3D Printed Polycaprolactone as a Scaffold for Bone Tissue Engineering

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Introduction
Congenital craniofacial bone anomalies occur in one in 250 live births, with alveolar clefts being the most common. Current treatment for these defects is autologous iliac bone grafting, but is limited in supply, and necessitates a secondary surgical site with attendant morbidities, including pain, infection, and contour abnormalities.

Hypothesis
Tissue engineered therapies (materials and cell based) are emerging to treat these bone defects, though few have been applied to the pediatric population clinically. When combined with autologous stem cells and bone-specific environmental cues, namely, the presence of BMP-2, the proposed 3D printed polycaprolactone (PCL) scaffold will serve as an ideal osteoinductive scaffold for the repair of congenital craniofacial defects or traumatic injury.

Methods
PCL scaffolds were fabricated using fused deposition modeling. Human umbilical cord mesenchymal stem cells (UC MSCs) isolated from Wharton's jelly and transduced with a lentivirus expressing green fluorescent protein (GFP) were seeded to the 3D printed PCL scaffolds. Attachment of differentiated, labelled cells implanted in the scaffolds was characterized using anti-GFP antibody. Cell proliferation was characterized using anti-GFP antibody and quantified by total DNA content. Cells were osteoinduced by introducing an osteogenic growth medium on day 3 post-seeding. To assess osteogenic activity, insoluble calcium deposition was characterized using Alizarin Red stain. Data for each experiment were generated from days 1, 3, 5, 7 and 14 post-seeding.

Results
UC MSCs attached on 3D printed PCL scaffolds of varying thickness at 0.6mm and 1.0mm. The 3D printed PCL scaffolds facilitated UC MSC proliferation at both widths. UC MSC proliferation was not statistically significant ($p = 0.18$) between each width. Osteoinduction was demonstrated under light microscopy at both widths, with visibly greater insoluble calcium deposition in the 0.6mm scaffolds.

Conclusions
Umbilical cord-derived MSCs will attach, proliferate, and undergo osteogenic differentiation on PCL scaffolds. Umbilical cord-derived MSCs on 3D printed PCL has the potential to address the structural and space filling needs presented in our alveolar cleft defect model.

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