3D RECONSTRUCTION AND COMPARATIVE VOLUME ANALYSIS OF EAR OSSICLES FROM SERIAL MICROCTOMOGRAPHIC SECTIONS IN CHRONIC SUPPURATIVE OTITIS MEDIA

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Aims

Chronic suppurative otitis media (CSOM) is an important cause of middle ear disease with an important complication being the dissolution of the ossicular chain. The pattern and extent of the ossicular chain destruction determines the type of ossiculoplasty1. The use of high-resolution micro-computed tomography (µCT) made it possible to perform virtual instead of physical sectioning, and computer assistance facilitated the construction of reliable 3-D anatomical models. In this study, we aimed that firstly to obtain 3D anatomical models of the middle ear ossicles from reconstructed µCT scans and secondly to analyze and compare volume data of normal middle ear ossicles with the ossicles taken surgically from CSOM patients.

Method

We used 3 set cadaveric normal ossicles from the archive of the Anatomy Department, Hacettepe University Medical School and Hospital and 3 sets CSOM patients’ ossicles, which were taken from surgically removed specimens, from the archive of the 2nd ENT Clinic, Ministry of Health, Diskapi Yıldırım Beyazıt Education and Research Hospital. Before scanning process we preserved the samples in 4% formaldehyde solution. All samples were scanned using a desktop X-ray microfocus CT scanner (SkyScan 1174, SkyScan, Aartselaar, Belgium) at Hacettepe University, Faculty of Medicine, Department of Anatomy and the scanning procedure was completed using 30-50 kV X-ray tube voltage, 600-800 µa anode current with or without 0.5 mm thick aluminium filter for define X-ray spectrum. We obtained panoramic .tiff images with 0.5-2 degree rotation step, approximately 2 hour scanning time, resulting in a pixel size of 6-30 µm. These digital data were further elaborated by reconstruction and volumetric softwares (NRecon, CTAn, CTvol and CTVox).
Results

Application of the softwares to the samples was seen in Figure 1 and 2. According to our data the most affected ossicle was incus especially its long process. We detected volume reductions in malleus(9%) and stapes(13%) were approximately 10% and in incus(41%) was approximately 40% according to volume calculations seen in Table 1. These volumetric data also supported our findings and the literature quantitatively.

<table>
<thead>
<tr>
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<th>Malleus(M±SD)</th>
<th>Incus(M±SD)</th>
<th>Stapes(M±SD)</th>
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<tbody>
<tr>
<td>Normal</td>
<td>13,160±2,784</td>
<td>19,221±3,441</td>
<td>1,500±0,435</td>
</tr>
<tr>
<td>CSOM</td>
<td>12,085±1,916</td>
<td>11,312±2,654</td>
<td>1,303±0,278</td>
</tr>
</tbody>
</table>

Table 1. Volume calculations of the normal and CSOM ossicles were done by CTAN software, CSOM: Chronic suppurative otitis media.

Figure 1. Malleus(one of the ossicles) is seen in NRecon and CTAn software for reconstruction and volumetric analysis.

Figure 2. 3D anatomical model of normal and destructed incus(one of the ossicles) obtained from CTVol software.
Conclusion

MicroCT avoids significant tissue destruction and artifacts introduced during the sectioning process such as fractures, soft tissue tears, fluid, blood, or bone dust in the pneumatized spaces, variable section thickness, and wrinkling that can occur during the mounting process. Unlike histological preparations, this digital volume dataset can be reformatted in any plane allowing the operator to gain a more thorough understanding of the anatomic region being studied. 3D images generated from the dataset can be most helpful in acquiring a better appreciation for the volumetric relationships that are critical to proper surgical technique.

MicroCT scanner also provides nondestructive imaging with resolution as small as 6-10μm resolution. The first application of the micro-CT to obtain the general geometry of the middle ear bones found more clarity than with MRI.

3-D virtual model of the human temporal bone provides a teaching tool for students in the basic science and clinical disciplines that delivers realistic, interactive, anatomic information with 3-D visualization.

Our future goals are to scan all tympanic cavity with its soft tissue to understand the effects of inflammatory process to the bone destruction and use scanning electron microscopy for better understanding soft and bony tissue damage.

References: