INSTITUTIONS	• Laboratory of Applied Biomechanics, UMRT 24, Gustave Eiffel university / Aix-Marseille University, Marseille, France • Department of Oral and maxillofacial Surgery, APHM, Conception University Hospital, Marseille, France. • Glad Medical, Salon de Provence, France
CONTRACT TYPE	One-year post-doctoral researcher position
TITLE	**Development and validation of an optimal patient-specific reconstruction plate for mandibular segmental defect bridging**
FIELD / DOMAIN	Biomechanics / Material Science / Computing Science
LOCATION	Marseille, France
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SALARY	40 000€
START DATE	September, 2023

CLINICAL AND SCIENTIFIC CONTEXT

Segmental mandibular defects after traumatic bone tissue loss, osteonecrosis or tumoral resection have to be treated by surgical technics including microvascular reconstruction with composite flaps (mostly fibular flaps) which is the gold standard. However, microsurgery and complex reconstructions are not suitable for all the patients due to bad general conditions of the patient or because of the size of the bone loss. In these cases, simple reconstructions, with reconstruction plates and local or regional flaps are more appropriate.

Most of the reconstruction plates currently available are standard plates which have to be cut and adapted to the curvature of the mandible before or during the surgery. Moreover, these plates are usually thick because they have to withstand repeated longstanding stresses related to mastication.

However, a complication rate up to 60% (Bede et al., 2019) including plate fractures, screw loosening and plate exposures is observed for this clinical indication underlying the need for a more appropriate solution. Based on recent literature data, one promising area is the use of optimized patient-specific plates that could improve the clinical results thanks to design optimization and the absence of prestress (Al-Ahmari et al., 2015; Koper et al., 2021).

In this context, the objective of this one-year post-doctoral research project is to develop and validate an optimized patient-specific medical device for this indication.

Recent studies have proposed methods coupling patient-specific design based on medical imaging, numerical simulation, optimization and additive manufacturing. However, the validation of numerical prediction of static and fatigue behavior of 3D printed metal has still to be addressed to ensure the safety and the performance of these medical devices. In particular, the following aspects will be addressed:

- Quantification of surface and internal properties of 3D printed products according to the design, production and post-processing parameters
- Development and validation of detailed finite element for the prediction of static and fatigue behavior of 3D printed plates under biofidelistic conditions
- Development of a multi-criteria optimization method aiming to consider mechanical as well as clinical and production constraints and/or objectives.

INSTITUTIONAL CONTEXT:

This project is initiated by a collaboration between the laboratory of applied biomechanics (LBA, UMRT 24, UGE, AMU, Marseille, France), the Department of Oral and maxillofacial Surgery, APHM, Conception University Hospital, Marseille, France and Glad Medical company.

The LBA is pioneer in the modelling of "virtual human". Strong of its experimented team and its numerical and experimental platforms (mechanical testing machines, sample preparation and microscopic analyses equipment, computing resources, …), the LBA develop innovative methods and concepts to go further in the prevention of traumatisms and the evaluation and optimization of medical devices and sport equipment.

The Department of Oral and maxillofacial Surgery, Marseille, and the Pr. Guyot, benefits from an experimented team and a state-of-the-art technical platform for the management of these cases.

Glad Medical is a start-up specialized in the research and development in the field of medical devices. Thanks to its collaboration with institutional partners as well as with major industrial actors, Glad medical developed an important experience in clinical, numerical, experimental and regulatory affairs aspects related to the medical devices and especially in dental and maxillofacial surgery. The company recently developed an additive manufacturing platform (SLM 3D printers, post-processing equipment, …)

Missions and responsibilities

The mission of the expected candidate is to developed and validate an optimized patient-specific medical device for segmental mandibular defect bridging. This will consist in developing an optimal patient-specific solution that encounter clinical, mechanical and production constraints. In this purpose, the candidate is expected to lead the clinical investigations and the experimental and numerical development with the supports of the partners.

Based on existing results obtained from previous projects, the following steps are planned:

- Clinical, biomechanical and 3D printing investigations and review
- Prototype design and production
- Experimental testing (mechanical performance testing, operative placement simulationl)
- Numerical finite element development, calibration and validation
- Pre-clinical study to validate the solution

Candidate

We are looking for a post-doctoral candidate with scientific background in mechanical and/or material engineering. Knowledge in metal 3D printing and/or metal sample analysis and characterization will be an asset. Moreover, previous experience in numerical simulation particularly in finite element analysis and biomedical would be appreciated.

Ability for multidisciplinary work and interest in clinical aspects are expected.

Work environment and location

The candidate will be located at the LBA (Marseille, France).

Key words:

3D printing, biomechanics, biomedical engineering, medical devices, material science, finite element model, optimization

Bede, S. Y. H., Ismael, W. K., & Hashim, E. A. (2019). Reconstruction plate-related complications in mandibular continuity defects. Oral and Maxillofacial Surgery, 23, 193-199.

Al-Ahmari, A., Nasr, E. A., Moiduddin, K., Anwar, S., Kindi, M. A., & Kamrani, A. (2015). A comparative study on the customized design of mandibular reconstruction plates using finite element method. Advances in Mechanical Engineering, 7(7), 1687814015593890.

Koper, D. C., Leung, C. A., Smeets, L. C., Laeven, P. F., Tuijthof, G. J., & Kessler, P. A. (2021). Topology optimization of a mandibular reconstruction plate and biomechanical validation. journal of the mechanical behavior of biomedical materials, 113, 104157.