Cochlear Anatomy via Microdissection with Clinical Implications

An Atlas

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Preface

In the following pages selected aspects of cochlear anatomy are described and illustrated using images obtained from material prepared in the authors' laboratory over the course of the last several decades. Much of that material was processed for temporal bone microdissection. However, in addition to photographs from dissections, photomicrographs from conventional temporal bone cross-sections and scanning electron microscopy are included. Taken together, these methods offer a perspective on inner ear anatomy not often found in the available literature on temporal bone morphology. Findings from human temporal bone studies relevant to cochlear implantation are emphasized, and comments relating to the functional and/or clinical significance of the anatomic observations are provided.

Temporal bone microdissection has a long history of use in research on inner ear anatomy and pathology and was in fact employed in the first postmortem studies of temporal bones from early cochlear implant recipients [1, 2]. As described below, the method provides a more three-dimensional view of cochlear anatomy than is obtained from conventional temporal bone histology. It is therefore ideally suited for in situ examination of implant electrode arrays following their insertion in human temporal bones, offering an effective means for assessment of electrode placement and evaluation of insertional trauma [3].

Microdissection can also be used in combination with a variety of other laboratory methods for study of inner ear tissues [4, 5]. That is, specimens obtained by dissection can be prepared as whole mount or so-called surface preparations for light microscopy or processed for scanning electron microscopic study. Specimens may also be embedded in various media to provide tissue sections for light or transmission electron microscopy. In addition, microdissection is well suited for use in parallel with conventional celloidin embedding and sectioning. The two methods yield different but often complementary views of inner ear structure, as illustrated in the images presented here.

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Contents

1 Microdissection for Study of Cochlear Anatomy

1.1 Summary of Microdissection Method

Several variations on the basic method of cochlear dissection have been employed by different investigators. The procedure used at our facility was adapted from that described in detail by Hawkins and Johnsson [1] and can be summarized as follows (Figs. 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, and 1.9). Human temporal bones to be prepared for microdissection should be obtained as soon as possible postmortem and not frozen. Upon arrival in the laboratory, the specimens are trimmed of excess tissue, and the middle ear cavities are opened for access to the round and oval window areas. The stapes is removed from the oval window, and a slit is placed in the round window membrane to permit perilymphatic perfusion of a fixative solution (2.5% glutaraldehyde is most often used in our laboratory). Temporal bones suitable for microdissection may also be fixed by immersion in 10% formalin if they are obtained within 12–15 h postmortem. When that method of preservation is used, inner ear fixation can be improved by filling the middle ear cavity with formalin via injection through the tympanic membrane prior to immersion.

Following fixation, the inner ear tissues are stained by perilymphatic perfusion of 1% osmium tetroxide. The otic capsule bone is then drilled to a thin shell so that the contours of the osmium-stained cochlear spiral are clearly visible. Subsequently, the bone overlying scala vestibuli is removed in order to view the interior of the cochlea. Once the cochlea is open, osmium-stained nerve fibers in the osseous spiral lamina are readily apparent. The organ of Corti and the underlying basilar membrane are also visible as a more lightly stained band adjacent to the osseous lamina. At that point, it is possible to identify and photographically document any reduction in density of the nerve fibers caused by age-related degeneration or other causes and to assess the general condition of the organ of Corti along the entire length of the basilar membrane.

An important advantage of the microdissection approach is that it allows a detailed evaluation of the whole length of the osseous spiral lamina, the organ of Corti, and the lateral wall tissues of the cochlear duct from a multidimensional perspective. After careful examination of the intact specimen using low-power microscopy, segments of the osseous lamina and basilar membrane may be removed for study as whole mount preparations by high resolution light microscopy, or they can be processed for scanning electron microscopy. Using the whole mounts, it is possible to quantitatively assess the hair cell population of the organ of Corti and to document the extent and location of sensory cell loss that may be present along the length of the basilar membrane. If the quality of tissue preservation is exceptionally good, whole mount specimens may

