AMERICAN OTOLOGICAL SOCIETY

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"Optimized 3-Dimensional Printed Tympanic Membrane Prosthesis"

Research Grant 2015

Amount Awarded by AOS: $55,000

Ongoing Funding: NIH, NIDCD K08 (2020-25), $950,400 (Mechanisms of Conductive Presbycusis)

DoD SBIR (2019-23), $488,278 (Innovative Solution to Tympanic Membrane Repair)

Foundation Grants (2016-23), $767,188 (Biomimetic Grafts for Tympanic Membrane Reconstruction)

PUBLICATIONS:

Remenschneider AK, Lookabaugh S, Aliphas A, Brodsky JR, Devaiah AK, Dagher W, Grundfast KM, Heman-Ackah SE, Rubin S, Sillman J, Tsai AC, Vecchiotti M, Kujawa SG, Lee DJ, Quesnel AM. *Otologic outcomes after blast injury: the Boston marathon experience*. Otol Neurotol. 2014 Dec; 35 (10):1825-34. PMID: 25393974

Kozin ED, Black NL, Cheng JT, Cotler MJ, McKenna MJ, Lee DJ, Lewis JA, Rosowski JJ, Remenschneider AK. *Design, Fabrication and In Vitro Testing of Novel Three-Dimensionally Printed Tympanic Membrane Grafts.* Hear Res. 2016 Oct; 340:191-203. PMID: 26994661

Trakimas D, Ishai R, Ghanad, I, Black N, Kozin ED, Cheng T, Remenschneider AK. *Otopathologic Evaluation of Temporalis Fascia Grafts Following Successful Tympanoplasty in Humans.* Laryngoscope 2018 Oct;128(10);E351-E358. PMID 29756238

Polanik MD, Trakimas DR, Black NL, Cheng JT, Kozin ED, Remenschneider AK. *High-Frequency Conductive Hearing following Total Drum Replacement Tympanoplasty.* Otolaryngol Head Neck Surg. 2020 Jun;162(6):914-921. PMID: 32097057

Ghanad I, Polanik MD, Trakimas DR, Knoll RM, Castillo-Bustamante M, Black NL, Kozin ED, Remenschneider AK. *A Systematic Review of Nonautologous Graft Materials Used in Human Tympanoplasty*. Laryngoscope 2021 Feb;131(2): 392-400 PMID: 33176008

Roychowdhury P, Polanik MD, Kozin ED, Remenschneider AK. *In Office Repair of Tympanic Membrane Perforation.* Otol Neurotol. 2021 Dec 1;42 (10):e1636. PMID: 34420025

Eberhard KE, Masud SF, Knudson IM, Kirubalimgam K, Khalid H, Remenschneider AK, Nakajima HH. *Mechanics of Total Drum Replacement Tympanoplasty Studied with Wideband Acoustic Immittance*. Otolaryngol Head Neck Surg. 2022 Apr;166(4):738-745. PMID: 34281437

Remenschneider AK, Cheng JT, Herrmann BS, Rosowski JJ. *Characterization and Clinical Use of Bone Conduction Transducers at Extended High Frequencies*. Hear Res. 2023 Mar 1;429:108688. PMID: 36628803

Patel H, Pavlichenko I, Grinthal A, Zhang CT, Alvarenga J, Kreder MK, Weaver JC, Li Q, Ling CWF, Choy J, Li Z, Black NL, Bispo PJM, Lewis JA, Kozin ED, Aizenberg J, Remenschneider AK. *Design of Medical Conduits with Selective Fluid Transport Properties*. Sci Transl Med. 2023 Apr 5;15(690):edadd9779 PMID: 37018418

Schmeltz M, Ivanovic A, Schleputz DM, Wimmer W, Remenschneider AK, Caversaccio M, Stampanoni M, Anschuetz L, Bonnin A. *The human middle ear in motion: 3D visualization and quantification using dynamic synchrotron-based X-ray imaging.* Commun Biol. 2024 Feb 7;7(1):157. PMID: 38326549

RESEARCH SUMMARY:

Our multidisciplinary team of otologists, acoustical engineers and materials scientists developed at-scale biomimetic scaffolds with fibrous structure similar to the tympanic membrane. A novel biocompatible degradable polymer was developed for use in ultra-high resolution 3D printing to fabricate grafts of varied fibrous architecture. Sound induced velocities of grafts were evaluated to optimize a wide range of frequency responses. In-vivo animal testing was performed to confirm biocompatibility, tympanic membrane perforation closure and hearing threshold improvement.

OUTCOMES:

We developed a novel biodegradable, printable polymer and to demonstrated tunable acoustic and mechanical properties for optimized biomimetic membranes that behave similar to the native tympanic membrane in vitro. Subsequent in vivo animal and histological studies demonstrated the safety and feasibility of the grafts as biodegradable scaffolding for the regrowth of normal TM structure.

FURTHER FUNDING HAS ENABLED US TO EXPAND OUR RESEARCH TO:

In 2021 a start-up company built around the technology was acquired by Desktop Health where pre-clinical testing, clinical trials and FDA submission have been initiated.

LAY SUMMARY OF FINDINGS AND IMPLICATIONS OF THIS RESEARCH:

Biomimetic grafts made with 3D printing improve our understanding of how eardrum structure affects function, and they represent a viable path to obtain consistent hearing outcomes after tympanic membrane repair.