

On the Significance and Predicted Functional Effects of the Crown-to-Implant Ratio: a Finite Element Study of Long-Term Implant Stability Using High-Resolution, Nonlinear Numerical Analysis

T.J. Seago*, Yung-Ting Hsu[†], Tien-Min Gabriel Chu[¶], Andres Tovar[‡]

* Graduate Research Assistant, Department of Mechanical Engineering, Purdue School of Engineering and Technology, Indiana University-Purdue University Indianapolis, Indianapolis, Indiana, USA

[†] Clinical Assistant Professor, Department of Periodontology and Dental Hygiene, University of Detroit Mercy, Detroit, Michigan, USA

[¶] Associate Professor, Department of Restorative Dentistry, Indiana University School of Dentistry, Indianapolis, Indiana, USA

[‡] Assistant Professor, Department of Mechanical Engineering, Purdue School of Engineering and Technology, Indiana University-Purdue University Indianapolis, Indianapolis, Indiana, USA

Background. As the use of short dental implants becomes increasingly popular, the effects of the crown-to-implant (C/I) ratio on stress and strain distributions remain controversial. Previous studies in literature disagree on results of interest and level of necessary technical detail.

Purpose. The present study sought to evaluate the strain distribution and assess its functional implications in a single implant-supported crown with various C/I ratios placed in the maxillary molar region.

Materials and Methods. A high-fidelity, nonlinear finite-element model was developed to simulate multiple clinical scenarios by laterally loading a set of single implants with various implant lengths and crown heights. Strain distribution and maximum equivalent strain were analyzed to evaluate the effects and significance of the crown height, implant length and C/I ratio. The consistency of predicted functional responses to resulting strain at the implant interface were analyzed by interface surface area.

Results. Results were evaluated according to the mechanostat hypothesis to predict functional response to strain. Overloading and effects of strain concentrations were more prevalent with increasing C/I ratios. Overloading was predicted for all configurations to varying degrees, and increased with decreasing implant lengths. Fracture in trabecular bone was predicted for at least one C/I ratio and all implant lengths of 10 mm or less.

Conclusions. Higher C/I ratios and lower implant lengths increase the biomechanical risks of overloading and fracture. Increasing C/I ratios augment the functional effects of other implant design factors, particularly implant interface features. Greater C/I ratios may be achieved with implant designs that induce less significant strain concentrations.