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The Role of Interproximal Contacts in Implant-supported Crown Stability: A Finite Element Analysis study.

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Purpose:

Evaluation of the biomechanical behavior of implant-supported crowns placed in the posterior mandible, through Finite Element Modeling (FEM). Two variables were investigated: (a) the impact of implant position (first molar vs. second molar), (b) the nature of interproximal contact with adjacent teeth (mesial vs. mesial and distal interproximal contacts).

Introduction:

Understanding the distribution of stress on the crown, implant, and surrounding bone complex is critical for optimizing implant longevity and patient outcomes. This study provides insights into how the position of the implant within the dental arch influences the stresses exerted on the entire structure. Furthermore, the findings highlight the role of interproximal contacts in maintaining implant crown stability.

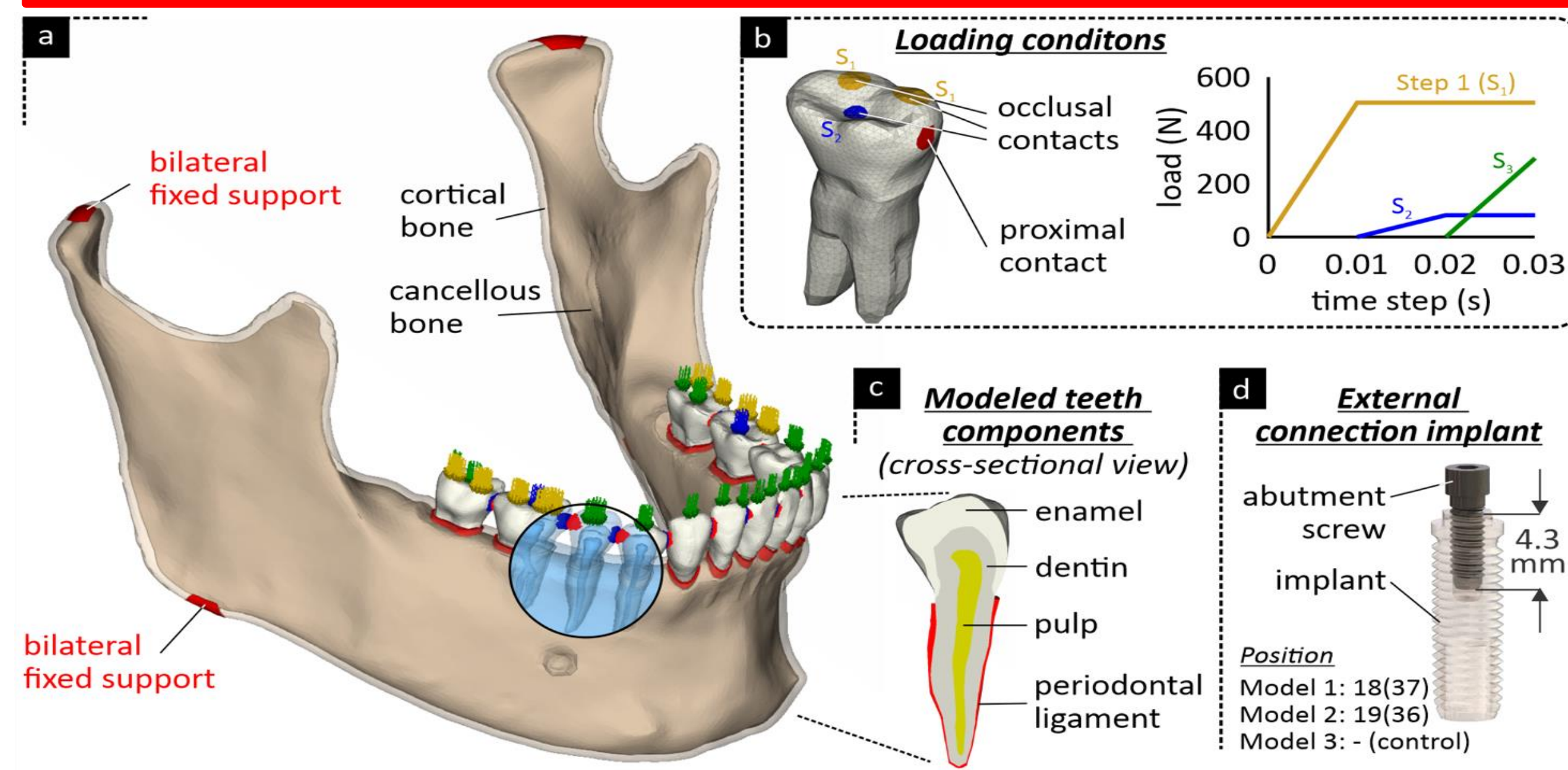


