The Value of Pre-operative High Resolution CT Scans in Cholesteatoma Surgery

N W C Chee, T Y Tan

ABSTRACT

Introduction: Cholesteatoma is traditionally diagnosed by otoscopic examination and treated by explorative surgery. The need for imaging in an uncomplicated case is contentious. This study assesses the usefulness of a pre-operative high-resolution CT scan in depicting the status of the middle ear structures in the presence of cholesteatoma.

Materials and Methods: 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.

Results: 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.

Conclusion: There is good to excellent radio-surgical correlation in cholesteatoma for most middle ear structures except for the integrity of the facial canal. The scan alerts the surgeon to potential surgical dangers and complications of disease. High-resolution CT scan is an important investigative tool prior to cholesteatoma surgery.

Keywords: mastoidectomy, ossicles, facial canal, labyrinthine fistula

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INTRODUCTION

Cholesteatoma is a sac of keratinising squamous epithelium in the middle ear cleft. The lesion is classically recognised by the presence of attic squames on otoscopic examination. The presence of cholesteatoma must also be suspected beneath polyps protruding from the pars flaccida or when there is a marginal tympanic membrane perforation or granulation. Cholesteatoma is a potentially serious condition as it can progressively enlarge and erode into neighbouring structures, giving rise to serious intracranial and extracranial complications. Barring any medical contra-indications, treatment of a suspected cholesteatoma is by surgical exploration and eradication of disease with a tympanomastoidectomy operation.

Unlike the situation with endoscopic sinus surgery whereby routine pre-operative CT scan is widely accepted as standard practice, the need for pre-operative imaging studies for cholesteatoma is controversial. Even amongst experienced otologists, there is no single accepted standard for the need of CT scan in uncomplicated cases[(1)].

The advent of high resolution CT scans (HRCT) has brought about significant enhancement in the pre-operative assessment of temporal bone pathology and fine anatomical details[(2)]. The intent of this study is to evaluate the accuracy and the usefulness of this imaging modality in our patients undergoing surgery for cholesteatoma.

METHODOLOGY

We assessed 40 consecutive ears with acquired cholesteatoma operated on by the first author between August 1994 and September 1998. 4 patients did not have CT scans and were excluded from the study, leaving 36 cases for evaluation.

The CT scans of the temporal bones were all performed in the Department of Radiology at Tan Tock Seng Hospital. The technique used had been described in a previous paper[(2)]. Cases scanned between August 1994 and July 1995 had axial and coronal plane slice thickness of 2 mm with an overlap of 1 mm. After July 1995 the scans were done in 1.5 mm contiguous slices.

Department of Otolaryngology
Tan Tock Seng Hospital
11 Jalan Tan Tock Seng
Singapore 308433

N W C Chee, FRCS (Edin), FRCS (Glasg), FAMS (ORL)
Consultant

Department of Radiology
Changi General Hospital
2 Simei Street 3
Singapore 529889

T Y Tan, MBBS, FRCR (UK), FAMS (Radiology)
Consultant

Correspondence to:
Dr Nelson Chee
Email: nelson_chee@notes.ttsh.gov.sg

Table 1. Correlation of operative findings with radiological features.

	Surgical findings	Radiological findings: Intact	Radiological findings: Abnormal*	Kappa
Malleus :	Intact	19	2	**0.83**
	Eroded	1	14	
Incus :	Intact	3	2	**0.62**
	Eroded	1	30	
Stapes :	Intact	23	1	**0.94**
	Absent	0	11	
Facial canal :	Intact	25	2	**0.30**
	Dehiscent	6	3	
Labyrinth :	Intact	29	1	**0.80**
	Fistula	1	5	
Tegmen :	Intact	34	1	**0.65**
	Eroded	0	1	

* refers to erosion of malleus and incus, absence of stapes suprastructure, dehiscence of facial canal, semicircular canal fistula or dehiscence of tegmen.

The pre-surgical HRCT scans were retrospectively assessed, by the second author, for the following radiological features of cholesteatoma: (a) the presence of a non-dependent tissue mass, (b) location of the pathology in a position typical for cholesteatoma, i.e. the epitympanum and mastoid antrum, and (c) presence of bony or ossicular erosion. In addition, being blinded to the surgical findings, the second author was asked to comment on the state of the ossicles (malleus, incus and stapes), the integrity of the facial canal, semicircular canals and the tegmen tympani, and any anatomical variations and disease complications that were present. The operative findings were reviewed retrospectively and compared with the radiological findings.

