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The anatomic applicability of transcanal endoscopic ear surgery in children

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ABSTRACT

Objective: The feasibility of TEES in dealing with pediatric middle ear disease is still under investigation. The goal of this study was to compare anatomical dimensions of the EAC between children and adults, and to analyze the anatomic applicability of TEES in children.

Methods: Forty pediatric (18 years old and younger) and 20 adult patients who received TB-HRCT to evaluate middle ear conditions were enrolled from December 2010 to December 2015. Dimensions including the diameters of the EAC orifice, isthmus and tympanic membrane annulus, the length of EAC, the height of the middle ear, and the angle between tympanic membrane and EAC axis were determined according to the TB-HRCT data.

Results: The diameters of the EAC orifice and isthmus and length of EAC in the pediatric patients were slightly smaller than those in the adult patients. The anatomical dimensions of middle ear were similar in both groups. Simple regression analysis indicated that the diameters of the EAC orifice and isthmus and the length of the EAC were positively correlated with the age of the pediatric patients. In the pediatric patients, 67 ears (83.75%) had an EAC isthmus diameter larger than 4 mm and are sufficient with a 3-mm endoscope manipulation.

Conclusion: TEES is applicable for most pediatric patients using an endoscope with a diameter of 3 mm or smaller. With an appropriate endoscope and instruments, TEES is a safe and effective alternative to treat pediatric middle ear disease.

1. Introduction

Microscopic ear surgery (MES) is the most widely used surgical management for middle ear disease. However, a microscope can only provide a straight-line view, and this is more likely to result in blind pockets and residual cholesteatoma occurring from the remnants of the matrix [1]. For a wider surgical view, a retroauricular approach may be preferable, especially in pediatric patients.

Thomassin et al. reported the first endoscopic ear surgery (EES) in 1993 [2]. EES was originally used with standard MES in order to provide better visualization of hidden pockets such as retrotympanum and supratubal recess. Combining MES and EES can ensure total removal of cholesteatoma [3–10,31], and EES has gradually become one of the major options for second-look procedures [11–13]. Transcanal endoscopic ear surgery (TEES) is widely used for the treatment of adult middle ear disease, and it is becoming a preferred alternative to MES via the retroauricular approach because it provides a wider surgical view, better mastoid functional preservation, smaller surgical wound, shorter surgical time and shorter hospital stay [1,14–17].

However, studies on the feasibility of TEES in pediatric patients are lacking. The external auditory canal (EAC) in children is shorter and narrower than in adults, and whether this limits the application of TEES in pediatric patients with middle ear disease is unclear. Only one previous study has investigated EAC measurements in Asian children [1]. Therefore, in this study, we measured the EAC in both children and adults and assessed the feasibility of TEES in pediatric patients.

2. Patients and methods

2.1. Patients

This study was approved by the Institutional Review Board of our hospital. Forty pediatric (80 ears) and 20 adult patients (40 ears) who received temporal bone high-resolution computed tomography (TB-HRCT) to evaluate the condition of the middle ear from December 2010 to December 2015 at Taipei Cathay General Hospital were included in this study. The characteristics of the patients are shown in Table 1. The pediatric patients were aged from 1 to 18 years (mean and median age of pediatric patients were 8.4 and 8.5), and the adult patients from 19 to 80 years (mean and median age of adult patients were 56.4 and 58). Those with congenital EAC or middle ear deformities (e.g. microtia or ear canal atresia) and previous EAC or middle ear surgery were

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Table 1
The characteristic of the patients (ears).

	Male	Female	Total (Ear number)	
0-4 y/o	4	6	10 (20)	40 (80)
5-8 y/o	5	5	10 (20)	
9-12 y/o	8	2	10 (20)	
13-18 y/o	7	3	10 (20)	
19-30 y/o	0	1	1 (2)	20 (40)
31-40 y/o	1	1	2 (4)	
41-50 y/o	2	2	4 (8)	
51-60 y/o	1	3	4 (8)	
61-70 y/o	4	2	6 (12)	
71-80 y/o	2	1	3 (6)	

excluded. The following measurements were then compared between the two groups:

2.1.1. Dimensions of the EAC

The measurements of the anatomical dimensions of the EAC included diameters of the orifice and isthmus and length of the EAC. The diameter of the orifice was measured at the junction of the auricle and EAC, and the diameter of the isthmus was measured at the narrowest part of the EAC, mostly at the bony cartilaginous junction. The length of the EAC was measured from the orifice to tympanic membrane annulus. All of the measurements were determined using TB-HRCT scans with 1-mm fine cut. For the diameters, the longest distance between the canal walls was measured in each patient start from soft tissue to soft tissue density on TB-HRCT to be more accurate applying to clinical anatomy. The anterior-posterior diameter in axial view and superior-inferior diameter in coronal view were both recorded (Figs. 1 and 2). All the measurements are done by Dr WH. Sun to avoid measurement bias.

