Normal diameters of the Cochlear Nerve and Facial Nerve on 3D-CISS at 3T

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Purpose

To evaluate the enlargement or atrophy of nerves in specific clinical conditions, comparisons with normal diameters are significant. Several studies have made comparisons of cochlear nerve (CN) diameters between normal and hearing-impaired ears. For example, the comparative study of the cross-sectional area (CSA) between elderly patients with sensorineural hearing loss and young patients with normal hearing had been published [1]. Another study represented the significant difference of the CSA between postlingually deafened and normal-hearing adults [2]. In those studies, three-dimensional constructive interference in steady state (3D-CISS) was applied to evaluate CN diameters. 3D-CISS, which reflects liquid T2/T1 contrast [3], is useful technique for figuring out the anatomy of cerebrospinal or labyrinthine fluid space and is in popular use in clinical application. Similar approach for CN could be applied for facial nerve (FN), which is located in the internal auditory canal (IAC) together with CN. For further research on CN or FN, to establish a normal value of nerve diameter on 3D-CISS should be significant. However, to the best of our knowledge, only one previous study [4] has focused on the CN diameter in normal-hearing ears, and no study has been reported about normal diameter of the FN on 3D-CISS, currently. Therefore, the purpose of the present study was to present normal values for CN and FN diameters on 3D-CISS at 3-tesla MR imaging scanner.

Methods and Materials

Study population

The present study was approved by the Ethics Review Committee of our institution. The records of 172 ears of 142 patients (41 men and 101 women; mean age, 36.4 years; range, 6-74 years) who underwent 3D-CISS MR imaging of the inner ear at our hospital from June 2006 to March 2011 were retrospectively examined. All ears included in the present study had normal hearing and no history of facial palsy on the ipsilateral side. In the present study, normal hearing ears were defined as follows: six-frequency average of pure-tone audiometry (PTA) at 250, 500, 1000, 2000, 4000, and 8000 Hz <25 dB. All patients had records of PTA within three months of MR imaging examinations.

MR imaging protocol

All scans were performed on a 3-tesla MR imaging scanner (Magnetom Trio; Siemens AG, Erlangen, Germany) using a 32-channel receive-only phased-array head coil. Parameters for 3D-CISS were: TR, 6.4 ms; TE, 3.2 ms; flip angle, 50°; matrix size, 256
MR imaging evaluation and statistical analysis

We analyzed images on a PACS workstation (Rapid Eye Station; Toshiba Medical Systems, Otawara, Japan). First, one radiologist drew the straight line passing through the modiolus and the point which vestibulocochlear nerve enters the pons (Fig. 1 on page 3a). Then 0.5-mm thick parasagittal images perpendicular to these lines were reconstructed and saved for each ear (Fig. 1 on page 3b). A few days after the reconstruction, the long diameter (LD) and short diameter (SD) of the CN and FN were measured on the parasagittal images (Fig. 2 on page 4a) by two independent observers. Measurement was performed at the slice nearest the fundus of the IAC where the margin of the CN or FN could be identified. CSAs \[\text{CSA} = \frac{\#(LD/2)(SD/2)}\] were also calculated on each nerve (Fig. 2 on page 4b).

On each measurement, the mean values of two observers were calculated and interobserver agreements were evaluated using the Pearson correlation coefficient. $P$ value $<0.05$ was considered statistically significant.

Images for this section:
Fig. 1: One radiologist drew the straight line passing through the modiolus and the point which vestibulocochlear nerve enters the pons (a). Then 0.5-mm thick parasagittal images perpendicular to these lines were reconstructed and saved for each ear (b).
**Fig. 2:** The long diameter (LD) and short diameter (SD) of the cochlear nerve (CN) and facial nerve (FN) were measured on the parasagittal images (a) by two independent observers. Measurement was performed at the slice nearest the fundus of the internal auditory canal (IAC) where the margin of the CN or FN could be identified. Cross-sectional areas (CSAs) \([\text{CSA} = \#(LD/2)(SD/2)]\) were also calculated on each nerve (b).
Results

In 157 CNs of 172 ears (91%) and 165 FNs of 172 ears (96%), measurement was possible by both observers. Some nerve diameters were impossible to measure because of the motion artifact or being close to the IAC wall (Fig. 3 on page 6).

The mean LD, SD, CSA of the two observers on CN were 1.35±0.16 mm, 0.99±0.18 mm, 1.07±0.30 mm$^2$, and those on FN were 1.18±0.17 mm, 0.87±0.16 mm, 0.83±0.27 mm$^2$, respectively. The measurement values of each observer and the mean of two observers are shown in Table 1 on page 6 and Table 2 on page 7. There were good interobserver correlations for each measurement value ($r = 0.569-0.691, P<0.01$).

