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IMPORTANCE OF OCCLUSAL LOADING ON THE DESIGN OF DENTAL IMPLANTS

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Partial and/or complete tooth loss (edentulism) strongly influences quality of life and its prevalence is likely to increase given an aging word-wide population [1]. Edentulism is typically treated with the use of dental implants such as full and/or partial dentures, dental implant supported restorations and/or dental bridges. Among the multiple causes of dental implant failure are those due to undesired mechanical loadings, which may arise due to improper implant selection or design and/or improper osseointegration. As such, a better understanding of the local deformation and loading of dental implants and surrounding dental structures may lead to better and more robust dental implant designs. In recent decades, virtual environments have provided a convenient alternative to carry out such detailed and rigorous investigations on implants.

However, the utility of dental simulations depends on their ability to realistically and accurately predict the local deformation and loading within dental structures. Among the chief factors influencing the accuracy and realism of dental simulations are the boundary conditions, such as the fixation of the dental structures and the loads applied at occlusal surfaces. Typically, single point loads are used to represent various masticatory states. While this is a convenient approach to obtain occlusal loading, the plausibility of the resulting dental structure deformation has been called into question in recent years [2] since point loads rarely represent natural loading conditions.

The current work attempts to answer two questions in relation to this, firstly, what is the quantifiable difference in dental structure deformation (and loading) under various occlusal loading conditions and secondly, in which situations should the use of single occlusal point loads be avoided? This is achieved by using a 3D model of the mandible with simplified dentition and associated oral structures to simulate a maximal bite of a deformable rubber. As described in previous works [3] this provides an accurate occlusal loading on the first mandibular molar and the resulting deformations in the dental structures are taken as reference. Lastly, various simplified occlusal loading conditions are additionally applied to the identical mandibular model and the resulting deformation differences compared and quantified.

By investigating differences which arise due to occlusal loading, recommendations can be made as to the appropriateness of simplified occlusal boundary conditions in dental simulations. The use of proper boundary conditions may lead to a more realistic prediction of the local deformation and loading of the implant and surrounding dental structures and ultimately may lead to better and more robust dental implant designs.

REFERENCES

[1] Tyrovolas, Stefanos, et al. "Population prevalence of edentulism and its association with depression and self-rated health." Scientific reports 6 (2016): 37083.

[2] Benazzi, Stefano, et al. "Comparison of occlusal loading conditions in a lower second premolar using three-dimensional finite element analysis." Clinical oral investigations 18.2 (2014): 369-375.

[3] Röhrle, Oliver, et al. "A Novel Method to Compute Subject-Specific Biting Forces During Mastication", submitted to Computer Methods in Biomechanics and Biomedical Engineering, 2017.