High Resolution Multi Detector Computed Tomography of Temporal Bone: Our Experience in a Tertiary Care Service Hospital

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Abstract High resolution multi detector computed tomography (HRMDCT) is an excellent tool for evaluation of a variety of congenital and acquired conditions affecting the temporal bones. We describe our experience of HRMDCT of temporal bones of 145 patients in a tertiary care and teaching hospital of Armed Forces Medical Services of India over a period of three and half years. Hearing loss was the most frequent indication for HRMDCT and congenital bilateral profound sensorineural hearing loss for evaluation prior to possible cochlear implant formed the single largest group (62, 42%) among all indications for HRMDCT of temporal bones. Major vestibule-cochlear and semicircular canal anomalies were noted in 11 such cases. Seven patients of microtia were studied and all had positive CT scan findings. All patients of vertigo had normal HRCT study. Extent of temporal bone injuries and inflammatory conditions were clearly delineated in all cases. Thinner collimations allowing image reconstructions

in planes of anatomical interest with near isotropic resolution has been a major advantage of HRMDCT of temporal bones.

Keywords Temporal bone · High resolution multi detector computed tomography · Multiplanar reconstruction

Introduction

Temporal bone imaging has always been challenging. With the advent of computed tomography (CT), need for plain radiography and multi directional polytomography has largely been eliminated. The earlier generation CT scanners were often associated with undesirable artifacts while studying the posterior fossa structures and temporal bones. With the advent of spiral CT technology and of late multi

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Fig. 1 a, a1 Coronal oblique reconstruction along the internal acoustic canal (IAC) depicting full length of the IAC clearly. Also demonstrated is the relationship of superior semicircular canal

(SSCC), lateral semicircular canal (LSCC), vestibule and oval window. **b, b1** Coronal oblique reconstruction demonstrating cochlear turns

detector CT (MDCT) technology with improved software, there have been dramatic improvements in the overall quality of images with significant reduction of indeterminate studies [1]. With the advent of MDCT (16 slice onwards) with improved software, it is now possible to obtain multi-planar reconstructions in orthogonal as well as non-orthogonal planes with nearly isotropic resolution. This helps immensely to delineate those structures which lie in different anatomical planes (Figs. 1, 2) not suitable for only axial imaging [2, 3]. In this article, we share our experience of high resolution (HR) MDCT of temporal bones (HRMDCT-TB) over a period of three and half years.

Study Design and Setting

This is a prospective study carried out in the Department of Radiodiagnosis of a tertiary care and teaching hospital of Armed Forces Medical Services along with Departments of Otolaryngology, Head and Neck Surgery of the hospital and Armed Forces Medical College.

Materials and Methods

All subjects undergoing HRMDCT-TB from 1st Jan 2006 to 30th Jun 2009 (three and half years) formed the study group. All were serving/retired armed forces personnel and their dependants being treated as OPD or indoor patients in

our hospital. All subjects were referred for high resolution multi detector computed tomography of temporal bone (HRMDCT-TB) by otorhinolaryngologist/s. Details of patients including the clinical diagnosis and indication for HRMDCT-TB were recorded before carrying out the CT scan study. Five radiologists having adequate experience of head and neck imaging did the HRMDCT-TB studies helped by an experienced CT technician. The HRMDCT-TB studies were carried out in a 16 slice multi detector CT scan machine (Somatom Sensation 16, Siemens, Germany). Oral/intravenous sedation was given in appropriate pediatric cases to ensure motion artifact free scan. 0.6 mm axial sections were acquired in all cases using a spiral/sequential pediatric/adult protocol (120 kV, 60/100 mAs, collimation 0.75) as deemed necessary. Appropriate orthogonal as well as non-orthogonal multi-planar reconstructions were carried out in all cases. The radiologists noted their findings in every case as per the departmental protocol during day to day practice. Soft copies of report as well as HRMDCT images of each patient have been archived. At the end of the study period, archived images of each patient were reviewed and findings correlated with the initial report given to the patient. Wherever, there were disagreement between initial findings and subsequent review it was sorted out by discussing amongst radiologists and a conclusion arrived at. The HRMDCT-TB findings of all cases along with their clinical diagnoses were tabulated and analyzed retrospectively.

