Imaging Profile of the Ear in Hearing Loss Patients in Hospital Universiti Sains Malaysia: 5 year Cross Sectional Analysis at a Tertiary Otologic Centre

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ABSTRACT

BACKGROUND: Hearing impairment is a major disability. The otologic assessment together with high-resolution CT images is an important step to obtain precise diagnostic profile of ear malformations. This study was conducted to obtain the detailed anatomy and objective assessment of the ear in patients presenting with hearing loss in a tertiary care otologic center using high-resolution CT scan.

METHODS: A cross-sectional study of 55 patients with hearing loss who had undergone high-resolution CT scans at Hospital Universiti Sains Malaysia from 1st January 2008 until 31st May 2014. Patients with temporal bone fractures, malignancy, post-operative ear and cholesteatoma were excluded.

RESULTS: Nine patients noted to have external ear anomaly on right ear and 7 patients on left ear. Middle ear abnormality in both ears was seen in 2 patients. Patients noted to have cochlear anomaly on the right ear (R) were 8 and left ear (L) were 4. Measurements of vestibular aqueduct diameter were 0.08 ± 0.09 cm (R) and 0.06 ± 0.04 cm (L), lateral semicircular canal diameter 0.10 ± 0.03 cm (R) and 0.10 ± 0.02 cm (L), vestibule diameter 0.30 ± 0.06 cm (R) and 0.31 ± 0.05 cm (L), bone width between the lateral vestibular wall and the inner wall of the lateral semicircular canal diameter 0.35 ± 0.07 cm (R) and (L) and internal acoustic meatus diameter 0.40 ± 0.08 cm (R) and 0.41 ± 0.08 cm (L). One patient had cochlear aplasia and common cavity deformity, 2 patients had lateral semicircular dehiscence and internal acoustic meatus stenosis, 4 patients had cochlear ossification and 5 patients were noted to have enlarged vestibular aqueduct.

CONCLUSION: High-resolution CT scan image is a good single imaging modality to obtain an objective measurement of the ear as well as to detect subtle or underestimated ear anomalies

Keywords: Imaging Profile; Hearing Loss; CT scan

INTRODUCTION

Hearing loss is significantly related to speech difficulties, lower quality of life and subsequently decreased cognitive function. Knowledge of morphology and morphometric study of human ears is very important for an otologist to plan the surgery as well as to predict the outcomes of surgery and hearing status. Early diagnosis and correction of hearing loss will maximize speech perception [1]. High-resolution CT scan of the temporal bone can obtain precise diagnostic profile of inner ear malformations. As there were no previous similar studies in the last 5 years, hereby this study is done to get objective measurement of the important inner ear structures because these details are essential to provide detailed anatomy and facilitate surgical planning.

METHODS

We studied all 55 patients and their high-

resolution CT scans of temporal bone from January 2008 to 31st May 2014 in Hospital USM. A complete and detailed audiological and clinical evaluation, tympanometry and pure-tone audiometry (PTA) or conditioned audiometry and brainstem auditory-evoked potential were performed routinely. Patients with temporal bone fractures, malignancy, post-operative ear and cholesteatoma were excluded.

All HRCT scans images were retrieved and evaluated for their diagnostic acceptability. The scanned area included entire temporal bone bilaterally and there was no image degradation including any artifacts due to low-density object, patient movement and low signal to noise. Multiplanar images (3D images) were reconstructed to axial, coronal and sagittal and all images were analyzed in bone window for most accurate anatomical identification and measurements. The external ear, middle ear and inner ear profile were reported. The measurement of inner ear structures was done on axial view as described in Figure 1.

All data collected were revised for statistical analysis. Categorical data were described in terms of frequency, while interval data were presented as mean ± standard deviation. Data gathered were analyzed with Statistical Package for Social Science (SPSS) software version 20.

