Anatomic Dimensions of the Bony External Auditory Canal

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OBJECTIVES:
To determine measurements of the external auditory canal (EAC) to aid in the design of hearing devices.

INTRODUCTION:
With increasing numbers of the new generation regularly using high-powered sound technologies but without adequate auditory protection, it is projected that hearing loss will reach record levels in the near future. As such, the hearing aid industry has been, in the past few decades, offering gradually more miniature and lightweight hearing aid technologies. The goal is to meet the current and future demand for patients seeking treatment while preserving a dimension of portability, if possible, aesthetic.

Among the varieties of hearing aids available to patients today, in-the-canal (ITC) and completely-in-the-canal (CIC) devices have received significant attention for their cosmetic appeal.1 In addition to providing a cosmetic effect, these devices also generally provide good auditory function.2,3 Of note, the newest innovation in hearing aid devices, the invisible extended-wear deep-canal device (Lyric®), InSound Medical, Newark, CA), depends entirely on fitting and securing the device in the patient’s external auditory canal (EAC) by an exterior mold.4 Currently, to overcome anatomical variation among different patients, a number of different EAC molds are available for in-clinic test fitting.

The human EAC is comprised of two parts—the cartilaginous portion, which is more lateral, and the bony portion, which is more medial. The contours of the bony EAC are reliably visualized using a temporal bone computed tomography (CT) scan.5-7 To our knowledge, no systematic measurement of anatomic dimensions of the bony and cartilaginous EAC, let alone standardized dimensions for auditory devices that fit into the EAC, have been reported in the literature. In this study, we report a novel method for performing standardized measurements of the bony EAC, as well as average EAC dimensions for 68 patients with special attention to dimensional differences among different age groups. Knowledge of these dimensions may be helpful in guiding surgical procedures or in the design of novel in-the-air devices (i.e., hearing aids).

METHODS (continued):
Measurements were compared on the basis of different age groups (ages 5-8, ages 9-12, ages 13-18, over 18 years of age) and the presence of chronic bony EAC inflammation secondary to chronic otitis media (COM) using an unpaired Student’s t-test. For measurements obtained in patients under 18 years of age, ANOVA was used to compare mean dimensions across different age groups (i.e., ages 5-8 vs. 9-12 vs. 13-18) within the normal and chronic inflammation groups. Differences were tested using a significance level of 0.05.

RESULTS:
The mean age was 29 years (standard deviation 23.3, range 5 to 85). Table 2 displays the mean, standard deviation, and range of measurements across all patient groups and age group history of chronic ear inflammation. With the exception of the midSD measurements in patients 18 years of age and older, there was no statistical difference in dimensional differences between patients with and without a history of chronic EAC inflammation within similar age groups (Table 2). There was a significant difference in the midSD (p = 0.03), MIdAP (p = 0.01), midP (p = 0.02), and midD (p = 0.05) dimensions across age groups in patients without a history of chronic EAC inflammation, but no difference in EAC dimensions was detected across age groups in patients with a history of chronic EAC inflammation.

DISCUSSION:
The measurements completed in this study will assist in the development of various standardized hearing devices for patients with different dimensions. Our research group is in the process of developing a novel invisible hearing aid that would fit entirely in the bony EAC. This device would not require the traditional ear canal molding process required for current conventional hearing aids. Novel devices which can overcome the problems of feedback, such as the one under study, will need to be fit with a few sizes fit-all configurations. This reduces the need for multiple visits and the potential issues of deep molding.

There was no difference in EAC measurements between ears with and without chronic inflammation secondary to chronic otitis media. Therefore, no adjustment needs to be made for these patients. Note that post-operative changes in the EAC can change the dimensions and the contour of the canal.

As expected in the case of normal development, in normal ears, measured EAC dimensions increased as a function of age. However, in patients with a history of chronic otitis media which can cause EAC remodeling, measured dimensions were not statistically different across age groups below 18 years of age.

Currently, these standardized dimensions are derived from direct measurement of anatomic structures on CT imaging. In the future, more rigorous methods of measurement, including laser scanning, and 3D shape modeling, may be used for the same purpose with increased accuracy and capacity for customization.

REFERENCES: