relaxation times were measured using OsiriX.

Table 1. Imaging parameters for 2D-FSE, DESS and CubeQuant using 16-channel knee coil in sagittal plane.

Technique	2D FSE	DESS	CubeQuant
TR/TE (ms)	1500/(8.6, 17.2, 25.8, 34.3, 42.9, 51.5, 60.1, 68.7)	26/(9.3, 42.7)	TE = 6, 12.4, 25.3, 38.1
Matrix size	256x160	256x256	256x256
Thickness (mm)	3.0	3.0	3.0
FOV (cm)	18	18	18
Bandwidth (kHz)	±31.25	±31.25	±62.5
Echo train Flip angle	ETL = 8	FA = 18, 35 degrees	ETL = 35
Scan time (min:sec)	16:13	09:20	07:26

Results and Discussion

Figure 2 shows images obtained on the same knee by qDESS, CubeQuant, and 2D-FSE. The mean and standard deviation for the T2 relaxation times, for MFC and MTC, are obtained directly from the ROIs. Figure 3 shows these values in a bar-graph format. Although the values from each of the three methods are not identical, they represent a similar trend between the T2 times for MFC and MTC acquired through different techniques across all scanned volunteers. Furthermore, Bland-Altman and Pearson correlation analysis demonstrated there was no significant difference between qDESS and 2D-FSE, or CubeQuant and 2D-FSE in T2 relaxation times ($p>0.05$). Using conventional 2D-FSE as a reference standard, qDESS and CubeQuant showed similarities in the T2 measurements.

Conclusion

DESS and CubeQuant are highly efficient and promising techniques for acquiring T2 relaxation times in knee cartilage [5,6]. They showed similar trends in T2 relaxation times to the conventional 2D-FSE. We believe that with further optimization and study, these techniques could replace standard 2D techniques, helping to substantially reduce the examination time.

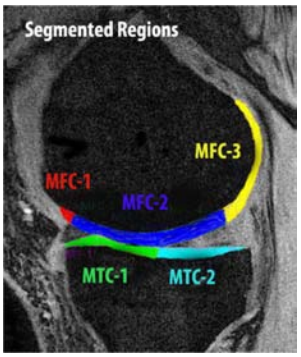

Figure 1. Medial cartilage of the knee segmented into 5 ROIs – 3 femoral and 2 tibial.

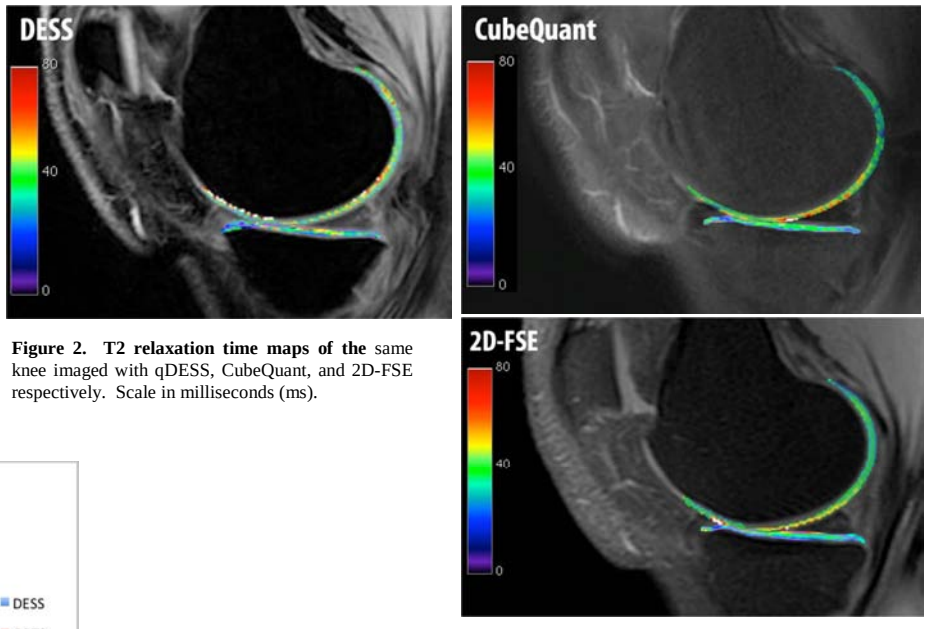

Figure 2. T2 relaxation time maps of the same knee imaged with qDESS, CubeQuant, and 2D-FSE respectively. Scale in milliseconds (ms).

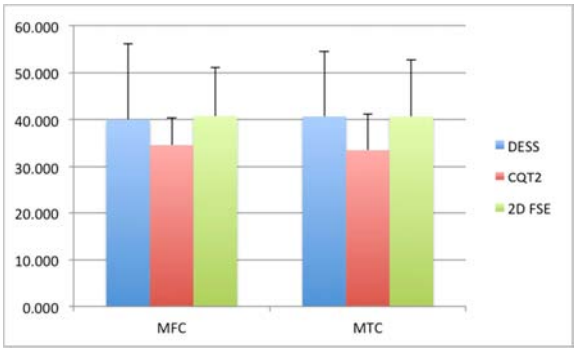

Figure 3. T2 measurement means (in ms units) at different segments of medial cartilage. n=30 for MFC and n=20 for MTC; Standard Deviation obtained from the ROIs were used to depict the error bars.

References

1. Gold et al. AJR 2009; 193:628–638
2. Mamisch et al. Radiology 2010; 254:818-826
3. Crema et al. RadioGraphics 2011; 31:37–62
4. Staroswiecki et al. Magn Reson Med 2012; 67:1086–1096
5. Nguyen et al. Proc. Intl. Soc.Mag. Reson. Med. 2012; 20:1384
6. Sveinsson et al. Proc. Intl. Soc. Magn Reson Med 2012; 20:1383

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