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3D Printed Polyurethane Prosthesis for Partial Tracheal Reconstruction

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A ready-made, acellular patch-type prosthesis is desirable in repairing partial tracheal defects in the clinical setting. However, many of these prostheses may not show proper biological integration and biomechanical function when they are transplanted. In this study, we developed a novel 3D printed polyurethane (PU) tracheal scaffold with micro-scale architecture to allow host tissue infiltration and adequate biomechanical properties to withstand physiological tracheal condition.

A half-pipe shaped PU scaffold (1.8 cm of height, 0.18 cm thickness, and 2 cm of diameter) was fabricated by 3D printing of PU 200 μm PU beam (Fig. 1). The 3D printed tracheal scaffolds consisted of a porous inner microstructure with $200\times200\times200\ \mu m^3$ sized pores and a non-porous outer layer. The mechanical properties of the scaffolds were 3.21±1.02 MPa of ultimate tensile strength, 2.81±0.58 MPa of Young's modulus, and 725±41% of elongation at break.

To examine the function of the 3D printed tracheal scaffolds in vivo, the scaffolds were implanted into $1.0\times0.7\ cm^2$ sized anterior tracheal defect of rabbits. After implantation, bronchoscopic examinations revealed that the implanted tracheal scaffolds were patent for a 16 week-period (Fig. 2). Histologic findings showed that re-epithelialization after 4 weeks of implantation and ciliated respiratory epithelium with ciliary beating after 8 weeks of implantation were observed at the lumen of the implanted tracheal scaffolds. The ingrowth of the connective tissue into the scaffolds was observed at 4 weeks after implantation. The biomechanical properties of the implanted tracheal scaffolds were continually maintained for 16 week-period.

The results demonstrated that 3D printed tracheal scaffold could provide an alternative solution as a therapeutic treatment for partial tracheal defects.

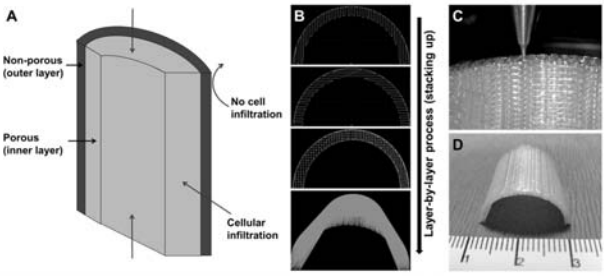

Figure 1. 3D printing of thermoplastic polyurethane tracheal scaffold.

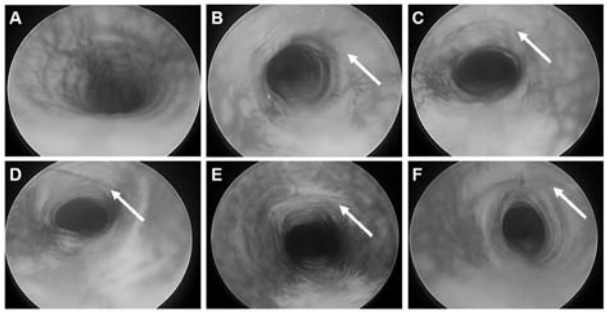

Figure 2. Bronchoscopy examinations of the 3D printed thermoplastic polyurethane tracheal scaffold.