Published in final edited form as:

J Comput Assist Tomogr. 2014 ; 38(5): 662–666. doi:10.1097/RCT.0000000000000096.

CT Findings in Temporal Bone Osteoradionecrosis

Salmaan Ahmed, MD^{*}, Nakul Gupta, MD[†], Jackson D. Hamilton, MD^{*}, Adam S. Garden, MD[‡], Paul W. Gidley, MD[§], and Lawrence E. Ginsberg, MD^{*}

^{*}Department of Diagnostic Radiology, University of Texas MD Anderson Cancer Center, Houston, TX

[†]Department of Diagnostic and Interventional Imaging, The University of Texas Medical School at Houston, Houston, TX

[‡]Department of Radiation Oncology, University of Texas MD Anderson Cancer Center, Houston, TX

[§]Department of Head and Neck Surgery, University of Texas MD Anderson Cancer Center, Houston, TX

Abstract

Purpose—The goal of this study is to describe CT findings in patients with clinically proven temporal bone osteoradionecrosis (TB-ORN).

Methods and materials—CT scans of twenty patients were retrospectively evaluated for bony and soft tissue abnormalities. Clinical severity was graded based on level of therapy administered: mild (observation), moderate (antibiotics/hyperbaric oxygen), or severe (surgery).

Results—Radiation dose to the primary tumor ranged from 30 to 75.6 Gy. Time to onset of ORN from completion of radiation therapy was 2 to 22 years (median=7yrs).

Clinical findings: Exposed bone=20/20, otorrhea=17/20, hearing loss=11/20, otalgia=10/20, facial nerve paralysis=2/20, gait imbalance=2/20.

CT findings: EAC erosions=18/20, mastoid effusion=18/20, mastoid bony coalescence=5/20, enhancing soft tissue=6/20, soft tissue gas=6/20, temporomandibular joint/condylar erosion=3/20.

3 patients developed an abscess.

Conclusion—Mastoid effusion and EAC erosions are commonly seen with TB-ORN. Clinically moderate or severe cases of TB-ORN are more likely to demonstrate enhancing soft tissue (p=0.002), soft tissue gas (p=0.002), and temporomandibular joint involvement (p=0.07).

Background and purpose

Chemoradiation is an essential component in the treatment strategy to achieve loco-regional control for tumors of the head and neck, either as first line therapy or following surgical resection¹. Osteoradionecrosis (ORN) of the mandible is a known complication and has been

well reported in the literature²⁻⁴. The temporal bone is included in the radiation field when treating tumors of the nasopharynx, retromolar trigone, external ear, and parotid glands. ORN of the temporal bone is an uncommon but serious delayed complication that may arise in a small number of patients⁵. Clinical symptoms may occur as early as three months⁶ or may be delayed as much as 40 years following completion of radiation therapy.⁷ While the most common clinical findings include otalgia and otorrhea, more severe cases demonstrate facial nerve paralysis, conductive, sensorineural, or mixed hearing loss, meningitis, and intracranial and/or neck abscesses.⁵ Additionally, host factors which impair wound healing such as diabetes mellitus, advanced age, and immunosuppression may predispose as well⁸.

While ORN in general was first described by Ewing in 1926⁹, it was not until the 1950's and 1960's that the first reports of ORN of the temporal bone began to appear¹⁰. The pathophysiology of ORN as described by Ewing is due to an obliterative endarteritis and periarteritis which results in avascular and aseptic necrosis. Histologically, there is death of osteocytes with a preponderance of osteolysis, decreased new bone formation, loss of marrow and infiltration of connective tissue around the spicules of dead bone^{9,11}. Although the initial process is aseptic, the resulting necrotic bone is prone to infection which may play a role in the evolution of temporal bone ORN. Breakdown of the ear canal skin, which is seen almost universally in patients with ORN, provides a route for pathogens to gain access to the devitalized temporal bone, and may even be a necessary precondition for the development of ORN¹⁰.

Despite an incidence of up to 12.5% in a recent study of patients receiving postoperative radiotherapy for parotid tumors and 8.5% in another cohort who had undergone postoperative radiotherapy to the temporal bone for a variety of head and neck cancers, no large case series describing the computed tomography scan (CT) findings of temporal bone osteoradionecrosis (TB-ORN) exists^{12,13}. We feel it is important for the radiologist to be aware of these findings when evaluating patients with a history of radiation therapy to the head and neck that present with new clinical findings. The goal of this article is to familiarize the radiologist and clinician with the CT findings of TB-ORN.

