Int. Adv. Otol. 2010; 6:(3) 337-341

ORIGINAL ARTICLE

Comparison of Reformatted Two-Dimensional Images with Three-Dimensional Reconstructions Based on Images from Multi-Detector Computed Tomography of the Temporal Bone in Surgical Candidates of Chronic Otitis Media Patients

Utku Aydil, Ali Koksal, Tuncay Ozcelik, Nuri Ozgirgin

Bayındır Söğütözü Hospital Department of Otolaryngology, (UA, TO, NO)
Bayındır Söğütözü Hospital Department of Radiology, (AK)

Objective: To evaluate benefit of three-dimensional reconstructed computed tomography images in preoperative assessment of the auditory ossicles in chronic otitis media patients.

Materials and Methods: This study was carried out in 30 ears with chronic otitis media. All cases underwent an axial multi-detector computed tomography imaging study. In addition to the axial images, sagittal and coronal multiplanar two-dimensional reformations and three-dimensional reconstructions were generated. Auditory ossicles were assessed in two-dimensional multiplanar images and three-dimensional reconstructions and compared with surgical findings.

Results: Diagnostic value of three-dimensional reconstructions were equal or lower to two-dimensional images for evaluation of the ossicular chain. Suprastructure of the stapes was difficult to visualise on the three-dimensional images.

Conclusion: Three-dimensional reconstructions are not useful in preoperative evaluation of the ossicular chain in chronic otitis media patients.

Submitted : 19 June 2010 *Revised : 11 August 2010* *Accepted : 27 August 2010*

Introduction

Ossicular chain lesions are very common in chronic otitis media patients and ossiculoplasty is an integral part of the surgical treatment in most instances. The pattern and extent of the ossicular lesions determines ossiculoplasty procedure that needs to be done with tympanoplasty. Computed tomography (CT) imaging of the temporal bone has become almost a standart procedure before chronic otitis media (COM) surgery. CT scans do not only reveal extent of the disease process in tympanic cavity and mastoid bone, but also show potential intratemporal complications and ossicular chain destruction.[1] In modern otology and radiology routine, besides axial temporal CT images, multiplanar two-dimensional (2D) reconstructions (sagittal and coronal) are widely used for better evaluation of the tympanomastoid disease process. However, detailed and complex anatomy of the middle ear makes comprehensive and accurate radiological evaluation difficult by 2D images. Therefore three-dimentional (3D) reconstructions of the data is considered to provide detailed and reliable information regarding ear structures.[2,3] Advances in imaging technology now makes it possible to reconstruct 3D images easily and automatically just in few minutes.

Although 3D visualisation of the temporal bone has been used for diagnosis, learning, teaching and treatment planning, there are only a few studies regarding its clinical benefit in ossicular chain assesment in COM patients.[4,5] Despite convenience of acquiring 3D images, this modality has not been well accepted in modern otology practice. At this point, if present, showing the benefits of 3D reconstructed images may help clinicians in preoperative evaluation of the effects of COM on ossicular chain. The aim of this study is evaluation of reformatted 2D images and reconstructed 3D images in the assesment of ossicular chain pathologies and investigate reliability and clinical usefulness of the two modalities.

Corresponding address:
Dr. Utku Aydil
Bayındır Hastanesi KBB Kliniği
06520 Söğütözü/Ankara/Turkey
Phone: +90 312 287 9000, Fax: +90 312 285 0733, E-mail: utkuaydil@yahoo.com

Materials and Methods

Twenty nine patients (16 male and 13 female, age 7-81, mean age 40.4 years) operated for chronic otitis media (COM) between July 2007 and October 2009 were included in the study. One patient had bilateral disease. Eleven of the patients had cholesteatoma at surgery. All patients had tympanoplasty with or without mastoidectomy according to the pathology. All patients underwent preoperative temporal bone multi-detector computed tomography imaging study. In all cases, the interval between the imaging and surgery was less than one month.

Radiological data acquisition and post-processing

A 16-row multi- detector computed tomography (MDCT) scanner (GE LightSpeed Pro 16; GE Healthcare, Milwaukee, Wisc., USA) was used for radiological data acquisition. MDCT image acquisition parameters were as follows: 0.625 mm effective slice thickness, 140 kV tube voltage, 335 mAs current, 0.4 s gantry rotation time, and 0.56 pitch. A field of view (FOV) of 20 cm and a matrix size of 512 x 512 was used. CT images were transferred to a workstation (ADW4.2; GE Healthcare, Milwaukee, Wisc., USA) for post-processing and evaluation. Axial, volume-rendered, and multiplanar reconstructed images (sagittal and coronal) were examined. The ossicular chain and the surrounding area was pre-selected manually in the axial two-dimensional images.

