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FIDUCIAL-BASED REGISTRATION OF 3D DENTAL MODELS TO MAGNETIC RESONANCE IMAGES

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Summary: Background: Many clinical contexts require representation of the 3-dimensional anatomy of the stomatognathic system, including the teeth, jaw, muscles, and soft tissues. Capturing this anatomy often requires fusion of different imaging modalities. For example, Magnetic Resonance Imaging (MRI) captures the anatomy of soft tissues, but the low hydrogen content of hard tissues compromises their representation by MRI. In the dentition, the only components which create a strong signal are the dental pulps; generally, the enamel, dentine, and cementum are invisible unless special steps are taken.
Objective: The goal of this research is to enhance the value of masticatory system MR imaging by enabling superimposition of high-resolution virtual dental models, acquired by intra-oral 3D surface scanning, on the MR volume.
Methods: A subject-specific intraoral dental splint, connected to a semi-circular extra-oral attachment extending towards the temporomandibular joints, is fabricated and 3D printed. The design is generated semi-automatically based on 3D models of the subject's dentition and direct anatomical measurements made from the subject's skull. The extra-oral attachment holds 10-20 semi-elliptical concavities in predetermined positions where ellipsoidal fiducial markers comprised of vitamin E capsules are placed. The markers resonate during MR imaging, and their spatial positions are used as references for registration. The MRI is acquired while the subject bites on the dental splint. The spatial position of the center of mass (COM) of each fiducial marker in the resulting image set is calculated by averaging its voxels' coordinates. The COMs of the fiducials on the extra-oral attachment are the center of semi-elliptical concavities, which are known components in the computer-aided design. This enables calculation of a rigid transformation based on corresponding fiducials via singular-value decomposition, and the virtual dental models can be superimposed on the MRI volume.
Conclusion: With this approach, detailed anatomy of dental surfaces can be incorporated into MRI-based reconstructions of the masticatory system. The combined data would be helpful in modelling the biomechanics of mastication and swallowing, and could be used in clinically-related software involving dental articulation, implant design and orthognathic surgery.