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SCOTLAND Pre-Operative Tympanomastoid CT Temporal Bone Mnemonic System

*Hurley R, Slim MAM, Locke R and Lim AE**

Department of Ear, Nose and Throat, Queen Elizabeth University Hospital, Glasgow, United Kingdom

Abstract

Computed-Tomography (CT) of the temporal bone is becoming a routine pre-operative investigation when surgical interventions are being considered for middle ear disease. Methodical pre-operative CT temporal bone evaluation checklist such as SCOTLAND could improve the surgical safety profile and assist in the consent process. Otorhinolaryngologists need to be able to interpret the pre-operative CT temporal bone findings and translate these into the surgical field. A simple mnemonic checklist system could assist this.

Keywords: Ear; Middle; Temporal bone; Checklist; Radiology; Otolaryngology

Introduction

Computed-Tomography of the Temporal Bone (CT temporal Bone) is becoming a routine pre-operative investigation when surgical interventions are being considered for middle ear disease, mainly cholesteatoma. This should not replace the anatomical knowledge required to operate safely. Pre-operative CT temporal bone can empower the surgeon with better knowledge of the surrounding structures allowing oneself to build a better mental 'road-map'. During any tympanomastoid surgery, multiple vital structures will be encountered during the procedure. Here, the authors have created a mnemonic system for pre-operative CT temporal bone evaluation (Table 1).

The SCOTLAND System

Pre-operative CT temporal bone for tympanomastoid surgery has also been shown to assist with surgical planning and the consent process [1,2]. Anecdotally, SCOTLAND has assisted the authors in evaluating the pre-operative imaging and correlating information gleaned from this with the possible difficulty that one might find oneself. During the pre-operative imaging assessment, a multiplanar reconstruction of the imaging is recommended. This allows both axial and coronal views to be inspected with SCOTLAND (Table 1), enabling individual salient structures to be evaluated.

Critical Surgical Anatomy Discussion

The position and bony quality of the sigmoid plate and sigmoid sinus can easily be evaluated on the axial view. This is one of the important structures one will encounter during mastoidectomy as low-lying dura will limit epitympanic view meanwhilehigh jugular bulb will limit hypotympanic view [3]. With contrast, filling defect in the sigmoid sinus can also indicate the operating surgeon on the presence of thrombosis [4]. In revision surgery, assessment of the sigmoid plate is essential to avoid unintentional injury to it if dehiscence is present [3]. Assessment of the other vascular foramina in the temporal bone i.e., carotid canal, jugular bulb and jugular foramen is also essential. A high or dehiscent jugular bulb on imaging will alert the surgeon pre-operatively, subsequently avoiding inadvertent injury during the development of the facial recess or tympanoplasty for middle ear examination [3]. The presence of lytic erosion on the jugular foramen should alert the operating surgeon regarding the possibility of paraganglioma [4]. The carotid canal should also be examined for any bony dehiscence or abnormal position. A neoplastic process will demonstrate bony destruction. Meanwhile, an aberrant carotid artery can sit more lateral than the contralateral side [4]. The position and integrity of the tegmen also play an important role. The combination of a low-lying tegmen, anteriorly placed sigmoid sinus and poorly pneumatized mastoid cells could make a routine operation an incredibly challenging one. During drilling, knowing the position of the low-lying tegmen and dura will allow the surgeon to exert extra caution as the mastoid cavity superior roof will become convex much earlier than expected during the drilling and saucerization process, thus avoiding inadvertent breach into the dura. Recognising the status of the bony integrity during primary and revision surgery of the tegmen pre-operatively will also allow the surgeon to tailor the

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Correspondence:
Alison E. Lim, Department of Ear, Nose and Throat, Queen Elizabeth University Hospital, Glasgow, United Kingdom.
Tel: *07724761798*
E-mail: *alison.lim@nhs.net*

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Table 1: SCOTLAND CT Temporal Bone Checklist System.