Figure 1: a) overview of the 3D mandible with boundary and loading conditions, b) occlusal and proximal contacts (medial in blue and distal in red) along with load steps, leading to a quasi-static masticatory scenario, c) modeled teeth components, shown indicatively on a premolar cross-section and d) detailed view of the external connection implant and the implantations sites (teeth positions) depending on the model.

Methodology:

Three mandibular models were constructed, using micro-tomography: (1) fully dentate (control), (2) partially edentulous with a second molar missing, replaced by a single implant-supported crown (mesial interproximal contact only), (3) partially edentulous with a first molar missing, replaced by a single implant-supported crown (mesial and distal interproximal contacts). Finite element analysis (FEA) simulated occlusal loading during masticatory function. Stress distribution was evaluated using the von Mises stress criterion, with principal stress analysis for bone anisotropy. Model validation was performed against experimental tooth displacement data.

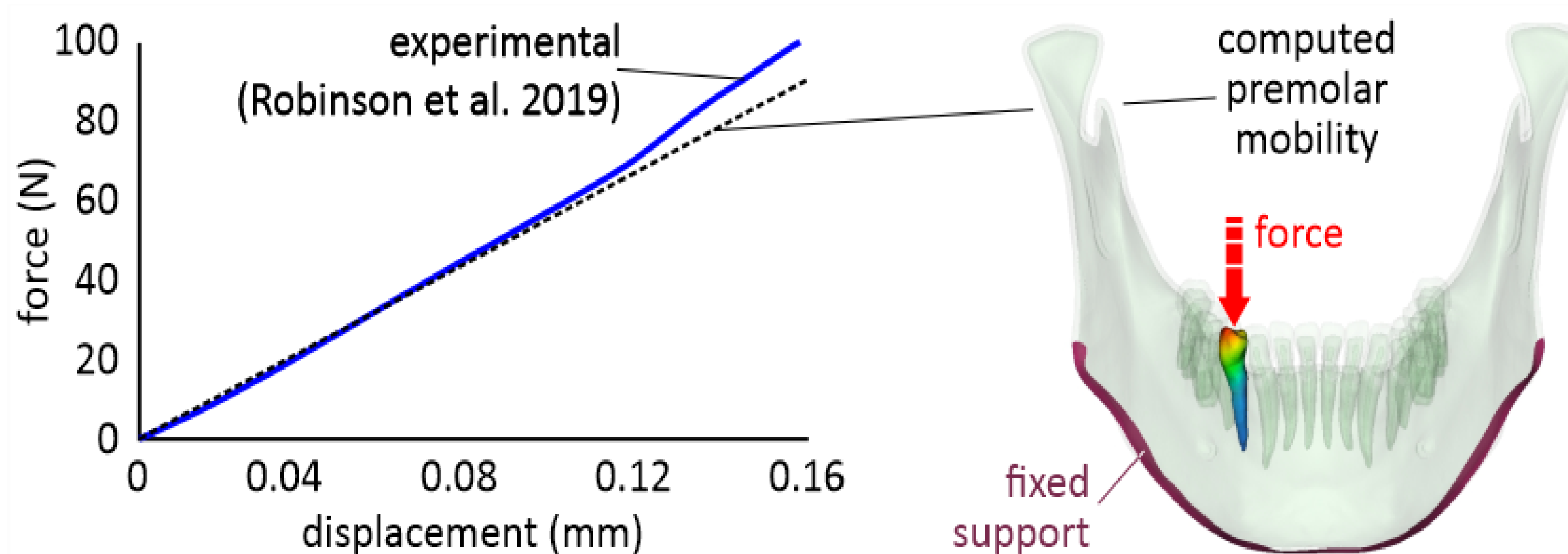


Figure 2: Experimental set-up employed for the validation of the FE models and comparison of the computed force-displacement values with experimental ones.