Surgical and radiological observations

All patients were operated by the same surgeon (N.O.) and the intraoperative observations regarding the integrity and destruction of ossicular chain were recorded in detail. The same experienced radiologist evaluated both the two-dimensional reconstructed images (sagittal, coronal together with axial) and three-dimentional reconstructed images (see examples in Figure 1). Both clinical and radiological evaluation of the ossicles were recorded in the same pattern. The same examination algorithm was used in all COM patients and the 3D images were compared with the reformatted 2D images and intraoperative findings in order to evaluate the diagnostic contribution of the 3D reconstructed images.

Statistics

Sensitivity, specificity, positive predictivity, negative predictivity and diagnostic value were calculated for both the reformatted 2D images and the 3D reconstructed images.

Results

In all cases, all parts of the ossicular chain could be radiologically evaluated successfully. The efficacy of the reformatted 2D images and the reconstructed 3D images for assessment of certain parts the ossicular chain is summarised in Table 1.

According to our results specificity and positive predictivity of both techniques are 100 % for evaluation of malleus, incus body and incus long process. Reformatted 2D images has also 100 % specificity and positive predictivity for evaluation of stapes suprastructure. However, specificity and positive predictivity of 3D reconstructed for evaluation of stapes suprastructure was quite low (45.8 % and 31.6 % respectively). Sensitivity of the reformatted 2D images for the evaluation of the ossicles was between 50.0 and 72.7 %, and diagnostic

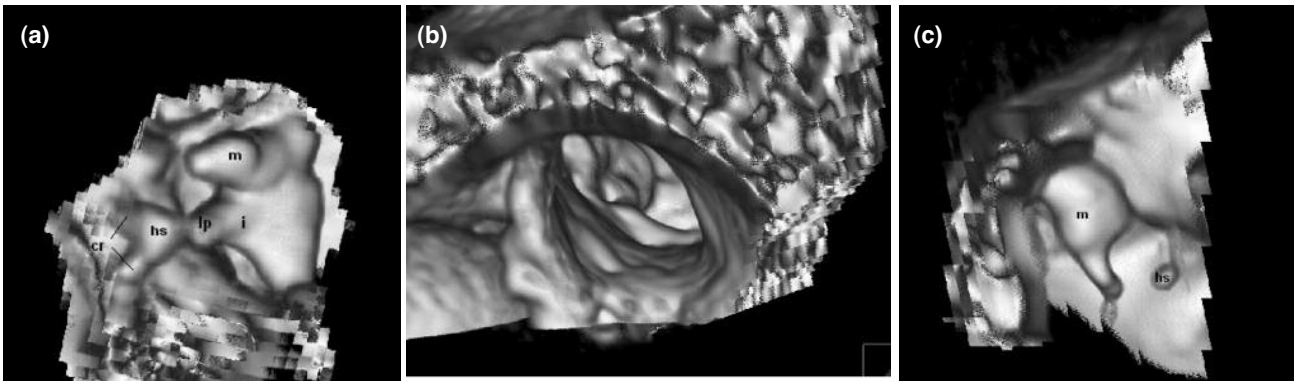

Figure 1. Examples of 3D reconstructions. **a.** Normal auditory ossicles from posteromedial point of view. **b.** Empty middle ear cavity without any ossicle in the middle ear from lateral point of view. **c.** The malleus is intact, the incus is absent, head of the stapes is visible, and crura of the stapes is not visible from lateral point of view. (m: malleus, i: incus, lp: lenticular process of incus, hs: head of stapes, cr: crura of stapes)

value of the reformatted 2D images was calculated between 90.0-93.3 %. Although sensitivity of the 3D reconstructed images for evaluation of stapes suprastructure was 100 %, the diagnostic value for stapes evaluation was quite low (56.7 %). When compared, the 2D reformatted images was equal or superior to 3D reconstructed images for evaluation of malleus, incus body and incus long process. 3D reconstructed images have high sensitivity for evaluation of stapes suprastructure but lacking specificity.

