Dynamic Ultrashort TE (UTE) Imaging of the Temporomandibular Joint (TMJ)

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Introduction

The temporomandibular joint (TMJ) is an articulation of considerable anatomic and biomechanical complexity. TMJ pain and dysfunction are important clinical problems. The fibrocartilaginous nature of the disc and articular cartilage of the joint which include a majority of short T2 components can make their MR imaging evaluation technically difficult. Ultrashort echo time (UTE) pulse sequences allow morphological and quantitative assessment of short T2 tissues and tissue components (1-2). In addition, for fully evaluation of TMJ function dynamic studies with rapid imaging to allow imaging of disc motion is necessary. Radial sampling conjugated with golden ratio based azimuthal increments can generate approximately uniform k-space coverage and allows robust sliding window reconstruction with variable temporal resolution and arbitrary duration reconstructions (3). Applying such a golden ratio based radial profile order to UTE pulse sequences may provide a useful method for TMJ dynamic imaging.

Materials and Methods

A 2D UTE pulse sequences was implemented on the 3T Signa HDx TwinSpeed scanner (GE Healthcare Technologies, Milwaukee, WI). The UTE sequence employed a short half pulse excitation followed by 2D radial ramp sampling of k-space, where two neighboring spokes have the golden ratio based azimuthal gap of 222.48° as shown in figure 1a. In this experiment, golden ratio based strategy were employed to image both static and dynamic TMJ. Dynamic TMJ imaging was realized by opening and closing the jaw continuously during 2D UTE data acquisitions. High temporal resolution was achieved by using a narrow time window (55 projections) for central k-space data. This was updated every 21 projections. Undersampling streak artifacts were suppressed by view sharing of high spatial frequency data using a new tornado filter (Figure 1b) (4), with a wide time window (610 projections). Typical UTE imaging parameters included: FOV = 13 cm, 3 mm thick slice, readout = 256, BW = ±62.5 kHz, FA= 10° , TR = 30 ms, TE = 10us, 987 projections for static golden ratio method and 1974 projections for dynamic scan. Regridding reconstruction was used with oversampling ratio of 2 and window width of 4.

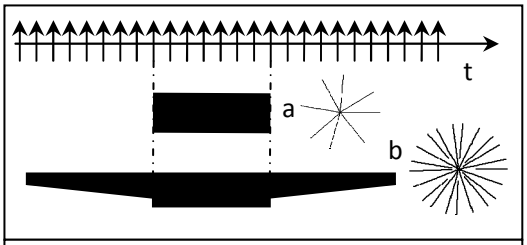

Figure 1. The scheme of golden ratio profile order generate (a) approximately uniform k-space and (b) allows sliding window reconstruction.

Results and Discussion

Figure 1 shows the golden ratio based strategy and use of the new tornado filter for sliding window reconstruction. Use of the golden ratio based profile order allowed arbitrary time point and arbitrary window reconstruction. Figure 2 shows a TMJ reference image reconstructed with fully sampled data using 987 projections. The dynamic images in figure 2 (from F1 to F7) shows the continuous movement of the TMJ disc. For each frame, 55 projections were used in gridding reconstruction conjugate with the tornado filter. The temporal resolution for each frame was 0.88s. Blurring in frames 4~6 was caused by the action of closing the jaw, which was a little faster than opening. The blurring caused by motion decreases the resolution of osseous and soft tissues. The temporal filter can be adjusted to increase the image resolution and decrease streak artifact.

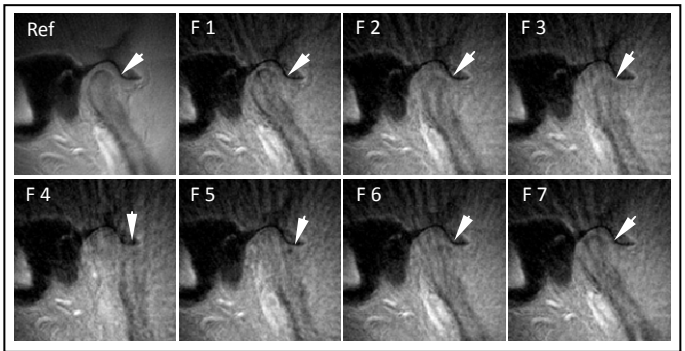

Figure 2. Dynamic Imaging of TMJ compared with reference image, which was reconstructed from fully sampling data. Dynamic image from frame 1-7 were reconstructed by 55 projections for central k-space data and view sharing high spatial frequency data from neighboring 610 projections by using the new tornado filter.

Conclusion

The motion of the TMJ disc can be dynamically imaged with 2D UTE sequences using golden ratio sampling. This has important diagnostic implications for the detection of TMJ disfunction. Future study may allow improvement of spatial resolution and reduction in motion artifact within each frame.

References

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