Hearing loss is a significant and growing issue worldwide, affecting over 430 million people, including 34 million children. By 2050, it is projected that more than 700 million individuals will suffer from disabling hearing loss, underscoring the urgency for advanced hearing treatments. Implantable middle ear hearing devices (IMEHDs) have emerged as a promising solution for both conductive and sensorineural hearing loss. This study introduces a novel method utilizing piezoelectric membrane (PM) for round window stimulation (RWS), which offers several advantages over traditional floating mass transducer (FMT) systems. The PM approach provides direct and efficient stimulation of the round window, offering a simpler design, broad and tunable frequency response, and less invasive surgical procedures.

The project aims to develop a hybrid biomechanical model of the human ear, integrating a lumped parameter model of the middle ear with a continuous model of the PM and a finite element model of the cochlea. The electromechanical coupling (EMC) between these components will be thoroughly studied, with a focus on addressing nonlinear interactions and preventing chaotic vibrations. Experimental validation will be conducted using laser Doppler vibrometry (LDV) on human temporal bone specimens to ensure the accuracy of the mathematical and numerical models.

The project focuses on nonlinear dynamics phenomena that are both intriguing and potentially hazardous in practice, particularly when chaos, bifurcations, and stability loss occur. These phenomena will be investigated through numerical, analytical, and experimental methods.

This interdisciplinary research leverages advances in materials science, bioengineering, and audiology to create a precise, controlled, and potentially non-invasive hearing restoration method. The findings are expected to significantly enhance our understanding of middle ear mechanics, improve hearing aid technology, and pave the way for future innovations in auditory science.