ANALYSIS OF MENISCI USING BI-EXPONENTIAL T2* FITTING WITH VTE SEQUENCE AT 3T

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Target audience

Musculoskeletal radiologists, physicists developing sequences for imaging of fast relaxing tissues

Introduction The MR signal from meniscus tissue should decay predominantly mono-exponentially[1]. In some regions of the knee, bi-exponential decay may be observable as a consequence of water molecules bound to the macromolecules in meniscal tissue[2]. In degenerated meniscus or in a meniscal tear, the amount of pixels revealing bi-exponential decay may increase[3]. The goal of this study was to investigate short and long components of T2* in menisci as a marker for distinguishing between healthy and degenerated/torn menisci.

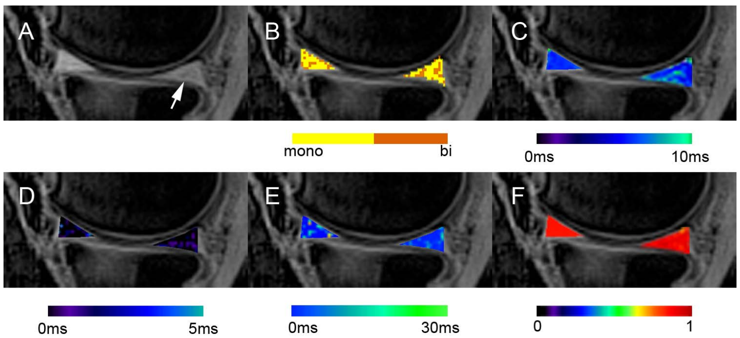

Figure 1. An example of the map evaluation of a 68-year-old patient with meniscus degeneration diagnosed in the posterior horn of the medial meniscus. A) The morphological image, calculated as the difference between the shortest (0.75ms) and the longest (22.42ms) echo acquired by the VTE sequence; B) the binary map of the pixels with bi-exponential (orange colored) and mono-exponential (yellow colored) fit; C) the conventional mono-exponential T2 map; D) the map of the short component T2* calculated bi-exponentially; E) the map of the long component T2* calculated bi-exponentially; F) the map of the coefficient of variation (R2) related to the precision of fit. Note that all maps are overlaid on the morphological image and pseudo-color-coded with the corresponding color bar below each image.*

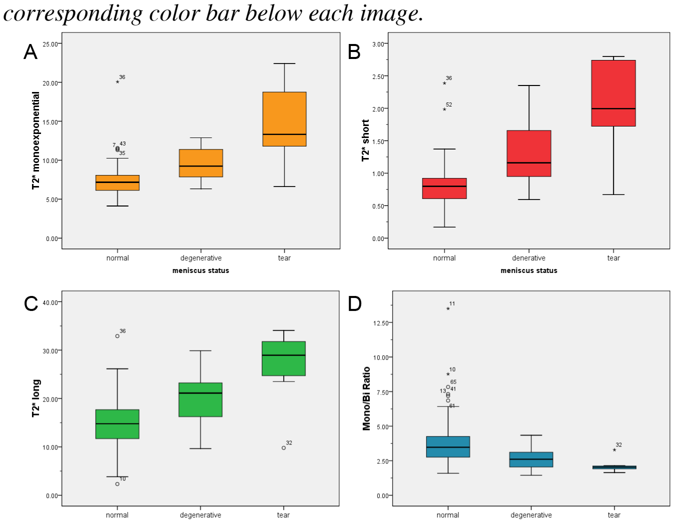

Figure 2. The box-plot interpretation of mono-exponential T2 (A), short component of T2* (B), long component of T2* (C), and the ratio between the pixels with mono- and bi-exponential characteristics (D).*

Materials and Methods For quantitative bi-exponential T2* assessment, a multi-echo, variable echo time (me-vTE) sequence[4] was performed. This sequence is based on 3D Cartesian spoiled gradient echo (SPGR) for sub-millisecond echo times using a variable duration of phase and slice encoding gradient. The center of the k-space is sampled with a much shorter echo time compared to the outer areas; this results in a sub-millisecond effective echo time. Ten echo times were used: TE = 0.75, 3.51, 5.87, 8.23, 10.6, 12.96, 15.33, 17.69, 20.06, 22.42 ms. Other parameters were set as follows: field of view, 118 x 180 mm; matrix, 168 x 256; section/slice thickness, 0.7 mm; 320 Hz/pixel bandwidth; 144 sections; and a total acquisition time of 12.16 min. Mono- and bi-exponential pixel-wise fitting was performed using the following functions SI=S0*exp(-TE/T2*) and SI=S0*[exp(-TE/T2*s)+ exp(-TE/T2*l)]. Pixels in which the ratio between long and short T2* components was higher than five were considered bi-exponential, otherwise mono-exponential. To distinguish T2* between different groups, an unpaired t-test with equal variances was used, and a p-value lower than 0.05 was considered statistically significant.

Results Forty eight normal menisci were examined (mean T2*mono was 7.61+/-2.49, mean T2*short 0.82+/-0.37, mean T2*long 14.99+/-5.39 and mono/bi ratio 3.87+/-1.72), 12 degenerative (mean T2*mono was 9.54+/-2.25, mean T2*short 0.82+/-0.53, mean T2*long 14.99+/-5.59, and mono/bi ratio 3.44+/-0.88) and eight meniscal tears (mean T2*mono was 14.59+/-5.24, mean T2*short 2.04+/-0.73, mean T2*long 26.83+/-7.73, and mono/bi ratio 2.13+/-0.49). P-values were below 0.05, and the lowest was for T2*short and mono/bi ratio (p=0.01298 and p=0.00226, respectively). Figure 1 depicts the evaluated menisci using a mono- and bi-exponential approach. Descriptive statistics of the various cases are summarized in Figure 2.

Discussion

Bi-exponential fitting in the meniscus may be useful for evaluating degenerative menisci by removing incorrectly calculated mono-exponential pixels. This reflects the changes in collagen fiber orientation, which is modified in degenerative menisci.

Conclusion

The results of this study suggest that biexponential fitting may help to improve the accuracy of T2* estimation and so make T2* more robust quantitative parameter for distinguishing between normal and degenerative/tear menisci.

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References **1.**Williams A, Qian Y, Golla S, Chu CR. UTE-T2 * mapping detects sub-clinical meniscus injury after anterior cruciate ligament tear. *Osteoarthritis and cartilage / OARS, Osteoarthritis Research Society.* Jun 2012;20(6):486-494. **2.**Aagaard H, Verdonk R. Function of the normal meniscus and consequences of meniscal resection. *Scandinavian journal of medicine & science in sports.* Jun 1999;9(3):134-140. **3.**Kirsch S, Kreinest M, Reisig G, Schad LR. In vitro mapping of 1H ultrashort T2 and T2* of porcine menisci: analysis of the signal decay reveals collagenous fibril texture. *Proc. Intl. Soc. Mag. Reson. Med.* . 2012;20:275. **4.**Deligianni X, Bär P, Scheffler K, Trattnig S, Bieri O. Water selective high resolution imaging of short T2 components of the knee at high and ultra high field strenghts. *Proc. Intl. Soc. Mag. Reson. Med.* 2012;20:3315.