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Main Article

Surgical treatment of osteoradionecrosis of the temporal bone in patients with nasopharyngeal carcinoma

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Abstract

Objective: To investigate methods of treating diffuse osteoradionecrosis of the temporal bone in cases of nasopharyngeal carcinoma, following radiotherapy.

Study design: Retrospective.

Methods: Fourteen post-irradiation nasopharyngeal carcinoma patients ($n = 14$ ears) with diffuse osteoradionecrosis received surgical treatment from March 1994 to May 2005. The patients underwent radical mastoidectomy (five ears), extensive radical mastoidectomy (one ear), or radical mastoidectomy and obliteration with local vascularised fascia flaps (eight ears).

Results: Six ears fully recovered; two ears were still infectious but sequestrum had not re-formed; five ears (50 per cent) still had repeated suppuration and did not epithelialise; and one ear had local re-formation of sequestrum requiring periodic dressing changes.

Conclusion: Diffuse osteoradionecrosis of the temporal bone following radiotherapy for nasopharyngeal carcinoma is difficult to treat surgically. The main objective of surgery is to facilitate drainage and to prevent complications. Radical mastoidectomy and obliteration with local vascularised flaps is an effective method.

Key words: Temporal Bone; Osteoradionecrosis; Nasopharynx Neoplasms; Mastoidectomy

Introduction

Nasopharyngeal carcinoma (NPC) is the most common head and neck cancer in the Chinese population, especially in southern China. Radiotherapy is the mainstay of treatment for NPC, allowing a five-year survival rate ranging from 37 to 70 per cent;[1–3] however, post-irradiation complications of NPC are very common.

Anatomically, the temporal bone is adjacent to the pharynx nasalis; hence, exposure cannot be avoided during radiotherapy for NPC. Radiation injury to the ear and temporal bone takes many forms. Immediate sequelae typically involve the soft tissues and include dermatitis and otitis media.[4] Delayed complications include persistent tympanic membrane perforation, external canal stenosis or atresia, facial nerve paralysis, sensorineural hearing loss, vestibulopathy,[4,5] and radiation-induced tumours of the temporal bone.[6–9]

Osteoradionecrosis

Osteoradionecrosis of the temporal bone is a rare but potentially serious complication of radiation therapy involving the head and neck. Osteoradionecrosis was first described in 1926 by Ewing.[10] In 1952, Block described the first case of osteoradionecrosis of the temporal bone after radiotherapy of the head and neck.[11] Ramsden *et al.* reviewed 29 cases of osteoradionecrosis of the temporal bone and characterised each as localised or diffuse.[12] The localised form was more common and was limited to the external auditory canal. The diffuse form involved the mastoid and the middle ear.

The treatment of osteoradionecrosis is difficult. In this study, we analysed the surgical treatment of 14 post-irradiation NPC patients initially diagnosed with diffuse osteoradionecrosis of the temporal bone, between March 1994 and May 2005.

Materials and methods

Clinical data

The study was approved by the institutional review board of the Second Affiliated Hospital of Sun Yat-Sen University, Guangzhou, China, in May 2006.

The medical files of 14 patients (nine right ears and five left ears) were reviewed. The patients (nine men and five women) were aged between 44.6 and 63.8 years, with an average age of 52.5 years. Diagnoses were confirmed by pathological studies; all patients had poorly differentiated nasopharyngeal squamous

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cell carcinomas. All patients received an average radiation dose of 60 Coγ (65–80 Gy). Two patients experienced recurrence, and radiation therapy was administered again at a dose of 70 Gy.

Twelve cases of osteoradionecrosis of the temporal bone were diagnosed, four to 12 years after single-treatment radiation therapy. The two patients who received radiation therapy twice were diagnosed with osteoradionecrosis at two and 2.7 years after radiation therapy.

No patient had a history of chronic otitis media before radiotherapy.

Clinical presentation

All 14 ears had purulent, foul-smelling otorrhoea. In addition, eight ears had a deep external canal and two were associated with serious headache, four with tinnitus and one with vertigo. All ears had varying degrees of hearing loss. There was no associated facial paralysis or hemiparalysis. All patients were in good physical condition, without blood dyscrasias or radiation encephalopathy.

On physical examination, the external canal was found to be covered with crusts and purulent or bloody secretions. Removal of the crusts and secretions revealed defects in the skin, with exposure of the mastoid bone or even free sequestrum on the posterior wall of the external canal in five ears, and on both the posterior and proximal walls in nine ears. In four ears, there was tympanic ring involvement. In all cases, there were tympanic membrane perforations, with granulation tissue in the tympanic cavity of six cases.

Temporal bone computed tomography

In addition to destruction of the external canal, the mastoid sclerotin was destroyed to varying degrees. Free sequestrum, surrounded by soft tissue, gave the appearance of an isolated island (Figures 1 and 2). Computed tomography (CT) scanning demonstrated that all 14 ears had soft tissue masses filling the mastoid cavity to varying degrees. Computed tomography scanning also revealed that two ears had os petrosum involvement, one had eustachian tube involvement, one had sequestration approximating the eustachian tube, one had canalis semicircularis lateralis destruction, two had tegmen destruction and two had suspected cholesteatoma formation.

Audiology examination

Pure tone audiometry demonstrated severe sensorineural hearing loss in five ears, moderately severe sensorineural hearing loss in six ears, and severe mixed hearing loss in three ears.

Treatment

All cases received conservative treatment for at least half a year. Treatment included clearing the external canal, local washing with hydrogen peroxide, and administration of oral or local antibiotics. Eight patients received hyperbaric oxygen treatment. These treatments were not effective, and some patients' conditions worsened; hence, all patients accepted surgical treatment.

FIG. 1

Axial computed tomography image of the right temporal bone, demonstrating destruction of mastoid sclerotin, a soft tissue mass filling the mastoid cavity and auricular meatus, and an isolated 'island' of free sequestrum (arrow).

All surgical procedures were performed by the same team within our otolaryngology department. Patients were divided into two groups, depending on the surgical method used. Patients in group one ($n = 6$, March 1994 to January 2000) received

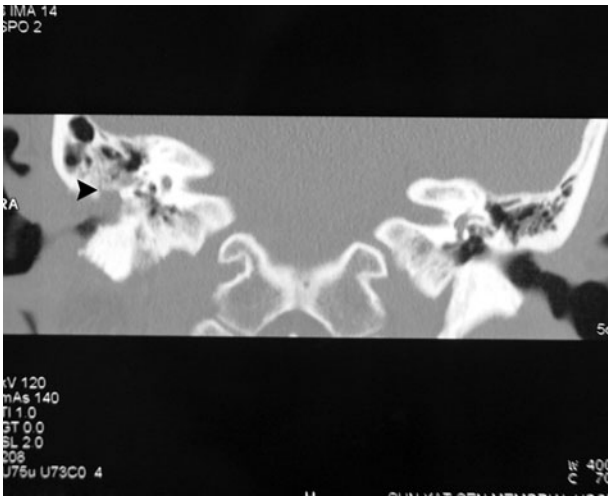

FIG. 2

Coronal computed tomography image of the right temporal bone, demonstrating destruction of mastoid sclerotin of the external canal and middle ear (arrow), osteomyelitis of the mastoid, and a soft tissue mass and free sequestrum filling the auricular meatus.

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radical mastoidectomy (five ears) or extensive radical mastoidectomy (one ear). Patients in group two ($n = 8$, June 2000 to May 2005) received radical mastoidectomy and obliteration with local vascularised fascia flaps (eight ears).

Radical mastoidectomy involved removing the mastoid process, mastoid antrum and tympanic cavity. After removing the posterior wall of the auricular canal, the open cavity thoroughly eliminated the sequestrum and the resulting pathological changes.

In those cases in which it was performed, obliteration with local vascularised fascia flaps involved the pedicle temporal muscular fasciae and Palva flaps. The surgical method proceeded as follows. After making a post-auricular incision, the incision was extended from the front upper extreme diagonal. The temporal muscular fasciae was then exposed and stripped away, retaining an approximately 1cm pedicle in the front. Then, the temporal muscular fasciae was shifted to the underlying cavity, covering it. In cases in which the CT scan showed sequestration involvement of the mastoid segment of the eustachian canal and canalis semicircularis lateralis, destruction was confirmed on surgery and local vascularised fascia flaps were created to cover the destroyed surface structure. Palva flaps were created by making a post-auricular incision and then fashioning a muscle and periosteal flap with the pedicle in the anterior aspect. This was then turned forward and downward into the cavity for padding. Only two surgical cases had visible damage of the fascia tissue, wherein the fascia tissue was thick and adherent to the temporal muscle, a change observed post-radiotherapy.

Results

In both groups, all incisions healed well without surgical complication. All patients were followed up for 18 months to two years after surgery. Necrotic bone, chronic osteomyelitis and inflammation granulation tissue within the excised tissue were confirmed by pathological analysis. Two cases considered to have cholesteatoma on the pre-operative CT scan were confirmed by pathological analysis. No cases showed malignant change.

In group one, one ear (16.67 per cent) fully recovered, being dry with no sequestrum re-formation. Two ears (33.33 per cent) were still infected and had granulation cavities but no sequestrum re-formation. Three ears (50 per cent) still suffered repeated suppuration, and the surgical cavity could not epithelialise. Two ears developed local sequestrum re-formation. One ear with diffuse sequestrum re-formation required further surgery; however, the ear still could not completely epithelialise and required periodic dressing changes.