2.1.2. Dimensions of the middle ear

The diameter of the tympanic membrane annulus and height of the middle ear were measured. The diameter of the annulus was measured at the medial end of the bony part of the EAC, and the height of the middle ear was measured from the plane of the annulus to the roof of the promontory. The angle between the tympanic membrane and EAC axis was measured from a line passing through the annulus plane and a line parallel to the medial bony part of the EAC. All of the middle ear measurements were performed using TB-HRCT scans. Axial and coronal views were both recorded (Figs. 1 and 2). All the measurements are done by first author alone to avoid the bios between different observers.

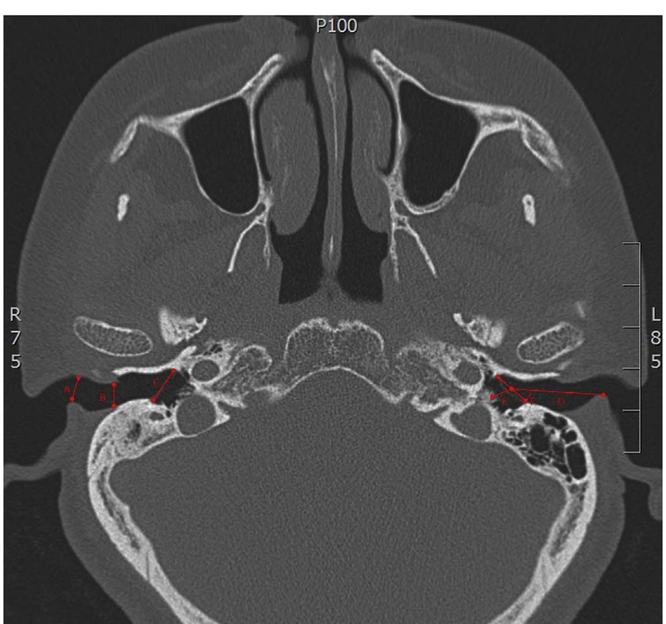

Fig. 1. The measurement method in axial view. (A) Diameter of the EAC orifice; (B) Diameter of the EAC isthmus; (C) Diameter of the EAC annulus; (D) Length of the EAC; (E) Height from the annulus to promontory; (F) Angle between the EAC axis and tympanic membrane.

2.1.3. Relationship between EAC and middle ear dimensions with age

The relationship between EAC and middle ear dimensions with age were compared in both groups using simple linear regression analysis.

2.1.4. Assessment of the anatomic applicability of TEES in pediatric patients

Since most of the instruments for ear surgery are no more than 1 mm in width, we defined that the minimum required working space for TEES should be at least the diameter of endoscope plus 1 mm for the instrument (Fig. 3). In other words, for a 4-mm endoscope, the narrowest part of the EAC (we adopted the smallest isthmus diameter in either view) should be at least 5 mm to fulfill the TEES minimum requirement, and for a 3-mm endoscope, the narrowest part of EAC should be at least 4 mm. We defined the minimum required working space for TEES based on the fact that, in the real situation, as long as the endoscope and instrument could pass the narrowest part of EAC simultaneously, there will no doubt be sufficient space for the movement and manipulation of the instrument. (Fig. 3). To assess the feasibility of TEES, we compared the anatomic applicability of both 3-mm and 4-mm endoscopes in the pediatric patients.

2.2. Statistical analysis

Statistical analysis was performed using SPSS for Windows (version 16.0; SPSS Inc., Chicago, IL, USA). All of the dimensions of the EAC were compared between the pediatric and adult patients. Differences were considered statistically significant with a p value of less than 0.05 unless otherwise specified. Correlations were analyzed with a simple linear regression model.

3. Results

3.1. Dimensional differences of EAC between the pediatric and adult patients

Table 2 shows the dimensions of the EAC in all patients according to the preoperative TB-HRCT images. All of the dimensions in the coronal view were larger than those in the axial view except for the length of the EAC. There were significant differences between the pediatric and adult groups in the orifice, isthmus and length of the EAC. The dimensions are shown in Table 2. Regarding the angle between the ear drum and EAC axis, the pediatric group had a larger angle than the adult group in axial view (pediatric vs. adult: 61.9° vs. 54.1°, $p = .003$) and smaller angle in coronal view (pediatric vs. adult: 41.6° vs. 53.8°, $p < .001$) (Table 2).

3.2. Dimensional differences in the middle ear between the pediatric and adult patients

The dimensions of the middle ear in the pediatric and adult patients are shown in Table 2. All of the measurements were similar in both groups, except for the annulus diameter in coronal view, regardless of the age or viewing aspect.

3.3. Relationship between EAC and middle ear dimensions with age

The simple linear regression analysis revealed that the length of the EAC, and the diameters of the orifice and isthmus were positively