Imaging of carcinoma of the external auditory canal: a pictorial essay

Cheng K. Ong\textsuperscript{a}, Uei Puab and Vincent F.H. Chonga

\textsuperscript{a}Department of Diagnostic Radiology, National University Hospital and Yong Loo Lin School of Medicine, National University of Singapore, Singapore; \textsuperscript{b}Department of Diagnostic Radiology, Tan Tock Seng Hospital, Singapore

Corresponding address: Dr Vincent Chong, Department of Diagnostic Radiology, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074.

Email: dnrcfhv@nus.edu.sg

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Abstract

Carcinoma of the external auditory canal presents a challenge in management, largely due to limited experience in treating this rare disease and the lack of a universally accepted staging system. Prognosis is most dependent on the extent of local disease at presentation, while resection margin status is also a strong determinant of survival in post-operative patients. The intent of this pictorial essay is to review the pattern of tumour spread and highlight the value of imaging, particularly magnetic resonance imaging in pre-operative tumour mapping.

Keywords: Carcinoma; external auditory canal; computed tomography; magnetic resonance imaging.

Introduction

Carcinoma of the external auditory canal (EAC) is a rare malignancy. Treatment planning is challenging because the accumulated experience of any particular individual or institution in managing this tumour is rather limited. This problem is further compounded by the absence of a universally accepted tumour staging system, making treatment outcome comparison difficult. It is now known that the single most important factor determining survival is the local tumour extent at presentation\cite{1}. It is therefore crucial to establish the disease extent in order to optimize treatment options. The patterns of tumour spread are well described in the surgical literature\cite{2,3}. Computed tomography (CT) can demonstrate bony erosion with exquisite detail but magnetic resonance (MR) imaging is preferred in the delineation of tumour spread along vascular channels, neural pathways, intracranial extension and involvement of the extra-temporal soft tissues.

Radiological features

On temporal bone CT, early carcinoma of the EAC commonly presents as a soft tissue mass within the EAC. As the disease progresses, aggressive underlying bony destructive changes are demonstrated. As the tumour infiltrates and spreads deep into the surrounding tissue, it is best shown as a heterogeneously enhancing lesion on contrast-enhanced MR imaging.

Carcinoma of the EAC most commonly spreads through the floor of the EAC into the soft tissue below the temporal bone\cite{4-6}. This may be related to the presence of the fissures of Santorini along the inferior aspect of the cartilaginous EAC. Less frequently, the tumour erodes posteriorly into the mastoid bone or anteriorly through the tympanic portion of the EAC to invade the temporomandibular joint (Fig. 1)\cite{7}. On the other hand, superior extension into the middle cranial fossa and medial extension into the middle ear are rare\cite{4-6,8}.

Medial extension into the middle ear cavity is of special interest because of the resultant poor prognosis\cite{8}. This negative prognostic indicator is related to the subsequent disease spread beyond the middle ear making surgical excision increasingly difficult. Tumour in the middle ear can readily extend superiorly through the thin tegmen tympani into the middle cranial fossa (Fig. 2). However, the presence of temporal lobe oedema...
associated with tumour extension into the middle cranial fossa does not necessarily indicate cerebral parenchymal infiltration.

From the middle ear cavity, tumour can spread medially to erode the inner ear structures. Tumour may gain access into the labyrinth through the lateral semicircular canal, oval or round windows. Malignant infiltration often extends further proximally along the vestibular or cochlear nerves into the internal auditory canal (Fig. 2). The resistant cortical bone of the inner ear, especially the otic capsule, often limits the amount of gross bone destruction but aggressive tumours will eventually involve the cochlea (Fig. 3).

In contrast to the difficulty of invading cortical bone, tumour can readily spread from the middle ear posteriorly through the aditus into the mastoid antrum (Fig. 4). Further posterior spread leads to extension into the posterior cranial fossa and involvement of the sigmoid sinus (Fig. 5).

Tumour erosion through the floor of the middle ear anteriorly results in the involvement of the carotid artery while inferior extension through the floor posteriorly involves the jugular foramen (Fig. 6). Cancers with extensive inferior spread involving the jugular bulb and internal carotid artery exclude the surgical options of lateral temporal bone resection and subtotal resection.

