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Review on Importance of High Resolution Computed Tomography (HRCT) in Chronic Otitis Media

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Abstract: ***HRCT has played a great role in understanding the complex anatomy of temporal bones. Especially in chronic otitis media it has played a pivotal role in delineating the landmarks, the extent of disease and its complications. It acts as a surgeon's roadmap in diagnosis and planning of the treatment keeping in view surgical risks and goals.***

Keywords: HRCT temporal bones, chronic otitis media, cholesteatoma

1.Introduction

With the advent of high resolution multi-slice CT scan, temporal bone pathology has become easy to understand. It is better than conventional radiological X Ray in understanding the surgical variations, extent of disease and gives a better view of structures in axial, coronal and sagittal cuts. More so it has led to better understanding of chronic otitis media with or without cholesteatoma. HRCT findings suggesting cholesteatoma include outer attic wall (scutum erosion), aditus ad antrum widening, dislocation of ossicular chain, erosion of ossicles, semicircular canal fistula, facial nerve canal (fallopian canal) erosion, tegmen plate dehiscence, mastoid destruction (auto-mastoidectomy), sigmoid plate dehiscence and external canal roof erosion and sagging. HRCT scan is useful for planning surgical approach, determining the extension and site of cholesteatoma and its sac, assessing the ossicles, evaluating the facial nerve, tegmen and sinus plate and determining dural, sigmoid sinus and jugular bulb positions. HRCT accurately depicts the boundaries between the external, middle and inner ear cavities thereby localizing the disease precisely and also greatly demarcating the thin boundary between temporal bone and intracranial compartment with exact details of intracranial spread of primary temporal bone disease.

2.Review of Literature

HRCT is most valuable for detection of early erosive changes in ossicles, particularly in smaller parts, as well as in detection of non –dependent soft tissue opacification suggestive of cholesteatoma, which is usually made on otological examination. In a prospective study conducted by Gomaa MA et al in Minia University Egypt that included 56 patients with chronic suppurative otitis media, an unsafe type who underwent full clinical examination and HRCT examination. This study showed a high incidence of cholesteatoma in the third decade of life. The scutum and lateral attic wall were the most common bony erosions in the middle ear bony wall (64.3%) and the incus was the most eroded ossicle in the middle ear (88.2%). Sclerosing of mastoid air cells were encountered in (60.7%) of the patients and lateral semicircular canal was affected in (9%), while facial canal erosion was found in (21.4%) Temporal bone complications are more common than intracranial complications. HRCT findings were compared with operative features; the comparative study included the accuracy and sensitivity of HRCT in detecting cholesteatoma (92.8%), its location and extension (96.4%), ossicular chain erosion (98%), labyrinthine fistula and intracranial complications (100%). The important role of HRCT scanning lies on early detection of cholesteatoma and more conservative surgical procedures can be used to eradicate the disease [1].

In a study conducted by Mafee et al in 1988 it was reported that in his series of 48 patients with cholesteatoma 46 of them (96%) were diagnosed correctly using preoperative HRCT scans. It also described the criteria indicating cholesteatoma as “blunting of the scutum’s normally sharp tip is often the earliest sign of attic cholesteatoma.” This study also mentioned that HRCT could demonstrate cholesteatoma in hidden areas such as post tympanic recesses, which could not be detected by the otological examination [2].

In a study conducted by Joselito et al, it was stated that signs indicating cholesteatoma in the attic include erosion or destruction of scutum and widening of aditus and antrum with loss of the appearance. Joselito et al stated that preoperative demonstration of facial nerve canal involvement was often difficult not only because of small size of facial nerve canal but also due to its oblique orientation and presence of developmental dehiscence, particularly when abutted by the soft tissue. Joselito et al reported in their series of 64 patients that the analysis of the preoperative HRCT scan correlated with the surgical findings and histopathological reports with a higher accuracy (96.8%) [3].

In a study conducted by O’Reilly et al in 1991, they found that in 36 of CSOM who underwent pre-operative CT scanning and their scans were compared with the operative findings. The results showed CT to be highly sensitive to the presence of soft tissue disease and bone

erosion, moderately sensitive to the presence of lateral canal fistulae but less sensitive to the presence of small areas of exposed dura, ossicular continuity and facial canal dehiscence. Axial scans were better able to demonstrate the lateral canal but otherwise coronal scans were superior; ideally patients should be scanned in both planes. Study concluded that the principal value of CT in CSOM is its ability to demonstrate disease which is not clinically apparent [4].

In a retrospective study conducted by Garber LZ Dort JC in 1994 on 44 patients operated on for cholesteatoma, CT compared with operative findings shows poor ability to diagnose cholesteatoma. Study concluded that CT should be used selectively in those patients presenting diagnostic dilemmas or when other concomitant pathology (i. e. complications, recurrent disease, etc.) is suspected [5].

In a study conducted by Berry S, Gandotra SC, Saxena NC published in 1998, 30 patients of unsafe chronic suppurative otitis media were subjected to preoperative CT scanning followed by surgical exploration of middle ear and mastoid and their scans were compared with the preoperative data. High resolution CT scanning has been advocated for evaluation of unsafe chronic suppurative otitis media as it is capable of delineating detail required to detect labyrinthine fistulae, facial canal erosion, sinus and dural plate erosion and ossicular integrity. It was concluded from this study that both axial and coronal scans should be done as important structures are best seen only on one of these planes. CT occasionally gives an erroneous impression of lateral canal fistula, tegmen erosion and facial erosion due to partial volume averaging of the thin bone covering of these structures with adjacent soft tissue. Abnormal soft tissue associated with bone erosion on CT is highly correlated with cholesteatoma [6].

A retrospective study conducted by Banerjee et al in 1998-2000, During the 18-month study period, 66 patients under the care of one otologist underwent temporal bone CT scanning. Of these scans, 59 were to investigate either cholesteatoma (43 patients) or tubo-tympanic disease presenting with otorrhoea refractory to medical treatment where cortical mastoidectomy might be considered (16 patients). Thirty-nine operations resulted; 33 were for cholesteatoma and six for non-cholesteatomatous CSOM. It was concluded that CT cannot reliably differentiate cholesteatoma from mastoid effusion or mucosal disease, secondary to failed ventilation. It may, therefore, underestimate the extent of the sac. It was concluded in this study that scanning was not reliable at predicting bone loss over the facial nerve and tegmen tympani. The authors conclude that CT scanning has limitations but that it is a useful adjunct to management [7].

In a study conducted in 2001 by Chee et al, the surgical findings of 36 ears with cholesteatoma operated on by the first author were retrospectively compared with the CT findings reported on by the second author. The following were analysed: diagnostic features of cholesteatoma on CT, status of the middle ear structures (ossicles, facial nerve canal, semicircular canals and tegmen tympani), and presence of any anatomical variations and disease complications. All cases had at least 1, and 30 cases (83.3%) had all of the following radiological features: (a) a non-dependent tissue mass, (b) a location typical for cholesteatoma and (c) bony erosion. The radio-surgical agreement was excellent for the malleus (kappa statistics, k=0.83), stapes (0.94) and semicircular canals (0.8), good for the incus (0.62) and tegmen (0.65), but poor for the facial nerve canal (0.3). Potential surgical hazards detected by the scans included: low lying dura, high jugular bulb, anterior lying sigmoid sinus, facial nerve dehiscence and other situations brought about by the destructive nature of the lesion [8].

In a cross-sectional study conducted on 80 patients by Gerami et al in 2000-2004 in Iran it was found that preoperative CT scan imaging in cases of mastoid cholesteatoma, tympanic cholesteatoma and ossicular erosion have moderate to good correlation with intraoperative findings (statistically significant with a 95% confidence interval). But the sensitivity and specificity of preoperative CT scan to detect facial canal dehiscence, tegmen tympani erosion and lateral semicircular canal fistula were weak and zero [9].

A prospective study was conducted in the department of otorhinolaryngology and radio-diagnosis at IGMC Shimla by Datta G, Mohan C et al in 2014.25 patients were selected whose clinical diagnosis was CSOM attico-antral type. All the cases were clinically examined; pure tone audiometry was done and duly investigated for surgery. HRCT was performed on all cases, 1mm sections in both axial and coronal planes were taken and findings recorded. All patients underwent surgery and intraoperative findings were noted. Finally, a comparison was done between HRCT and intraoperative findings. Soft tissue density mass was depicted by HRCT in all the patients and confirmed in all 25 patients i. e.100%. On HRCT malleus was eroded in 76% and incus in 80% and all these cases were confirmed per-operatively. Dural plate found to be eroded in 16% cases on HRCT but found per-operatively in 8% only. It was concluded that HRCT has significantly enhanced the preoperative evaluation of unsafe types of CSOM. This study has shown that CT imaging for CSOM accurately depicts soft tissue mass. It also effectively depicts the integrity or erosion of the dural plate, sinus plate, lateral semicircular canal and lateral cortical wall. The ear ossicles were well depicted; however, it could not effectively depict the integrity or erosion of facial nerve canal and more so the status of stapes.

It was concluded from the study that computed tomography despite its pitfalls such as more radiation exposure and higher cost delineates the location and extent of the disease and provides information on anatomical variations and complications. It serves as a roadmap to assist the surgeon during surgery [10].

In a study on 35 patients with cholesteatoma at Shree Sayajirao General Hospital and medical college Vadodara, HRCT showed 100% non-dependent homogeneous soft tissue in the middle ear cavity. The soft tissue was extending in aditus ad antrum (85.6%), mastoid antrum (82.9%), external auditory canal (31.4%), extra temporal

soft tissue (14.3%), Eustachian tube (2.9%), labyrinth (5.7%) and internal auditory canal (2.9%). Erosion of the long process or body of incus was seen in 85.7% of cases (90% sensitivity and 66 % specificity) and the long process of malleus eroded in 45.7% cases (81.3% sensitivity and 94.1% specificity). Stapes supra-structures couldn't be visualized in 11 cases 31.4% which were considered to be eroded (80% sensitivity and 95.7% specificity).22.9% cases of the facial nerve canal were found to be eroded and the tympanic segment was most commonly affected. Only 1 case showed erosion of the mastoid part of the facial nerve canal.

Erosion of the lateral semicircular canal was seen in 22.9% cases (sensitivity of 85.7% and specificity of 96.1%). Erosion of the superior semicircular canal was seen in 5.7% cases (sensitivity specificity of 100%). Cochlear erosion was seen in 5.7% cases, vestibule erosion in 11.4% and internal auditory canal erosion in 2.9% cases all with 100% sensitivity and 100% specificity.8.6% cases had cerebral /cerebellar abscess out of one had temporal abscess and two had cerebellar abscess. Lateral semicircular canal is the most commonly affected canal by cholesteatoma as in this study. In all patients with middle ear disease, this area should be carefully evaluated on both axial and coronal images for cortical thinning. The diagnosis of the fistula is made when the mass is seen in direct opposition to the lumen of the labyrinth. HRCT clearly depicts bone erosion even in the absence of fistula which helps surgeon intra-operatively in careful resection of cholesteatoma to prevent labyrinthine fistula [11].

