Minimizing Insertion Trauma with a Novel Shape Memory Polymer Cochlear Implant Array

Roxanne Lee[1], Tiffany Pham[1], Hans Ajieren[2], Dongmei Shao[1], Walter Voit Ph.D.[2], Kenneth Lee M.D., Ph.D.[1]

[1]University of Texas Southwestern Medical Center, Dallas, TX-75235

[2]University of Texas at Dallas, Richardson, TX-75080

Introduction

Linear electrode arrays used in current cochlear implants cause trauma to cochlear walls during insertion, resulting in destruction of inner ear structures and suboptimal post-implantation patient outcomes. Implant arrays made of shape memory polymer (SMP) offer the solution of completely atraumatic cochlear implantation. SMPs can reliably store a metastable shape and return to a native shape in response to a stimulus. SMP arrays change shape during implantation from a linear to a curved spiral conformation that mimics the curves of the cochlear spiral, allowing for completely atraumatic yet full insertion into the cochlea.

Materials and Methods

Shape Memory Polymer Fabrication

Methyl acrylate (MA), isobornyl acrylate (IBOA), photoinitiator (PI), and TCMDA in an MA:IBOA weight ratio of 1:1 were combined and UV-cured to make a shape memory polymer sheet.

Implantation Method

The SMP spiral was heated to 37°C, straightened by hand, and allowed to cool. A life-size model of the human cochlea was heated to 37°C and the SMP spiral was implanted into the model, apical tip first. A straight silicone array was also implanted into the cochlear model for comparison. Both arrays were inserted manually and reached a maximum insertion angle of 360°.

Results

Amount of contact between both implants and cochlear walls was recorded at insertion angles of 45°, 90°, 135°, 180°, 225°, 270°, 315°, and 360°.

Insertion Angle	Contact with Cochlear Walls	
	Shape Memory Polymer Implant	Linear Silicone Implant
45		X
90	X	X
135		X
180		X
225		X
270	X	X
315		X
360		X

Table 1. Comparison of insertional trauma caused by shape memory implant versus linear silicone implant. (X indicates presence of contact with cochlear wall.)

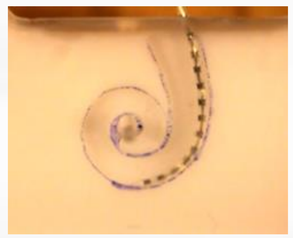
Insertion Angle	SMP Implant	Straight Implant
180		
360		

Table 2. Still photographs of implantation of shape memory polymer implant and linear silicone implant.

Discussion

The results demonstrate that shape memory polymers can be used in a novel way to make self-coiling cochlear implants that offer full yet atraumatic insertion, minimizing the adverse side effects usually experienced with implantation of more traumatic conventional linear implants.

The relative lack of physical contact with cochlear walls caused by insertion of the SMP implant as compared to that caused by the straight silicone implant indicates that the SMP implant caused less insertional trauma.

Continued plans for this project include histological analysis of insertional trauma caused by SMP versus straight implants in rat cochlea to further demonstrate the enhanced biological compatibility of shape memory polymer implants.

Acknowledgements

This project was supported by the AFAR Medical Student Training in Aging Research Program, the DARPA Young Faculty Award, and the DARPA Director's Fellowship. Special thanks are given to Dr. Lee for his mentorship and supervision, Dr. Voit for his assistance and use of lab facilities, and Dr. Rubin for his guidance with the MSTAR program.