Figure 1 A 64-year-old female with EAC carcinoma involving the temporomandibular joint. (a) Axial T1-weighted MR image shows intermediate signal tumour in the left EAC (asterisk) extending into the temporomandibular joint and displacing the mandibular condyle (arrow) anteriorly. (b) Axial contrast-enhanced MR image shows tumour enhancement. Note the tumour extension into the left parotid region (asterisk).

Figure 2 A 58-year-old male with right EAC carcinoma. (a) Coronal contrast-enhanced MR image shows tumour in the right middle ear (arrow) with extension through the tegmen tympani into the middle cranial fossa. (b) Coronal contrast-enhanced MR image (posterior to (a)) shows tumour in the right EAC (asterisk) with middle ear and intracranial extension. Note enhancement in the labyrinth (black arrow) and the internal auditory canal (white arrow).
temporal bone resection, and are often unresectable (Figs. 6 and 7).

Tumour in the hypotympanum often extends anteromedially along the Eustachian tube. This manner of spread can be diagnosed by the identification of soft tissues anterior and parallel to the petrous segment of the internal carotid artery (Fig. 8). When this manner of spread occurs, tumour comes into close proximity with the foramen ovale and the mandibular nerve in the central skull base. Proximal perineural

**Figure 3**  (a) Axial CT shows a right EAC tumour eroding the otic capsule and destructing the cochlea (asterisk). Note the normal left cochlea for comparison. (b) Axial CT (inferior to Fig. 4a) shows inferior spread of the right EAC tumour involving the internal carotid artery and jugular bulb (asterisk). Note the normal left carotid foramen (black arrow) and jugular foramen (white arrow) for comparison.

**Figure 4**  (a) Axial T1-weighted MR image shows an intermediate signal intensity tumour in the left middle ear cavity with extension posteriorly into the mastoid (arrow). (b) Axial contrast-enhanced MR image shows heterogeneous tumour enhancement. Note tumour surrounding the left petrous internal carotid artery (arrow).
spread along the mandibular nerve leads to intracranial extension. At this stage, signal changes in the muscles of mastication may be seen, indicating the onset of denervation atrophy. Tumour extending medially along the Eustachian tube may eventually reach the nasopharynx (Fig. 8). The superior portion of the parapharyngeal space is adjacent to the Eustachian tube. The parapharyngeal space is a well-recognized route for the spread of inflammatory and malignant disease[9]. Tumour may therefore extend into the parapharyngeal space and spread into the neck with relative ease[10].

Figure 5 A 55-year-old female with a left EAC tumour extending into the posterior cranial fossa. (a) Axial T1-weighted MR image shows intermediate signal intensity tumour in the left EAC (asterisk) with extension into the posterior cranial fossa (arrow). (b) Axial contrast-enhanced MR image shows heterogeneous contrast enhancement in the tumour. There is obliteration of the left sigmoid sinus (asterisk). Note normal signal void in the right sigmoid sinus for comparison (arrow). (c) Coronal T1-weighted MR image shows intermediate signal intensity tumour in the posterior aspect of the left mastoid bone (arrow) and along the dural venous sinus (arrowheads). (d) Coronal contrast-enhanced image shows enhancement of the tumour (arrow).
Lymph node disease in carcinoma of the EAC is a significant negative prognostic factor\textsuperscript{[6]}\textsuperscript{[6]}. Any malignant nodal involvement should therefore be classified as advanced disease. The parotid nodes are the first echelon nodes\textsuperscript{[5,6]}\textsuperscript{[5,6]}. Malignant pre- and post-auricular lymphadenopathy is also commonly seen.

**Figure 6** A 57-year-old male with carcinoma of the right EAC showing intracranial infiltration and spread below the skull base. (a) Coronal CT shows tumour in the right EAC eroding the cochlea (short arrow) and the floor adjacent to the carotid canal (long arrow). (b) Coronal CT (posterior to (a)) shows permeative erosion of the roof of the right middle ear (short arrow), and the floor adjacent to the jugular foramen (long arrow). (c) Coronal contrast-enhanced MR image shows enhancing tumour in the right EAC spreading into the right middle cranial fossa causing gross dural thickening (asterisk). Note tumour extension through the floor of the middle ear cavity (arrow). (d) Axial contrast-enhanced MR image shows moderate tumour enhancement. The tumour has obliterated the right jugular foramen and vein (asterisk). Note the normal enhancing left jugular vein (arrow) for comparison.