Kappa statistics was used to measure the degree of agreement between surgical and radiological findings. Kappa values exceeding 0.75 represented excellent agreement, values between 0.4 and 0.75 fair to good agreement, and values less than 0.4 poor agreement.

RESULTS

The HRCT scans showed the presence of a non-dependent tissue mass in 30 of the 36 cases (83.3%). The location of the pathology on the scan was typical for cholesteatoma in 35 cases (97.2%), and in 34 cases (94.4%) there was radiological evidence of destruction of the bony walls of the middle ear, mastoid antrum or ossicles. All cases had at least 1 of the above radiological features, and 30 (83.3%) cases showed all 3 features.

The radio-surgical correlation of the middle ear structures is shown in Table I. The correlation was found to be excellent for the malleus, stapes, and semicircular canals, good for the incus and tegmen tympani, but poor for the facial nerve canal.

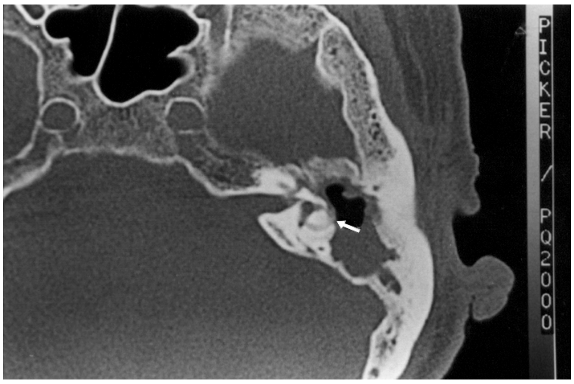

Fig. 1 Axial scan showing erosion of the lateral semicircular canal (arrow).

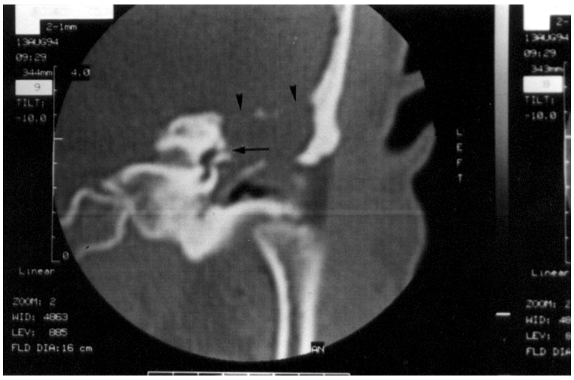

Fig. 2 Coronal section showing fistula of the lateral semicircular canal (arrow) and dehiscence of the tegmen tympani (arrow head).

State of the ossicles

The incus was the most frequently eroded ossicle, followed by the malleus and the stapes. Out of the 31 incus which were found at surgery to be eroded, 30 were demonstrable with the scan. Of the 15 eroded malleus, 14 were seen by the scan, while all 11 cases of absent stapes suprastructure were correctly predicted by imaging.

Semicircular Canal Fistula (Fig. 1 and 2)

There were 6 patients with surgically confirmed labyrinthine fistula. All 6 involved the lateral semicircular canal, and 2 had additional fistula of the superior semicircular canal. Five of the 6 cases were visible in the pre-operative scans, while the remaining case showed thinning of the otic capsule but with no discernible fistula on the scan. In the remaining 30 cases where the semicircular canals were intact clinically, the CT scan was incorrect in one case.

Erosion of Tegmen Tympani (Fig. 2)

One patient had erosion of tegmen exposing dura and this was shown with the scan. Of the remaining 35 cases, the scan misread 1 case as having tegmen dehiscence when there was not any.

Facial Canal Dehiscence (Fig. 3)

Out of the 9 cases with surgically confirmed facial canal dehiscence, only 3 could be detected by the radiologist.

Fig. 3 This patient had total dehiscence of the tympanic facial nerve in the right ear (arrow). The facial canal was difficult to assess on this axial scan because of the adjacent soft tissue in the middle ear and was erroneously reported to be intact.

Fig. 4 Axial scan showing erosion of the left posterior bony external auditory canal wall (arrow).

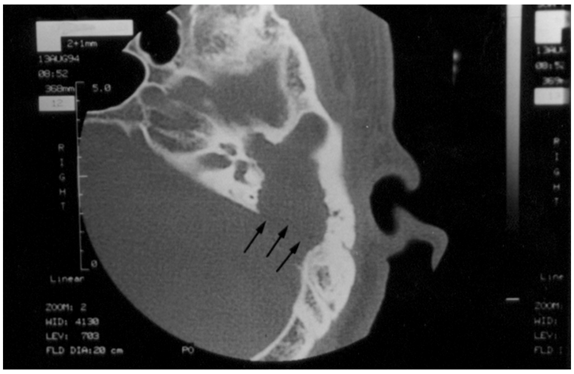

Fig. 5 Axial scan showing erosion of the sigmoid plate (arrows indicate expected position of sigmoid sinus).

