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The tooth on-a-chip as model of dental pulp cell response to biomaterials and oral biolfim

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Keywords

organs on a chip, stem cells, dental pulp, biomaterials

Abstract

Objective

There is a shortage of in-vitro model systems that mimic the dentin-pulp interface while enabling a real-time evaluation of dental pulp cells, dentin and biomaterials. Here, we optimized an organ-on-a-chip model system, the 'Tooth-on-a-chip' and tested different biomaterials in real-time. Moreover, we developed a model of secondary caries on-chip co-culturing oral microcosm with dental pulp cells.

Methods

The tooth-on-a-chip is a micromolded polydimethylsiloxane (PDMS) device assembled onto a glass slide containing a dentin slice functioning as a semi-permeable membrane that separates two perfusable chambers. Human dental pulp stem cells (hDPSCs) cultured in osteoinductive medium were seeded on one surface of dentin, forming a monolayer after 24h. Next, collagen type I was added to emulate the extracellular matrix environment of the pulp. Dentin on the opposite chamber was treated with MTA (ProRoot), Biondentine, or Theracal and cell morphology was tracked for 7 days. Cells were fixed, stained with Actin Red/DAPI and imaged using a confocal microscope. The dentin release of transforming growth factor-beta (TGF-β) when in contact with biomaterials was determined using an ELISA test. To test the interaction of oral bacteria with pulp cells, we added an aliquot of oral microcosm biofilm on the opposite side of the hDPSCs monolayer. Cells were stained for live cell imaging and tracked in real time. As for the secondary caries groups, dentin was acid etched, restored with dental adhesive and flow resin and placed on-chip with bacteria co-culture.

Results

ProRoot and Biodentin showed biocompatibility on-chip and elicited more TGF-β release. It was possible to co-culture oral microcosm on-chip and track hDPSC responses for 5 days. Live and dead stain showed hDPSCs viability for up to 3 days.

Conclusion

The tooth-on-chip is a physiologically accurate platform and useful tool to study pulp response to biomaterials in near-physiologic conditions.