COMPARISON OF TMJ BEHAVIOR BETWEEN HEALTHY AND SHORT-TERM EDENTULOUS MANDIBLE WEARING FIXED PROSTHESIS. CASE OF INCISAL FOODSTUFF BITING

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1. Introduction

The dental restoration of a complete edentulous state by prosthesis can change the vertical dimension of occlusion (VDO). Any modification on the occlusal scheme affects the Temporo-Mandibular Joint (TMJ). The aim of this study is to compare condylar forces exerted during a foodstuff biting for healthy and edentulous person wearing a complete fixed prosthesis on the mandibular arch. This analysis is done by finite element methods (FEM).

2. Methods

The finite element model used in this study is based on the geometry of a healthy individual studied by Creuillot et al [1]. Their TMJ model has been improved by adding cartilage layers on condyles and fossae and by encapsulating the discs, the volume of which was adapted to the free spaces between condylar processes and fossae.

The edentulous mandible is derived from the healthy one. Teeth have been removed numerically and a moderate bone resorption of type III [2] has been considered resulting from the hypothesis of short-term restoration. Dentist designed a prosthesis adapted to the edentulous morphology without knowledge of the initial healthy dentition of the mandible. The prosthesis is supported by four dental implants (NobelBiocare® SpeedyGroovy,- diameter of 3.75mm) following the all-on-four concept.

When superimposing the condyles of healthy and edentulous cases, mandibular dental arches are not overlaid. The vertical gap was estimated here to 1.1 mm. The edentulous finite element model is settled in occlusion occurring, as in the healthy case, mainly on molar teeth. It corresponds to the simulations' starting position. In this position, the orientations and locations of condylar processes and TMJ discs are different.

The finite element model of the healthy (respectively edentulous) case is composed of 69397 (respectively 90080) nodes and 179659 (respectively 294261) elements.

The elastic linear properties of involved bone tissues and metallic materials are gathered in table 1. The same hyperelastic properties were assigned to the discs and cartilage following the experimental work of Beek et al [3]. The foodstuff was supposed to be elasto-plastic obeying the flow rule associated with Huber-von Mises criterion and linear isotropic hardening.

Same boundaries conditions as those used by Creuillot et al [1] have been applied here. Contact between disc and capsula has been added. In the edentulous finite element model, implants are considered as completely osseo-integrated. For both analyses, the loading cycle corresponded to a jaw opening ($t < 1.3$) followed by the foodstuff insertion ($1.3 \leq t < 1.4$) closing of mandible leading to the contact between teeth and foodstuff ($1.4 \leq t < 1.7$) and biting ($t \geq 1.7$).

3. Results and discussion

The maximum biting force at t=2.04 reached F_b=16.4N for the healthy case and F_b=17.2N for the edentulous case inducing significant irreversible strain in foodstuff ($\varepsilon_{eq}^{p} = 0.25$). Graphs of Figure 1 show the TMJ contact normal force evolutions in function of time. Globally, the healthy case (continuous lines) demonstrates higher condylar forces than edentulous one (dotted lines). Three

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particular instants can be identified on curves. The peak at t=1.3 corresponds to the maximal mouth opening. Condylar process is in front of maxillary tuberosity. On the right healthy condyle, the contact force reached 7.8N against 7.0N in the edentulous case. On the left condyle, the contact forces are more equilibrated and reached 7.5N and 7.4N respectively for the healthy and prosthetic cases. Discrepancy observed on the right side is due to the initial condylar and disc positions, different in the edentulous case. The closing of the mandible produces the decrease of the condylar forces which reached their minimal values of about 5N at t=1.7, corresponding to the contact instant between teeth and foodstuff. At t=2.04, the right condyle supports the contact normal force of 11.2N in the healthy case and 10.8N in the edentulous one. These forces on the left condyles attained respectively 12.2N and 13.0N in the healthy and edentulous cases.

Component	E (MPa)	ν	σ_y (MPa)
Bone	4500	0.3	-
Capsule	2	0.4	-
Muscles	0.2	0.0	-
Foodstuff	7	0.33	1.5

Table 1. Material properties

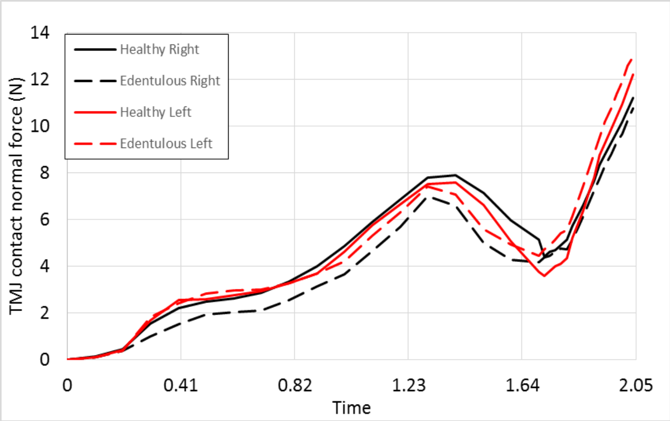

Figure 1 : TMJ contact normal force evolution

During the whole loading cycle, the TMJ discs worked in compression. The minimal (negative) principal values of stress and strain in the healthy case (respectively edentulous) reach approximately -3.45MPa (respectively -2.88 MPa) and -0.18 (respectively -0.18) due to the biting force of F_b=16.4N (respectively F_b=17.2N).

4. Conclusion

These obtained results don’t show great differences between the edentulous and healthy cases. This is mainly due to relatively low loads induced by biting of soft foodstuff and short-term restoration of the edentulous case manifested by the quasi-identical positions of TMJ discs. However, the more equilibrated response of TMJs was observed in the healthy case due to better occlusion among natural teeth.

Results show that the initial condylar displacement and discs reorientation has influence on the TMJ behavior. The work will be followed in case of long-term edentulous configuration manifested by discs' dislocation and mandible rotation.

5. References

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