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Normative size evaluation of internal auditory canal with magnetic resonance imaging: review of 3786 patients

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Background: *A narrow internal auditory canal (IAC) is significantly associated with congenital sensorineural hearing loss. It would therefore seem likely that any patient with an IAC measured radiographically to be under the normal range represents an abnormality and probable IAC stenosis. If narrow IAC is diagnosed with routine magnetic resonance imaging (MRI), then the cochlear nerve may be evaluated with special MRI studies. However, there is no consensus in the literature on the normal measurements of the IAC or on what parameters should be used to determine narrow IAC using MRI. In this study, we aimed to assess the normative size of IAC in normal-hearing ears and to determine whether canal size varies with age and gender using MRI.*

Material and methods: *A retrospective review was undertaken from 2010 to 2012. A total of 7572 normal-hearing ears of 3786 patients were assessed, who had MRI due to various reasons except hearing loss. Patients under 20 years old and over 60 years old were excluded, and the subjects were divided into 4 groups at 10-year intervals. All subjects were divided by gender also. Anteroposterior (AP) and craniocaudal (CC) measurements were obtained in the middle of the IAC on axial and coronal images of 1.5-T MRI.*

Results: *The mean age was 42 years (range 20–60 years). The mean IAC diameters were 5.93 mm with a standard deviation of 0.25 mm (max 6.99 mm, min 4.73 mm) on AP measurements and were 5.70 mm with a standard deviation of 0.26 mm (max 6.82 mm, min 4.71 mm) on CC measurements. There were no differences in the IAC diameters between males and females or with age groups.*

Conclusions: *These measurements should provide a normative reference for comparison in radiographic assessment of any patient with suspected IAC stenosis. This measurement can help the diagnosis of narrow IAC. To our knowledge, this is the first study using MRI with a large group of patients in the literature.* (Folia Morphol 2012; 71, 4: 217–220)

Key words: internal auditory canal, magnetic resonance imaging

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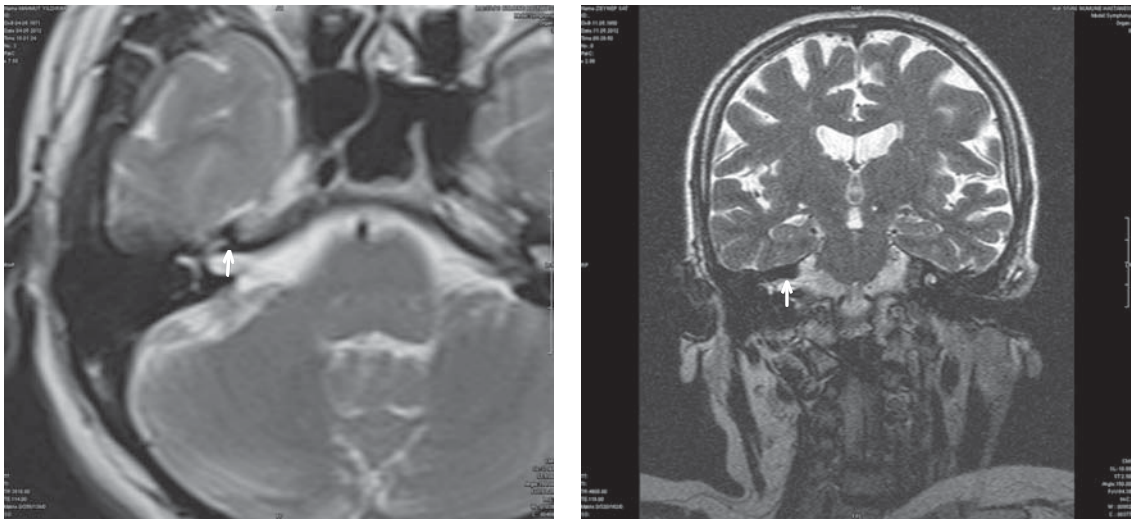

Figure 1. The anteroposterior and craniocaudal dimensions the internal auditory canal on T2/TSE axial and coronal slices. Arrows shows the location of the measurement.