Methods

Twenty patients with clinical diagnosis of TB-ORN made between 9/10/2002 and 2/20/2012 were included in this retrospective review. None of the patients had evidence for tumor recurrence at the time the ORN was diagnosed. The temporal bone was confirmed to have been included in the radiation field for treatment of adjacent neoplasms of the head and neck. CT technology improved over the course of our study from slice thickness of 5 mm to our current standard of 1.25-mm-section thickness and 25-cm FOV. Most patients had a 120-mL iohexol (Omnipaque; GE Healthcare, Princeton, New Jersey) contrast bolus injected at 3-mL/s with a 90-second delay on an Excite scanner (GE Healthcare, Milwaukee, Wisconsin). Scans were displayed with a window width and level of 300 and 70, respectively. CT images were reviewed by a CAQ (certificate of added qualification) neuroradiologist, for the presence of (1) external auditory canal (EAC) erosions, (2) mastoid effusion, (3) mastoid bony coalescence, (4) new enhancing soft-tissue, (5) air within the deep spaces, and (6) Temporomandibular joint (TMJ) condylar erosion. Medical records

were reviewed to document the presence or absence of (1) exposed bone, (2) otorrhea, (3) hearing loss, (4) otalgia, (5) facial nerve paralysis, and (6) gait imbalance. All patients were managed by a single neurotologist (PWG). Clinical severity of the TB-ORN was graded based on the clinical care administered in each case; Mild = periodic cleanings +/- antibiotic drops, Moderate = medical management including hyperbaric oxygen and/or IV antibiotics, Severe = dispositioned to surgery. P-values were calculated using Fisher's exact test (two-tailed).

Results

Of the 20 cases reviewed in our study, 13 were male and 7 were female. Patient age's ranged between 28 and 91 years (median, 61 years). Radiation dose to the primary tumor ranged from 30 Gy to 75.6 Gy (median, 60 Gy). Time to onset of ORN following completion of radiation therapy varied between 2 and 22 years (median, 7yrs). Tumor types that had been irradiated in our patient population are shown in Figure 1.

The clinical severity of TB-ORN in the 20 patients was: mild, 11; moderate, 4 and severe, 5 (grading system for clinical severity was based on level of care administered). Exposed bone was the most common clinical finding present in all cases, followed by otorrhea that was present in 85% of cases (Figure 2). Fifty-five percent of the patients reported hearing loss and 50% reported otalgia. Facial nerve paralysis and gait imbalance were infrequent findings, and present in only 10% of cases.

External auditory canal (EAC) erosions and mastoid effusions were present in 18 of the 20 cases (Figure 3). Five patients (25%) had loss of mastoid bony septa consistent with coalescence, while 6 patients had more aggressive findings of enhancing soft tissue and air within the deep soft tissues. The temporomandibular joint was involved in 3 cases. One patient did not demonstrate any CT abnormality with respect to the temporal bone, and had exposed bone on clinical exam which was managed conservatively.

EAC erosions and mastoid effusions were seen in all three subgroups of mild, moderate, and severe TB-ORN with a high frequency (80–100%). However, the advanced CT findings of enhancing soft tissue, air within the deep spaces, and TMJ involvement were not present in any of the 11 patients with clinically mild TB-ORN, and at least one of the advanced CT findings was present in 7 of the 9 cases classified as clinically moderate or severe (Figure 4). One patient without advanced CT findings declined conservative management and opted for lateral temporal bone resection as she could no longer tolerate the otorrhea and otalgia, and was therefore classified as severe. The other patient without any advanced CT findings and requiring HBO (moderate), demonstrated progressive bony erosions of the EAC with mastoid opacification.

Three patients, each with clinical grade of moderate or severe TB-ORN, presented with or developed abscesses; 1 infratemporal fossa abscess, 1 Bezold abscess, and 1 intracranial (middle cranial fossa abscess).