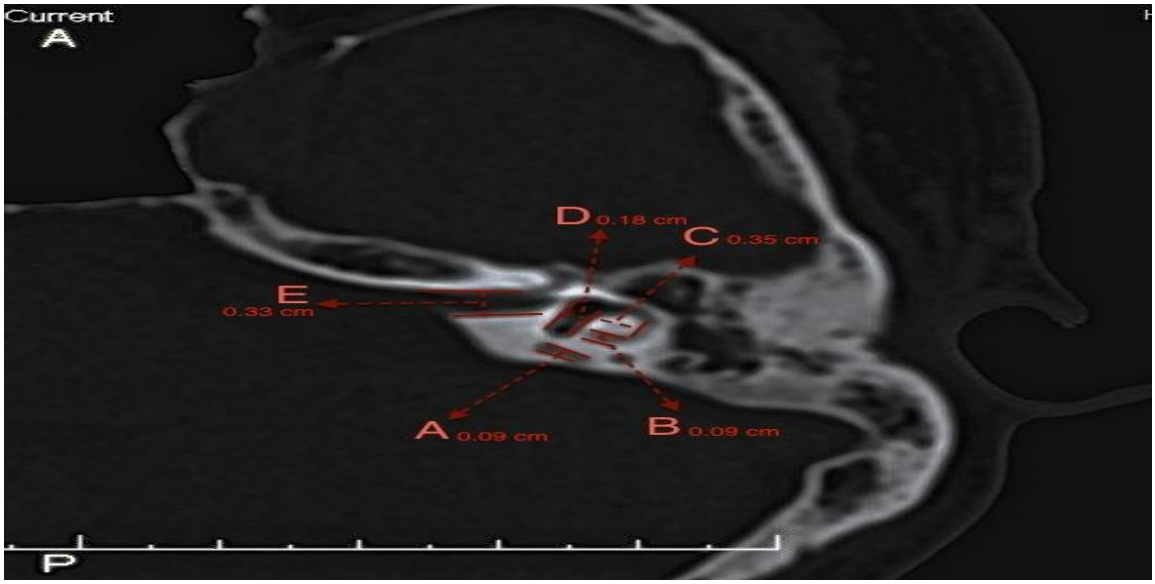
RESULTS

In this study, 30 patients were male. The youngest patient was 1 year 4 months old and the oldest was 76 years old. The mean age was 24.0 years old. Pre-school and school-going children defined by age less than 18 years old, accounted 49.1% of the respondent (27 patients). The parameters measured on CT scan are summarized in Table 1.

Nine patients noted to have outer ear anomaly on right ear and 7 patients on left ear. Middle ear abnormality in both ears was seen in 2 patients. Eight patients and 4 patients noted to have cochlear anomaly on the right and left ear, respectively.

According to World Health Organization (WHO) guidelines 2017 for severity of hearing loss; mild is defined as 26-40 decibel (dB) hearing loss, moderate (41-60 dB), severe (61-80 dB) and profound (more than 81 dB). Patients with external ear abnormality were observed to have normal to severe hearing loss, patients with middle ear abnormality had mild to severe hearing loss and patients with inner ear abnormality had normal to profound hearing loss. The most common external ear anomaly that we encountered was microtia, which ranged from grade I to grade III according to Aguilar classific-

Figure 1: High-resolution axial CT image of temporal bone shows parameters taken for the study. A=diameter of vestibular aqueduct, best measured away from skull base opening; B= diameter of lateral semicircular canal, serves as maximum reference for vestibular aqueduct width; C=diameter of vestibule; D=width of bone between vestibule and lateral semicircular canal, serves as reference for maximum vestibular width; E=diameter of internal auditory canal



-ation scheme in 1996. In cases with bilateral grade III microtia as seen in two patients, pure-tone audiometry demonstrated mild to severe hearing loss, with threshold of 27 to 63 dB and did not have concomitant inner ear anomaly.

Almost all patients had normal middle ear clinically. Only two patients had tympanic membrane perforation. One patient with tympanic membrane retraction had coexisting microtia on the same side. The hearing loss was noted to be from normal to severe, with PTA 23 to 63 dB.

The most common inner ear abnormalities in this study were enlarged vestibular aqueduct and cochlear ossifications, each affecting 4 patients. Patients with cochlear ossification and without any other abnormality had normal to profound audiological performance. Other cochlear abnormalities in this series were common cavity malformations, cochlear aplasia and cochlear dehiscence (each affecting one patient).

DISCUSSION

Hearing loss may arise from morphologic abnormalities of the external ear canal, the middle ear or the inner ear and their various combinations during embryogensis. Malformations of the external, middle and inner ear can be caused by genetic defects (such as chromosomal abnormality, mutations and polygenic inheritance) or acquired factors (such as drugs, nutritional deficiencies, viral infections or maternal influences).

As one of the most important cause of hearing loss, 9.1% of our subject had enlarged vestibular aqueduct diameter. This was consistent with previous study stating that the most common congenital inner ear anomaly seen on CT is a large vestibular aqueduct, although the percentage was significantly less in our study. Agha *et al*. (2014) reported as high as 63.3% for vestibular aqueduct dilatation [3]. The vestibular aqueduct is considered too wide when its diameter is more than 1.5 mm, at the midpoint between the common crus and the external aperture of the vestibular aqueduct [1, 2].

Casselman *et al*. (2001) reported that patients with enlarged vestibular aqueduct had associated cochlear malformations in 76% of the cases compared to our study with 50% [1]. The audiologic assessment ranged from severe to profound, with PTA 70-102 dB compared to other studies that showed moderate to profound hearing loss, with PTA 47 to 113 dB [4]. Other study had reported a normal hearing, but hearing loss can fluctuate or deteriorates progressively [5].

In our study, we found that all parameters were generally smaller compared to previous studies (Table 1). The mean diameter of the vestibular aqueduct was 0.2 mm smaller compared to a previous study [6]. The mean diameter of the lateral semicircular canal was 0.7 mm smaller [7]. The mean diameter of the vestibule was almost 50% smaller [6]. The mean diameter of the bony width between the lateral semicircular canal and vestibule was about 0.5 mm smaller and lastly, the mean diameter of the internal acoustic meatus was about 2.0 mm smaller compared to previous study [6]. We opined that all our respondents were Asian and majority were

Table 1: Parameters of the vestibular aqueduct, lateral semicircular canal, vestibule, internal aco--ustic meatus and width of bone between the vestibule and lateral semicircular canal; and para--meter comparison to previous studies

Parameters (mm)	VA diameter		LSCC diameter		Vestibule diameter		Width of bone between the vestibule and LSC		IAM diameter	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Minimum diameter	0.4	0.3	0.4	0.4	1.6	2.2	1.3	1.5	1.4	2.7
Maximum diameter	5.8	2.0	1.7	1.6	4.2	4.7	4.8	4.8	6.9	6.2
Mean	0.8	0.6	1.0	1.0	3.0	3.1	3.5	3.5	4.0	4.1
Standard deviation	0.9	0.4	0.3	0.2	0.6	0.5	0.7	0.7	0.8	0.8
Dewan et al, 2009	1.0 ±0.7	0.09 ±0.4	-	-	6.7 ±1.1	6.8 ±1.1	3.9 ±0.8	4.1 ±0.8	6.1 ±1.5	6.3 ±1.6
Lee et al, 2013	-	-	1.7 ±0.3	1.7 ±0.3	-	-	-	-	-	-

VA: vestibular aqueduct; LSCC: lateral semicircular canal; IAM: internal acoustic meatus

pre-school and school-going children who contributed to these smaller values. Cochlear ossification (Figure 2) was found in an unexpectedly high rate (14/64, 22%) of patients with acute deafness in Braun *et al*. (2013) [8]. These findings were three times lower from our study (7.3%).

There were two patients with stenotic internal acoustic meatus (Figure 3) and there was severe to profound hearing loss. The stenotic internal acoustic meatus may suggest aplasia or hypoplasia of the vestibulocochlear nerve that causes the sensorineural deafness. The condition of the vestibulocochlear nerve is important prior to cochlear implantation since it will affect the outcome post-surgery [1, 10].

