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ORIGINAL ARTICLE

Formation of the Cochlear Nerve in the Modiolus of the Guinea Pig and Human Cochleae

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Background. Central processes of the bipolar neurons in the spiral ganglion converge in the modiolus to form the initial portion of the auditory branch (cochlear nerve) of the eighth cranial nerve. This occurs before the cochlear nerve passes through the internal auditory meatus. The neurons of the spiral ganglion send their central processes towards the internal acoustic meatus, through a single canal to form the cochlear nerve. These processes are described in many textbooks as running through numerous longitudinal small canals called canales longitudinales modioli before entering the internal acoustic meatus. Results of this study indicated that the term; "canalis longitudinalis modioli" was considered to be more appropriate than the former.

Methods. Central processes of the bipolar neurons in the spiral ganglion of the guinea pig and human cochleae were investigated using stereo, light and electron microscopy.

Results. Detailed examination of the guinea pig and human cochleae by light, electron and stereomicroscopy did not reveal multiple longitudinal canals but a single canal for the cochlear nerve.

Conclusions. The singular term canalis longitudinalis modioli is more appropriate than canales longitudinales modioli.

Key Words: Cochlea, Modiolus, Cochlear nerve, Guinea pig, Human, Microscope.

Introduction

The modiolus is a spongy bony axis. Blood vessels and nerves are located within this structure. The spiral osseous lamina extends from the modiolus in a shelf-like manner. The spiral canal of modiolus is located where the spiral osseous lamina joins the modiolus. The spiral ganglion is located within this canal. The central processes of the bipolar neurons forming this ganglion constitute the cochlear nerve.

Initial portion of the cochlear nerve in the modiolus was described with the name canales longutidunales modioli or not mentioned in a number of textbooks, papers and also in Terminologia Anatomica–1998 (1–12). Although a few studies on the human cochlea were performed, the similarity between the guinea pig and the human cochlea was accepted by most of the investigators. In this study, the modiolar course of the cochlear nerve was examined in guinea pig cochleae and the human cochleae obtained from preserved cadavers.

Materials and Methods

The guinea pig and human cochleae were prepared for light and electron microscopy and the human cochleae were also observed and photographed under the stereomicroscope.

Guinea pig. Five guinea pigs were anesthetized with ether and sacrificed by decapitation. Temporal bone was removed and a window of 1.5–2 mm was opened from the bulla for better diffusion of the chemicals used for the processing of the tissues (anterior wall).

Each temporal bone was fixed immediately with 10% formalin for 24 h for light microscopic examination. They were decalcified with 5% nitric acid for 6 h, washed with

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tap water for up to 24 h and dehydrated by using a graded series of alcohol. Xylol (twice, 1/2 h) and cedar oil (24 h) washes were performed and then paraffin blocks were prepared. Six-μm-thick sections were taken from these blocks in two planes. The first plane was parallel and the second one was perpendicular to the axis of the modiolus. These sections were stained with hematoxylin/eosin and were investigated by light microscopy.

For electron microscopic study, the entire cochlea was removed and placed in EDTA-glutaraldehyde solution for 2 weeks for fixation and decalcification. The tissue was postfixed with OsO_4, dehydrated in a graded series of alcohol (for 10 min at 50, 60, 70, 80%, for 60 min at 96% and 100%) and then embedded in Araldit CY212 (Sigma, St. Louis, MO). All chemicals used were from Agar®, Essex, England. Semi-thin sections (2 μm) were stained with toluidine blue and observed by light microscopy. The cochlear nerve in modiolus was cut serially by LKB® ultramicrotome (60–90 nm, Leica, Bensheim, Germany), stained with uranyl acetate–lead citrate, studied by Jeol JEM 1200EX electron microscope (Jeol, Tokyo, Japan) and photographed.

Human. The cochleae of five formalin-fixed cadavers were prepared for study under the stereo, light and electron microscopes. Three cochleae were used for stereomicroscope and two cochleae were used for light and electron microscopy. The cranium of each cadaver was opened and the brain was removed. The petrous part of the temporal bone including the inner ear was removed. Each tissue sample was immersed in 5% nitric acid solution over 3 weeks. The solution was refreshed every 3 days.

