STANDARDIZED MODEL DEVELOPMENT FOR KOREAN'S EAR CANAL

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Abstract
The purpose of this paper is to get standardized ear canal model of Korean hearing impairment persons with the regard of the structure and the size of Korean ear canal. The results of the study make possible further study about the resonant effect of the ear canal and the ear shell fabrication process of the hearing aid. 99 ear molds were collected from 49 Korean men and 50 Korean women with hearing impairment. Not all of them supplied ear mold of both ears nor their ages were fixed. The collected ear molds were three dimensionally scanned for geometrical and morphological analysis. From those digitally geometric information, the structure and the size of the ear canal were investigated. Many possible parameters such as volume, elliptical circumferences, angles, lengths were digitally measured from the opening of the ear canal to the second band of the ear canal. Digital measurements include the tetrahedron and the surface triangles mesh generations from three dimensional cloud point data. The results show the statistically mean values of the various geometrical parameters of the ear canal.

1. INTRODUCTION
A hearing aid(HA) is an electronic device that people wear to listen sound voice loudly so that a hearing impairment person can listen and communicate in daily activities. There are four styles of hearing aids. The styles are Behind-the-ear (BTE), In-the-ear (ITE), In-the–canal (ITC) and Complete-in-canal (CIC). They have a earmold or earshell that is custom made from a silicon ear impression. The collected silicon ear molds are three dimensionally scanned for geometrical and morphological analysis. Korea people in general favour CIC HA which is nearly hidden in the canal. Therefore, Korean’s external ear canal model is meaningful to be made from a canal opening to a past second bend. Firstly the volume of the external ear canal may be calculated by tetrahedral volume elements from surface triangular meshes. We can get such elliptical circumferences at the opening of the ear canal, at the first bend, and at the second bend. Also we can have angles and lengths between the centre of the ear canal opening and the first bend and between the first bend and the second bend. The results show the statistically mean values of the various geometrical parameters of the ear canal about 99 Korean people.

2. EAR CANAL VOLUME CACULATION
An external ear canal, which was acquired by a silicon ear impression, was three dimensionally scanned. The digital ear canal model was generated by surface triangular meshes. An original silicon ear canal impression [2] is shown in figure 1 which was scanned and viewed in green colour. The viewed green model is the equivalent of CIC hearing aid.
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The tetrahedral volume is calculated by equation (1) [3]:

\[ V = \frac{1}{6} \det \begin{vmatrix} x_i & y_i & z_i \\ x_j & y_j & z_j \\ x_m & y_m & z_m \\ x_p & y_p & z_p \end{vmatrix} \]  

(1)

Where \( i, j, m, p \) above equation are correspond to \( i, j, m, p \) nodes in figure 2. The volume calculation is verified with 1cm x 1cm x 1cm cube shown in figure 3. The cube in figure 4 is the total volume meshed by Tetgen. The result of the total volume was 1cm³.