Fig. 2 **a, a1** Sagittal oblique reconstruction in the line of facial nerve canal shows clearly 1st genu, tympanic segment, 2nd genu and mastoid segment of the facial nerve canal. **b, b1** Sagittal oblique reconstruction in the line of SSCC depicts full curve/length of the SSCC

Fig. 3 Graphical representation of age wise distribution of patients

Fig. 4 Graphical representation of year wise distribution of patients

Results

Over a period of three and half years extending from 1st Jan 2006 to 30th Jun 2009 a total of 150 patients underwent HRMDCT-TB studies at our CT scan centre. Five patients were excluded from the study because of lack of clinical details and or unavailability of archived images. The rest 145 patients formed the study group. The youngest patient was 6 months of age while the eldest was 78 years old. Age wise distribution of patients is shown in Fig. 3. Children of 1–5 years constituted maximum numbers (52,

35.8%). There were 89 (61.3%) male and 56 (38.6%) female patients. Year wise distribution of patients is shown in Fig. 4. A gradually increasing number of cases of HRMDCT-TB cases have been noted over the study period with 32, 36, 57, and 25 cases having been carried out in the year 2006, 2007, 2008, and 2009 (up to June), respectively. HRMDCT-TB represented 1.03, 0.96, 1.52, and 1.24% of the total number of CT scan studies performed in our centre

in the year 2006, 2007, 2008, and 2009 (up to June), respectively.

Hearing loss was the most frequent indication for doing the HRMDCT-TB (87, 60%). Congenital bilateral profound sensorineural hearing loss (SNHL) for evaluation prior to possible cochlear implant formed the single largest group (62, 42%) among all indications for HRMDCT-TB. Majority of these patients were less than 5 years of age. Major vestibule-cochlear and semicircular canal anomalies were noted in 11 cases (Fig. 5). Minor anomalies and surgically relevant anatomical variations like anteriorly placed/large/dehiscent jugular fossa, lateralized internal carotid artery (Fig. 6), prominent vestibular/cochlear aqueduct, anteriorly placed mastoid segment of facial nerve, bulbous internal acoustic canal (Fig. 7), etc. were

noted in 34 cases. A case of post meningitic bilateral SNHL revealed features of bilateral labyrinthine ossificans. Nearly all patients (19 out of 20) of unilateral SNHL had normal HRMDCT-TB studies.

All seven patients of microtia had features of varying degree (mostly grade III) of auricular and ossicular dysplasia (Fig. 8). All patients of vertigo (BPPV and Episodic variety), who underwent HRMDCT-TB to rule out any evidence of post traumatic sequel, had normal HRCT study. Extent of all cases of suspected chronic suppurative otitis media and related conditions were well documented on HRMDCT. Important HRCT findings included: (a) uncomplicated otitis media—three cases, (b) cholesteatoma—seven cases, (c) ossicular erosions/destructions—four cases, (d) labyrinthine (LSCC) fistula—three cases,

Fig. 5 Cystic vestibulocochlear anomaly; axial scans at two different levels

Fig. 6 Lateralised internal carotid artery canals (white arrows): two different cases

Fig. 7 Bilateral bulbous internal acoustic canal

Fig. 8 Severe microtia. **a**, **b** Clinical photograph. Note complete atresia of EAC with anteroinferiorly displaced rudimentary ear lobule. **c**, **d** HRMDCT axial sections depict hypoplastic non-pneumatised middle ear clefts with absence of middle ear ossicles bilaterally

(e) VII nerve canal (tympanic segment) dehiscence—three cases, (f) intracranial extension—four cases, (g) mastoid abscess—one case (Fig. 9). Temporal bone fractures with associated injuries were demonstrated well in all cases. Ten

patients had undergone HRMDCT-TB in the post cochlear implant phase. One had the implant with active electrodes abutting the mastoid segment of facial nerve canal resulting in twitching of the facial muscles on activation of the

Fig. 9 Mastoid abscess. **a** Axial section (contrast enhanced, soft tissue window) shows enhancing soft tissue lesion in the region of mastoid (Lt) with associated bony destruction. Also note abnormal enhancement at the petrous apex with associated bony destructions. **b, c** HRMDCT axial (**b**) and coronal (**c**) sections clearly demonstrates the extent of bony destruction by the inflammatory process

electrodes. Another patient showed cochlear implant tip misplaced in the middle of internal acoustic canal. Most of the HRMDCT findings in the pre cochlear implant patients were corroborated with operative findings.

Discussion

Temporal bone is unique in the sense that many small yet important structures exist within with wide range of densities like cortical bone, air spaces, and soft tissues. Hence no single modality of imaging is suitable for all cases. HRMDCT remains an excellent non-invasive tool which allows depiction of exquisite detail of the bony labyrinth structures, such as, cochlea, vestibule, semicircular canals, and aqueducts of the labyrinth [1–3]. It also enables detailed evaluation of facial nerve canal, internal acoustic canal, and various anatomical details of the temporal bone including surgically relevant normal variations.

Adequate visualization of middle as well as inner ear structures by an imaging modality (CT scan/MRI) demands ability to obtain sub millimeter sections. HRCT in earlier generation CT scanners were limited by section thickness (1–1.5 mm) depending on the type and configuration of the machine. Images were also limited by presence of artifacts as well as inability to carry out suitable multi-planar reconstructions with optimum resolution. With the advent

of MDCT technology, it is now possible to obtain sub millimeter (0.5–0.6 mm) sections of the temporal bones depicting the exquisite detail of the middle and inner ear structures. HRMDCT also enables reconstructions virtually in any plane of anatomical interest with near isotropic resolution (Figs. 1, 2). This has resulted in better delineation of smaller yet important structures within the temporal bones with overall great increase in diagnostic accuracy. In today's era, a thorough knowledge of these structures is an essential prerequisite for a successful cochlear implant surgery in the appropriate candidates. HRMDCT also plays a vital role in the evaluation of post cochlear implant surgery patients besides evaluating various other disease processes involving the temporal bone [4, 5]. MRI is often complementary to HRMDCT scan in the evaluation of potential cochlear implant candidates especially for soft tissue structures like cranial nerves and membranous labyrinth (Table 1).

