

Clear E-A-R™ Model

Booklet for Teaching & Training



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Introduction

The “Clear E-A-R™” is a replica molded from an impression of a human external ear. The anatomic features are representative of structures which form the entire external ear from the outer auricle (or pinna) throughout the length of the earcanal up to, and including, the location and shape of the tympanic membrane (eardrum). This transparent model allows easy visualization of outer ear structures from positions as viewed from outside the head, and from top and bottom, and front and back as seen from inside the head. The Clear E-A-R illustrates the features of an external ear in relation to accommodation exhibited by various types of insert or semi-insert hearing protection devices (HPDs).

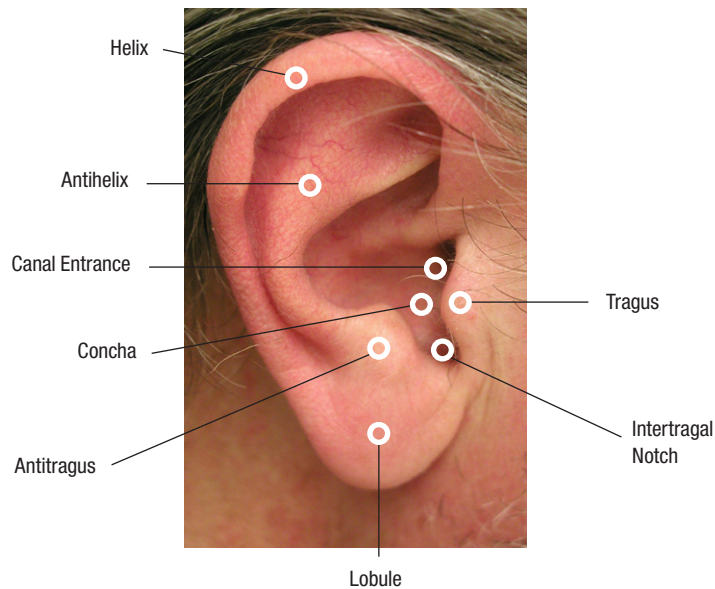
The model is constructed of clear silicone material that allows a certain degree of physical manipulation and bending. This permits the user to demonstrate with a fair degree of realism the manner in which pulling, pushing, and similar physical displacements transfer and distort adjoining structural elements. The entire cartilage composing and underlying all outer surfaces of the pinna or auricle is formed as one continuous inter-connecting structure. Therefore, movement within one exterior area of the pinna tends to translate mechanical distortions to adjacent parts. Only the lobule (lobe) at the bottom of the pinna does not contain underlying cartilage.

Anatomic Features

By being able to gain a truly three-dimensional view of outer ear structures one can demonstrate the manner in which different types of insert HPDs attain a compliant seal and conformity with surrounding outer ear and earcanal features. This offers possibilities for examining the design features of a given protective device and the manner in which an ear insert or earcap does, or does not, accommodate optimal placement in, around, and within the earcanal.

The external earcanal in this model presents an average size and shape; ranging between 8 to 9.5 mm (about 5/16 to 3/8 inch) in diameter at the initial opening into the canal proper, and with diminishing diameter as it extends inward to the eardrum. The length of the canal in the model is about 37 mm (1 7/16 inches) from the outermost tip of the tragus to the lower boundary of the tympanic membrane (eardrum) and about 23 mm (7/8 inch) from the area of the concha at the point where the concha forms the outer entry into the earcanal.





The front wall of the ear canal, which is formed by the rear structure of the tragus, is relatively flat or slightly convex. The rear portion of the ear canal, which is continuous with the concha (concave shape) area of the pinna, does not present a 360-degree closure as a tube until about 12-13 mm (1/2 inch) behind the outer rim or tip of the tragus. This means the main body of an earplug has to be inserted at least 12 mm (1/2 inch), or about the length of the index fingernail, behind the outer tip of the tragus before the outer channel of the opening into the ear canal proper forms a 360-degree seal around an insert or semi-insert device.

Surface structures within the ear canal assume an elongated S shape from its outer end to the innermost portion at the eardrum. This creates in most people a pronounced curve or bend; i.e., the typical canal is neither straight nor round in cross section. The canal tends to curve from a relatively shallow turn at its entrance, bending rather sharply backward, and then forward and slightly upward, and then slightly backward again, as it progresses from the entrance to the eardrum. Some insert devices can accommodate this tortuous path better than others. The dynamic nature of the bends and twists presented by an ear canal is most strikingly evident when the canal is viewed either from above or below. Viewing the canal from either the front or back also illustrates the manner in which it tends to rise (ascend) in an upward and slightly backward direction from the outermost area at the entry of the canal to the innermost end.

The rear wall forming the entry into the canal from the margin of the concha assumes a relatively acute angle at the first bend of the canal, most easily viewed by looking directly into the canal from outside and then changing the perspective to view from either the top or bottom of the model. Looking inward from the outside, notice the manner in which the canal presents a distinct oval shape within the vertical plane. At the margin where the first turn or bend occurs, the distance between the front and back walls is smaller than between the top and bottom (roof and floor) of the canal.



Anatomic Accommodations

It can be more or less challenging for different types of insert and semi-insert hearing protector designs and materials to accommodate the elliptical shape and various bends in the ear canal. For example, a vinyl expandable foam plug (like the 3M™ E-A-R™ Classic™ foam plug), when tightly compressed, forms a somewhat stiffer central core and, as a result, the user can easily insert the body of a tightly compressed device through and around the natural initial bend of the canal. During expansion the entire length to which the foam has been inserted fills and contacts all the surface areas along the ear canal. Premolded devices, especially those designed and constructed with radial flanges, must be able to achieve compliant accommodation with the ear canal to the depth required to achieve and retain a secure seal. Some premolded plugs with radial flanges may distort and fail to achieve such a seal at all contact points. A premolded flanged plug, like the 3M™ E-A-R™ UltraFit™ earplug, is designed so the surfaces of the flanges bend and fold back to accommodate 360-degree surface contact. The UltraFit earplug achieves a more secure and comfortable fit because the flanges run parallel with the shank of the plug and do not present a perpendicular contact with canal walls. Also, movements of the canal due to jaw motion can be well accommodated by the flexibility of flanges in the radial direction in order to maintain an elastic and consistent airtight seal during wearing.

The Plastic Nature of the Human Earcanal

The outer one-third of the human earcanal is plastic in nature. This plays an important role regarding compliance features of an insert or semi-insert device. Dynamics of this action cannot be demonstrated using the Clear E-A-R™ Model, but you can more easily experience the resulting effect of jaw movement on the outer structures within your own earcanal. Simply insert the pad of your little finger into your earcanal against the concha area along the back side of the canal. Move your lower jaw up and down, and from side to side. Manually feel the distortions that such movements transfer to the front and lower area within your earcanal. Unless an insert or semi-insert device has been designed to accommodate these normal canal movements without breaking the seal or becoming dislodged, the device may fail to adequately protect hearing during periods of normal use.

Semi-Insert Devices

Even though the Clear E-A-R™ Model is not a full head representation, it can still be used to study semi-insert eartip designs and features. Simply, place the tip of a semi-insert device into the outer opening of the Clear E-A-R™ as it would be aligned if the headband was positioned either over the head, behind the neck, or under the chin. If the semi-insert device is fitted only with a single-position type band, usually placed under-the- chin, align the band to simulate this placement. Most single-position, under-the-chin, band units are designed so the portion of the band that curves at the location at the entry into the outer earcanal slots into the intertragal notch, located below the tragus and the lower portion of the antitragus.

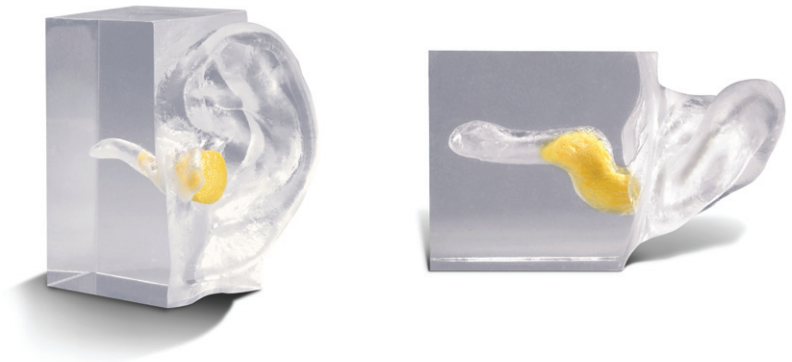
Most eartips attached to bands do not penetrate far into the interior of the outer canal; instead they rest against the surrounding structural surfaces that comprise the area leading into the entrance of the earcanal proper. For this reason, care should be taken to ensure the location and position of the supporting band is properly aligned as it would be if actually being worn. The design of the eartip should be able to successfully accommodate the rather flat or convex surfaces forming the rear portion of the tragus and also adapt to the more concave shape of the upper, lower, and back surface areas leading into the canal. Since the back side of the tragus presents a relatively flat or convex shaped surface, the design of the tip should be able to accommodate these opposing structural features while still allowing and preserving a compliant seal.

Hands-On Training

The image on page 2 identifies structures that comprise a typical human pinna or auricle. Dimensional sizes and shapes vary among people and some features may be more or less prominent or obvious. Few have ever actually visually observed details of their auricle, especially those structures forming the initial entry into their earcanal. This presents a challenge when attempting to instruct an individual on how to properly insert, manipulate, and remove an HPD to achieve optimum fit. For best training, a safety-health provider will guide prospective users of such devices through a manual inspection of prominent anatomic features and characteristics of their own ears prior to attempting a fitting. Such guidance helps the user better understand the actions required during fitting and removal of any insert or semi-insert device. Unfortunately, the vast majority of HPD users never receive this type of hands-on training. Simply assuming an individual can properly wear a given device in the absence of sufficient individual training can significantly compromise the success with which any device can prevent noise-induced hearing loss.

Following a hands-on training session, ask the user to fit the device while under observation. Critique the individual's performance — pointing out strengths and weaknesses. Review and highlight key areas where the user appeared confused or encountered difficulty. Subsequently, have the subject go through the task from start to finish one more time. During this session, provide hands-on guidance only if needed. At the end of each individual training session, record the performance achieved by the person and, if necessary, schedule a follow-up session accordingly.

Remember – motivation and training are the hallmarks of an effective hearing conservation program.





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