Results:

Implants with both interproximal contacts (first molar position) exhibited more evenly distributed stress and significantly lower stress concentrations on the implant neck compared to the implant with only a mesial interproximal contact.

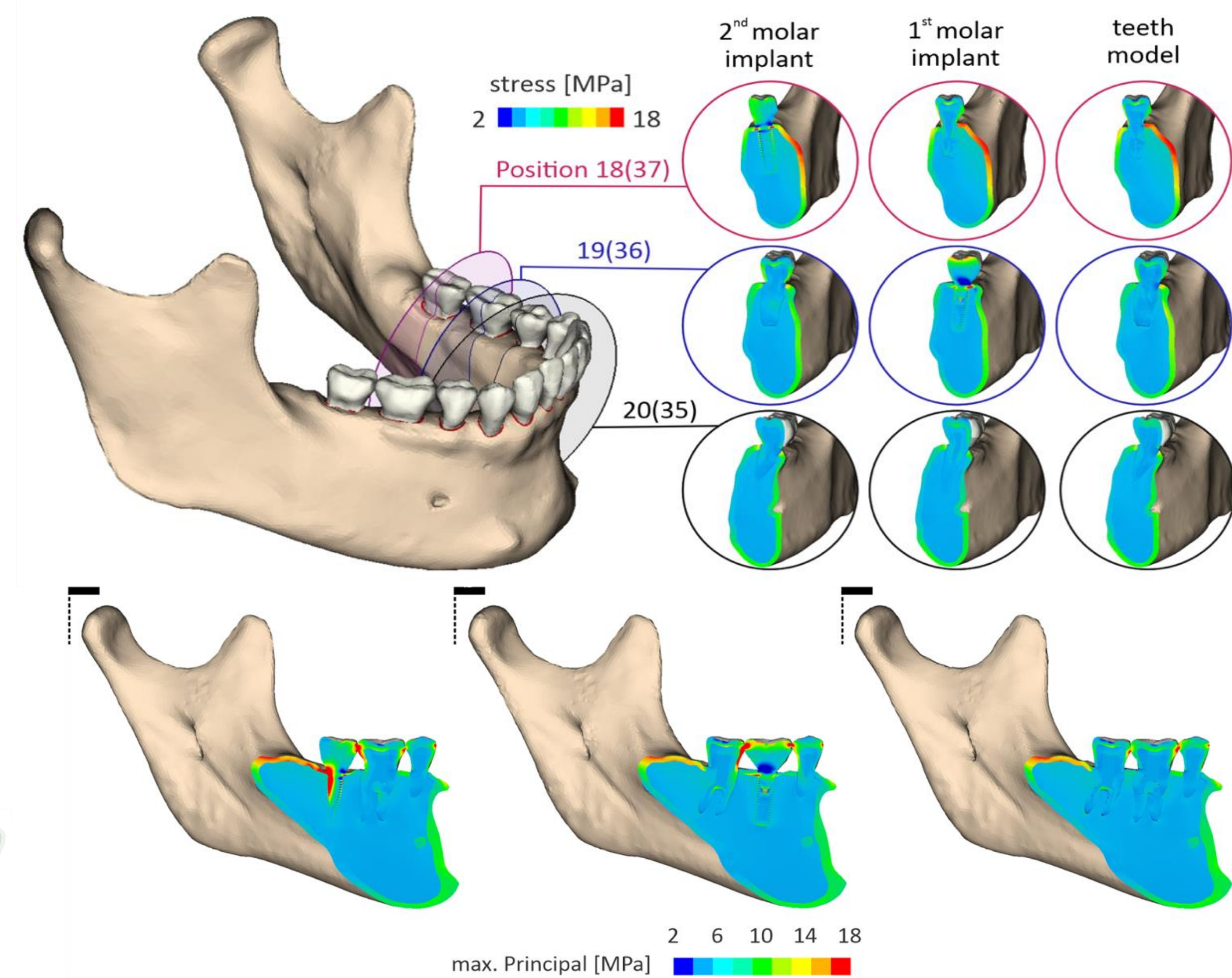


Figure 3: Cross-section of the 3D model showing stress distribution in the lower left segment.

