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ORIGINAL ARTICLE

Sensitivity and Specificity of High-Resolution Computed Tomography (HRCT) of Temporal Bone in Diagnosing Cholesteatoma and Its Correlation with Intraoperative Findings

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Abstract High resolution computed tomography (HRCT) of temporal bone helps in understanding the complex anatomy of temporal bone and in identifying disease in temporal bone. However, its role in diagnosing cholesteatoma and analyzing its extent and complications is not established unequivocally. Present study was undertaken to check sensitivity and specificity of HRCT in diagnosing cholesteatoma and assessing its extent and in identifying ossicular destruction and other complications. In this prospective study in 50 patients with clinical diagnosis of cholesteatoma, preoperative high-resolution temporal bone CT scans axial and coronal view were carried out and compared with intra-operative findings. Kappa statistics was used for radio-surgical correlation. Comparison of CT scan findings with intraoperative findings revealed perfect correlation for sigmoid plate erosion, mastoid cortex dehiscence and scutum erosion, strong correlation for erosion of malleus, posterior superior wall and peri labyrinthine cells, good for erosion of incus and stapes, labyrinthine fistula, tegmen erosion and extent of disease and moderate correlation for facial canal dehiscence. HRCT scan of the temporal bone is useful preoperative investigation for cholesteatoma surgery for identification and documentation of ossicular status, location and extent of disease, erosion of tegmen or sinus or labyrinthine dehiscence, with the exception of facial canal dehiscence. Although it serves as road map for surgery, it still has some false positives and false negatives and the importance of a skilful, aware and alert surgeon cannot be overemphasized.

Keywords Cholesteatoma · High resolution computed tomography (HRCT) · Temporal bone · Middle ear

Introduction

Cholesteatoma is a potentially serious condition as it can progressively enlarge and erode into neighbouring structures, giving rise to bony destruction, hearing impairment, grave extra cranial and intracranial complications like facial nerve paralysis, labyrinthine fistula, brain abscess and meningitis [1]. It is more often acquired than congenital, recognised clinically and radiologically.

Barring any medical contra-indication, treatment of suspected cholesteatoma is by surgical exploration and eradication of disease with a tympanomastoidectomy operation [2].

As compared to sinus surgery whereby routine pre-operative computed tomography (CT) scan is widely accepted as standard practice, the need for pre-operative imaging studies for cholesteatoma is somewhat debatable. Even amongst experienced otologist, there is no consensus for the need of CT scan in uncomplicated cases [3].

The advent of high-resolution computed tomography (HRCT) has significantly altered the contribution of radiological imaging in the pre-operative diagnosis of cholesteatoma of middle ear cleft. It not only displays internal bony architecture of skull base, but also detects the associated soft tissue pathology and the progress of disease,

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which helps in deciding the approach to surgery and also foresee the expected intraoperative and post-operative complications [4]. However, HRCT cannot always be relied to detect the entire extent of disease due to difficulties in diagnosing cholesteatoma from co-existing granulation tissue, mucosal oedema or effusion [5].

Various studies conducted to assess utility of preoperative HRCT temporal bone in identifying presence of cholesteatoma and its complications and defining the extent of disease have shown some conflicting findings with widely differing sensitivity and specificity in diagnosing cholesteatoma, ossicular erosion, complications, and bony dehiscence [6–9]. As such there is a need for further studies on usefulness of preoperative HRCT temporal bone. Present study was undertaken to check sensitivity, specificity and kappa correlation of HRCT in diagnosing cholesteatoma and assessing its extent as well as identifying ossicular destruction and other complications.

Materials and Methods

In this prospective study conducted over 2 years (June 2016–May 2018), 50 cases of cholesteatoma were recruited by convenience sampling. Patients with history of previous ear surgery or history of radiotherapy to head-neck, malignancies of temporal bone, and systemic diseases like granulomatous diseases which may involve ears, were excluded. Institutional Ethical clearance was obtained.