In group two, five ears (62.5 per cent) fully recovered, being dry and completely epithelialised without sequestrum re-formation. Two ears (25 per cent) were still locally infected and showed no epithelialisation, and required periodic dressing changes. The last ear had local sequestrum re-formation because of poor local blood supply and local necrosis of the obliterated fascia tissue. Although this ear did not fully dry or achieve complete epithelialisation, requiring periodic dressing changes, the symptoms did improve.

Discussion

Nasopharyngeal carcinoma is the most common malignant tumour of the head and neck. The main treatment is radiotherapy. There have been few reported reviews of osteoradionecrosis of the temporal bone induced by radiotherapy, and the applications and methods of surgical treatment are still controversial.

Osteoradionecrosis represents progressive development of a pathological process. Earlier in this progression, radiation therapy induces swelling of the tunica intima vasorum of the temporal bone, with thickening and fibrosis, resulting in stenosis and obstruction of the vascellum and ischaemia of the substantia ossea. Radiation therapy itself directly induces a number of pathological changes: osteocyte death, osteolysis and loss of healthy myeloid tissue; sclerotomal cell injury; lack of osteanaphysis; and connective tissue infiltration replacing osseous tissue, inducing aseptic osteoradionecrosis. Radiation therapy can induce dermatitis and inflammatory changes in the temporal bone air cells and mucosa. Once initiated, the inflammatory process can lead to osteoradionecrosis. Osteoradionecrosis can have life-threatening complications such as facial nerve paralysis, basal fracture of the temporal bone, cerebrospinal fluid leakage, cerebral meningitis and brain abscess.[13,14] Cholesteatomas may arise in the mastoid air cells after epithelialisation, through a necrotic defect in the external auditory canal. Patients with osteoradionecrosis and purulent otitis media always have purulent, foul-smelling or bloody otorrhoea and deep otalgia. These symptoms greatly limit their quality of life.

Treatment of osteoradionecrosis is very difficult. At present, the literature regarding use of hyperbaric oxygen for this condition is limited.[15] Use of hyperbaric oxygen to treat osteoradionecrosis of the mandible has been well documented, and such treatment has been shown to improve radiation-induced changes (i.e. hypoxia, hypocellularity and hypovascularity), creating an environment conducive to tissue healing and inhibitory to infection. However, hyperbaric oxygen treatment alone cannot cure osteoradionecrosis. It may help control early, acute inflammation, and it is an effective adjunct to surgical intervention. Conservative treatment involving hyperbaric oxygen therapy for diffuse osteoradionecrosis may relieve local symptoms and promote resolution of sequestrum, but such treatment makes it difficult to control infection and promote healing. It is especially difficult to absorb sequestrum, which influences raw surface healing.

Based on the above clinical features and pathophysiology, we investigated surgical treatment for osteoradionecrosis of the temporal bone. Our observations were as follows: (1) conservative treatment has no effect, and symptoms recur; (2) patients were very

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concerned to obtain an improvement of their symptoms and quality of life; and (3) CT scanning of the temporal bone revealed mastoid cavities filled with soft tissue and with drainage problems. The observed sequestrum may extend to the mastoid cavities and involve important structures such as the eustachian tube, labyrinth and skull base. Patients with dyscrasia, uncontrolled primary tumour or poor attendance should not be considered for surgical treatment. In cases of osteoradionecrosis, we believe that the objective of surgery is to radically cure the condition. Drainage helps to control infection and prevent complications, and allows pathological examination to rule out the possibility of cancer. Surgery always involves radical mastoidectomy or extensive radical mastoidectomy. During the operation, the surgeon should carefully discern the extent of disease, resect tissue where necessary (including free sequestrum and bone tissue lacking blood supply) and expose viable bone. Special attention must be paid when resecting sequestrum adjacent to an important structure such as the eustachian tube, skull base, labyrinth or sigmoid sinus, in order to prevent stretch injury and surgical complications. It is sometimes difficult to determine the extent of involvement of surgery required for a radical cure, because of the poor blood supply to the temporal bone and chronic osteomyelitis. This may be why some patients have a non-dry ear and sequestrum re-formation after operation. This is also why the operation is controversial.

- **Osteoradionecrosis of the temporal bone is one of the most serious complications of radiotherapy for nasopharyngeal carcinoma**
- **Surgical treatment should be considered when conservative treatment is ineffective and important structures are involved**
- **The main objective of surgery is drainage and prevention of complications**
- **Radical mastoidectomy and obliteration with local vascularised flaps is an effective surgical method**

Of the six patients treated from 1994 to 2000 with radical mastoidectomy or extensive radical mastoidectomy, only one (16.6 per cent) had a dry cavity and no sequestrum re-formation. Half of these six patients (three ears) continued to have repeated suppuration, no epithelialisation of the surgical cavity and various degrees of sequestrum re-formation. Because radiotherapy had resulted in poor blood supply to the temporal bone and chronic osteomyelitis, these patients could not form dry mastoid cavities. Even if the free sequestrum and bone tissue lacking blood supply had been excised, without suitable post-operative management this pathology condition would have redeveloped. In order to resolve this issue, some reviews describe the use of various tissues to cover or obdurate the cavities, e.g. muscle and fat tissue, or skin grafting with a free fascial flap.