INTRODUCTION

Narrow internal auditory canal (IAC) has been well correlated with both unilateral and bilateral congenital sensorineural hearing loss (SNHL) cases [7, 9, 10, 12, 14–16]. During embryologic development, a layer of mesoderm surrounds the vestibulocochlear complex. This mesoderm layer becomes cartilaginous and ultimately transforms into bone as IAC. Some investigators feel that the IAC develops with a smaller ca-libre when there is a problem with embryogenesis of the vestibulocochlear complex. Other investigators have theorised that the small calibre IAC may consequently cause dysfunction of the auditory or vestibular nerves from compressive damage [15]. In either case, there is a clear association between the radiographic findings of a small IAC and documented congenital SHNL, both unilaterally and bilaterally. It is known that cochlear nerve (CN) hypoplasia is associated with narrow IAC, and Glastonbury et al. [5] found that most patients evaluated for congenital SNHL had a qualitatively deficient CN.

Several studies over the last 10 years have been aimed at radiographically evaluating the structure of the cochlea, cochlear nerve, and IAC [1, 2, 5, 6, 17]. However, there is no consensus in the literature on the normal measurements of the IAC or what parameters should be used to determine IAC stenosis using magnetic resonance imaging (MRI). Since there is no MRI study measuring the normative sizes, this study was taken up to determine the normative size and effects of gender-age on IAC in normal-hearing Turkish ears.

MATERIAL AND METHODS

Ethical clearance for the present study was obtained. A retrospective review was undertaken in our radiology clinic. A total of 7572 normal-hearing ears of 3786 patients who were referred to our department between 2009 and 2012 to obtain cranial MRI for various reasons except hearing loss were included in this study. The patients who had no past medical history or clinical signs and symptoms related to ear diseases, and who had no significant abnormalities on the cranial MRI were included. Patients under 20 years old and over 60 years old were excluded, and the subjects were divided into 4 groups at 10-year intervals. All subjects were divided by gender also.

Anteroposterior (AP) and craniocaudal (CC) diameters were obtained in the middle of the IAC on axial and coronal T2W images of 1.5-T MRI (Fig. 1). All MR examinations were performed on a whole-body 1.5 T unit (Magnetom Symphony, Siemens, Germenay, 2007) by using an 8-channel sensitivity-encoding (SENSE) head coil. The imaging parameters for T2W-TSE axial slices were 3810 ms/114 ms/1 (repetition time [TR]/echo time [TE]/number of signal average [NSA]), 150 flip angle, 259 × 118 matrix, 800-cm field of view (FOV), 130 kHz bandwidth, and 13 echo train length, slice thickness 5 mm, with an acquisition time of 4 min 26 s. SPSS 15.0 software was used to analyse the data.

RESULTS

The study includes 2061 males and 1725 females. The mean age was 42 years (range 20–60 years). The mean IAC diameters were 5.93 mm with a stan-

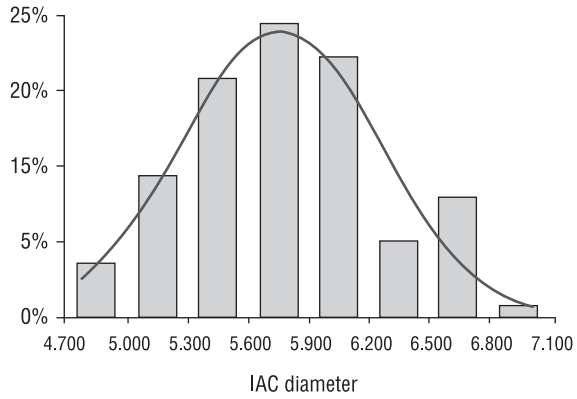

Figure 2. Histogram of internal auditory canal (IAC) diameter with a normal density curve.

dard deviation (SD) of 0.25 mm (maximum was 6.99 mm, minimum was 4.73 mm) on AP measurements and were 5.70 mm with a SD of 0.26 mm (maximum was 6.82 mm, minimum was 4.71 mm) on CC measurements. The histogram (Fig. 2) showed that the IAC diameter roughly followed a normal distribution for both AP and CC diameters. The Shapiro-Wilk test had a p-value of 0.25, which supported the normality hypothesis.

The mean IAC diameters did not show any significant difference between male and female with means 5.93 ± 0.24 mm vs. 5.87 ± 0.25 mm, respectively, on AP measurements and with means 5.71 ± 0.24 mm vs. 5.68 ± 0.25 mm, respectively, on CC measurements (p-value from two sample t-test was 0.12).

There was no significant change in IAC measurements with increasing age on AP (slope of –0.0019, $p = 0.091$; Pearson's correlation coefficient = –0.12, $p = 0.092$) and on CC (slope of –0.0022, $p = 0.099$; Pearson's correlation coefficient = –0.08, $p = 0.098$) dimensions. Table 1 provides the means and SD for the different age groups.

DISCUSSION

The narrow IAC has been well correlated in both unilateral and bilateral congenital SNHL cases, and there is a clear association between the radiographic findings of small IAC and documented congenital SNHL [7, 9, 10, 12, 14–16].

There are a few theories extrapolated to the aetiopathogenesis of CN canal and IAC stenosis. According to these theories, if the absence of the CN results in a smaller calibre of the IAC during development, then certainly a narrowing of the IAC may also be associated with some auditory nerve anomalies.

It is known that CN hypoplasia is associated with narrow IAC, and Glastonbury et al. [5] found that most patients evaluated for congenital SNHL had a qualitatively deficient CN. Papsin [13] found that children with narrowing of the IAC and/or CN canal performed more poorly than all other groups of children with anomalous cochlea on speech perception scores after cochlear implantation. Miyasaka et al. [11], using both MRI scans and computed tomography (CT) scans on the same patients, found that CN hypoplasia on MRI scan is highly correlated with a narrowing of the CN canal and IAC. On the other hand, Fatterpekar et al. [3, 4] used CTs from patients evaluated with inflammatory and neoplastic disease to measure the dimensions of the bony canals located at the fundus of the IAC and found that the length and width of the bony canal for the CN were significantly smaller in patients with SNHL than in the control group [3, 4, 17, 18]. Stjernholm and Muren [17] used casts from temporal bone specimens and CTs from patients evaluated for cholesteatoma or chronic otitis media to measure the mean dimensions of the CN canal but arrived at a mean canal width that was smaller than that reported by Fatterpekar et al. [3, 4].

There is no standard text reference available on the measurements of IAC by using MRI. Glastonbury et al. [5] determined the IAC to be abnormal if it was < 4 mm in either the vertical or transverse diameter. They studied only 22 patients with MRI. Our results were significantly larger than they found in both dimensions (in the current study minimum AP value was 4.73 mm and minimum CC value was

Table 1. Mean and standard deviation (SD) of anteroposterior (AP) and craniocaudal (CC) diameter by age group

Age range	Mean AP diameter ± SD	Mean CC diameter ± SD
20–30	5.96 ± 0.28	5.74 ± 0.28
31–40	5.92 ± 0.19	5.69 ± 0.19
41–50	5.89 ± 0.27	5.73 ± 0.27
51–60	5.91 ± 0.22	5.68 ± 0.22

4.71 mm on 3786 normal-hearing ears). This mismatch can be explained by the number of cases in both studies and the racial differences. More research is needed to clarify this discrepancy.

The IAC has been previously well documented as virtually symmetric in healthy individuals, with a difference of < 1 mm in 99% of patients and 1–2 mm in 1% [18]. Kolagi et al. [8] found that the vertical diameter of IAC ranged between 3 and 7 mm on a dry adult human temporal bone study in 224 cadavers. Our results were larger than they found. These temporal bones were fixed and dehydrated. We found larger diameters, suggesting that postmortem processing may have affected their measurement.

Our results suggest that when an IAC has a diameter of < 4.73 mm on AP measurements and < 4.71 mm on CC measurements, it is two SDs below the average, and it would therefore seem likely that any patient with an IAC measured radiographically using MRI under 4.69 mm on AP slices and under 4.67 mm on CC slices represents an abnormally small IAC for any age and gender. In these cases, aggressive auditory testing, including cochlear promontory stimulation and special MRI studies, may be performed because of the significant association of hearing loss.

CONCLUSIONS

On average, the IAC was 5.93 mm on AP diameter and was 5.70 mm on CC diameter on MRI sections. There were no differences with increasing age or between males and females in terms of the IAC measurements. This paper serves as a reference point for normative size of IAC by using MRI and may also present a cut-off value.

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