All 50 cases were evaluated by detailed history and examination, and HRCT scan of temporal bone in both axial and coronal sections followed by ear exploration surgery. Patients were explained about the procedure and written informed consent was taken. All findings on HRCT and Intraoperative cases were noted and tabulated.

HRCT Temporal Bone scan without contrast (axial and coronal) was done by "SEIMENS SOMATOM Single slice CT scanner" in axial and coronal view, with slice thickness—1 mm, KV—120, MA—200, scan time—1.5 S, section spacing (interval) 1 mm, mode—Bone Algorithm, Window width (extended) 4000HU, window level—3000, collimation—1.5 mm. The interpretations were done by an expert head-neck radiologist.

Ear exploration surgery was conducted with Zeiss Movena microscope and Medtronic drill. Cholesteatoma was followed by inside out technique and intraoperative findings were noted in detail. The findings during surgery were recorded by the otolaryngologist surgeon and tabulated. Correlation between findings of HRCT scan of Temporal bone and intra operative findings was explored. Intra-operative findings were regarded as gold standard for determination of sensitivity, specificity of HRCT scan for various parameters. Criteria proposed by Liu and Bergeron [10] were used to diagnose cholesteatoma on HRCT which include erosion of scutum, widening of the additus ad antrum, destruction of ossicles, labyrinthine fistula, facial canal erosion, dehiscence of tegmen tympani, sigmoid plate erosion and erosion of posterior superior wall.

Data was analysed using software package -Statistical Package for Social Sciences (SPSS). Statistical method of kappa was used to assess radio-surgical correlation for various study parameters. Kappa value Interpretation: Exceeding less than 0 indicates less than chance agreement, 0.2–0.4 fair, 0.4–0.6 moderate, 0.6–0.8 good, 0.8–0.9 strong, 1 almost perfect agreement.

Results

This study covered 50 patients in which 29 were males (58%) and 21 were females (42%). The percentage of positive surgical findings for ossicles erosion i.e., malleus, incus and stapes was 46%, 76% and 28% respectively. Erosion of scutum (68%) and aditus antrum widening (94%) was noted during surgery.

The percentage of positive findings of temporal bone CT Scan included soft tissue mass in mastoid air cells (58%). Ossicular erosion i.e. malleus (42%), incus (70%), stapes (34%), scutum erosion (68%) and additus ad antrum widening (94%). The greatest precision of CT scan in study was in detecting sigmoid plate erosion (100%). Widening of additus ad antrum (94%) and scutum erosion (100%).

The results based on age and sex distribution are given in Tables 1 and 2. Percentage of complications of Cholesteatoma on HRCT is shown in Fig. 1.

Table 1 Age distribution of cholesteatoma

Age group	Count	Percentage (%)
0–10	2	4.0
10–20	14	28.0
20–30	18	36.0
30–40	6	12.0
40–50	6	12.0
50–60	3	6.0
60–70	1	2.0
Total	50	100.0