COM can be at times life-threatening and warrant that all otolaryngologist surgeons be familiar with the standard approach to these patients. Advent of HRCT and improvements in radiological technique has definitely improved study of the temporal bone in patients with COM, which includes evaluation of the extent and sites of involvement and inter-relationships of tympano-mastoid compartment with adjacent neurovascular structures. This was concluded in a study conducted by the department of ENT in Mysore Medical College. Study showed that HRCT has got high reliability for the parameters such as scutum erosion, ossicular erosion, mastoid pneumatization, low lying dura, anterior lying sigmoid, korner's septum, cholesteatoma extension in the middle ear and mastoid and presence of complications such as mastoiditis and mastoid abscess, mastoid cortex dehiscence, sigmoid sinus plate erosion, facial canal, dehiscence, tegmen mastoideum erosion and labyrinthine fistula and intracranial complications 13 with a $p<0.05$ but unreliable for tegmen tympani and post fossa dural plate erosion. This study concludes that HRCT is recommended not only in cases suspected with potential complications but also in all cases of COM to know the extent of disease, varied pneumatization and the presence of anatomical variations, which should alert the clinician and guide in surgical approach and treatment plan [12]. HRCT offers excellent spatial and density resolution using special algorithms. It provides information not only about bony outline but also soft tissue changes making it possible to demonstrate the location and extent of disease as well as its complications. Furthermore, coronal and axial CT scanning together has dramatically improved the imaging of temporal bone. HRCT accurately depicts the boundaries between the external, middle and inner ear cavities thereby localizing the disease precisely and also greatly demarcating the thin boundary between temporal bone and intracranial compartment with exact details of intracranial spread of primary temporal bone disease. Contrast media help to evaluate the vascularity and contrast enhancing characteristics particularly in soft tissue lesions of temporal bone giving clues to the histopathology.

In a retrospective study carried out on 334 patients with cholesteatoma who had been operated on for chronic otitis media in Izmir Katip Celebi University, Ataturk Research and Training Hospital, Ear, Nose, and Throat Clinic between April 1997 and April 2010, the incidence of facial canal dehiscence was found to be 23.6% and it was localized most commonly in the tympanic segment. The incus was the ossicle destroyed most commonly. The incidence of facial canal dehiscence was significantly higher in patients with LSCC fistulas, the presence of EAC in the posterior wall and stapes destruction. Identification of such findings before the operation may be considered a warning of the presence of facial canal dehiscence because of the facial canal dehiscence was not adequate determination in computerized tomography of temporal bone [13].

A study was conducted at Govt. ENT hospital Hyderabad in 2011 by Sirigiri R, Dwarakanath K. et al with selected 25 patients whose clinical diagnosis was CSOM attico-antral disease, all of them underwent surgery. Out of the 25 patients 14 were males and 11 were females.15 of them were between 20 and 40 years of age, six of them were less than 20 years age and four of them were more than 40 years age. Patients presented with a wide spectrum of symptoms like otorrhoea, hearing loss, earache, tinnitus, post aural abscess and vertigo. On examination we found postero-superior granulations, attic perforations, polyp, posterior canal wall sagging and cavity with granulations. Preoperative CT Scan could diagnose non-dependent soft tissue density mass in 23 of the 25 cases (92%), with two false positive and one false negative interpretation. On the whole CT was 92% sensitive and 66% specific in identifying soft tissue density mass. CT was 100% sensitive for cholesteatoma in pro-tympanum, posterior tympanum, hypotympanum and peri-labyrinthine cells and sensitivity varied from 95 to 86% for other regions. CT was 100% specific for cholesteatoma in epitympanum and mastoid air cells and specificity varied from 86 to 66% for other regions [14].