As noted earlier, there has been persistent increase in the usage of HRMDCT-TB during the study period of three and half years and is likely to continue in a similar fashion in near future too. Patients of congenital bilateral profound SNHL for possible cochlear implant formed the single largest group referred for HRMDCT evaluation. As expected, HRMDCT revealed a variety of major and minor anomalies including surgically relevant anatomical variations in a sizeable number of cases. These findings have

Table 1

Clinical diagnosis		No. of patients	Remarks (includes HRMDCT findings)
Hearing loss (87)	Congenital Bilateral SNHL (evaluation for possible cochlear implant)	62	Normal studies 22 Major vestibule-cochlear, semicircular canal anomalies 11 Surgically relevant anatomical variations and minor anomalies 34
	Post meningitic bilateral SNHL	1	Bilateral labyrinthine ossificans on HRMDCT
	Post traumatic bilateral SNHL	1	Normal study
	Bilateral mixed hearing loss	1	Normal study
	Unilateral SNHL	20	Normal study 19, unilateral labyrinthine ossificans 1
	Unilateral conductive hearing loss	2	Normal study
Microtia (7)	Bilateral	5	Varying degrees of auricular/ossicular dysplasia in all cases. Mostly grade III dysplasia
	Unilateral	2	
Vertigo (8)	Benign paroxysmal positional vertigo	5	Normal study
	Episodic vertigo	3	
CSOM related (18)	Bilateral	4	Positive HRCT findings in all cases, uncomplicated otitis media 3, Cholesteatoma 7, ossicular erosions 4, labyrinthine (LSCC) fistula 3, VII nerve canal dehiscence 3, intracranial extension 4, mastoid abscess 1
	Unilateral	6	
	Mastoiditis	2	
	Post operative	6	
Post head injury facial nerve palsy		8	Temporal bone longitudinal fracture with possible injury to VII nerve in all cases
Post head injury (to rule out # temporal bone)		2	Temporal bone fractures 2
Post cochlear implant		10	Normally inserted implant 8, implant abutting descending facial nerve canal 1, misplaced implant tip 1
Others (5)	Recurrent facial nerve palsy	1	Normal study
	Glomus jugulare	1	Positive HRCT
	Glomus tympanicum	1	Normal study
	Post cerebral palsy hearing loss	1	Normal study
	Recurrent osteoma (EAC) Optd	1	Post op status

helped the cochlear implant surgeons in two ways; firstly, in deciding suitability of a case for cochlear implant surgery and secondly, in planning the surgery keeping in mind particularly important anatomical landmarks and relevant anatomical variations which could affect surgical approach and outcome. At this point, it is important to note that HRMDCT-TB though extremely useful for determining the candidacy as well as surgical planning for cochlear implant, it is not a stand-alone imaging modality for the same purpose. MRI is required for evaluation of cranial nerves and higher auditory pathways before considering for cochlear implant surgery and thus both imaging modalities are complementary to each other [6].

Utility of HRCT-TB for evaluation of auricular and EAC dysplasia has been described in literature [7]. Our experience also has been similar. HRMDCT-TB studies enabled detailed evaluation of all seven patients of microtia. It has been possible to delineate the ossicular abnormality clearly which ranged from dysplastic and fused ossicles to absence of ossicles (Fig. 8). The degree of EAC atresia including thickness of the bony plate could be

accurately assessed in all cases which helped in appropriate classification of aural dysplasia. All patients of post head injury facial nerve palsy and two suspected cases of fracture temporal bones had positive HRCT scan. It was possible to accurately delineate the fracture lines, hemisinus/hemotympanum, and ossicular injuries wherever present. Out of ten patients, eight had longitudinal fracture lines and two had comminuted fractures. Probable site of facial nerve injury could be indicated in six out of eight cases. HRMDCT has been very helpful in the evaluation of suppurative otitis media and related conditions like mastoiditis (Fig. 9).

Conclusion

High resolution multi detector computed tomography of temporal bone has been found to be extremely useful for evaluation of patients of congenital bilateral profound hearing loss who are potential candidates of cochlear implant surgery. Besides, various other conditions like

microtia, trauma to the temporal bone and infective conditions of the middle ear cleft, and mastoid are accurately evaluated by HRMDCT. Because of volume imaging with a capability of thinner slices, HRMDCT will be used more and more in future.

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