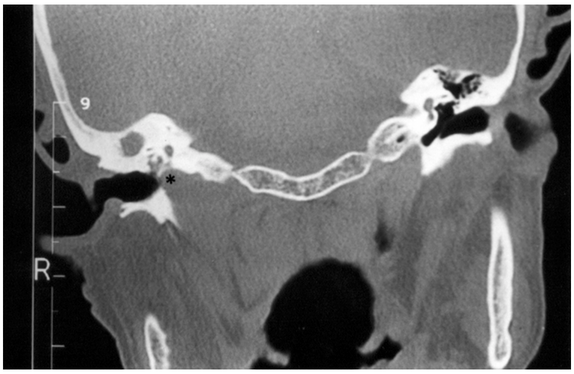

Fig. 6 Coronal scan of a high riding and dehiscent jugular bulb (*) on the right.

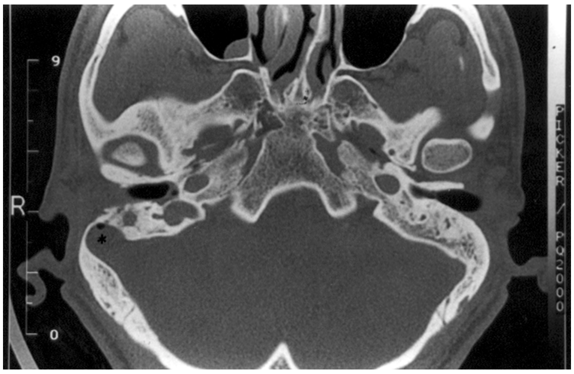

Fig. 7 Axial scan of an anteriorly placed sigmoid sinus on the right (*). The scan also showed an air pocket within the sigmoid sinus fossa suggesting a breach in the overlying bone. There was no intracranial abscess.

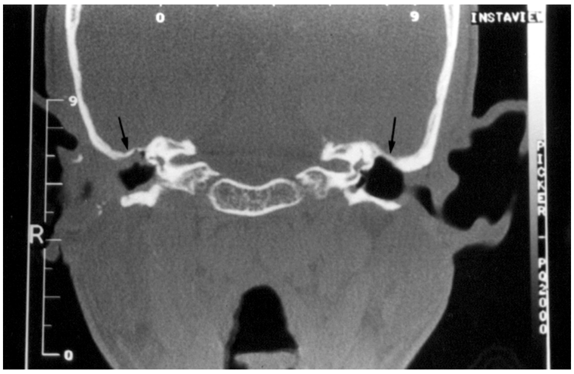

Fig. 8 Coronal section showing low lying tegmen (arrows) on both sides.

In 27 cases, the facial canal was judged during surgery to be intact, but the scan suggested possible erosion in 2 of these cases.

In addition to the above findings of dehiscent facial canal, labyrinthine fistula and tegmen erosion, various other congenital anatomical variations and surgical hazards were detected in the course of reviewing the scans and included:

a) Erosion of posterior canal wall (Fig. 4)
b) Erosion of sinus plate (Fig. 5)
c) High and dehiscent jugular bulb (Fig. 6)
d) Anteriorly lying sigmoid sinus (Fig. 7)
e) Low lying dura (Fig. 8)

DISCUSSION

Cholesteatoma can be accurately diagnosed by the HRCT scan in the vast majority of cases. Mafee et al[3] 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 we associate with cholesteatoma, i.e. tissue mass, typical location and bone erosion, and 30 cases (83.3%) had all the 3 features. When we base our diagnosis of cholesteatoma on the scan having at least 2 of the 3 features, 34 cases (94.4%) would be correctly diagnosed with cholesteatoma. However further study comparing the scan findings of cholesteatoma to other middle ear pathologies would be needed to determine the specificity of these radiological criteria. Also, one should be careful of the limitation of CT to pick out early or limited diseases, since it is difficult to diagnose cholesteatoma on the scan if the soft tissue mass is not associated with bone erosion(4).

While a definitive diagnosis of cholesteatoma can only be made at the time of surgery, the scan picture may at times influence the decision and timing of surgical exploration. Scan evidence of cholesteatoma with significant bony destruction or other complications could prompt the surgeon to operate earlier, particularly if polyps or a tortuous bony canal obscures visualisation of the tympanic membrane and hinders clinical diagnosis. On the other hand, the threshold to explore the ear may be higher when the scan is non-confirmatory, particularly if the patient has medical risks for surgery.