For stereomicroscopic study, bony structure around the cochlea was stripped under stereomicroscope. The cochleae were finely dissected to observe the course of the cochlear nerve in modiolus and photographed.

Decalcified petrous parts of the temporal bones were dissected to remove the cochleae. The cochleae prepared for examination under the light and electron microscope. It was postfixed with OsO_4, dehydrated in a graded series of alcohol and then embedded in Araldit CY212. Semi-thin sections (2 μm) were stained with toluidine blue and observed by light microscopy. The cochlear nerve in modiolus was cut serially at a right angle to the axis of the modiolus. The ultra-thin sections (60–90 nm) were stained with uranyl acetate–lead citrate, studied on Jeol JEM 1200EX electron microscope and photographed.

Results

Guinea pig. The spiral ganglion SG (spiral ganglion) was observed while passing through the modiolus by light microscope. Perpendicular and longitudinal section planes of the cochlear nerve in modiolus were examined. When the section plane was perpendicular to the axis of the modiolus above the middle coil, it was discovered that the cochlear nerve CN (cochlear nerve) coursed within a single canal (Figure 1).

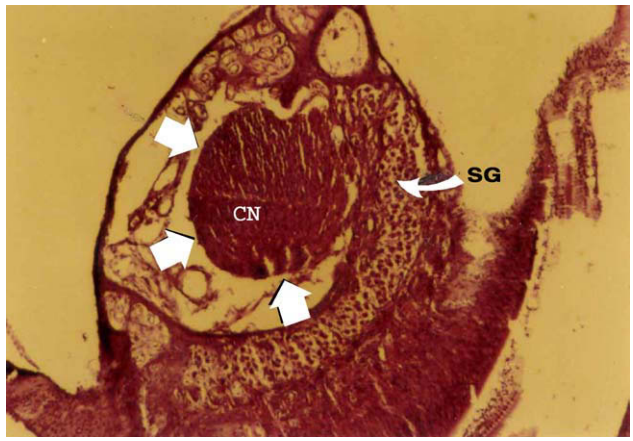

Figure 1. Guinea pig cochlea, light microscopy. Section plane is at right angles to the axis of the modiolus, middle coil (paraffin block, hematoxylin-eosin, original magnification ×40).

Examination of longitudinal sections of the modiolus revealed spiral ganglion cells and their axons. These central processes coursed downwards spirally and contributed to the cochlear nerve. The cochlear nerve coursing into its individual canal and the spongy bone around it were seen (Figure 2). All of the sections, both longitudinal and perpendicular to the modiolus, showed that there was no bony structure around the nerve fibers or bundles. Higher magnifications of the sections (Figure 3) and electron microscopic examination (Figure 4) also supported this observation.

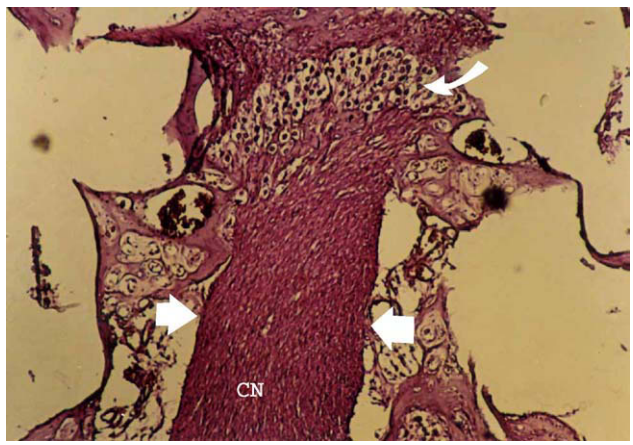

Figure 2. Guinea pig cochlea, light microscopy. Section plane is at the 15° angle to the axis of the modiolus (paraffin block, hematoxylin-eosin, original magnification ×40).