CONCLUSION

In our study, 40% of patient showed some form of abnormality on the HRCT temporal bone and the most common inner ear abnormalities were enlarged vestibular aqueduct and cochlear ossifications. The morphometric measurements of the inner ear of patients with hearing loss were comparable with international data and few subjects had extreme values. In term of hearing loss, patients with external ear abnormality had normal to severe hearing loss, patients with middle ear abnormality had mild to severe hearing loss and patients with inner ear abnormality had normal to profound hearing loss.

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Figure 2: 3D MPR image, bone window on axial view shows enlarged vestibular aqueduct on the right ear measuring 0.58 cm on its largest diameter compared to the left side it is barely visible

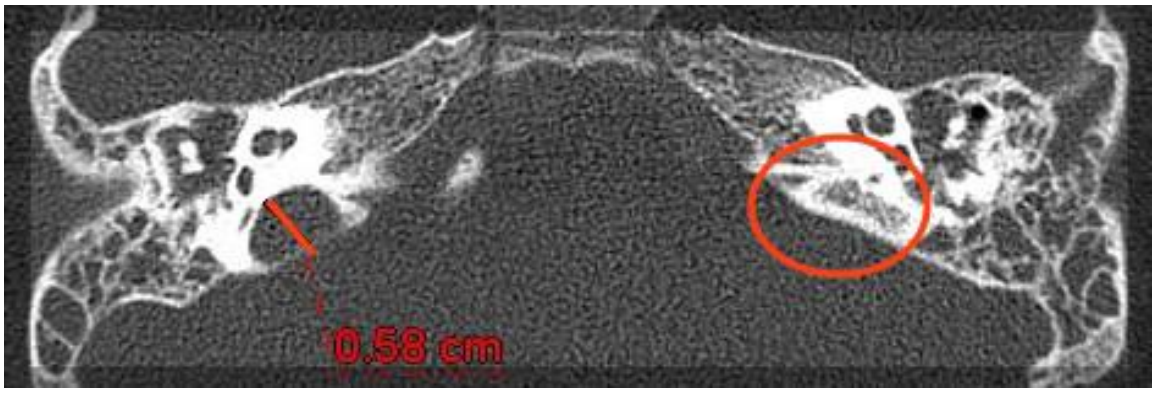
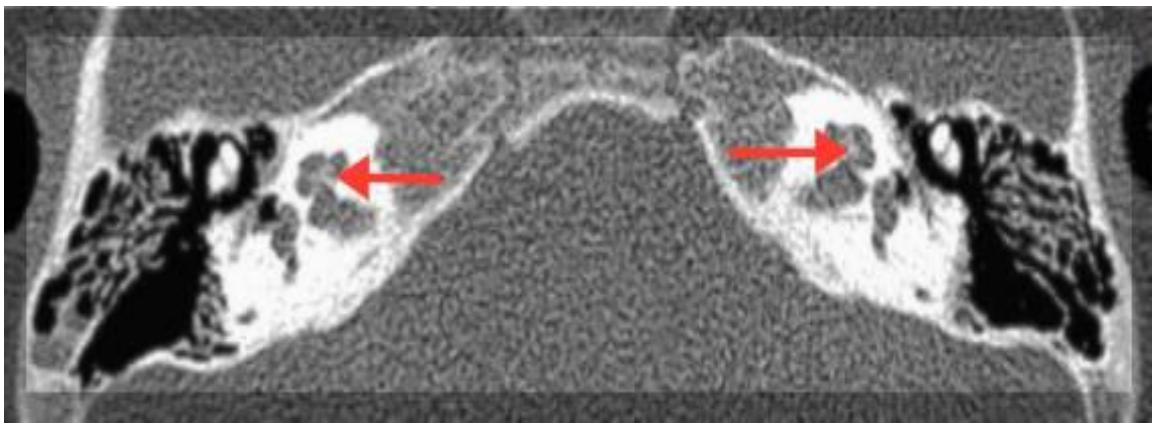


Figure 3: 3D MPR image, bone window on axial view depicts bilateral trapezoidal calcified interscala septum indicating cochlear ossification (arrow).



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