# A Critical Review of Middle Ear Implant Technology

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**Abstract**

The leading causes of hearing impairment amongst individuals in the United States are sensorineural and conductive hearing loss which inhibits the ability of the ossicle chain to vibrate with the strength needed to stimulate the cochlea. Middle ear implants receive a sound frequency and then send an electric signal to actuate an electromagnetic or piezoelectric transducer which causes sufficient vibration in the ossicle chain to stimulate the cochlea. Attaching the transducer directly to the middle ear is a difficult surgical procedure, which can damage the ossicle chain. In a floating mass transducer, the electromagnetic or piezoelectric device is coupled to the ossicle chain which does not present a risk to the integrity of the ossicle chain. While electromagnetic implants have widespread use today, piezoelectric materials are gaining acceptance due to lower power consumption, better performance, and resistance to environmental electromagnetic forces. The optimal implant is a total implantable device, which is entirely encased in the body. Multi-layer piezoelectric floating mass transducers, due to the advantage of lower power requirements, will make it possible to implant the entire hearing device into the body and provide a capable, aesthetically pleasing option for hearing improvement.

## 1. Introduction

### *1.1. The Human Ear*

The human ear is divided into three parts. These are the outer ear, the middle ear, and the inner ear. The outer ear functions to funnel sound to the middle ear. The middle ear contains the ossicle chain, which is a series of bones which transmit sound by vibrations to the cochlea in the inner ear. The bones that make up the ossicle chain are the malleus, incus, and stapes, the malleus being the closest to the outer ear and the stapes connected to the cochlea (Figure 1). Within the cochlea of the inner ear are hair cells immersed in fluid. As the hair cells vibrate, they pass electrical impulses through nerves to the brain which are then interpreted as sound [1, 2].