Universität Basel
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From Nature to the Operating Room:

A Biomimetic Approach to Mandible Fracture Plate Design

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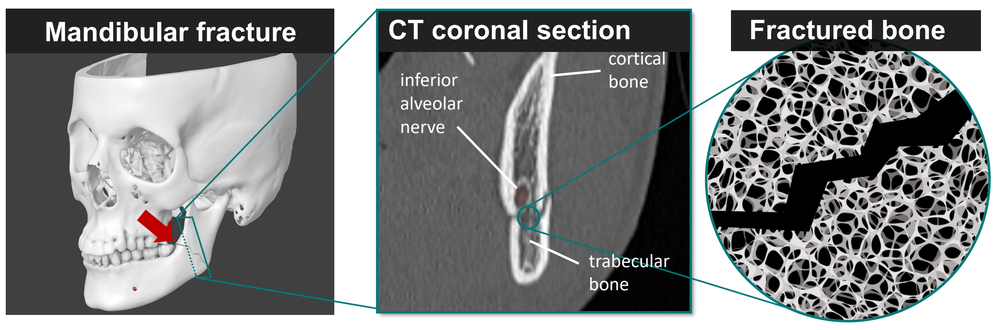
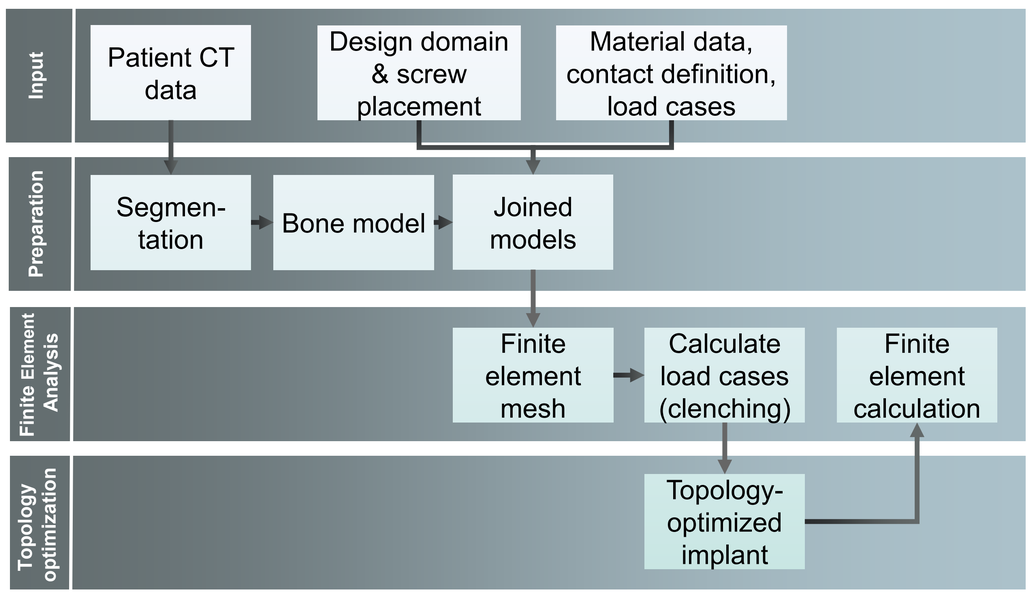
Introduction



"Every change in the function of a bone is followed by certain definite changes in its internal architecture and its external conformation." - Julius Wolff, 1899

In a biomimetic approach, our research aims to enhance mandibular fracture treatment using topology optimized, personalized 3D-printed implants and finite element analysis. Our goal is to improve implant fit, stability, and patient outcomes.

Methodology



Topology optimization resembles bone growth principles, maximizing implant strength and efficient material allocation.

Selective laser melting of titanium to precisely build complex, patient-specific geometries with high structural integrity, ensuring optimal implant fit and functionality while minimizing material waste.

Implant performance: to assess implant stability, finite element analysis can be used to model the performance under masticatory load (mandible clenching).

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Acknowledgements:

This work was financially supported by the Werner Siemens Foundation through the MIRACLE II project and the University of Applied Sciences and Arts Northwestern Switzerland School of Life Sciences (HLS ResearchPROJECTS, Stiftung**FHNW**)

Results

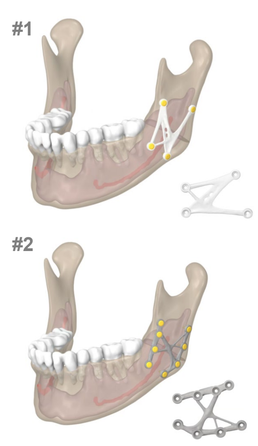

Figure 1. The implants generated with the topology optimization algorithm with four (#1) and eight (#2) screws and 3D printed implant-mandible model.

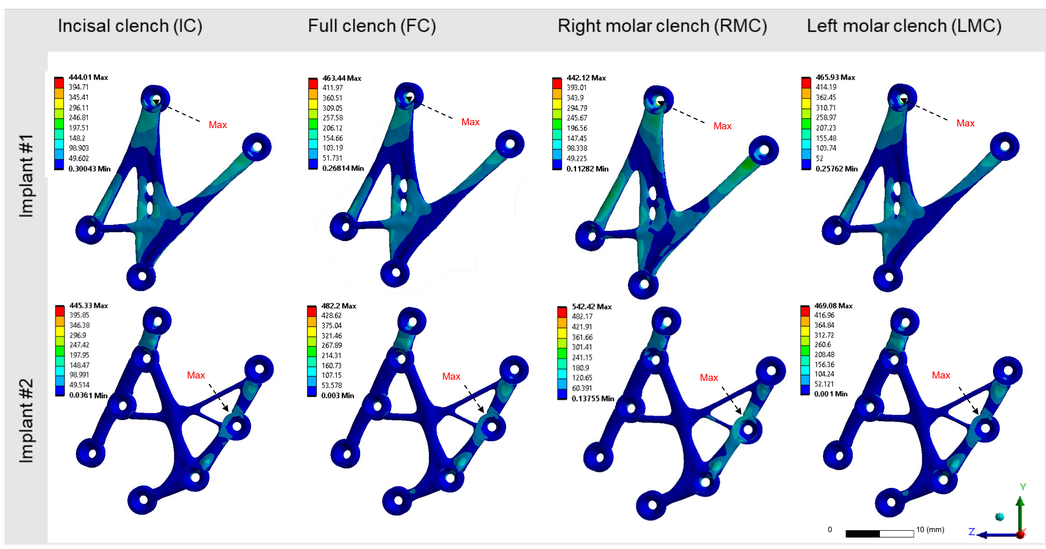

Figure 2. Using calibrated process parameters, the study found that the implants and screws were strong enough to handle the jaw's chewing forces, as their stresses stayed within the safe limits of the commercially pure titanium used in 3D printing. [3]

Conclusion

The nature-inspired topology optimization algorithm and finite element validation could significantly speed up the process to bring effective implants to patients with time-critical traumatic injuries.

References
[1] Wolff, J., 1899. Archiv für pathologische Anatomie und Physiologie und für klinische Medicin, 155, pp.256-315.
[2] Maintz, M., et al., Journal of the Mechanical Behavior of Biomedical Materials, 144: p. 105948, 2023.
[3] Maintz, M., et al., Current Directions in Biomedical Engineering, 8(2): p. 177-180, 2022
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