

Delayed Gadolinium-Enhanced MRI of the Fibrocartilage Disc of the Temporomandibular Joint - feasibility study

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Target audience

Radiologists who specialize in biochemical MR imaging and dentists who specialize in temporomandibular joint function and dysfunction.

Purpose

The temporomandibular joint (TMJ) is a small but complex structure with a fibrocartilage disc. The amount of glycosaminoglycans (GAG) in cartilage tissue plays an important role in its functionality. The purpose of this study was: 1) to test the feasibility of delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage (dGEMRIC) at 3 Tesla in the temporomandibular joint disc; 2) to determine the optimal delay for the measurement of the articular cartilage in the TMJ disc after i.v. contrast agent (CA) administration; and 3) to correlate the regional intradiscal T1 relaxation time differences with histological findings.

Methods

Institutional Review Board approval and written, informed consent were obtained. MRI of the right and left TMJ of six asymptomatic volunteers (mean age, 24.83 ± 2.99 years; BMI < 25) was performed at 3 Tesla using a dedicated eight channel coil. Figure 1 shows the TMJ morphology. Inversion recovery (IR) was performed pre-contrast and at 30, 60, and 120 minutes after i.v. post-contrast agent administration of 0.2 mmol/kg of Gd-diethylenetriamine pentaacetic acid (Gd-DTPA)²⁻. In addition, 3D dual flip-angle gradient-echo (3D-GRE) sequences were performed pre-contrast and subsequently every 10 minutes up to 130 minutes post-contrast agent administration using (Gd-DTPA)²⁻. Pairwise tests were used to assess differences between pre- and post-contrast T1 values.

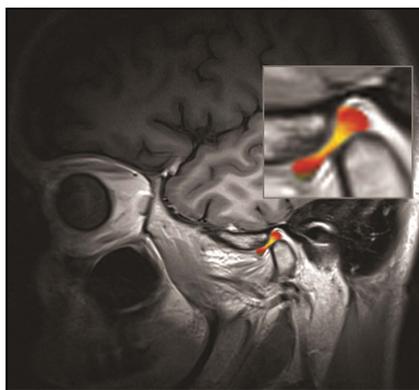


Figure 1: Morphology of TMJ. Zoomed area shows detail of TMJ stratification

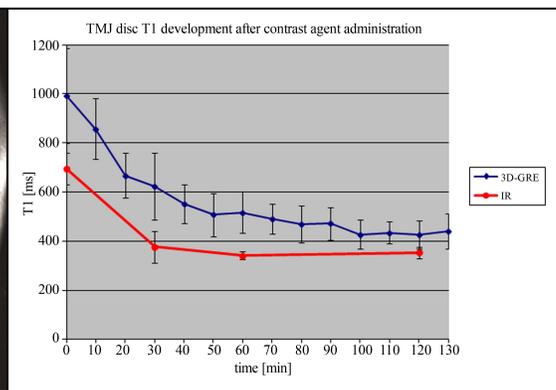


Figure 2: Both 3D-GRE technique and IR technique show statistically significant drop in T1(Gd) values over time

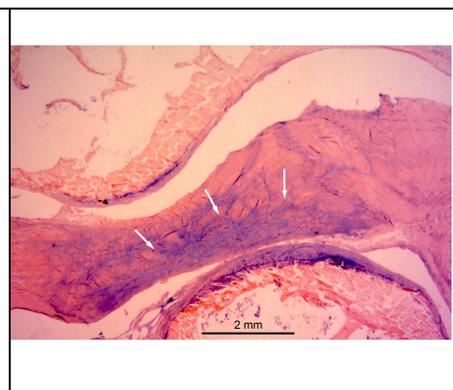


Figure 3: Histological specimen with proteoglycan-specific staining of the TMJ disc

Results

2D-IR sequences showed a statistically significant drop ($p < 0.001$) in T1 values after i.v. CA administration in the articular disc of the TMJ (Fig. 2). The 3D-GRE sequence-based T1 mapping confirmed these results ($p < 0.001$), providing higher temporal resolution due to the shorter measurement time. The regional distribution of T1(Gd) values showed similarities to histological GAG-specific staining techniques in the TMJ disc (Fig. 3). IR provides T1 values in longer time increments, but the values of T1 are more reliable, due to the insensitivity of IR to flip angle imperfections. The disadvantage of IR is the long measurement time (30 min for nine IR delays in the range of 60 ± 2500 ms).

Discussion

To the best of our knowledge, to date, no attempt has been made to test the feasibility of dGEMRIC for GAG-specific biochemical MR imaging in the fibrocartilage disc of the TMJ. T1 values from meniscal tissue ($T1(Gd) 90$ minutes after contrast agent administration = 660 ± 93.78 ms)¹ are higher compared to our results for the fibrocartilage disc of the TMJ ($T1(Gd) = 341.4 \pm 17.3$ ms with 2D IR and 470.9 ± 65.4 ms with 3D-GRE 90 minutes after CA administration). The mean T1(Gd) drop of 50% was reached 60 ± 70 minutes after bolus injection in the case of 3D-GRE measurement, and 60 minutes in the case of IR. This means that contrast agent uptake in the TMJ is faster compared to meniscal tissue (nearly 40% drop of T1(Gd) after three hours)². Differences in absolute T1(Gd) values between IR and 3D-GRE are caused by the known sensitivity of 3D-GRE to the imperfection of the excitation profile of the coil³.

Conclusion

T1(Gd) maps calculated from dGEMRIC data are feasible for the *in vivo* assessment of the fibrocartilage disc of the TMJ. The recommended diagnostic window for dGEMRIC in the TMJ after i.v. CA administration is from 60 to 120 minutes. The regional T1 values reflect the distribution of GAG in TMJ disc histology.

References

1. Mayerhoefer ME, Welsch GH, Riegler G, et al. Feasibility of texture analysis for the assessment of biochemical changes in meniscal tissue on T1 maps calculated from delayed gadolinium-enhanced magnetic resonance imaging of cartilage data: comparison with conventional relaxation time measurements. *Investigative radiology*. Sep 2010;45(9):543-547.
2. Mayerhoefer ME, Mamisch TC, Riegler G, et al. Gadolinium diethylenetriaminepentaacetate enhancement kinetics in the menisci of asymptomatic subjects: a first step towards a dedicated dGEMRIC (delayed gadolinium-enhanced MRI of cartilage)-like protocol for biochemical imaging of the menisci. *NMR in biomedicine*. Dec 2011;24(10):1210-1215.
3. Trattnig S, Mamisch TC, Pinker K, et al. Differentiating normal hyaline cartilage from post-surgical repair tissue using fast gradient echo imaging in delayed gadolinium-enhanced MRI (dGEMRIC) at 3 Tesla. *European radiology*. Jun 2008;18(6):1251-1259.