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► **To cite this version:**

Elodie Ehrmann, Feghali Sara, Marie Bernabeu, Yannick Tillier. Finite Element Modeling of The Masticatory System: Application To Bruxism. CMBBE2023 18th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering, May 2023, Paris, France. hal-04373868

HAL Id: hal-04373868

<https://minesparis-psl.hal.science/hal-04373868>

Submitted on 5 Jan 2024

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FINITE ELEMENT MODELING OF THE MASTICATORY SYSTEM: APPLICATION TO BRUXISM

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1. Introduction

Bruxism is responsible for temporo-mandibular joint (TMJ) disorders and tooth wear [1]. This work is part of a larger project that aims to better understand the biomechanical impact of such a parafunction on the TMJ and teeth, by comparing two finite element models (FEMs) of the masticatory system of a patient, before and after an oral rehabilitation. Retrieving the geometry of the different tissues from medical images is relatively common. The originality of this work is to propose to use an extraoral device (Modjaw® [2]) to record the kinematic data of a patient and apply them, as a loading condition, to the FEMs.

2. Materials and Methods

A FEM corresponding to the situation before oral rehabilitation of a 37-year-old male patient with mild bruxism was created. Geometric data were obtained after the alignment of multimodal medical images (CBCT, MRI, 3D scan acquisition of a dental arch plaster model). The bones, the soft tissues, and the teeth were modelled (segmented and meshed with Mimics (Materialize®), and transferred to the FE analysis software FORGE (Transvalor®). Mechanical properties were assigned to each anatomical structure (all of which are considered linear elastic materials). Particular attention was paid to the application, as a loading condition, of the real kinematics of the patient. For this purpose, he was asked to perform 3s grinding movements (a right and then left latero-deviation). The Modjaw® medical device was used to record, as a function of time, the coordinates of 3 points denoted I, RC and LC on Fig. 1 and corresponding respectively to the inferior incisal edge point, and 2 points away from the right and left condyles. Three rigid objects were then created in the FEM and assigned the same coordinate evolutions to set the mandible in motion.

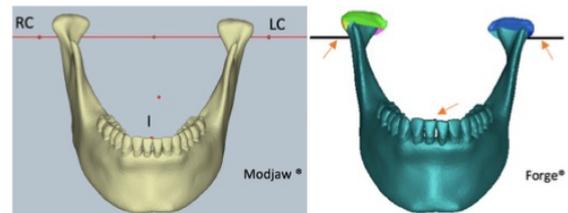


Figure 1: Application in Forge® of the boundary conditions recorded by Modjaw®

3. Results

The von Mises stress distribution, given by the FEM, on the teeth and in both joints during a grinding cycle was analysed and compared to the experimental contact areas given by the Modjaw® device (Fig. 2).

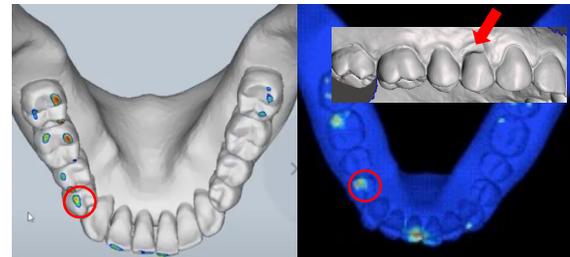


Figure 2: Right lateral excursion. Comparison of von Mises stress distribution (FEM, right) vs dental contact areas (Modjaw®, left). Teeth 44/14 in red.

4. Discussion and Conclusions

The similarities observed seem to confirm the accuracy of the chosen approach, although we can note a very high level of stress at the I-point used to move the mandible. It is interesting to note that tooth 44 at the neck of which a stress peak is observed numerically (red circles in Fig. 2) is slightly worn in the patient and that gingival recession was clinically observed on the facing tooth 14 (red arrow in Fig.2).

5. References

1. Guillot M et al., CRANIO®; 39(5):412-423 (2021).
2. Bapelle M et al., CRANIO®; 1-7 (Published online: 06 Nov 2021).