Anatomy and Orientation of the Human External Ear

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Abstract
A knowledge of the external ear and tympanic membrane is essential to practicing audiologists. This article provides an introduction to the anatomy of this area including dimensions, orientation, vasculature, innervation, and relations to other structures. Traditional diagrams are often inadequate in describing these structures. For example, typical frontal and sagittal views of the external auditory meatus do not adequately describe its anteroposterior course. Axial (transverse) views provide easier visualization of these areas. A nomenclature is also provided for areas and angles of the external auditory meatus.

Key Words: Anatomy, external auditory meatus, external ear, nomenclature, orientation, tympanic membrane

Abbreviations: TM = tympanic membrane

A thorough knowledge of the external ear and tympanic membrane (TM) is essential to those involved in the diagnosis or rehabilitation of auditory disorders. Audiologists are increasingly involved in making impressions of deep portions of the external auditory canal as well as the fitting of hearing instruments near the TM. Such procedures should be preceded by a thorough examination of these areas in order to ensure that variations may be taken into account or appropriate referrals made. This paper provides an introduction to the anatomy of the external ear, including the TM. In addition, new labels for various angles and cross-sectional areas of the external auditory canal are provided.

EXTERNAL EAR

The external ear consists of the auricle (Latin, pertaining to hearing), also called the pinna (Latin, meaning wing), and the external auditory meatus (ear canal). The external ear is closed medially by the TM.

AURICLE

The auricle consists of a network of yellow elastic fibrocartilage covered by a very thin layer of skin, which tightly adheres directly to the perichondrium. Since the auricle does not contain the usual subcutaneous layer of fat, susceptibility to frostbite is greatly increased.

Major portions of the auricle are shown in Figure 1. These include an outer ridge, the helix; an inner ridge, the antihelix, with its two branches or crura; a lobe inferiorly, which consists mainly of fatty tissue; and the tragus anteriorly, which is opposed by the antitragus. Several spaces have also been named including the concha, which consists of an upper and lower portion termed the cymba and cavum, respectively, separated by the crus of the helix. Other

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Figure 1 Anatomical subdivisions of the pinna.
spaces include the scaphoid fossa, triangular fossa, and intertragic incisure (intertragal notch). A recent article uses these labels to suggest a formal terminology for portions of the earmold (Alvord et al., 1997).

The auricle, which extends from the skull at an angle of approximately 30 degrees (Glasscock and Shambaugh, 1990), is attached to the skull by way of three extrinsic muscles, the superior, anterior, and posterior auricular, which each have corresponding ligaments of the same name. More secure attachment, however, is provided by the cartilage of the concha bowl, which is continuous with that of the external auditory meatus. In addition to the three extrinsic muscles, the auricle has six small intrinsic muscles of unknown purpose.

**EXTERNAL AUDITORY MEATUS**

The external auditory meatus (ear canal) consists of an outer cartilaginous portion, comprising one-third to one-half of its length, and an inner bony or osseous portion. The junction of these two sections is termed the osseo-cartilaginous junction. Figure 2 is a typical view of the external auditory canal as seen in frontal section. With this view only, it is impossible to observe the first and second bends or the antero-posterior direction changes of the canal. This view does allow for visualization of the upward-downward course, which usually occurs due to the upward swelling of bone just medial to the osseo-cartilaginous junction. This upward bony prominence sometimes results in a narrowing of the canal at this point called the "isthmus." Medial to this point, water or other debris may become easily trapped at the inferior angle of the canal and TM referred to as the sulcus.

The cartilaginous portion of the canal is a continuous extension of the cartilage of the concha while the bony section is formed from the tympanic and squamous portions of the temporal bone (Austin, 1991). The ear canal, which is rather straight early in life, assumes a definite "S" shape in adulthood that becomes more tortuous and narrowed in later life. Its length is approximately 2.5 cm superiorly and 3.0 cm inferiorly.