In a prospective correlational study conducted from (January2014 to December 2016) on 40 patients with clinically suspected chronic suppurative otitis media with cholesteatoma at Shridevi Institute of Medical Sciences & Research Hospital, Tumkur, Karnataka HRCT findings of 40 patients with CSOM with cholesteatoma were compared with operative findings. With the help of HRCT status of the middle ear structures (ossicles, scutum, facial nerve canal and tegmen tympani), semicircular canals and sigmoid plate were assessed and compared with operative

findings. Correlation between radiological and intra-operative findings was calculated. A good radio surgical correlation is seen in CSOM with cholesteatoma for status of most middle and inner ear structures except for the integrity of the facial canal. A poor radio-surgical correlation was observed for differentiating cholesteatoma from chronic mucosal thickening as the underlying pathology in cases with CSOM. HRCT was found to be sensitive in detecting erosions of incus (85%), stapes (82.3%), scutum (91.67%), sigmoid plate (100%) and mastoid cortex (100%) whereas less sensitive in erosions of malleus (68.75%), tegmen (32.6%), semicircular canal (71.4%) and facial canal (53.3%).100% specificity was obtained for erosions of malleus, incus, scutum, sinus plate and mastoid cortex whereas it was relatively less specific for erosions of facial canal (84%) and tegmen (81%) [15].

In a prospective study conducted by Sharmila D et al, at tertiary care hospital in Guntur between 2015 and 2016 in the Department of ENT, on 60 patients of CSOM with attico-antral disease, it was concluded that in diagnosing Cholesteatoma, HRCT was found to be very sensitive (96%) but it could not differentiate cholesteatoma from granulations and hence was less specific (87%). HRCT scan diagnosed erosion of malleus with 100% sensitivity and 98% specificity. Commonest overall ossicular pathology is erosion of incus in 56 patients (93%) with next erosion of handle of malleus in 20 patients (33 %,) followed by erosion of head of malleus in 16 patients (27%), least ossicular pathology seen is stapes erosion in 12 patients (20%). HRCT scan diagnosed erosion of malleus with 100% sensitivity and 98% specificity. Diagnosis of erosion of incus was made with 91% sensitivity and 100% specificity and that of erosion of stapes with 67% sensitivity and 100% specificity. HRCT showed inconsistent visualization of stapes in this study and has less sensitivity for detecting erosive changes of stapes, hence more cases were found with normal ossicles in CT compared to per-operative findings [16].

In prospective study conducted by Khavasi P et al in the department of ENT & HNS, SNMC & SHKH, and RC Bagalkot during June 2016 to September 2017. Total 40 cases were selected who were diagnosed as chronic suppurative otitis media attico-antral disease. All the cases were clinically examined, Pure Tone Audiometer done. HRCT is done for all cases. All the cases underwent surgery and intraoperative findings were noted. HRCT showed non-dependent soft tissue density ranging from 30-40 HU to 60-70 HU involving middle ear, attic and mastoid in all cases 40 (100%). In total 40 cases retraction pocket in 2 cases (5%), granulation tissue in 4 cases (10%). Cholesteatoma 18 (45%) and both granulations and cholesteatoma 16 cases (40%). HRCT couldn't distinguish soft tissue mass as granulations and cholesteatoma. HRCT showed erosion of LSCC in 2 cases but intra-op we had 4 cases with erosion of LSCC thus showing sensitivity only 33% and specificity 48%. HRCT showed erosion of malleus in 34 (85%) cases. But during surgery only 22 (55%) cases had partial erosion. HRCT showed erosion of incus 36 (90%) cases, but intra-op 36 (90%) cases had partial or total erosion of incus. On HRCT stapes erosion was found in 34 (85%) cases and intraoperatively only 18 (45%) cases had erosion and only superstructure was eroded in all cases [17].