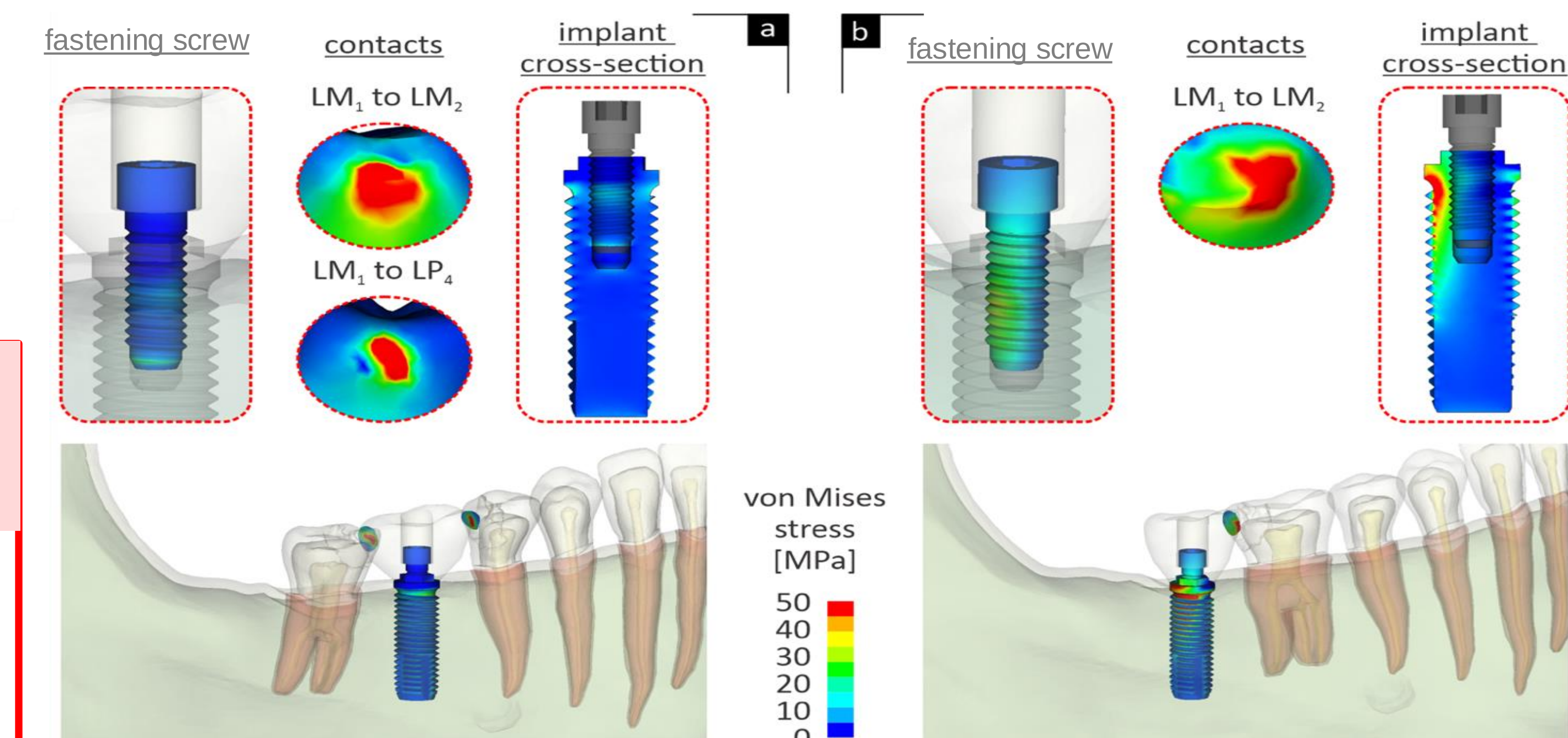


Figure 4: Details of the stresses developing in the implant, abutment and contacts of the crown to the adjacent teeth/tooth, for the restoration a) in position 18 and b) in position 19

Conclusions:

- Implant positioning and the number of interproximal contacts significantly influence stress distribution and prosthesis stability.
- The absence of mesio-distal interproximal contacts, typical of implants placed in positions with no distal tooth, leads to increased bending moments and axial movement, which are critical factors contributing to screw loosening.
- Strategic positioning of implants to ensure contact with adjacent teeth can significantly minimize the biomechanical challenges associated with non-axial loading.

References:

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