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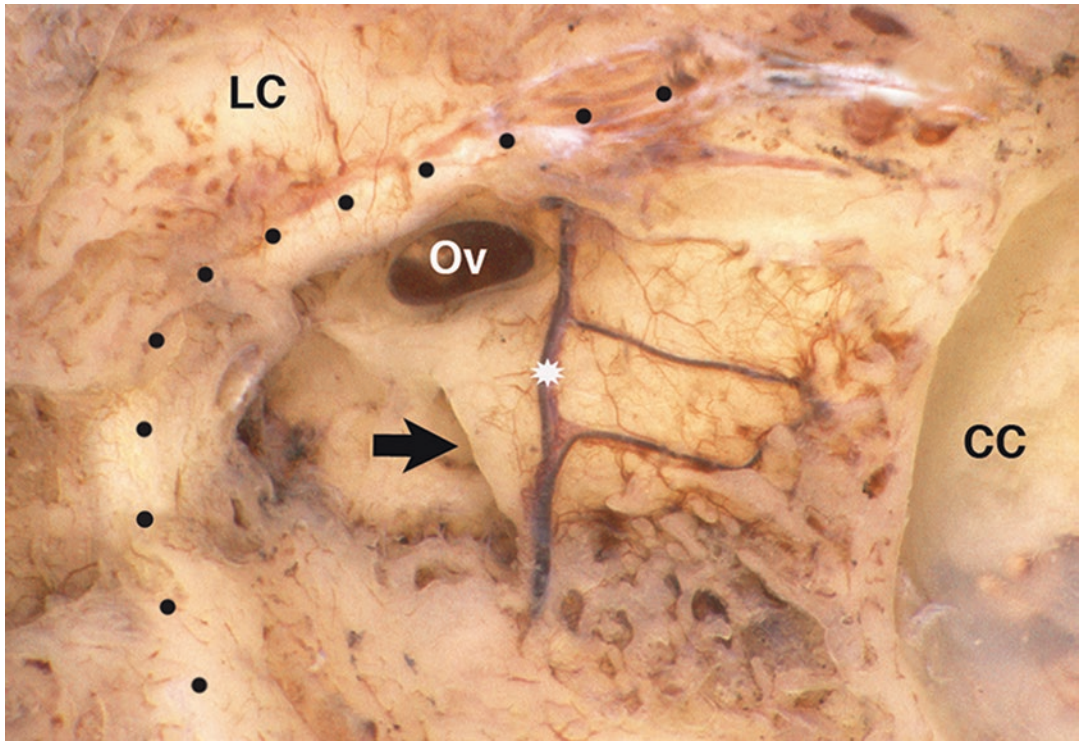

Fig. 1.1 Medial wall of a human middle ear in a right temporal bone. *LC* lateral semicircular canal. The dotted line traces the course of the facial nerve. *Ov* oval window (stapes removed). The white asterisk marks Jacobson's nerve on the cochlear promontory. (It is a branch of the glossopharyngeal nerve that is joined by the caroticotympanic nerve from the sympathetic plexus on the internal carotid artery.) *Arrow* entrance of the round window niche, *CC* carotid canal immediately anterior to cochlea. Osmium stain

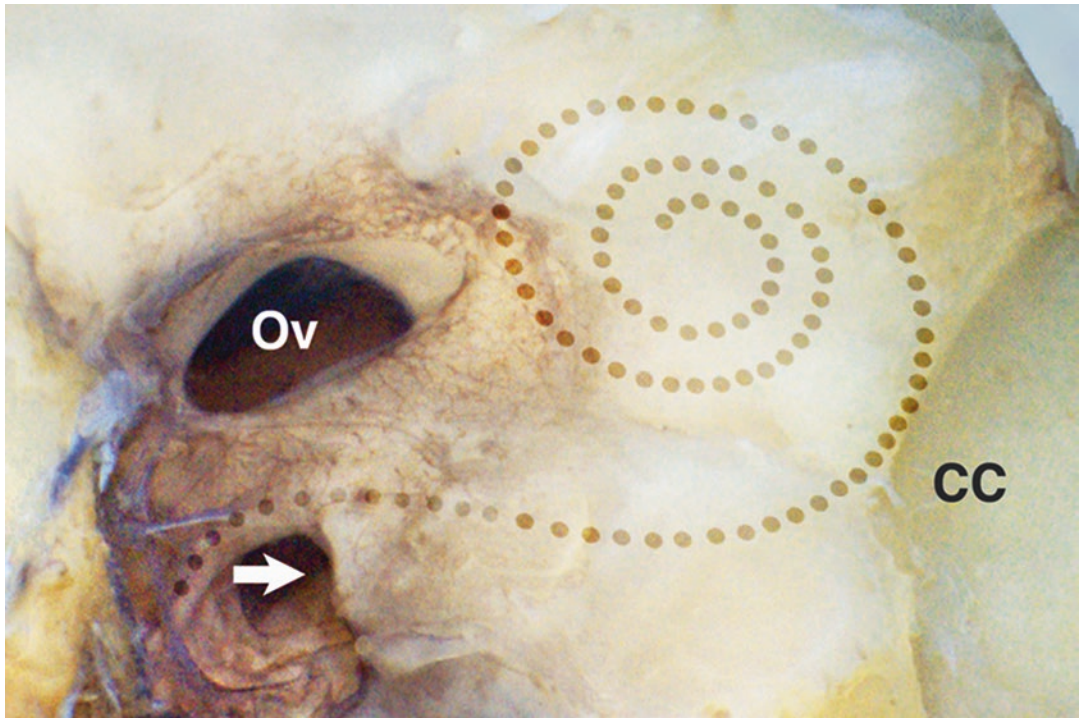

Fig. 1.2 Petrous portion of temporal bone after trimming and removal of middle ear mucosa in preparation for cochlear dissection. The dotted line indicates the approximate position of the cochlear spiral inside the bone. The arrow at lower left indicates the entrance of the round window niche. *Ov* oval window, *CC* carotid canal