

Fabricate Custom Occlusal Device Using A Markerless Stereo Mandibular Jaw Tracking

by

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Introduction:

Mandibular Jaw Tracking involves a dynamic process in jaw motion, including vertical, anteroposterior, and lateral motions. Jaw tracking has helped improve diagnosing oral facial pain, restorative procedures, occlusal analysis, and the fabrication of prosthetics. Historically, jaw tracking has shown to introduce many restrictions such as human error and operator difficulty. However, with the use of digital technology, these restrictions are minimized (Figure 2). The mandibular motion trajectory and occlusal surface can be visualized for analyzing static and dynamic dental occlusion quantitatively. Combined with the virtual 3-dimensional (3D) models generated by intraoral scanners; mandibular tracking techniques provide reliable data to virtually analyze the mandibular motion by presenting to the dentist. The digital analysis and virtual visualizing techniques have effectively addressed the clinical restrictions, such as the inability to record real-life dynamic occlusion. Markerless mandibular jaw tracking assists dentists in analyzing the conditions of the temporomandibular joint and the evaluation the patient's occlusion. Considering the limited research on purely photometric mandibular motion tracking systems, an innovative, markerless stereo vision technique is described from the operator's perspective. Without the use of intraoral markers or extraoral trackers, this technique utilizes a precisely aligned stereo camera system to optically capture and record unrestricted motion trajectories, relative maxillomandibular spatial data, and occlusal surfaces during mandibular movements

Material and Methods:

1. Model Upload: The maxillary and mandibular jaw models of the participant are uploaded into the system as separate standard tessellation language (STL) files in maximal intercuspal position (MIP). Subsequently, the software lists all the names of default mandible movement patterns.
2. Patient Positioning: The patient is in an upright position around 16 inches between the participant and the stereo camera system. An oral retractor is placed for greater oral visibility. Adjust the patient position to center the mouth within the frame of both cameras, ensuring the mouth is aligned with the main axis of the camera system (Figure 1).
3. Motion Recording: Click on the motion name to start the video recording. Then guide the patient to perform the corresponding motion patterns, starting each motion from the MIP and moving the motion patterns slowly.
4. Result Analysis: In about 15 seconds after confirming the results, the corresponding motion results show in the actions column. These results include side, front, and top views of the mandibular midpoint trajectory tracked from the motion (Figure 3). Also, the software displays a real-life simulation of the maxillary and mandibular motion merged with the 3D model from the intraoral scanner. With this data one can upload the patient's dynamic movements into a CAD design software and design a customized occlusal device. The real time occlusal contacts is highlighted in green (Figure 4).

