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PREDICTING BONE REMODELLING STIMULUS AROUND ROOT-FORM DENTAL IMPLANTS

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Dental implants are a common treatment for the partially or fully edentulous patient. Increasing patient demands have driven implant development, most recently to patient-specific root-analogue implants that resemble the patient's natural root-form. Laser sintering technology has increased the range of candidate implant materials, including metals, ceramics and polymers [1].

Many implant patients experience crestal bone loss and gingival recession, which impairs functional and aesthetic outcomes. Crestal bone loss may be caused by stress shielding, and finite element (FE) analysis can be used to predict the remodelling stimulus in orthopaedic applications by comparing the strain energy density (SED) in intact and implanted models. The aim of this study was to compare root-form implants using three differing stiffness materials.

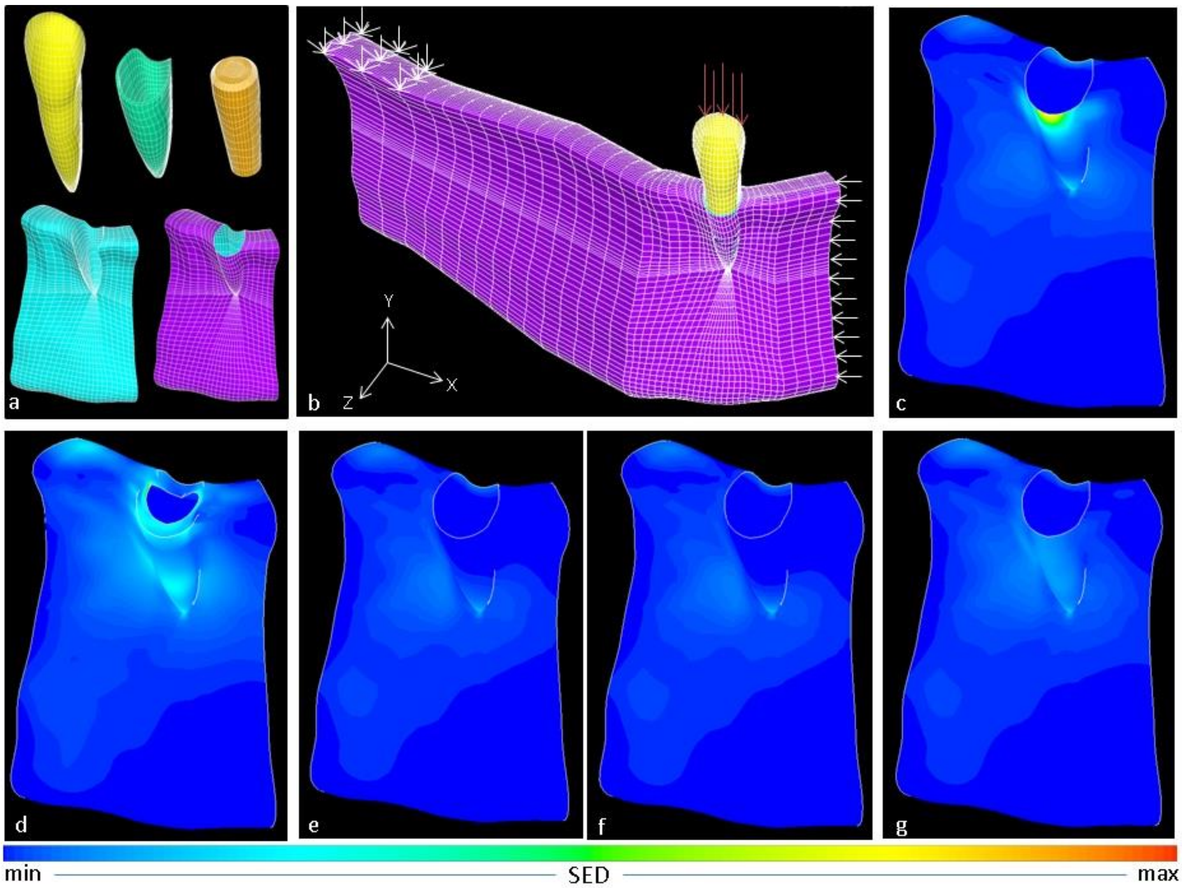

Figure: FE model of mandible. A) meshed components of model (top-left to bottom right) canine tooth/root-form implant , PDL, screw-form implant , cancellous bone and cortical bone. B) assembled intact model including mandibular structure and boundary conditions. C) intact model SED plot. D) I-SF SED plot. E) I-RF-T SED plot. F) I-RF-Z SED Plot. G) I-RF-P SED plot.

A model of a mandibular canine and local osseous structures was produced from patient CT data. The model included three variants: 'intact', 'implanted – root form (I-RF)' and 'implanted – screw form (I-SF)'. The I-RF model was solved using Ti-6Al-4V (E=110GPa, I-RF-T), zirconia (E=200GPa, I-RF-Z) and PEEK (E=4GPa, I-RF-P) implant materials. Linear-elastic material properties were applied to the implant, enamel, dentin and cortical/cancellous bone. A hyperelastic material model was applied for the periodontal ligament in the intact case. The model was loaded with 200N at 12° over the occlusial surface. The SED was interrogated in the elements surrounding the implant.

The mean cortical SED was 2.4e-3 for the intact model, compared with 2.5e-3, 0.39e-3, 0.32e-3 and 1.5e-3 for the I-SF, I-RF-T, I-RF-Z and I-RF-P respectively (Figure). In the intact model, the peak SED values were focused around the crestio-labial region. The I-SF model showed a bi-modal distribution of SED, with peaks occurring in the region of the implant apex and the crestal edge. The I-RF-T and I-RF-Z models showed low SED at the labial crest, whilst the I-RF-T model exhibited relatively uniform SED over the labial cortical surface.

This study highlights the influence of implant material and morphology upon initial bone remodelling stimulus. The limitations of the model must be considered when drawing direct comparisons between implant configurations, but the results support root form geometry and suggest that high construct stiffness materials should be avoided.

[1] Figliuzzi M, Mangano F and Mangano C, 2012, *A novel root analogue dental implant using CT scan and CAD/CAM: selective laser melting technology*, Int. J. Oral Maxillofac. Surg. 41, p858–862.