Figures 3, 4, and 5 are axial (transverse) views seen from below a right ear canal. This view is beneficial in visualizing the course of the canal as it travels first anteriorly, then posteriorly, and finally anteriorly again. We have designated the following labels for areas and angles of the canal (Fig. 6): the first and second bends divide the canal conveniently into three sections, sections 1 and 2 constituting the cartilaginous portion and section 3 consisting of the bony portion (see Fig. 6, top). Distinct angles in the horizontal plane occur at the first and second bends of the canal. The angle at the first

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**Figure 2** Frontal section of the external auditory canal.

**Figure 3** Axial CT scan of the RT external auditory meatus of an 81-year-old male, viewed from below.
bend has previously been designated as the "concho-meatal angle (CM)" (Abel et al, 1990). An appropriate name for the angle formed at the second bend is the "cartilaginous-bony angle (CB)" (see Fig. 6, middle). Abel also labeled the cross-sectional areas found at the first and second bends with the arbitrary designators (OA) and (IA), respectively (see Fig. 6, bottom). The cross-sectional area is less at the second bend than at the first in most individuals. This notwithstanding, a flaring often occurs after the second bend as may be attested by many who have made deep impressions of the canal. Figure 7 shows how this flaring occurs. It is the narrowing of the canal in its middle section in the anteroposterior dimension that results in its flaring just beyond the second bend. Our observations from transparent "investments" (the negative of the impression used by hearing aid companies), as well as CT scans such as Figure 3, show that the narrowing prior to the second bend is due to the anterior displacement of the cartilaginous portion of the canal relative to the bony portion (see Fig. 7). The flaring then occurs at the opening to the bony portion as the canal resumes its original size (Polyak et al, 1946).

Oliveira (1995) and Polyak et al (1946) have stressed the dynamic nature of the canal, indicating that the dimensions of the cartilaginous portion change with jaw movement. In particular, the anteroposterior width increases when the jaw is opened. These dynamic properties are particularly important to consider for "deep canal" hearing instrument fittings.

The skin covering the ear canal has many unusual properties that are significant to practicing audiologists. An understanding of these characteristics will aid in preventing injury to this area. The thinness of the skin and its adherence directly to the perichondrium or periosteum make it especially susceptible to bleeding when touched due to the lack of flexibility usually afforded by a subcutaneous layer of fat. Bleeding occurs easily, due also to the profuse
blood supply to the area. The skin is approximately 0.2 mm thick in the osseous region but somewhat thicker in the cartilaginous region (0.5 – 1.0 mm), where the epidermis is composed of four layers (Lucente, 1995). Skin in the ear canal is continuous with the outer layer of the TM. Outward migration of skin occurs actively at deep levels in the stratified epithelium and more passively on the surface. This migration allows for normal expulsion of cerumen if this process is not inhibited by the use of cotton swabs, fingers, or ear inserts. Use of these objects may also damage the natural properties of the skin by removal of natural oils that keep the skin lubricated.

Cerumen, or “ear wax,” is a waxlike substance that lubricates the skin, preventing its desiccation (Polyak et al, 1946); has antibacterial properties (Stone and Fulghum, 1984); and may prevent intrusion of insects. Cerumen is produced only in the outer one-third of the canal by a mixture of secretions of numerous sebaceous and deeper apocrine sweat glands. As shown in Figure 8, ducts from these glands meet in the channel of the hair follicle, or follicular canal, through which they are transported to the skin.
surface. Hairs in the external auditory meatus are of two types. Large hairs found mainly in the outer one-third of the cartilaginous portion, termed tragi, are a secondary sexual characteristic and are found to a much greater extent in males. These hairs occasionally require removal as they may inhibit visualization of the TM, earmold impression, or natural expulsion of wax. They may also occur on the tragus, antitragus, and, occasionally, the helix. In addition to the tragi, tiny, almost invisible vellus hairs cover nearly all of the auricle and cartilaginous canal wall. In the osseous canal, small hairs and glands occur only rarely and on the posterior and superior walls. A more detailed description of the hairs and glands of the ear canal has been provided by Lucente (1995).