Figure 1: Overview of the Markerless Stereo Vision Mandibular Tracking System

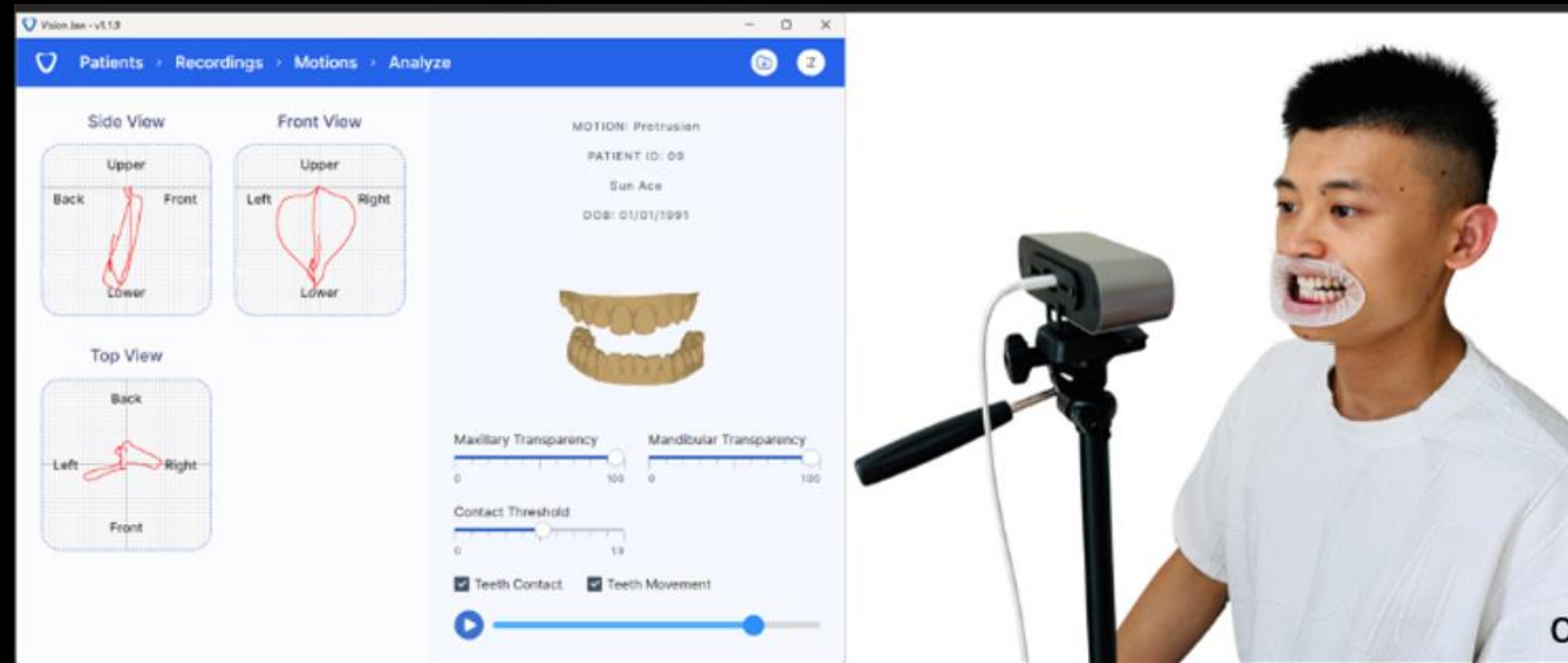
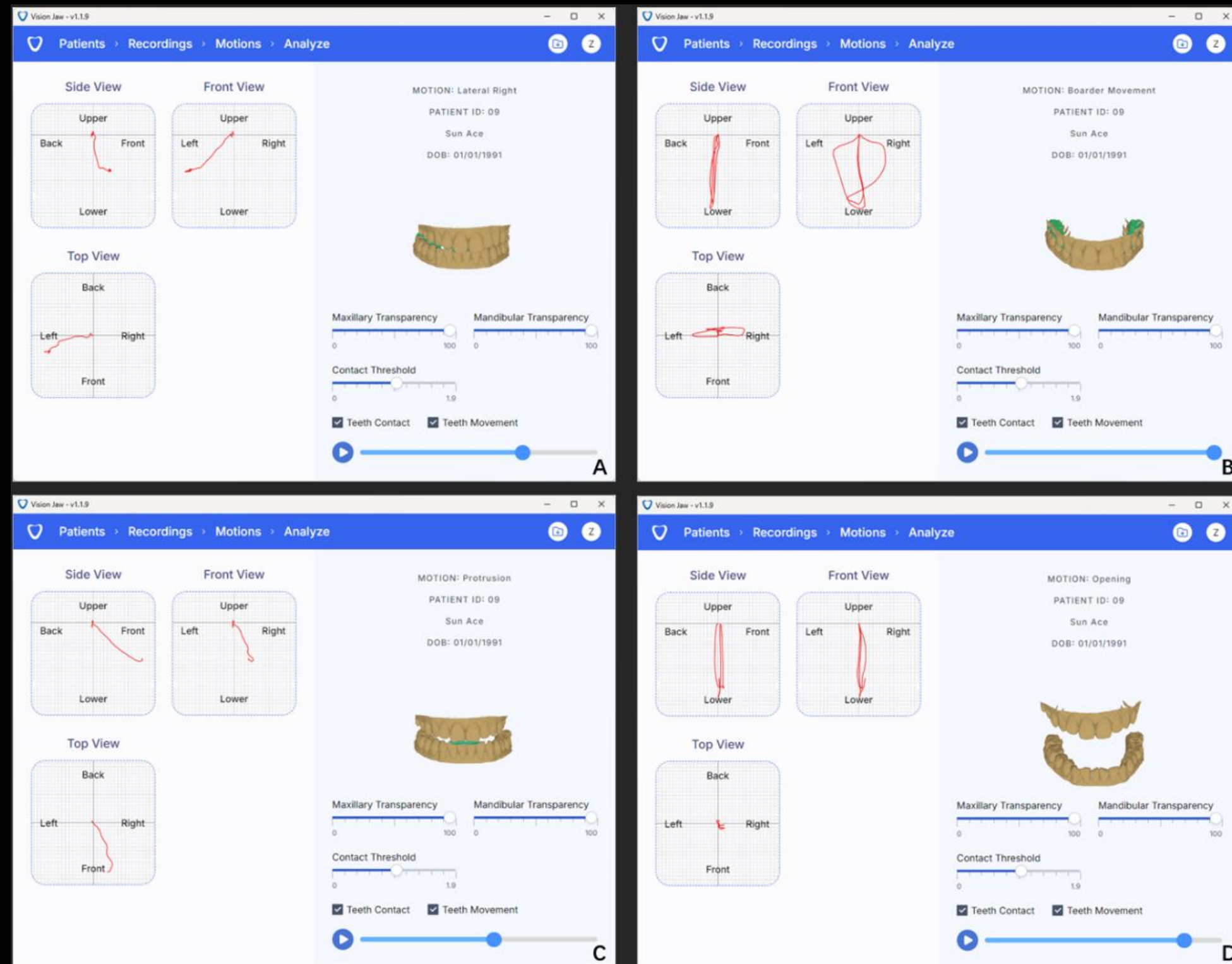