**Discussion**

The incidence of carcinoma of the EAC is estimated as between one and six cases in every one million population. The majority of tumours occur in the fifth and sixth decades of life. Pooled data shows approximately even
gender distribution\cite{8}. Several aetiological factors have been implicated, including exposure to ultraviolet radiation, chlorinated disinfectants and human papillovirus infection. Chronic otitis media has been implicated for a long time as an aetiological factor but no definite correlation has been proven. A high association has also been reported in patients previously treated with radiation therapy\cite{11}. Histologically, most of these tumours are squamous cell carcinomas, others being mucoepidermoid and adenoid cystic carcinomas.

Carcinoma of the EAC is treated with surgical resection with or without post-operative radiation therapy. Tumours confined to the cartilaginous portion of the EAC are removed by local wide excision. Tumours arising from or spreading to the bony EAC but lateral to the tympanic membrane are treated by limited partial temporal bone resection or ‘sleeve’ resection with subsequent reconstruction by a local flap or a microvascular myocutaneous free flap, and refashioning of an auditory canal for preservation of hearing. Tumour involvement of the tympanic membrane, malleus, incus and tympanic bone may necessitate lateral temporal bone resection, which was first reported by Conley and Novack\cite{12}.

Subtotal temporal bone resection, pioneered by Parson and Lewis\cite{13}, is a combined extracranial and intracranial procedure for treating advanced cancers involving the middle ear, the temporomandibular joint and the middle cranial fossa. The facial nerve is almost invariably sacrificed, as opposed to lateral temporal bone resection. However, the inferior margins of resection are similar in both lateral temporal bone resection and subtotal temporal bone resection, being just lateral to the internal jugular vein and internal carotid artery.

In patients with even more extensive disease, total temporal bone resection may improve patient survival as well as increase the palliative benefits, notably decreased pain and improved hygiene\cite{14}. However, there is increased risk of morbidity, including damage to the cavernous sinus and notably, the internal carotid artery as well as the third, fourth, fifth and sixth nerves. A viable alternative in advanced disease is piecemeal resection of all visible tumour beyond the margins of a subtotal temporal bone resection, followed by post-operative radiation therapy\cite{15}.

En bloc surgical resection with complete tumour excision remains the primary aim and the critical determinant of patient survival. In two retrospective studies, the 5-year survival rate was almost 80% for patients with negative resection margins at the time of surgery, significantly higher than those with positive margins (0–35\%)\cite{3,16}.

In order to achieve clear margins, most cases will invariably require a superficial or total parotidectomy and not uncommonly, a partial mandibulectomy and clearance of the infratemporal fossa.

Surgical planning therefore, involves meticulous pre-operative radiological tumour mapping. A high-resolution, non-enhanced bone algorithm temporal bone CT and contrast-enhanced MR imaging are recommended for this purpose.

For early disease confined to the EAC, CT is sufficient. CT can also readily detect erosion of the bony external auditory canal, which is often the first sign of local spread of tumour. Axial and coronal sections are routinely acquired. Sagittal reconstruction may provide additional value for complex tumour infiltration of the temporal bone. However, CT is inadequate to demonstrate the extent of tumour spread beyond the EAC. Contrast-enhanced MR imaging is thus preferred over contrast-enhanced CT.

Post-contrast T1-weighted sequencing with fat saturation in the axial, coronal and sagittal planes allows the

\textbf{Figure 7}  (a) Coronal contrast-enhanced MR image shows a left EAC tumour (asterisk) spreading and involving the left internal carotid artery (arrow). (b) Axial contrast-enhanced MR image shows the tumour with heterogenous enhancement surrounding the left petrous internal carotid artery (long arrow). Note tumour infiltration along the left Eustachian tube anteromedially (short arrow).
Figure 8 A 67-year-old male with recurrent carcinoma of left EAC with spread to the nasopharynx. (a) Axial T1-weighted MR image shows an intermediate signal intensity tumour in the left EAC and middle ear extending anteromedially along the Eustachian tube (arrow). (b) Axial contrast-enhanced image shows heterogeneous enhancement of the tumour with non-enhancing areas, probably due to necrosis. Note enhancement in the left foramen ovale (arrow). (c) Axial T1-weighted MR image shows tumour in the left parapharyngeal space and nasopharynx (arrow-heads). (d) Axial contrast-enhanced image shows heterogeneous tumour enhancement. (e) Coronal T1-weighted MR image shows an intermediate signal intensity tumour in the left nasopharynx (asterisk) extending to the left foramen ovale (arrow). (f) Coronal contrast-enhanced MR image shows tumour enhancement and intracranial spread (arrow). Note the oedematous left temporal lobe, which may be due to radiation therapy, intracranial tumour or both.
In addition to CT, MR imaging is essential for precise delineation of the extent of tumour spread beyond the EAC, which at presentation, is the single most important prognostic factor. This accurate pre-operative tumour mapping is also critical in deciding surgical options, with a clear resection margin the primary objective.