The HRCT scan gives a good to excellent radio-surgical correlation for the middle ear ossicles in our cases, and this is also the experience that others have reported(3-5) While prior knowledge of the state of the ossicles is probably not critical insofar as the operative risk is concerned, it has bearing on the likelihood of hearing preservation that can be achieved after surgery. For example, the hearing outcomes in patients with an intact stapes tend to be better than those where the stapes suprastructure is absent(6). Pre-surgical knowledge of the status of the ossicular chain would allow the surgeon to better advise the patient on the degree of hearing attainable after surgery.

Labyrinthine fistula can be accurately detected most of the time when both axial and coronal images are taken to look for erosion of the semicircular canals. The most common canal affected is the lateral semicircular canal and reliance on coronal sections alone may lead to a 50% false positive rate of dehiscence due to the artifact of partial volume averaging(4). Even with the addition of the axial scans, minute fistula may still be missed as seen in 1 patient. The scan in this case showed thinning of the bone over the lateral semicircular canal but no obvious fistulisation. Careful dissection of the cholesteatoma matrix over the dome of the lateral semicircular canal revealed a tiny bony canal fistula. The surgeon is well advised to treat every case as a potential fistula until proven otherwise.

Tegmen erosion is well seen on coronal imaging, but again misinterpretations may result from volume averaging effects(4). Such is the case in one patient where the scan suggested the tegmen to be breached but surgically proven to be intact. The reverse is also possible whereby a dehiscent area may appear intact radiologically(3).

Facial canal dehiscence is a fairly common finding in 55% of temporal bones, and usually occurring in a focal area in the tympanic portion of the fallopian canal(7). The problem with partial volume averaging artifact is again evident here as the fallopian canal can be so thin even in a non-pathological ear as to appear dehiscent on a CT scan. This explains for the poor radiological correlation with the surgical findings. In addition, we also found visualising the tympanic portion of the facial canal to be especially difficult when there is an adjacent pathologic soft tissue mass in the mesotympanum (Fig.3)(3,4). Knowledge of facial nerve anatomy, careful dissection technique in the vicinity of the nerve and the use of intra-operative facial nerve monitoring all help towards reducing the likelihood of an iatrogenic facial nerve injury.

Besides giving information on the status of the middle ear structures, the CT scan can also delineate the extent and location of disease. Cholesteatoma has a tendency to reside in hidden areas such as the sinus tympani and the anterior epitympanum. Knowledge of the disease extent and information on the degree of mastoid pneumatisation aid in planning the surgical approach, e.g. whether to keep the canal wall up or down. However one should note that the scan may overestimate the extent of disease as it often cannot distinguish definitively between cholesteatoma and granulation tissue(3). An enhanced MRI scan can discern the 2 better and may be used if clinically indicated(8).

Complications of cholesteatoma are associated with a high morbidity and can even be life threatening. However the surgical treatment itself is also fraught with risks to many important structures because of the complex anatomy of the temporal bone. Whilst we cannot quantify how the pre-operative scan decrease the rate of surgical complications, it is undoubtedly helpful in teaching our surgeons in training, and enhancing their spatial orientation of the middle ear cavity. A thorough understanding of the surgical anatomy and knowledge of normal variations are crucial when performing operations for chronically infected ears, and the pre-operative high resolution CT scan is useful in this regard. The scan aids even the experienced otologist by alerting him to the presence of anatomical variations (such as a high riding jugular bulb or a prominent sigmoid sinus), and potential surgical hazards that may arise from the destructive nature of the disease (such as a labyrinthine dehiscence).

Because this was not a blinded study, there is a possible inherent bias for the surgeon when reporting the surgical results since he would have looked at the scans before operating. The radiologist may also be biased, as he is blinded to the surgical findings but not to the clinical diagnosis of cholesteatoma. A better study may have been to compare the radio-surgical correlation of those with and without cholesteatoma, with the radiologist blinded to the clinical diagnosis. The problem is that most patients with chronic otitis media without cholesteatoma do not require pre-operative scans and so cannot be used as controls.

CONCLUSION

The advent of HRCT scans of the temporal bone has significantly enhanced the pre-operative evaluation of cholesteatoma. This study has shown that CT imaging for cholesteatoma accurately depicts the status of the middle ear structures, with the exception of the facial canal.

The scan delineates the location and extent of the disease, and provides information on anatomical variations and complications. It serves as a road map to assist the surgeon during cholesteatoma surgery.

The HRCT scan is a valuable and useful investigative tool prior to cholesteatoma surgery.

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