Eight patients in group two received radical mastoidectomy and obliteration with local vascularised fascia flaps. In cases of osteoradionecrosis, the radical mastoidectomy excision must be thorough, and the resulting cavity is thus bigger, so petal cover scope is limited, making blood supply out of the question. To ensure that the organisation petal area was enough, we manufactured simultaneously a pedicle temporal musculofascial flap and a post-aurem Palva flap, compounding the pads into the surgical cavity in order to provide a suitable blood supply to promote cavity healing. Over an 18-month to two-year follow-up period, five ears (62.5 per cent) had dry, clean mastoid cavities and no sequestrum re-formation. Only one ear (12.5 per cent) continued to have local free sequestrum and could not be completely dried or epithelialised, requiring periodic clearing and conservative treatment; however, the patient's symptoms improved.

Although the ear may suffer varying degrees of radiation damage as a result of radiotherapy for nasopharyngeal carcinoma, not all blood vessels of the fascial tissues sustain obvious injury or visible damage, except in cases in which the fascial tissues were slightly thickened and adherent to the temporal muscle. In only one case was the local blood supply to the fascial tissue poor, with local necrosis. This may be related to the poor blood supply to the raw surface of the surgical cavity; with periodic clearing and conservative treatment, symptoms still improved. Shifting the pedicle tissue covers important structures such as the eustachian tube and semicircular canals, and also prevents or treats corresponding complications.

Contraindications for tympanoplasty include poor blood supply to the middle ear, infection, destruction of the ossicle and tympanic ring, need for resection, unsuitable patient condition, or need for auditory rehabilitation. Since this study involved few cases, larger studies are needed to confirm both the surgical methods and treatment outcomes.

References

1 Payne DG. Carcinoma of the nasopharynx. *J Otolaryngol* 1983;**12**:197–202
2 Hsu MM, Tu SM. Nasopharyngeal carcinoma in Taiwan: clinical manifestations and results of therapy. *Cancer* 1983;**52**:362–8
3 O'Neill JV, Katz AH, Skolnik EM. Otologic complications of radiation therapy. *Otolaryngol Head Neck Surg* 1979;**87**: 359–63
4 Smouha EE, Karmody CS. Non-osteitic complications of therapeutic radiation to the temporal bone. *Am J Otol* 1995;**16**:83–7
5 Huang SC, Lui LT, Lynn TC. Nasopharyngeal cancer: study III. A review of 1206 patients treated with combined modalities. *Int J Radiat Oncol Biol Phys* 1985;**11**:1789–93
6 Coatesworth AP, Martin-Hirsch DP, MacDonald A. Post-irradiation liposarcoma of the temporal bone. *J Laryngol Otol* 1996;**110**:779–81
7 Goh YH, Chong VF, Low WK. Temporal bone tumours in patients irradiated for nasopharyngeal neoplasm. *J Laryngol Otol* 1999;**113**:222–8
8 Lustig LR, Jackler RK, Lanser MJ. Radiation-induced tumors of the temporal bone. *Am J Otol* 1997;**18**:230–5
9 Friedland DR, Lustig LR. Osteoradionecrosis of the temporal bone: assessment and management. *Curr Opin Otolaryngol Head Neck Surg* 2002;**10**:366–70

https://doi.org/10.1017/S0022215107001399 Published online by Cambridge University Press

10 Ewing J. Radiation osteitis. *Acta Radiol* 1926;**6**:399–412
11 Block E. Radiation injury of the temporal bone. *Z Hals Nas Ohrenheilkol* 1952;**3**:45–6
12 Ramsden RT, Bulman CH, Lorigan BP. Osteoradionecrosis of the temporal bone. *J Laryngol Otol* 1975;**89**:941–55
13 Lim BY, Pang KP, Low WL, Tan HM. CSF otorrhea complicating temporal bone osteoradionecrosis in a patient with nasopharyngeal carcinoma. *Ear Nose Throat J* 2005;**84**:39–40
14 Leonetti JP, Origitano T, Anderson D, Melian E, Severtson M. Intracranial complications of temporal bone osteoradionecrosis. *Am J Otol* 1997;**18**:223–9
15 London SD, Park SS, Gampper TJ, Hoard MA. Hyperbaric oxygen for the management of radionecrosis of bone and cartilage. *Laryngoscope* 1998;**108**:1291–6

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Dr Ou Yong-Kang takes responsibility for the integrity of the content of the paper.
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