Discussion

Preoperative radiological studies are accepted as standart in many otologic and neurootologic procedures to better understand the normal anatomy and pathological changes. Among the modalities, CT is gold standart for preoperative evaluation of COM patients. A preoperative CT scan can reveal the extent of disease in COM and therefore influence the surgical approach. Besides the axial images, reformatted sagittal and coronal images are also obtained in routine clinical practice at most major medical centers.

Parallel to advances in imaging and computer technology, 3D reconstructions are advancing for clinical applications. The quality of 3D images is gradually getting better and acquisition times are becoming shorter. Opposite to more commonly used 3D reconstructed bronchoscopy, colonoscopy and angiography techniques, 3D reconstructions of the temporal bone are not widely used yet and only has attracted academic interest. The main reason for that may be the rising quality of 2D reformatted images. Many ear surgeons find 2D multiplanar images sufficient. If any value of 3D images beyond 2D images can be demonstrated, clinicians would profit from 3D reconstructions.

Various conditions of the temporal bone, such as inflammatory situations, trauma, congenital malformations, vascular anomalies and neoplastic conditions can be evaluated by 3D images.[2,6-8] Resolution of 3D images depends on the source 2D images. Generally 0.5 to 1.5 mm axial slices are used as source images however 0.2-0.3 mm thin slices may result in better resolution and reliable assessment of smaller parts of the ossicular chain may be possible. The most important limitation of 3D reconstruction is in case of soft tissue density in the middle ear cavity. Because a high contrast between structures of different attenuation value is required, cholesteatoma, fluid collection, mucosal swelling and granulation tissues make it difficult to identify ossicles on 3D images.

Several studies have been done regarding 3D reconstructions of middle ear structures and temporal bone.[2,6,9-13] In these studies, 3D reconstruction technology has been proved to be applied in teaching, learning and in many aspects of clinical use including surgical planning. However there are only a few studies regarding benefit of 3D reformatted images in preoperative assesment of ossicles in COM patients and data is very limited regarding usefulness of the 3D images. Pandey et al. reported accurate and reliable assesment of lenticular process and stapes suprastructure with 3D reconstructed images build on 0.3-mm-thick slices.[5] According to the authors 3D images are better than 2D high resolution computed tomography images in evaluation of smaller parts of auditory ossicles. Trojanowska et al reported that 3D reconstructions are useless in diagnosing middle ear inflammatory diseases and ossicular chain problems.[4] The slice thickness in this study is 0.6 mm, which is similar to ours.

Table 1. Sensitivity, specificity, positive predictivity, negative predictivity and diagnostic value of 2D reformatted images and 3D reconstructed images in evaluation of middle ear ossicles.

	2D reformatted images					3D reconstructed images				
Ossicles	**Sensitivity (%)**	**Specificity (%)**	**Positive predictivity (%)**	**Negative predictivity (%)**	**Diagnostic value (%)**	**Sensitivity (%)**	**Specificity (%)**	**Positive (%)**	**Negative predictivity (%)**	**Diagnostic predictivity (%)**
Malleus	66.7	100	100	7.7	93.3	66.7	100	100	7.7	93.3
Incus body	57.1	100	100	11.5	90.0	42.9	100	100	14.8	86.7
Incus long process	72.7	100	100	13.6	90.0	45.5	100	100	24.0	80.0
Stapes suprastructure	50.0	100	100	11.1	90.0	100	45.8	31.6	0	56.7

In this study, we have investigated potential diagnostic benefits of 3D reconstructed images in preoperative evaluation of ossicular chain in COM patients and compared with 2D multiplanar reformatted images. According to our results 3D reconstructed images does not have any additional advantage compared to the 2D reformatted images in the assessment of ossicular chain overall. The diagnostic value of the 2D reformatted images are 90 % and over according to our results for all investigated parts of ossicular chain. One of the striking points in our study is low accuracy of the 3D reconstructed images in the assessment of the stapes suprastructure. Despite high sensitivity (100 %), achieved quite low specificity value (45.8 %) for assessment of stapes suprastructure cannot be acceptable for such a preoperative diagnostic tool. There are conflicting results about this issue in previous studies. In a study by Pandey et al. stapes suprastructure was reported to be better assessed in 3D reconstructed images.[5] However as in our study, suprastructure of the stapes was difficult to visualise and evaluate on 3D images in some other studies.[7,10]

We found that the 3D reconstructed images are not superior to the 2D multiplanar images for assesment of any part of the ossicular chain. During the 3D reconstruction process, 2D data is automatically reduced so that informative quality and perfection of the 3D images may be thought as lower despite impressive appearance. Our study has some limitations. First, our study includes only 30 ears. Studies with larger series may have greater contribution to the issue. Second, our study group is heterogeneous and consist of COM patient with and without colesteatoma. Accuracy of 3D reconstructions may be variable in patients with and without cholesteatoma. Third, thinner slice thickness may increase the quality of 3D reconstructed images and may improve diagnostic power. Studies with thinner slice thickness are required to evaluate the diagnostic accuracy of 3D images.

