

# Anatomical variations of landmarks for implantation at the cochlear nucleus

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## Abstract

A knowledge of the microanatomy of the cochlear nucleus complex and its variations is essential for successful implantation and for the design of stimulation devices.

One hundred cerebellopontine angle specimens were dissected under surgical conditions using the Zeiss NC31 surgical microscope. The topographical anatomy of the exit of the vestibulocochlear nerve, the cochlear nucleus and the surface of the medulla and their relation to the surrounding structures was recorded and measured.

The mean distances between the exits of the VIIth and VIIIth cranial nerves were  $4.7 \pm 0.9$  mm, between the VIIth and IXth  $6.3 \pm 1.2$  mm and between the VIIIth and IXth  $5.5 \pm 1.0$  mm. The visible area of the cochlear nucleus covered a square of  $10.0 \pm 2.9$  by  $3.3 \pm 1.0$  mm. A major AICA-loop had to be re-routed in 17 per cent of specimens. The taenia of the choroid plexus was present in 92 per cent and had to be cut in 51 per cent in order to enter the foramen of Luschka, that had a mean size of 3.5 by 2.0 mm. It was wide open in 24 per cent, open only after incision of the arachnoid in 53 per cent, functionally closed but opened by extensive dissection in 18 per cent and anatomically occluded in five per cent of the specimens. The typical straight vein at the cochlear nucleus leading to the entrance of the foramen of Luschka was found in 76 per cent of specimens.

Constant anatomical landmarks are very helpful for finding the cochlear nucleus, but variations may endanger dissection and implantation in a remarkable number of cases.

**Key words:** Cochlear Nucleus; Anatomy; Brain Stem; Prosthesis Implantation

## Introduction

The knowledge of the microanatomical variations of the cochlear nucleus complex from laboratory studies and surgical procedures in the CPA is essential for successful implantation and designing stimulation devices. Opening of the lateral recess in the scarred surface of the brainstem after removal of a large acoustic neuroma is a difficult task even for someone with great experience in CPA surgery: in tumour surgery, the pia/arachnoid surface should be preserved, and it is important to enter the foramen of Luschka in the correct position. For this purpose we must know the distances between the landmarks and the most frequent variations.

## Materials and methods

Following the experiences of 50 qualitative micro-anatomical dissections and the first Freiburg ABI-workshop, 100 cerebellopontine angle specimens have been systematically dissected under surgical conditions using the Zeiss NC31 surgical microscope. The topographical anatomy of the exit of the vestibulocochlear nerve, the cochlear nucleus at the

surface of the medulla and its relation to the surrounding structures was recorded and measured.

## Results

The cochlear nucleus is found in the surface of the medulla close to the exit of the IVth ventricle.<sup>1</sup> It creates a small visible bulging of the brainstem caudally to the middle cerebellar peduncle. However, the three-dimensional extension of the cochlear nucleus gives access to only a small superficial area – the greater part is hidden inside the medulla. Examination of transverse sections of the brainstem at the level of the cochlear nucleus show a higher density of neurons in the accessible ventral cochlear nucleus, that has more ascending fibres, less inhibitory synapses and a better tonotopy and should be preferably stimulated (Figure 1).<sup>2</sup>

The most important landmarks are the exits of the cranial nerves VII, VIII and IX, the choroid plexus with its taenia, and the visible prominence of the cochlear nucleus at the exit of the IVth ventricle with



FIG. 1

Transverse section of the medulla oblongata at the level of the inferior olives. The position of the cochlear nucleus is marked by arrows.

its straight vein running in the direction of the nucleus and separating it from the pontobulbar body (Figure 2).<sup>3</sup>

Mean distances between the exits of the VIIth and VIIIth are  $4.7 \pm 0.9$  mm, between the VIIth and IXth  $6.2 \pm 1.2$  mm and between the VIIIth and IXth  $5.5 \pm 1.0$  mm. The visible area of the cochlear nucleus covers a square of  $11.7 \pm 2.7$  by  $3.1 \pm 0.7$  mm, the area of the nearby pontobulbar body a square of  $10.0 \pm 2.9$  by  $3.3 \pm 1.0$  mm.<sup>4</sup>

A major AICA-loop had to be re-routed in 17 per cent of specimens, a branch of the vena pontis lat. in 68 per cent. The taenia of the choroid plexus is present in 92 per cent and has to be cut in 51 per cent in order to enter the foramen of Luschka, which has a mean entrance size of 3.5 by 2.0 mm. It is wide open in 24 per cent, open after incision of the arachnoid in 53 per cent, functionally closed with opening only by extensive dissection in 18 per cent and anatomically occluded in five per cent of the specimens.

The vessels in the retro-olivary region are usually very coiled. So a surprising finding in surgery as well as in micro-anatomical dissection is the presence of a

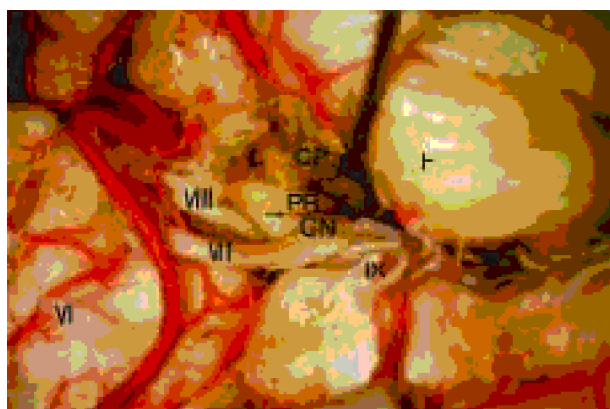


FIG. 2

Lateral view of the cerebellopontine angle. Cranial nerves VI-IX, flocculus (F) choroid plexus (CP), cochlear nucleus (CN) and pontobulbar body (PB) exposed. Arrows mark the course of the vena nuclei cochlearis and the direction of ABI implantation.

TABLE I

DISTANCES BETWEEN EXITS OF CRANIAL NERVES VII, VIII AND IX

	VIII-VII	VII-IX	VIII-IX
Mean	4.7	5.5	6.2
SD	0.9	1.0	1.2
Maximum	7.0	8.0	9.0
Minimum	2.0	4.0	4.0

SD = standard deviation.

straight-running small vein parallel to the course of the cochlear nucleus. It usually starts medially to the taenia and divides the bulgings of the rostral cochlear nucleus and the caudal pontobulbar body or lies on the cochlear nucleus itself. It may be covered by a small layer of tissue shining through only on very strong illumination or after incision of the taenia and removal of the overlying cortex. The typical straight vein at the cochlear nucleus leading to the entrance of the foramen of Luschka is found in 76 per cent. Its positive identification gives the best security for an optimal implantation.<sup>5-8</sup>

### Conclusions

Constant anatomical landmarks are very helpful in finding the cochlear nucleus. The exits of the nerves VII, VIII and IX form a triangle of about 5 by 6 mm.<sup>9,10</sup> So, if the first of these nerves is identified, the others and the entrance to the lateral recess will be found within an area of 6 mm. Variations may endanger dissection and implantation in a remarkable number of cases. A functional closure of the foramen of Luschka should be passed by meticulous dissection – an anatomical occlusion may not be artificially opened. Difficulties in surgery can be minimized by previous anatomical studies. The design of the Nucleus 22-auditory brainstem implant corresponds well to the size and shape of the entrance to the lateral recess and the surface of the cochlear nucleus.

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