Figure 3. Software interface for results display in the mandibular tracking system for four example motions. A. Lateral right motion results, B. Boarder movement motion results, C. Protrusion motion results, D. Opening motion results.



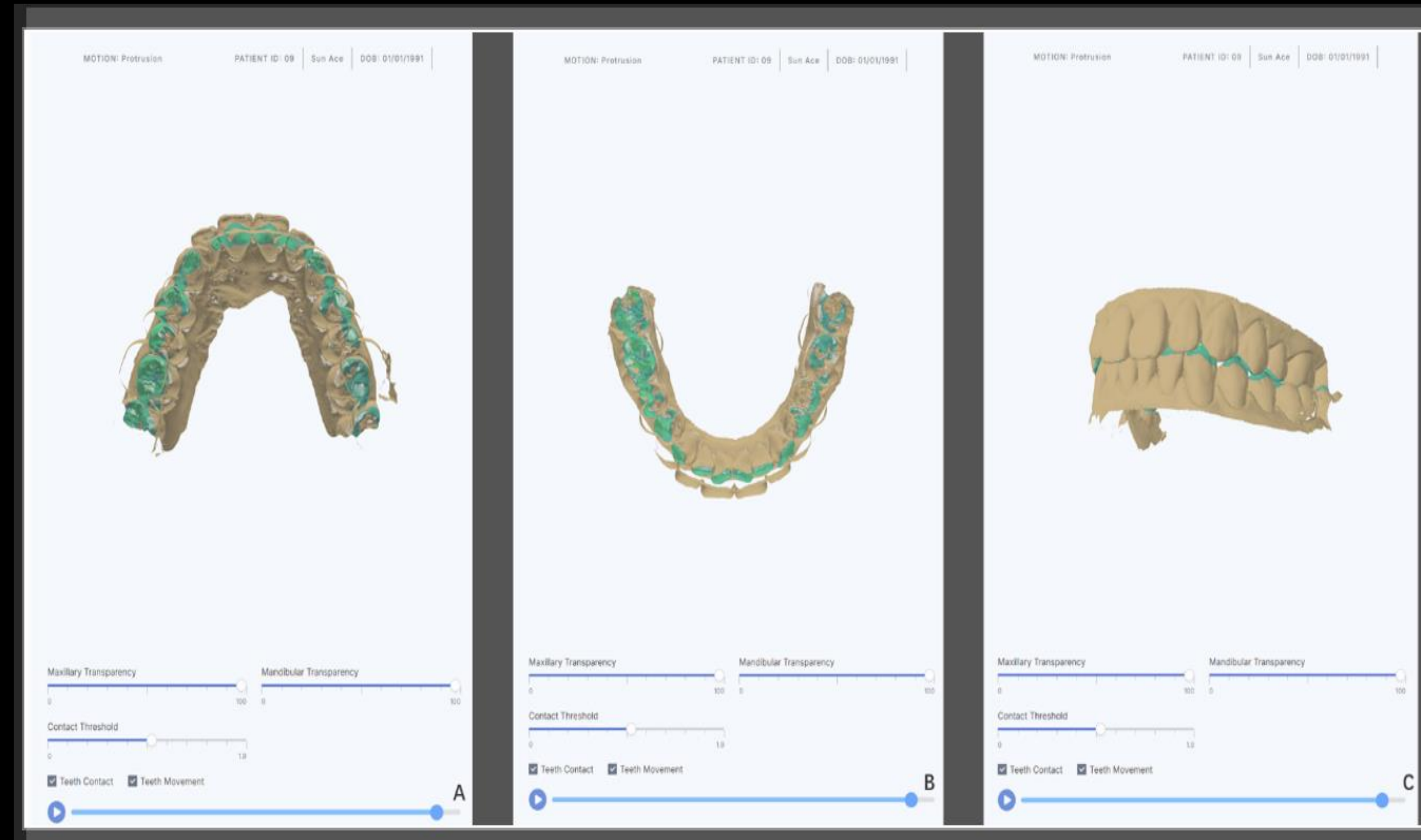
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Figure 2: Component of markerless stereo vision system



Figure 4: Occlusal surface results displayed in the mandibular tracking system A. Bottom View B. Top View C. Side View



Discussion:

This technique's goals are to reduce pre-preparation steps and to simplify the procedures required for recording mandibular jaw motions by using markerless stereo vision mandibular tracking system. Additionally, by adjusting the software program variables, this mandibular tracking system enables more fine-tuning motion simulation results, making this system more practical for clinical solutions. This innovative, markerless stereo vision system records and presents digital results on a computer screen. These results are digitally recorded for future replay and can be viewed from multiple perspectives. The virtual mandibular jaw motion simulation helps dentists evaluate patient's occlusion and help execute prosthodontic restorations such as an occlusal device. Additionally, the annotated occlusal surface data supports the occlusal conditions in patients, this can assist in pain management for patients with temporomandibular joint dysfunction (TMD).

Markerless jaw tracking does offer several advantages, such as eliminating movement deviations caused by external mechanical attachments and decreases the discomfort for the patient. Also, the simplicity of the camera standalone equipment significantly reduces setup time to a few minutes. Lastly, this technique has enhanced system accuracy due to the use of artificial intelligence algorithms. These improvements have the potential to expand the application of this technique in clinical trials.

There are, however, two limitations. First, using a soft oral retractor must be installed throughout the video recording to ensure oral visibility. A soft oral retractor has shown no impact on jaw movement in our studies and observations.

Secondly, obtaining the correct jaw relation record of the maxillary and mandibular meshes is critical for the accuracy of the jaw tracking results.