In conclusion, our study shows that 3D reconstructed images are not superior to conventional multiplanar 2D reformatted images in assesment of auditory ossicles in COM patients when 0.625 slice thickness is used. However, by using thinner slice thickness and more advanced software reconstruction programs, 3D imaging of the auditory ossicles may have diagnostic value. Despite these improvements, 3D reconstructions may still have limitations especially in COM cases with cholesteatoma. To clarify this issue, more studies should be done in the future in homogenous patient groups with and without cholesteatoma.

References:

1. Ozgirgin ON, Çamurdanoğlu M, Akyar S, Nalca Y. High resolution computed tomography of the tempral bone in chronic otitis media. Pakistan J Otolaryngol 1989; 5: 4-13.

2. Howard JD, Elster AD, May JS. Temporal bone: three-dimensional CT. Part I. Normal anatomy, techniques, and limitations. Radiology 1990; 177: 421-425.

3. Frankenthaler RP, Moharir V, Kikinis R, van Kipshagen P, Jolesz F, Umans C, et al. Virtual otoscopy. Otolaryngol Clin North Am 1998; 31: 383-392.

4. Trojanowska A, Trojanowska P, Olszanski W, Klatka J, Drop A. How to reliably evaluate middle ear diseases? Comparison of different methods of post-processing based on multislice computed tomography examination. Acta Otolaryngol 2007; 127: 258-264.

5. Pandey AK, Bapuraj JR, Gupta AK, Khandelwal N. Is there a role for virtual otoscopy in the preoperative assesment of the ossicular chain in chronic suppurative otitis media? Comparison of HRCT and virtual otoscopy with surgical findings. Eu Radiol 2009; 19: 1408-1416.

6. Rodt T, Ratiu P, Becker H, Bartling S, Kacher DF, Anderson M, et al. 3D visualisation of the middle ear and adjacent structures using reconstructed multi-slice CT datasets, correlating 3D images and virtual endoscopy to the 2D cross-sectional images. Neuroradiology 2002; 44: 783-790.

7. Nakasato T, Sasaki M, Ehara S, Tamakawa Y, Muranaka K, Yamamato T, et al. Virtual endoscopy of ossicles in the middle ear. Clin Imaging 2001; 25: 171-177.

8. Fatterpekar GM, Doshi AH, Dugar M, Delman BN, Naidich TP, Som PM. Role of 3D CT in the evaluation of the temporal bone. Radiographics 2006; 26 Suppl 1: S117-32.

9. Jun BC, Song SW, Cho JE, Park CS, Lee DH, Chang KH, et al. Three-dimensional reconstruction based on images from spiral high resolution computed tomography of the temporal bone: anatomy and clinical application. J Laryngol Otol 2005; 119: 693-698.

10. Karhuketo TS, Dastidar PS, Ryymin PS, Laasonen EM, Puhakka HJ. Virtual endoscopy imaging of the middle ear cavity and osscles. Eur Arch Otorhinolaryngol 2002; 259: 77-83.

11. Reisser C, Schubert O, Fortsing M, Sartor K. Anatomy of the temporal bone: detailed three-dimensional display based on image data from high-resolution helical CT: a preliminary report. Am J Otol 1996; 17: 473-479.

12. Himi T, Sakata M, Shintani T, Mitsuzawa, H, Kamagata M, Satoh J, et al. Middle ear imaging using virtual endoscopy and its application in patients with osscilar chain anomaly. ORL J Otorhinolaryngol Relat Spec 2000; 62: 316-320.

13. Yamada M, Tsunoda A, Muraoka H, Komatsuzaki A. Three-dimensional reconstruction of the incudostapedial joint with helical computed tomography. J Laryngol Otol 1999; 113: 707-709.