**TYPANIC MEMBRANE**

The TM or eardrum (Fig. 9) is a smooth, translucent, pearl-gray membrane having an average thickness of 0.074 mm (Donaldson and Duckert, 1991). It is elliptical in shape and approximately 10 mm high and 8 mm wide (Duckert, 1993). Its mass is approximately 14 mg (Zemlin, 1988). The TM is slanted so that its upper section is closer to the examiner than the lower section. This slanting forms an acute angle of approximately 40 degrees with the floor of the external auditory canal. This angle is much smaller at birth, however, when the TM is nearly horizontal. The TM is concave, being inwardly displaced by about 2 mm, except for at its center or umbo (apex), where there is an outward jutting caused by the inferior tip of the manubrium of the malleus. The outer edge of the TM is a fibrocartilaginous ring or annulus (annular ligament), which is imbedded in a groove in the tympanic bone, the tympanic sulcus. The annulus is deficient superiorly at the notch of Rivinus (incisura tympanica).

Common visible landmarks of a right TM are seen in Figure 9. The most prominent landmark is the manubrium of the malleus or malleolar stria running in a superior-anterior direction from the umbo. The upper portion of the manubrium is slanted to the right in a right TM. At the upper edge of the malleolar stria, the malleolar prominence formed by the lateral process of the malleus may be seen. From this prominence, two ligamentous bands, the anterior and posterior malleolar folds, form a "V" and run superiorly to the edge of the TM where they insert at each end of the notch of Rivinus. These folds, along with the lateral process of the malleus, encompass the thin upper section of the TM, the pars flaccida or Shrapnell's membrane. All regions of the TM below these folds are considered the somewhat thicker pars tensa. The TM may be conveniently divided into four equal quadrants, namely, anterior-superior, anterior-inferior, posterior-superior, and posterior-inferior. An important diagnostic landmark, the cone of light or light reflex, is a reflection of the examiner's light running anteroinferiorly that indicates normal shape and displacement of the TM.

Other landmarks are sometimes visible behind more transparent eardrums. These include the long process of the incus, which runs posteriorly and parallel to the upper part of the manubrium of the malleus; the head of the stapes, seen as a round whitish spot just below the incus; the recess of the round window; the opening of the eustachian tube; and the chorda tympani nerve, which dangles freely in the middle ear space.

The TM is thickest anterosuperiorly and near the annulus inferiorly (0.09 mm) and thinnest in the middle of the posterosuperior quadrant (0.055 mm) (Donaldson and Duckert, 1991). Considering its thinness, the TM is surprisingly tough and resilient (Zemlin, 1988). These qualities are due to the TM's layered architecture. The major layers consist of an outer cutaneous layer, which is continuous with the lining of the external auditory canal; a middle fibrous layer or lamina propria; and an internal layer or serous (mucous) membrane, which is continuous with the lining of the middle ear.

The cutaneous layer may be subdivided into an outer layer of squamous epithelium and a
deeper layer of cuboidal epithelium. Migration of the outer epithelial layer begins at the umbo and continues outward through the external auditory canal carrying debris out of the ear. The rate of this centrifugal migration at the eardrum has been shown to be approximately 0.05 mm per day (Litton, 1963).

The middle fibrous layer may be subdivided into an outer (lateral) layer of radial fibers resembling the spokes of a wheel and an inner layer of circular (circumferential) fibers. The radial fibers are responsible for giving the TM its tent-like shape. The circular fibers, which are most dense near the center or outer edge, lend flexibility. In addition to these two main fibrous layers, there are some intertwining fibers running transversely and parabolically connecting the main layers (Duckert, 1993). Although it was originally believed that the TM lacked the middle fibrous layer in the pars flaccida region, Duckert (1993) maintains that all layers are present throughout the TM.