### References

[1] Arriaga M, Curtin H, Takahashi H, Hirsch BE, Kamerer DB. Staging proposal for external auditory meatus carcinoma based on preoperative clinical examination and computed tomography findings. Ann Otology 1990; 99: 714–21.

[2] Arriaga M, Curtin H, Takahashi H, Kamerer DB. The role of CT scans in staging external auditory meatus carcinoma: radiologic pathologic correlation study. Otologyng Head Neck Surg 1991; 105: 6–11.

[3] Gillespie MB, Francis HW, Chee N, Eisele DW. Squamous cell carcinoma of the temporal bone: a radiographic-pathologic correlation. Arch Otologyng Head Neck Surg 2001; 127: 803–7.

[4] Pulec JL, Duguine C. Squamous cell carcinoma of the external auditory canal. Ear Nose Throat J 2004; 83: 9.

[5] Choi JY, Choi EC, Lee HK, Yoo JB, Kim SG, Lee WS. Mode of parotid involvement in external auditory canal carcinoma. J Laryngol Otol 2003; 117: 951–4.

[6] Testa JR, Fukuda Y, Kowalski LP. Prognostic factors in carcinoma of the external auditory canal. Arch Otologyng Head Neck Surg 1997; 123: 720–4.

[7] Treasure T. External auditory canal carcinoma involving the temporomandibular joint: two cases presenting as temporomandibular disorders. J Oral Maxillofac Surg 2002; 60: 465–9.

[8] Barrs DM. Temporal bone carcinoma. Otologyng Clin North Am 2001; 34: 1197–218.

[9] Harnsberger HR. The parapharyngeal space and the pharyngeal mucosal space. Handbook of head and neck imaging. 2nd ed. St Louis, MO: Mosby; 1995, p. 29–45.

[10] Mukherji SK, Chong V. Tumour spread from temporal bone. Atlas of head and neck imaging. New York: Thieme; 2004, p. 389–91.

[11] Goh YH, Chong VFH, Low WK. Temporal bone tumours in patients irradiated for nasopharyngeal neoplasms. J Laryngol Otol 1999; 113: 222–8.

[12] Conley JS, Novack AJ. The surgical treatment of malignant tumours of the ear and temporal bone. Arch Otologyng 1960; 71: 635–52.

[13] Parsons H, Lewis JS. Subtotal resection of the temporal bone for cancer of the ear. Cancer 1954; 7: 995–1001.

[14] Moffat DA, Grey P, Ballagh RH, Hardy DG. Extended temporal bone resection for squamous cell carcinoma. Otologyng Head Neck Surg 1997; 116: 617–23.

[15] Zhang B, Tu G, Xu G, Tang P, Hu Y. Squamous cell carcinoma of the temporal bone: reported on 33 patients. Head Neck 1999; 21: 461–6.

[16] Yeung P, Bridger A, Smege R, Baldwin M, Bridger GP. Malignancies of the external auditory canal and temporal bone: a review. ANZ J Surg 2002; 72: 114–20.

[17] Kwon BJ, Han MH, Oh SH, Song JJ, Chang KH. MRI findings and spreading patterns of necrotizing external otitis: is a poor outcome predictable? Clin Radiol 2006; 61: 495–504.

[18] Grandis JR, Curtin HD, Yu VL. Necrotizing (malignant) external otitis: prospective comparison of CT and MR imaging in diagnosis and follow-up. Radiology 1995; 196: 499–504.

[19] Pathak I, Bryce G. Temporal bone necrosis: diagnosis, classification, and management. Otologyng Head Neck Surg 2000; 123: 252–7.

[20] Harnsberger HR, Hudgins PA, Wiggins RH. Post-irradiated Temporal bone diagnostc imaging: head and neck. Amirsys Inc 2004, 1–212–5.

[21] Kinney SE. Squamous carcinoma of the external auditory canal. Am J Otol 1989; 10: 111–6.