Dental Implant Cement Flow Simulations with STAR-CCM+

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In recent years, cement-retained dental implant restoration (as opposed to screw-retained restoration) has seen a significant increase in popularity by virtue of its improved aesthetics, cost-effectiveness and reduced chair time. Although it is now common place for dentists to apply this method, excess extrusion of cement into the soft tissue surrounding the implant has been shown to cause long-term peri-implant disease when using this approach. Unfortunately, limited data are available to help understand how to achieve optimal cementation to avoid these health issues by controlling the amount of residual excess cement (REC) that is inadvertently extruded into the soft tissue surrounding the implant.

STAR-CCM+ is used to address the problems associated with REC through virtual prototyping of the complete implant, abutment, cement and crown system. The objective of this study is to gain insight into the cement flow patterns during the seating of the crown and to explore the effects of various implant abutment designs and cement application techniques on the cement flow during the seating of the crown on the implant abutment.

The implant shape is fully parameterized using 3D CAD, allowing for quick design changes using one single simulation file. An overset mesh is utilized to simulate the motion of the crown over the implant, making it easy to handle the relative movement of implant and crown without requiring morphing of the mesh. The Volume of Fluid (VOF) multiphase model is used to capture the position and shape of the interface between the non-Newtonian dental cement material and surrounding air as the crown is seated.

Cement flow for various cement application techniques (change in amount and location) and designs of the implant are explored, including leaving the screw access chamber open and adding internal vent holes to the abutment geometry. Simulations show realistic cement flows and provide an increased level of insight into the details of the cement flow in this complex system, opening the door for developing improved and innovative implant designs.

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