Images for this section:

**Fig. 3:** Some nerve diameters were impossible to measure because of the motion artifact or being close to the internal auditory canal (IAC) wall.
Table 1: Cochlear nerve diameter

<table>
<thead>
<tr>
<th></th>
<th>LD (mm)</th>
<th>SD (mm)</th>
<th>CSA (mm²)</th>
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<tbody>
<tr>
<td>observer A</td>
<td>1.35±0.19</td>
<td>1.00±0.19</td>
<td>1.08±0.34</td>
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<tr>
<td>observer B</td>
<td>1.36±0.17</td>
<td>0.99±0.20</td>
<td>1.07±0.33</td>
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<tr>
<td>r</td>
<td>0.572**</td>
<td>0.682**</td>
<td>0.671**</td>
</tr>
<tr>
<td>mean value</td>
<td>1.35±0.16</td>
<td>0.99±0.18</td>
<td>1.07±0.30</td>
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<tr>
<td>of the two</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>observers</td>
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</table>

LD: long diameter, SD: short diameter, CSA: cross-sectional area \([\pi(LD/2)SD/2])\)

r: correlation coefficient

** P<0.01
Table 2: Facial nerve diameter

<table>
<thead>
<tr>
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<th>LD (mm)</th>
<th>SD (mm)</th>
<th>CSA (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>observer A</td>
<td>1.19±0.20</td>
<td>0.88±0.19</td>
<td>0.85±0.31</td>
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<tr>
<td>observer B</td>
<td>1.17±0.19</td>
<td>0.86±0.17</td>
<td>0.81±0.29</td>
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<tr>
<td>r</td>
<td>0.569**</td>
<td>0.691**</td>
<td>0.685**</td>
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<tr>
<td>mean value of the two observers</td>
<td>1.18±0.17</td>
<td>0.87±0.16</td>
<td>0.83±0.27</td>
</tr>
</tbody>
</table>

LD: long diameter, SD: short diameter, CSA: cross-sectional area \( \pi(\text{LD}/2)(\text{SD}/2) \)

\( r \): correlation coefficient

** \( P<0.01 \)
Conclusion

From the results of the present study, we believe we could present reliable normal values for CN and FN diameters on 3D-CISS because good interobserver correlations were observed for all measurement values. These values should contribute to the development of the research which evaluating the diameters of CN or FN using MR imaging.

There must be some advantages of using 3D-CISS to measure CN or FN diameters. Since 3D-CISS is in popular use in clinical application, the measurement of CN or FN diameters on 3D-CISS should be possible in many institutions. In addition, since 3D-CISS requires no gadolinium contrast agent, we could evaluate the CN or FN of the patients with history of allergy or impaired renal function, without the risk of nephrogenic systemic fibrosis (NSF) [5].

We made some discussions between the results of the present study and the previous reports. In the previous histopathological study [6], the maximum diameter of the CN was 1.04±0.11 mm, which is slightly shorter than mean LD of the CN in the present study (1.35±0.16 mm). This might be caused by dehydration of the CN in the fixed sample. In addition, we compared the mean LD and SD of the CN in the present study with the mean vertical and horizontal diameters of the CN in the previous study using 3D-CISS [4], applying Welch's t-test (Table 3 on page 9). There was no statistical difference between the results of these two studies, although the measurement locations were not necessarily identical.

The present study has some limitations. Since the measurement of the present study was performed on multi-planar reconstruction (MPR) images reconstructed from axial CISS images, there might be effects associated with the interpolation. In addition, the patients included in the present study were not necessarily normal healthy adult volunteers, although included ears had normal hearing and no history of facial palsy. Furthermore, there was gender imbalance.

In conclusion, we presented normal values of CN and FN diameters on 3D-CISS at 3-tesla. These results warrant a further study to clarify the pathological state of the CN or FN using 3D-CISS without gadolinium contrast agents.

Images for this section:
Table 3: We compared the mean long diameter (LD) and short diameter (SD) of the cochlear nerve (CN) in the present study with the mean vertical and horizontal diameters of the CN in the previous study using 3D-CISS [4], applying Welch’s t-test. There was no statistical difference between the results of these two studies, although the measurement locations were not necessarily identical.

### Table 3: Welch’s t-test

<table>
<thead>
<tr>
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<th>previous study*</th>
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<tbody>
<tr>
<td>LD</td>
<td>vertical</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>horizontal</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>CSA</td>
<td>CSA</td>
<td>0.59</td>
<td></td>
</tr>
</tbody>
</table>

LD: long diameter, SD: short diameter, CSA: cross-sectional area \( \pi(LD/2)(SD/2) \)

References


Personal Information