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Computational Fluid Dynamics as a Predictive Technique for the Patient-Specific Success of Mandibular Repositioning Appliances

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The obstructive sleep apnea-hypopnea syndrome (OSAHS) is a sleep related breathing disorder that is characterized by repeated partial or complete closure of the pharynx. A popular treatment is the use of a mandibular repositioning appliance (MRA) which advances the mandibula during the sleep and decreases the collapsibility of the upper airway. The success rate of such a device is however limited and variable within a population of patients. A technique to predict the patient-specific success would be of significant clinical importance.

Previous studies using computational fluid dynamics have shown that there is a decrease in upper airway resistance in patients who improve clinically due to an MRA. In this study, correlations between patient-specific anatomical and functional parameters are examined in order to understand how MRA induced biomechanical changes can have an impact on the upper airway resistance and to create a predictive technique that can separate responders from non-responders.

Low-dose computed tomography (CT) scans were obtained for 143 patients suffering from OSAHS. A baseline scan and a scan with the mandibula in an advanced position using a prefabricated bite registration were performed to study the variations in parameters before and after mandibular repositioning (MR). The registration bites used in this study were prepared by a dental technician and fitted as well as adjusted intra-orally by the dentist titrating mandibular advancement to the maximal comfortable protrusion.

It is found that the change in the upper airway resistance due to MR is determined by the change in pharyngeal lumen. However, in 20.3% of the patients, the resistance increases or stays the same while the volume increases. This can be explained by the fact that MR can induce a rotation of the tongue, causing a partial or full occlusion of the upper airway. On the other hand, an increase in the minimal cross-sectional area corresponds to a decrease in upper airway resistance for 96.5% of the patients. Therefore, the minimal cross-sectional area is a

better parameter to compare the changes in resistance as compared to volumetric changes.

It is discovered that baseline parameters can also give indications about the change in resistance. Women tend to have a larger resistance decrease compared to men. Also, patients with a high initial resistance tend to improve more. However, people with a baseline occlusion or very concave airways have a higher chance of an occlusion while wearing the protrusive bite registration. This is especially true if the minimal cross-sectional area is close to the tongue and can be explained by the assumption that even a small rotation of the tongue can cause an occlusion in these patients.

The ideal patient for MR treatment seems to be a women with short airways, a high initial resistance and no baseline occlusion. The results of this study show that patient-specific computer models can provide an added value for the MRA treatment of OSAHS.