COMPUTER-AIDED DESIGN, FABRICATION AND ANIMAL TESTING OF POLYURETHANE AURICULAR IMPLANT WITH OPTIMAL MATERIAL PROPERTIES FOR MICROTIA TREATMENT

Vladimir Mironov[1], Rodrigo Rezende[1], Frederico Pereira[1], Pedro Noritomi[1], Júlia Nogueira[1], Huey An[2], Xuejun Wen[3], Vladimir Kasyanov[4], Jorge Vicente da Silva[1]

[1] Renato Archer Center of Information Technology, Campinas, SP, Brazil; [2] Medical University of South Carolina, Charleston, SC, USA; [3] Virginia Commonwealth University, Richmond, USA; [4] Riga Stradins University, Riga, Latvia

Introduction

Microtia is a congenital malformation with defect of development of external ear. Existing surgical methods of treatment of microtia are not optimal. Non-biodegradable auricular implant from porous polyethylene ("Porex") is too rigid and induces skin penetration. It has been suggested to use tissue engineering approach for fabrication tissue engineered auricular construct for treatment microtia (1). However, due to scaffold degradation the shape and size of auricular implant have been compromised after implantation. Here, we report design, fabrication and animal testing of non-biodegradable polyurethane (PU) auricular implant with optimal material properties and biocompatibility.

Methods

The material properties of human cadaver external ear have been estimated using three point flexure method. Based on these data and properties of PU the optimal design for auricular implant has been developed using finite element analysis software. The shape of external ear of volunteer was scanned using a free 3D scanner ExaScan Creaform. PU auricular implants have been fabricated using fused deposition modeling method through Fab@CTI machine. Material properties of porous polyethylene and fabricated PU were estimated using three point flexure method and compared with material properties of cadaver ear. The PU auricular implants have been implanted subcutaneously into the back of nude rats. One month after implantation animals have been sacrificed, the size and shape of auricular implants have been measured and histological analysis of implants with surrounding tissue has been performed.

Results

PU auricular implant has been fabricated with biomimetic material properties using fused deposition modeling. The material properties of fabricated PU auricular implant have been comparable with material properties of cadaveric external ear (Fig. 1). One month after subcutaneous implantation fabricated auricular implants maintain their size and shape. Histological analysis confirmed optimal level of biocompatibility (no signs of inflammatory reaction and extensive fibrosis).

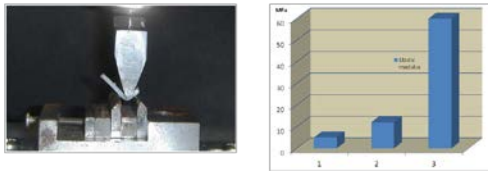

Figure 1: Material properties of cadaveric external ear (a) mechanical test (b) estimated by three points flexure methods.

Discussion

Commercially available porous polyethylene auricular implants are too rigid and can induce skin penetration. Tissue engineered auricular construct based on using biodegradable scaffolds could not maintain their proper shape and size after implantation. Non-biodegradable PU implant maintains size and shape, has optimal material properties and biocompatibility. Using rapid prototyping technology such as fused deposition modeling and non-biodegradable PU as a biomaterial allowed to design and fabricate patient specific auricular implant with desirable material properties and optimal biocompatibility.

Conclusion

PU auricular implant for treatment microtia with optimal material properties and biocompatibility has been designed, fabricated using fused deposition modeling and tested on experimental animal. The fabricated auricular implants maintain shape and size after implantation and demonstrate optimal level of biocompatibility.

References

Bichara *et al*. The tissue-engineered auricle: past, present, and future. Tissue Eng Part B Rev. 2012 Feb;18(1):51-61.