Sound Transmission:
Air vs. Bone Conduction

By Janice D. Janas, MD
The human ear is a complex and fascinating organ that over the course of evolution has allowed us to hear in an air-filled world, rather than the fluid filled oceans of our ancestors. To understand how sound transmission works, the anatomy of the ear can be divided into three portions: the outer ear, the middle ear and the inner ear. The outer ear is composed of the auricle and ear canal. The tympanic membrane (ear drum) separates the outer ear from the middle ear. Within the middle ear are the tiny ossicles or bones of hearing: the malleus (hammer), incus (anvil) and stapes (stirrup).* The inner ear, within the bones of the skull, contains a complex array of fluid filled spaces in part separated by the basilar membrane. The organ of Corti rests on the basilar membrane and contains the sensory cells which transmit nerve impulses to the auditory portion of the brain via the cochlear nerve.

The human ear functions on the principal of air conduction. Sound waves produced by an external source travel down the ear canal and cause vibrations of the tympanic membrane. These vibrations set in motion the tiny ossicles. The footplate of the stapes rests on a tiny membrane (the oval window) which vibrates in response to the motion of the stapes. A traveling wave is established in the fluid surrounding the basilar membrane and organ of Corti. The resultant vibration of the basilar membrane then stimulates the sensory cells to transmit nerve impulses that are translated into the perception of sound within the brain. Though complex, this system is extremely efficient and allows our human ear to perceive the faintest of sounds in our air-filled environment.

Athletes have long enjoyed music during their arduous workouts. Portable radios, CD players and now MP3 players use air conduction to transmit sound. Unfortunately, anything that blocks the ear canal interferes with the air conduction of sound waves. As such, swimmers whose ears are underwater most of the time have been prevented from enjoying music during their workouts.

The new SwiMP3 is revolutionary in that it relies on bone conduction of sound. When the SwiMP3 is placed on the cheek bones, the device causes direct vibration of the skull. This vibration then triggers the onset of the traveling wave of the fluid within the inner ear, either via a direct effect or by triggering movement of the stapes footplate (a point that is debated by auditory physiologists). In either case, the air conduction mechanism is bypassed, and “normal” hearing is still achieved. Swimmers and other aquatic athletes can now enjoy clarity of sound with the SwiMP3 device that was never before possible.

Bone conduction is a safe, well-established hearing mechanism in humans. The medical interest in bone conduction rests both in its diagnostic usefulness in testing the integrity of the air conduction pathway and in amplifying sound for the hearing impaired. Audiologists have used bone conduction studies since the 1920’s as part of a complete assessment of hearing. Bone conduction hearing aids have historically been the treatment of choice for patients with congenital absence of the normal air conduction pathway. Typically these have been body aid devices** or eyeglass mounted hearing aids. Since the 1970’s a technique for implanting an osseo-integrated bone conduction hearing aid
has been performed by ear surgeons, and over 15,000 patients have benefited from this technology around the world.

Bone conduction hearing is essentially an ancient sensory capability that the new SwiMP3 leverages to enhance the experience of swimmers, scuba divers, surfers and the like. It is a safe, proven technology that the SwiMP3 offers to the wide audience of aquatic athletes.

* Hammer, anvil and stirrup are the lay terms for the bones of the middle ear.

** External battery pack attached to a vibrating receiver secured by a headband to the tip of the mastoid bone.

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