INNERVATION

Figures 10 and 11 show sensory innervation of the medial (posterior) and lateral (anterior) surfaces of the pinna. The “great auricular nerve,” which is a branch of the third cervical nerve, innervates most of the medial and lateral surfaces of the pinna (Duckert, 1993). To a lesser extent, the medial surface is also innervated inferiorly by the “auricular branch” of the vagus nerve and superiorly by the “lesser occipital” nerve. The lateral surface of the pinna (see Fig. 11) is innervated primarily by the greater auricular nerve but also receives fibers in the concha area from the auricular branch of the vagus nerve, and in superior areas by the “auriculotemporal nerve,” which comes from the mandibular branch of cranial nerve V. While the above-mentioned nerves provide most of the pinna’s innervation, some authors also attribute minor contributions by cranial nerve IX (glossopharyngeal), as well as the first and second cervical nerves (English, 1976; Lucente, 1995).

The external auditory meatus and the TM’s lateral surface are innervated mainly by the auricular branch of the vagus nerve (inferior and posterior canal wall) and the auriculotemporal nerve (anterior and superior canal wall). These two nerves continue on to the lateral surface of the TM where they innervate its posterior and anterior halves, respectively. A sensory branch of cranial nerve VII also contributes in a minor way to the innervation of the postero-superior wall of the external auditory canal, which explains the hyperesthesia experienced by some patients with acoustic neuroma (Roeser, 1996). Small branches of cranial nerves IX and VII may also play a minor role in the innervation of the TM’s lateral surface. The inner (medial) surface of the TM is innervated by the tympanic branch of cranial nerve IX.

The only motor innervation to the external ear is to the minor extrinsic muscles of the auricle provided by the temporal and posterior auricular
branches of the facial nerve, which allows for movement of the pinna in some individuals.

The large number of nerves involved in the innervation of the external ear explains the “referred otalgia” experienced by many whose actual disorder is located in the mouth, nose, throat, neck, or viscera (Schulier and Schleuning, 1994). The presence of the vagus nerve at the midpoint of the posterior wall explains the cough or syncope (fainting) reflex experienced by many who are touched in this area such as when a hearing aid impression is made.

VESSELS AND LYMPHATICS

Figure 12 shows the major arteries that supply the pinna. These include subdivisions of the external carotid artery, namely, the posterior auricular and superior temporal arteries. These two arteries also supply the external auditory canal with aid from the deep auricular artery, a branch of the internal maxillary artery.

Principal veins for both the pinna and external auditory meatus are branches of the temporal vein (the anterior auricular tributaries) and the posterior auricular vein (auricular branches) (Anson, 1966). Lymphatic drainage is into lymph nodes located just anterior, posterior, and inferior to the auricle.

The external (lateral) and internal (medial) surfaces of the TM receive blood from separate sources. The external surface receives blood from the deep auricular artery, which enters through the bony wall of the osseous meatus. This vessel completely surrounds the TM, giving off smaller branches that cover most of the pars tensa and area of the manubrium. The internal surface receives blood from the posterior auricular artery’s stylomastoid branch and also from the tympanic branch of the maxillary artery. Venous drainage from the TM is into the external jugular veins, transverse sinus, and veins of the dura mater and, to a lesser extent, into veins of the eustachian tube.

RELATIONS

The external auditory meatus is related anteriorly to the condyle of the mandible and the parotid gland. Swelling of the anterior lymph node can sometimes be mistaken for a parotid gland mass. The close proximity of this large saliva gland sometimes allows infections or tumors to spread into the ear canal or vice versa by way of the fissures of Santorini, which are vertical slits in the cartilage of the anterior wall of the canal. Under normal conditions, these slits allow flexibility of the auricle.

The superior wall of the bony canal is separated from the epitympanic recess of the middle ear by a thin layer of bone. If middle ear infections invade this area, there may be a sagging of the roof of the canal. Similarly, the close proximity of the mastoid air cells to the posterior wall of the canal may result in a fistula into the canal in acute mastoiditis (Roeser, 1996).

SUMMARY

A thorough knowledge of the anatomy of the external ear is essential to those involved in the diagnosis and treatment of hearing disorders. The new nomenclature proposed for areas and angles of the external auditory meatus should prove useful for purposes of teaching and communicating between professionals.

REFERENCES


