

Retrospective Gated MRI for High-Resolution Imaging of the TMJ Dynamics During Active Mastication

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Background Assessment of the masticatory motion of the temporomandibular joint (TMJ) is of interest for a variety of pathologies. Current approaches for measuring mastication mainly include tracking of external devices, which are attached to the teeth, thus enabling the indirect measurement of the TMJ motion. MRI has been applied for the direct visualization (1,2), but the dynamic visualization of the TMJ under realistic mastication is still limited by the poor image quality (motion artifacts, poor spatial and temporal resolution). It is the objective of this contribution to investigate the feasibility of using a gated retrospective reconstruction to provide a temporally resolved cine MRI data set from MRI data acquired during continuous active mastication.

Methods and Materials Ten volunteers were enrolled in this study. In order to acquire the TMJ's angular position, an MR-compatible tracking device was connected to the MRI-system. The TMJ tracking device was designed as a head set holding a bail, which was attached to the chin of the patient. The bail drove an angle encoder, which monitored the actual angular position of the joint. The device was synchronized with the MRI scanner and the actual position of the encoder was recorded once prior to each excitation pulse. Data acquisition was performed applying a projection reconstruction steady-state gradient echo technique. Acquisition parameters were as: TE/TR = 2.0/4.7ms, flip angle = 10°, pixel bandwidth of 432 Hz, and spatial resolution of 1x1x5mm³. Data was acquired continuously over a period of 120s during continuous mastication at a frequency between 8-15 cycles per minute.

Results The normalized recorded encoder positions are shown exemplarily for one volunteer in fig. 2. It is obvious from the graph that the reproducibility of the open position (1) is limited, yielding an uneven number of projection data for those bins not covered during each cycle. Four temporal snapshots reconstructed at 0%, 33%, 66%, and 100% of the maximal recorded angle are shown in fig. 3 for two volunteers. Despite the continuous motion of the TMJ, sharp, artefact-free images can be reconstructed for the different motion states. The image quality is dependent on the number of projections and their distribution over k-space and in bins not covered during each cycle, streaking artefact can be appreciated.

Discussion The application of a gated retrospective reconstruction of the TMJ appears feasible. The approach may facilitate reconstruction of dynamic images of the TMJ during active mastication. The achievable temporal and spatial resolution can be adapted by adjusting the duration of the continuous scanning. Since no real-time imaging is required, the proposed technique may facilitate dynamic reconstruction of the TMJ with multiple image contrast not possible with rapid imaging techniques. In combination with three-dimensional imaging techniques, a full 3D assessment of the TMJ motion may become possible. For further improving the image quality, the proposed technique may be combined with more efficient update of the k-space (3) preferably in combination with parallel image reconstruction techniques enabling high degrees of undersampling (4).

References (1) Tymofiyeva O, et al. *Annals of Anatomy* 2007;189:356-361; (2) Thomas X, et al. *Radiographics* 2006;26:765-781; (3) Winkelman S, et al. *IEEE Trans Med Imaging*. 2007;26:68-76; (4) Uecker M, et al. *NMR Biomed*. 2010;23:986-94.; (5) *zahnspangen.de* (1) Tymofiyeva O, et al. *Annals of Anatomy* 2007;189:356-361; (2) Thomas X, et al. *Radiographics* 2006;26:765-781; (3) Winkelman S, et al. *IEEE Trans Med Imaging*. 2007;26:68-76; (4) Uecker M, et al. *NMR Biomed*. 2010;23:986-94.

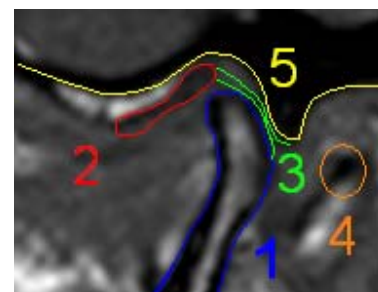


Figure 1 Important anatomic structures in the TMJ: 1 condyle, 2 discus, 3 ligaments, 4 ear canal, 5 skullbase

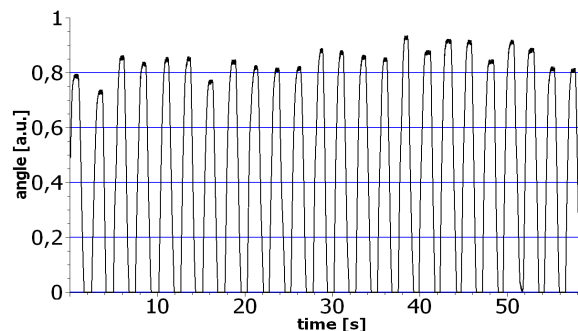


Figure 2 Recorded angular positions, the red lines indicate the jaw positions used for retrospective reconstruction.

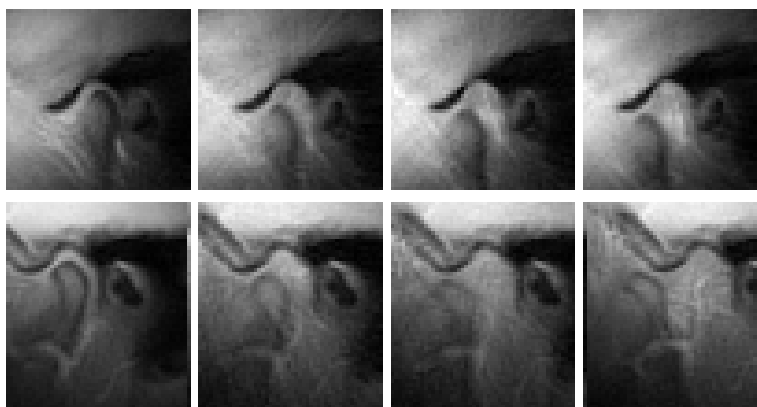


Figure 3 Four temporal snapshots (columns) of the mastication cycle reconstructed from data acquired continuously during active mastication in two volunteers (rows).