Structure	CT View	Concerns
S Sigmoid sinus	Axial	Bony dehiscence Anterior sigmoid sinus position
Scutum	Coronal	Blunting of scutum Opacification in Prussak Space
C Canal (ear)	Axial	Stenosis Bony destruction
Cochlear	Axial and coronal	Congenital abnormality (relevant for paediatric cases and cochlear implant)
Carotid canal and Jugular Bulb	Axial and coronal	Bony dehiscence High Jugular bulb position Aberrant or Lateralize stapedial artery
O Ossicles	Axial and coronal	Erosion Disarticulation Footplate thickening Prosthesis
T Tegmen	Coronal	Bony dehiscence Low lying dura
Temporomandibular Joint	Axial	Anterior canal wall bony dehiscence
L Lateral semi-circular canal	Axial and coronal	Bony dehiscence
A Air cells mastoid	Axial and coronal	Degree of pneumatization Opacification in air cells
Attic	Axial and Coronal	Opacification in epitympanum
N Facial nerve	Axial and coronal	Abnormality and bony dehiscence at the second genu, horizontal tympanic and vertical mastoid portion
D Drum	Axial	Retraction Perforation Thickening Ventilation Tube
Deformity	Axial and coronal	Previous tympanomastoid operations or congenital abnormalities

consent process allowing one to prepare the patient for possible fat or fascia-lata graft if needed for tegmen defect repair. If a large tegmen defect is present with soft tissue surrounding, it should also alert the operating surgeon regarding the possibility of meningoencephalocele which will need to be confirmed with Magnetic Resonance Imaging (MRI) before embarking any surgical exploration as it carries added risk for meningitis [4]. The condition of the bony ear canal is also an important consideration. When a destructive pattern is shown, one should bear in mind regarding other causes of this pattern such as necrotising otitis externa or a malignant process, e.g. squamous cell carcinoma. In keratosis obturans, there will be an asymmetrical canal appearance consistent with canal expansion without any bony destruction when compared to the contralateral side and in contrast to ear canal cholesteatoma [4]. A combination of history, physical examination and imaging findings could also help surgeons in revision cases, to identify the previous type of surgery previously performed in the absence of available operative notes. In the Canal Wall-up Mastoidectomy (CWU), the posterior wall of the bony ear canal will remain intact, depicting two air-filled spaces; the mastoid cavity and the ear canal [5]. Meanwhile, in the Canal Wall-down Mastoidectomy (CWD), the posterior wall will be removed creating one open space between the previous ear canal and the mastoid cavity [5]. Knowing this will allow the operating surgeon to discuss the frequency of follow-up required if a CWU is converted to CWD mastoidectomy [3]. In the middle ear, the combination of soft tissue opacity in the epitympanum mainly the Prussak space and bony erosion of the scutum is highly suggestive of cholesteatoma by at least 83% when compared with intraoperative findings [2]. However, one should always remember that a soft tissue opacity on its own in the CT temporal bone cannot differentiate between cholesteatoma, mucosal disease or fluid [2]. The status of the ossicles pre-operatively will enable the surgeon to consent the patient regarding the options available and risk involved with ossiculoplasty ranging from incus transposition to prosthesis replacement. Signs suggestive of otosclerosis such as thickening of the stapes footplate or fissula ante fenestram; area anterior to the footplate should be assessed [5]. The integrity of the semicircular canals is of concern when the patient presents with vertigo and positive fistula test. The lateral semicircular canal dehiscence status will be the primary concern for any cholesteatoma cases as complete removal of the cholesteatoma matrix at this area could jeopardise the labyrinthine and hearing function on that side. Furthermore, specificity and sensitivity of the CT temporal bone to detect it is high [2]. Knowing this early on will empower the surgeon to consent the patient regarding the risk involved and the possibility of CWD mastoidectomy [3]. Most dehiscence of the bony covering at the facial nerve occurs at the horizontal portion in the middle ear which can be better appreciated in the coronal view [1]. However, the assessment for bony dehiscence here is difficult due to its size and the oblique course in the temporal bone [2]. The presence of soft tissue density structure near this area causes loss of contrast gradient making the bony integrity assessment harder with CT [1].

Conclusion

A systematic approach to pre-operative CT temporal bone evaluation for the trainee surgeon is an essential skill that one needs to obtain as it will assist in the drilling process during any mastoid operation. This may also help the trainees in assessing the information needed, both in an on-call setting and in the outpatient setting to formulate an action plan. Cooperation and understanding between the radiologist and the surgeon regarding the information needed from the modality will help with effective pre-operative planning and increase the overall safety profile of the procedure.

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