Table 2 Sex distribution of cholesteatoma

Sex	Count	Column N (%)
Female	21	42.0
Male	29	58.0
Total	50	100.0

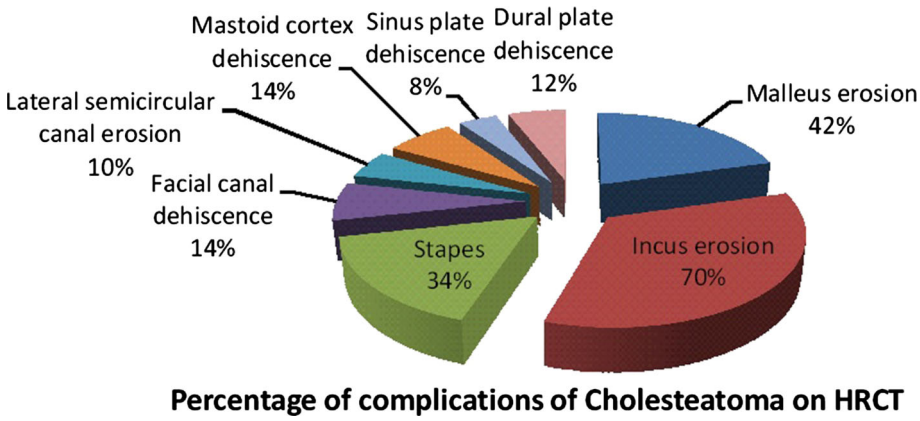

Fig. 1 Complications of cholesteatoma on HRCT

Table 3 Sensitivity, specificity, kappa correlation of HRCT temporal bone with intraoperative findings of cholesteatoma

Structure	Sensitivity	Specificity	Kappa	Correlation
Malleus	94	100	0.9	Strong
Incus	86	84	0.65	Good
Stapes	80	85	0.63	Good
LSCC erosion	100	95	0.73	Good
Facial canal dehiscence	55	95	0.55	Moderate
Tegmen plate erosion	100	95	0.77	Good
Sigmoid sinus erosion	100	100	1	Perfect
Mastoid cortex dehiscence	100	100	1	Perfect
Auto mastoidectomy	100	100	1	Perfect
Scutum	100	100	1	Perfect
PSW erosion	85	100	0.89	Strong
Protympanum	100	84	0.7	Good
Mesotympanum	97	65	0.64	Good
Posterior tympanum	95	73	0.68	Good
Epitympanum	97	100	0.79	Good
Antrum	100	66	0.64	Good
Additus	97	66	0.64	Good
Mastoid air cells	100	90	0.74	Good
Peri-Lab cells	100	97	0.9	Strong

LSCC lateral semicircular canal, *PSW* posterior superior wall

Table 3 shows sensitivity, specificity and kappa values for different CT findings. The greatest radio surgical correlation was in sigmoid plate erosion, scutum erosion and mastoid cortex dehiscence. Kappa was equal to 1 in all the three parameters in all of the above.

The lowest surgical correlation was in facial canal dehiscence (k = 0.55) with moderate agreement and stapes erosion in second place with k = 0.63.

HRCT scan accurately predicts extent of disease and is helpful for detection of lateral semicircular canal erosion, erosion of dural plate and ossicular erosion. However, the technique is unable to distinguish between cholesteatoma and mucosal disease, facial canal dehiscence, incus and stapes erosion in early stages.

Discussion

For diagnosing cholesteatoma, otoscopic recognition is fundamental. However imaging modalities are increasingly being used on patients suspected of harbouring cholesteatoma to look for gross or subtle changes in temporal bone, extent of disease and presence of any complications. CT is sensitive for detection of early bone erosions, assessing extent of cholesteatoma and provides information that may affect the surgical resection. CT is helpful in assessing extent of cholesteatoma by detailed study of soft tissue mass and bone erosion, with 80% specificity [5].

The present study explored the advantage of temporal bone HRCT scan in the detection of mastoid cholesteatoma and ossicular chain erosion as also in diagnosing complications due to bone erosions. HRCT was used instead of conventional CT as it has already been shown to have better diagnostic value than conventional CT [11].

Cholesteatoma could be accurately diagnosed by HRCT scan in the vast majority of cases. The presence of soft tissue with expansile effect and erosion of adjacent bony borders of part or all of middle ear cleft was considered diagnostic. Mafee et al. [12] reported in his series of 48 patients with cholesteatoma that 46 of them (96%) were diagnosed correctly with the pre-operative CT scan. All our cases exhibited at least 1 of the radiological features that were associated with cholesteatoma, i.e. *tissue mass, typical location and bone erosion*, and 43 cases (86%) had all the 3. Our study demonstrated exceptional correlation between preoperative imaging, and surgical findings in cholesteatoma cases. The 1 mm thickness slices in axial and coronal plane showed excellent contrast between bone, air and soft tissues.

As with several similar studies, CT findings such as soft tissue mass, ossicular and scutum erosions was excellent.

