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PREDICTING THE RISK OF FRACTURE OF OSTEOSYNTHESIS PLATES

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1. Introduction

The case of a partially edentulous patient who underwent orthognathic surgery is presented. A fracture of a right double plate was observed several weeks after surgery (Fig. 1, right). The objective of this work is to demonstrate whether it is possible to predict the risk of postoperative fracture of osteosynthesis plates using finite element (FE) modeling.

2. Materials and Methods

Fortunately, a CT scan of the patient had been performed prior to surgery. The 3D images were sent to Materialise Medical (Leuven, Belgium), for image segmentation and surgical planning. This allowed them to provide mesh files of the patient's facial structure and of the custom osteosynthesis plates used for the surgery. All meshed objects (ramus, mandible, maxilla, teeth, plates) were imported into the FE model Forge® NxT 3.2 (Transvalor, Sophia Antipolis, France). They were placed in contact with their neighbors and were considered as linear elastic and compressible materials in first approximation. The material data were taken from the literature [1].

Two different methods to get the desired jaw clenching movement for the simulations were used: (i) a set of muscle forces (masseter, temporalis and medial pterygoid) gradually increased up to 200 N along x , y and z axes respectively, resulting in an upward displacement of the mandible [2] and (ii) an upward displacement of a translation tool under the mandible. The calculations were arbitrarily stopped after a maximum imposed displacement of 0.016 mm, the forces becoming too high beyond that (teeth are already in contact at the beginning).

Two kinds of boundary conditions to simulate plate fixation (representative of a consolidated

state after healing) were evaluated: (i) with screws inside drilled bones (perfect contact) or (ii) without screws through a condition of bilateral sticking contact at the interface between the plate and the bone (Fig. 1, left).

3. Results

Not considering screws in the simulation does not allow the computations to converge. Screws tend to stabilize the system while increasing the contact surfaces and thus the computation times. Only the cases with screws were then analyzed. To push under the mandible allows the calculation to converge much faster than using a set of muscular forces, while also being much easier to define. The results show that the von Mises stress levels are higher at the plates, differently on the left and on right sides, with the highest values on the right plate (22 MPa vs 13 MPa), i.e. the side where the patient is partially edentulous, and furthermore in the area where the plate broke after surgery.

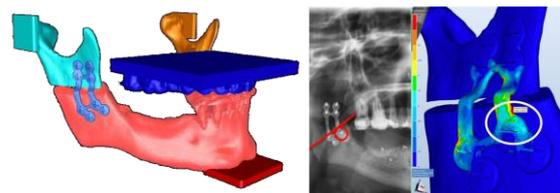


Figure 1: Finite element model (left) and von Mises stress distribution in the plate failure area (right).

4. Discussion and Conclusions

The surgical planning tools currently used in maxillofacial surgery are mainly based on geometric data. This study shows that the mechanical aspects should not be neglected.

5. References

1. Savoldelli C et al., Sci Rep. 11(1):8755 (2021)
2. Savoldelli C et al., IJOMS, 41(12) :1474-1482 (2012)