Discussion

Temporal bone ORN is an uncommon but severe complication of radiotherapy. Normal mature bone is relatively resistant to the harmful effects of radiotherapy¹⁴. The temporal bone is at increased risk given its superficial location, its thin skin covering, and its communication with the upper airway via the Eustachian tube⁷. Therapeutic levels of radiation exposure result in vasculitis, with aseptic inflammation of the endothelium of the blood vessels, eventually leading to obliteration of the vascular lumen¹¹. The histologic changes include death of osteocytes, increased osteolysis, compensatory fibrosis in the area of dead bone, decreased osteoblastic activity, and loss of marrow substance¹¹. The tissue then becomes prone to injury and highly susceptible to infection. In cases of superinfection, the necrotic process accelerates and the ORN continues⁶. Additionally, host factors which impair wound healing such as diabetes mellitus, advanced age, and immunosuppression may predispose as well⁸.

In a series of 29 cases of temporal bone ORN, Ramsden et al. identified two main patterns of disease, which they described as 'diffuse' and 'localized'. Patients with the localized form had exposed dead bone in the external auditory canal, and extent of disease was limited to this region. These patients usually presented with otalgia and otorrhea and were managed conservatively with regular aural toilet and analgesics as necessary. Those patients with diffuse disease presented with extensive ORN of the temporal bone. These patients presented with extreme boring pain, profuse otorrhea, foul odor and disastrous complications such as mastoid necrosis with fistula formation, exposed dura, meningitis, and brain abscess. Many of these patients were managed surgically, including mastoidectomy and petrosectomy in order to remove as much of the dead bone as possible.^{7,13}

When a patient irradiated for head and neck cancer presents with exposed bone, otorrhea and/or otalgia, the clinical differential includes infection, cholesteatoma, recurrent tumor, and ORN. The presentation of temporal bone ORN with crusts, otalgia, and otorrhea overlaps with that of chronic otitis media, and may be neglected by clinicians.¹⁵ There is also overlap with signs of malignancy when patients present with unhealed ulcer, exposed bone and accompanying granuloma, and differentiation can be challenging¹⁵. In a study by Hao et al, 21% of cases initially diagnosed as ORN, were reclassified as cancer and on average, 2.4 sequestrectomy procedures were carried out before reaching the correct diagnosis¹⁶. This finding underscores the need to biopsy granulation tissue to identify cancer as the potential cause.

The role of the radiologist is to define the extent of temporal bone involvement, while evaluating for an underlying soft tissue mass, intra or extracranial abscess, dural sinus thrombosis, meningitis, and other potential complications. In our review, EAC bony erosion and mastoid opacification were the only CT findings in clinically mild cases of TB-ORN. The extent of bony erosion is often subtle and can be overlooked by the radiologist evaluating for local recurrence of the head and neck tumor, adenopathy, and new primary. Figure 5 demonstrates a representative case of clinically mild TB-ORN with subtle imaging findings. This patient was treated with routine cleanings and had one course of antibiotic

drops. Four years after initial diagnosis of temporal bone ORN, the patient continues to have exposed bone and crusting with some improvement, and is being followed closely.

Clinically moderate or severe cases of temporal bone ORN are more likely to demonstrate advanced CT findings of new enhancing soft tissue ($p=0.002$), soft tissue gas ($p=0.002$), and involvement of the temporomandibular joint ($p=0.07$) in comparison to clinically mild cases. The presence of these additional findings in conjunction with EAC bony erosions and mastoid effusions raises the concern for clinically advanced TB-ORN that might require HBO, IV antibiotics, or surgical resection. The patient in Figure 6 presented with otalgia and otorrhea, and on exam there was exposed bone from the 10 O'clock to the 2 O'clock position. A fistulous communication was noted to the temporomandibular joint, with debris and drainage expressed with jaw movement. He was treated with a trial of HBO and antibiotics, with initial improvement in drainage after three months. However, 5 months later, he returned with severe pain (10/10), left sided trismus, and otorrhea and on exam there was left post-auricular ulceration and foul drainage from a Bezold abscess. He was taken to the operating room for left mastoid wound exploration, irrigation and biopsies. Involved areas of the SCM were also debrided. The entire process was repeated 3 days later. Five days later the patient returned to the OR for left lateral temporal bone resection with myocutaneous anterolateral thigh flap reconstruction (Figure 7). Selective neck dissection was performed for enlarged lymph nodes. There was no tumor on final pathology. In long term follow-up, he has not had any recurrence of infection at this operative site. This example illustrates the devastating complications that can arise in patients with advanced TB-ORN despite aggressive therapy, and the importance of accurate clinical and radiographic diagnosis for appropriate management.