However it was not possible to detect fallopian canal by imaging with CT scan as precisely as in other studies.

There was excellent correlation seen between temporal bone HRCT scans with surgical findings, as regards additus widening (k = 1), sigmoid plate erosion(kappa statistics, k = 1), mastoid cortex erosion(k = 1), scutum (k = 1), good for the tegmen erosion (k = 0.77), strong for malleus erosion (k = 0.9), good for incus erosion (k = 0.65), stapes erosion (k = 0.63) and lateral semicircular canal erosion (k = 0.73), but moderate for facial canal dehiscence (k = 0.55).

The radio-surgical correlation was also good for extension of diseases in protympanum, mesotympanum, posterior tympanum, epitympanum, additus and antrum. HRCT showed strong correlation erosion of posterior superior wall (k = 0.89) and peri labyrinthine cells (k = 0.9).

Rocher and colleagues revealed excellent correlation for the scutum, the horizontal semicircular canal (> 0.7), and the tegmen (0.77), and poor correlation for the facial nerve canal (< 0.5) [13].

As observed by Rogha et al. [14] in their study, we too observed a correlation between fallopian canal erosion and labyrinthine fistula with both coexisting in some cases. As such presence of one should alert the surgeon to look for the other with a view to avoid any iatrogenic trauma. Assessment of preoperative dehiscence of site and size of facial canal, enables exercise of caution by the surgeon during exploration of middle ear cleft. On CT it is difficult to diagnose any dehiscence in vertical part of facial canal because of close relationship of inflamed mastoid air cells with facial nerve, or soft tissue. This imposes a limitation on CT in detecting facial canal dehiscence. Gerami et al. [15] in their study too reported a weak kappa value between pre-op CT and intra operative findings for FND.

The relatively acceptable radio surgical correlation for stapes erosion observed may be the result of 1 mm slice thickness used in this study as warranted by small size of stapes bone. Some studies which have used 2–3 slices of temporal bone CT scan to detect stapes status have reported lesser correlation [11]. Employing finer cuts in high resolution can improve detection of findings with low specificity resulting from partial volume effect. Gerami et al. and Singh et al. in their studies had moderate to good correlation for ossicular erosion [15, 16].

Reddy et al. in their study, stated that CT is most accurate in diagnosing destruction of sinus plate with high sensitivity and specificity which matched with present study [4].

Overall, HRCT temporal bone is useful in preoperative detection of cholesteatoma and delineation of its extent and presence of any complications. However CT scan is not without limitations for interpreting soft tissue in mastoid and as such cholesteatoma sac, associated granulation tissue, mucosal oedema and effusion may be indistinguishable [5, 12]. Although cholesteatoma has supposedly lower attenuation than granulation tissue, the difference often is subtle and only magnetic resonance imaging can differentiate the two.

In summary, our study highlights the valuable role of HRCT in diagnosis and preoperative planning of surgery for cholesteatoma, thereby improving its surgical management.

Conclusions

- HRCT scan of the temporal bone is a useful preoperative investigation for cholesteatoma surgery for successful identification and documentation of ossicular status, location and extent of disease, erosion of tegmen or sinus or labyrinthine dehiscence. However, its not so useful for detecting facial canal dehiscence.
- Although it serves as roadmap for surgery, high levels of false positive and false negative prevent wholesome reliability on HRCT. A skilful, aware and alert surgeon still remains the lynchpin of successful diagnosis and surgical treatment of cholesteatoma.

Author Contribution SM, YD, SB: Study idea and design. SM, YD, NC, AS: Data acquisition. SM, YD, SB, HV, NC: Data analysis. SM, YD, SB, HV, NC, AS: Manuscript. SM, YD: Critical review of the manuscript. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest The authors declare that there were no conflicts of interests whatsoever in the conduct or writing of this research.

Ethics Approval Institutional Ethical Clearance was obtained for the study.

Informed Consent Informed consent was obtained from all participants.

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