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THREE DIMENSIONAL KINEMATICS OF THE HUMAN MANDIBLE

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Introduction

The temporomandibular joint (TMJ) links the mandible to the skull. The articular surfaces (temporal fossa and mandibular condyle) are separated by a mobile articular disc. Mouth movements are the result of simultaneous motions of the left and the right TMJs, due to 3D translations and rotations of the mandible. However, many studies only analyze the planar path of an incisal point or a condylar point [1] [2]. Thus, the purpose of our study is to quantify the 3D kinematics of the mandible for asymptomatic volunteers.

Methods

Eighteen asymptomatic volunteers (6 women, 12 men, 22 to 45 years old) were recruited and provided written informed consent to participate. The mandibular movements relative to the skull were recorded using the CMS-20-JMA device (Zebris Medizintechnik GmbH, Isny, Germany - figure 1) with an accuracy of 0.26 mm in translation and 1.5° in rotation.

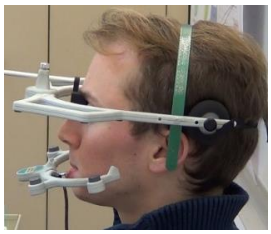

Figure 1: Jaw Motion Analysis Device

Anatomical landmarks were selected to create the skull and mandibular frames. Twenty anthropometrical measures were done on the mandible. After one training test, the volunteers were asked to move 10 times their jaw at their maximum towards the bottom (opening-closing movement), the right and the left (lateral movements) and forwardly (propulsion). The magnitude of the incisal point's displacement was quantified along the inferior axis during opening, along the medial-lateral axis for lateral movements and along the posterior-anterior axis for propulsion. Mandibular motions were quantified at each time step relative to the anatomical skull frame. Finally, the link between the morphological parameters and the kinematic ones was tested using the Spearman rank test (two-tailed level of significance of 0.05 and ρ- parameter > 0.51).

Results

The magnitude of displacement of the incisal point is on average equal to 41.8 mm inferiorly during opening, 11.3 mm laterally during lateral movements and 7.9mm forwardly during propulsion. These magnitudes are slightly correlated with the mandibular dimensions. Rotations and translations simultaneously occur for every mouth movement. For opening movements, the intercondylar rotation, the backward-forward and the superior-inferior translations are predominant (with average values up to 30°, 10.3 mm and 9.9 mm respectively). For propulsion movements, the backward-forward and the superior-inferior translations (up to about 6 mm) are predominant. The intercondylar rotation is the largest rotation but it is very small (up to about 1.3°). No principal motions are observed for the lateral movements. By comparing people with occlusion from class I, II and III, differences are observed for motions in opening and propulsion. Finally, four subjects with moderate TMJ dysfunctions (3 women, 1 man, 22 to 43 years old) move their jaw in a different way than asymptomatic people.

Discussion

The magnitude of displacement of the incisal point is the first evaluation of the patient's ability to move the mandible. It is used to detect limitations as a first approach for the diagnosis of TMJ pathologies [3]. However, there is no globally accepted threshold value due to the link with the morphology [4]. Studying the 3D kinematics of the mandible could help to detect compensatory strategies done by the patients during the movements. In this context, the aim of the study is to quantify the 3D kinematics of the mandible for asymptomatic subjects. Contrary to the usual description of the mouth opening movement, rotations and translations simultaneously occur at each time step. By considering the predominant motions, opening and propulsion could be seen as planar sagittal movements. However, off-plane motions are not negligible and a symmetrical representation could be discussed. Differences in motions are observed for the different classes of dental occlusion but this result is limited by the small and non-homogeneous number of subjects included in each group. Finally, motions vary in a different way for people with TMJ moderate dysfunctions compared to asymptomatic subjects, which is a promising result despite the small number of involved subjects.

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