In Vivo Imaging of the Motion of the Temporomandibular Joint Components Using a Pseudo-Dynamic 3D Imaging Technique

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Purpose: The temporomandibular joint (TMJ) is a complex bilateral hinge and gliding joint that allows normal everyday function such as mastication and speaking.[4,6] TMJ disorders (TMJDs) such as tissue degeneration or displacement of the articular disc can lead to loss of jaw function.[4] Static MRI has proven valuable for TMJ imaging as it provides excellent tissue contrast between the osseous and soft tissue components of the joint.[1,2,3] Dynamic MRI of the TMJ has been less explored and has been previously performed only in two dimensions.[5] Three dimensional (3D) imaging may provide further information about the coordination and interaction of the TMJ components during motion.[1,2,5] **The goal of this study was to develop a technique to determine motion of TMJ components in 3D using pseudo dynamic imaging with Cube sequences.**

Methods: The TMJ of a healthy volunteer (25 y.o. female) received MRI (3T GE Signa HDx). **MRI:** A custom mouth opening device was positioned between the upper and lower incisors. The subject was imaged at an incisor opening of 7 mm (baseline), 10 mm, 20 mm, and 30 mm. 3D Cube sequence was performed in the sagittal orientation (3" surface coil, TR = 1100 ms, TE = 63 ms, NEX = 1, matrix = 192 x 128, slice thickness = 1 mm, FOV = 10 cm, ETL = 60, flip angle = 90, bandwidth = 41.67 kHz, scan time per position= 41 sec.) **Image Processing:** MR images at each position were post-processed using ImageJ to segment the temporal bone, TMJ disc, and mandibular condyle.

Results: MR images (Figure 1ABCD) showed with high contrast the cortical bone of the condyle (circle), glenoid fossa (arrowhead), articular eminence (*), TMJ disc (arrow), and surrounding soft tissues. After segmentation and 3D modeling, major components of the TMJ were seen prominently (Figure 1EFGH). With increased jaw opening (Figure 1E to H), anterio-inferior translation, as well as anterior rotation, of the condyle can be seen. The disc showed antero-inferior translation with posterior rotation, but stayed more posterior than the condyle, as it was partially lodged in the fossa.

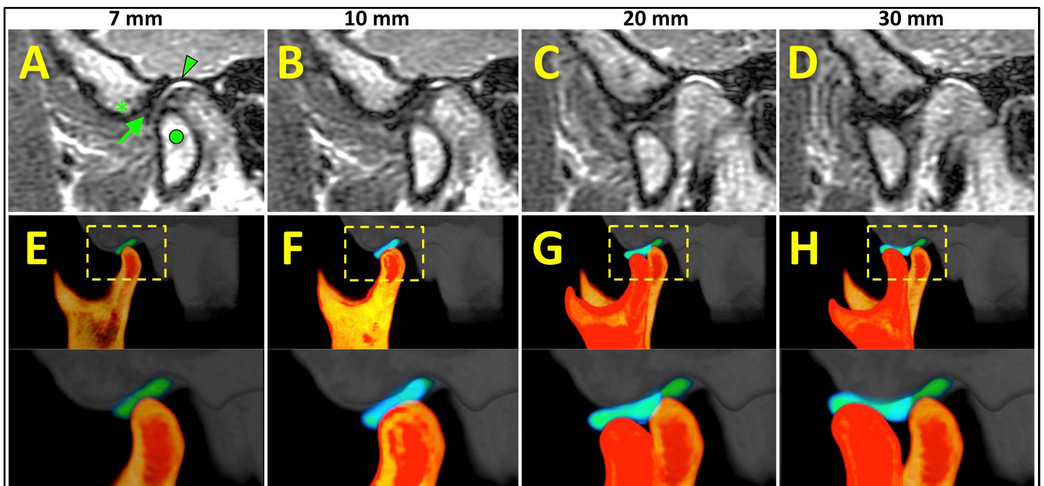

Figure 1. 3D Cube images (TR=1100 ms, TE=63 ms) of the TMJ taken at incisor distance of (**A**) 7 mm, (**B**) 10 mm, (**C**) 20 mm, and (**D**) 30 mm. 3D modeled surfaces of (**EFGH**) of the temporal bone (gray), mandibular condyle (orange) and TMJ disc (green/blue) at the corresponding incisor distances.

Discussion: The techniques presented here enable visualization as well as quantitative analysis of TMJ motion in three dimensions. Motion of normal versus patients with TMD can be compared, including the position of the disc relative to condyle. For quantitation of motion, rigid body registration will be used for bony components, while deformable registration may be used for the disc. In addition, the motion data can be combined with a static, high-resolution dataset, to create a high-resolution dynamic model of the TMJ components.

Conclusion: Dynamic MRI combined with 3D analysis enables modeling of the TMJ and visualization of complex patterns of the motion of different components. This provides additional information regarding joint motion and congruity in health and disease.

References: (1) Bag+ World J Radiol 6:567,2014. (2) Cassetta+ Dentomaxillofac Radiol. 43:1, 2014. (3) Geiger+ Skel Rad 43:19, 2014. (4) Willard+ Arc Oral Biol 57:599, 2012. (5) Yen+ Am J Neuroradiol 34:E24, 2013. (6) Thomas+ AJR 203: 1047,2014.