Treatment of temporal bone ORN

All 11 patients with clinically mild temporal bone ORN in our study were managed with periodic cleanings and some received short course antibiotic drops. All 4 patients with clinically moderate TB-ORN received hyperbaric oxygen. Of the 5 patients dispositioned for surgery, 3 had lateral temporal bone resection, surgery was deferred for 1 due to significant co-morbidities, and surgery was recommended for 1 and has not yet been scheduled.

Isolated, small areas of exposed bone can be managed expectantly with ear canal cleaning every three or four months. With time, spontaneous closure can occur. Patients are admonished not to use cotton swabs or insert other objects into the ear canal. In some patients, soft tissue undermines the necrotic bone, and this island of bone can easily be removed in the outpatient clinic. Frequently, this new epithelium heals to cover the bone of the ear canal, and resolution of infection and crusting takes place.

Patients who present with severe or diffuse disease will require surgical management. Clinical findings of canal-mastoid fistula or mastoid-cutaneous fistula will require surgical management. Radiographic study helps to identify these patients and to determine the extent of disease. Surgical planning involves either mastoid obliteration or lateral temporal bone resection. Closure of the ear canal and coverage of bone is required, since open cavity canal wall down defects take years to epithelialize fully. A temporalis muscle flap can be

employed when it has not been irradiated. Microvascular free tissue transfer is required for larger defects.

Conclusion

Temporal bone osteoradionecrosis is a rare, although severe complication of radiotherapy to the head and neck. EAC bony erosion was present in all cases of TB-ORN, and along with mastoid opacification may be the only finding in the early stages. Enhancing soft tissue, soft tissue gas, and TMJ involvement are more likely to occur in clinically advanced cases, and these patients can develop hearing loss, meningitis, facial nerve paralysis, and brain and neck abscesses. High index of suspicion is necessary for early diagnosis in order to prevent disastrous complications.

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Figure 1.

Irradiated tumor types by histology and tumor subsite. Total patients=20. SCC= squamous cell carcinoma. BCC=basal cell carcinoma. RMT=retromolar trigone.

Figure 2. Clinical findings at diagnosis of TB-ORN. All 20 patients were evaluated by a single otologist.

Figure 3.
High resolution contrast enhanced CT scan findings in 20 patients with TB-ORN

Figure 4.

CT Findings as a percentage within each of the clinical grade subgroups of mild, moderate, and severe.

Figure 5.

54 yo female presenting with tinnitus and otalgia 2½ years following completion of chemoradiation for T3 N2 nasopharyngeal carcinoma. No otorrhea, imbalance or dizziness. (A) Pretreatment axial T1weighted image shows an isointense mass in left nasopharynx (*) and left lateral retropharyngeal nodal metastasis (arrow). (B) Radiation consisted of IMRT using 6 MV photons directed at the nasopharynx and bilateral neck to a total dose of 6996 cGy in 33 fractions of 212 cGy each (C) Otoloscopic exam with exposed bone inferiorly in the ear canal, crusting, and an intact tympanic membrane. (D) High resolution bone algorithm CT image shows subtle bony erosions along the anterior and posterior wall of the EAC with loss of overlying soft tissue (arrows). (E) Normal appearance of contralateral EAC in the same patient.

Figure 6.

TB-ORN in a 56 yo male presenting 12 years following parotidectomy, facial nerve and skin grafting, and radiation therapy for recurrent basal cell cancer. (A) Radiation consisted of a total dose of 60 Gy in 30 fractions. (B) High resolution bone algorithm CT (HRCT) image at diagnosis of TB-ORN demonstrates left mastoid opacification and bony erosions (arrows) along the anterior and posterior wall of the external auditory canal (C) HRCT 5 months later shows progression of EAC bony erosions (arrows), (D) new enhancing soft tissue (arrow), and (E) development of an extensive left postauricular abscess resulting in skin ulceration (arrow).

Figure 7.

Same patient as in Figure 6 following lateral temporal bone resection with myocutaneous anterolateral thigh flap reconstruction.