In a prospective study conducted by Chavada PS et al on 100 cases of chronic suppurative otitis media of unsafe type requiring ear surgery admitted in the E. N. T. department of P. D. U. Civil Hospital Rajkot in 2 years from December 2015 to December 2017, it was concluded that most of the patients were having ear discharge (98%) and reduced hearing (83%) as chief complaints.52% were having ear ache and 29% were having giddiness.9% had facial asymmetry and 11% had associated nasal blockage. At surgery, cholesteatoma was present in 82 out of 100 patients (82%). There were 76 patients (73.91%) in whom the cholesteatoma was predicted correctly by the CT scan and 17 patients (98.70%) where it was excluded correctly. In one patient (2%) it was excluded by CT scan but was present at surgery. It was concluded that the sensitivity of the scan in detecting cholesteatoma is 98.70%, specificity is 73.91%, positive predictive value is 92.68% and negative predictive value is 94.44%. Ossicular chain erosion was present in 89 out of 100 patients. Erosion was also reported on 89 of the100 CT scans. There were 11 patients in whom the ossicular chain was intact in both CT as well as during surgery. Hence the sensitivity of the scan in detecting ossicular chain erosion is 100%, specificity is 100%, positive predictive value is 100% and negative predictive value is 100%. It was also concluded from the study that the sensitivity of the scan in detecting semicircular canal dehiscence is 78.94%, specificity is 87.65%, positive predictive value is 60% and negative predictive value is 94.66% [18].

3.Discussion

Almost all studies confirm that CT is increasingly the imaging study of choice for definitive preoperative temporal bone imaging. High resolution Computed Tomography (HRCT), a modification of routine CT provides a direct visual window in the temporal bone providing minute structural details. HRCT accurately depicts the boundaries between the external, middle and inner ear cavities thereby localizing the disease precisely and also greatly demarcating the thin boundary between temporal bone and intracranial compartment with exact details of intracranial spread of primary temporal bone disease. HRCT has got high reliability for the parameters such as scutum erosion, ossicular erosion, mastoid pneumatization, low lying dura, anterior lying sigmoid, korner's septum, cholesteatoma extension in the middle ear and mastoid and presence of complications such as mastoiditis and mastoid abscess, mastoid cortex dehiscence. CT finding indicating cholesteatoma as "blunting of the scutum's normally sharp tip is often the earliest sign of attic cholesteatoma." It is also helpful in detecting cholesteatoma of hidden areas like sinus tympani and facial recess. Among ossicles it is more reliable to detect incus and malleus erosion, but studies also point towards its limitation for stapes bone. Studies also point towards its limitation to distinguish between granulation and cholesteatoma. A poor radio-surgical correlation was observed for differentiating cholesteatoma

from chronic mucosal thickening as the underlying pathology in cases with CSOM. CT occasionally gives an erroneous impression of lateral canal fistula, tegmen erosion and facial erosion due to partial volume averaging of the thin bone covering of these structures with adjacent soft tissue. Yet it gives prior information regarding potential surgical hazards like low lying dura, high jugular bulb, anterior lying sigmoid sinus and facial nerve dehiscence. The decision whether to do an open or closed cavity operation depends on the degree of pneumatization and ventilation of the temporal bone and extent of disease, all of which can be determined on HRCT. Axial as well as coronal images are needed for preoperative evaluation and should always be in the operating theatre and visible to the surgeon as intraoperative reference. Patients with cholesteatoma should be scanned in both axial and coronal planes as many relevant structures are best seen in only one of these planes. The use of single plane may lead to mistakes because the structures parallel to the plane of section are not visualized.

4.Conclusion

HRCT of temporal bone plays a promising role in pre-operative assessment of cholesteatoma as it depicts the extent of the disease and integrity of most of the middle ear structures. Abnormal soft tissue associated with bone erosion on HRCT is highly correlated with cholesteatoma. HRCT scanning is a unique method of detecting the early cholesteatoma as well as detection of cholesteatoma in hidden areas like sinus tympani and facial recess. As the scan alerts the surgeon to potential surgical dangers and complications of disease, advising patients a routine HRCT prior to surgery can be justified. It can predict the outcome of the surgery and also helps in discussing these possibilities with the patient. Patients with cholesteatoma should be scanned in both axial and coronal planes as many relevant structures are best seen in only one of these planes. HRCT gives a good idea about the dehiscence of the semi-circular canal. Thus, it warns the surgeon to take more care during the surgery. To conclude HRCT of temporal bones is a roadmap for otologists.

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