Main Articles

A simple reconstructive procedure for radiation-induced necrosis of the external auditory canal

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Abstract
Localized necrosis of the bone, cartilage, and soft tissue of the external auditory canal is an uncommon side effect of radiotherapy to the parotid region. Five patients developed late onset skin necrosis of a quadrant of the ear canal secondary to an underlying osteoradionecrosis of the tympanic ring. We report a one-stage procedure to excise the necrotic tissue and replace it with a local rotational flap derived from the post-auricular skin. Otological side effects of radiotherapy are discussed.

Key words: Ear, canal; Surgical flaps; Radiotherapy, high-energy; Parotid neoplasms

Introduction
Radiotherapy to tumours of the head and neck has the potential to produce adverse side-effects. The use of orthovoltage irradiation, now obsolete in radical treatment protocols, resulted in full dose absorption by the skin, and was associated with an acute cutaneous reaction, sometimes with subsequent necrosis. Absorption by bone within the treatment field was even greater, producing bone whose blood supply was precarious and vulnerable to osteoradionecrosis following trivial local trauma or sepsis (Schuknecht and Karmody, 1966; Maran et al., 1993). Modern treatment techniques have made radiation-induced damage to normal tissues much less common than previously. Contemporary megavoltage techniques, with photon and electron irradiation, characteristically spare the skin, and absorption by bone is no greater than in surrounding soft tissues, so that such side-effects are now unusual.

Radiotherapy has a role in the management of parotid tumours in certain clinical situations. In the case of the commonest parotid tumour, pleomorphic adenoma, indications include tumour enucleation surgery, tumour spillage, residual tumour within the gland or evidence of malignancy. Other malignant parotid tumours of various types may also require radiotherapy. The treatment field typically extends from the top of the zygomatic arch superiorly to the level of the bone of the hyoid inferiorly, and from the outer ocular canthus anteriorly (thus including the parotid duct which opens opposite the second upper molar) to the mastoid process posteriorly (Maran et al., 1993).

In the patients we report there is a late onset skin necrosis of the external ear canal within the irradiated field, despite the use of contemporary megavoltage techniques. Three patients had radiotherapy for parotid tumours, one had had treatment for a cutaneous carcinoma of the pinna, and one had had treatment for a temporal lobe astrocytoma. These patients all developed a late onset necrosis of a quadrant of the ear canal and were initially assumed to be suffering from otitis externa, but were later correctly diagnosed on the basis of characteristic signs and symptoms. In this paper we report an effective one stage procedure to excise the affected skin and necrotic bone and repair the defect with a local flap. Although the local vascular supply of this area is particularly rich, and allows great flexibility in reconstruction techniques, the clinical problem posed by these patients is a good example of the factors involved in flap design and use.

Case reports
Case 1
A 70-year-old man was treated for a pre-auricular basal cell carcinoma with involvement of the tragus and pinna. Megavoltage electrons to a dose of 44 Gray (Gy) were delivered in 11 fractions of 4 Gy over 19 days. There was a significant acute local reaction, with ear discharge which resolved with topical

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FIG. 1
The left pinna is turned forward, and the post-aural flap marked. The dimensions of the donor site are approximately 1.5 x 4 cm.

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The flap is raised, and is turned back out of the operative field (arrow). Dissection leads to elevation of the posterior meatal wall until the defect is encountered. Slings are passed through the lateral canal wall to maintain forward traction on the pinna.

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FIG. 2
The flap has been raised, and is turned back out of the operative field (arrow). Dissection leads to elevation of the posterior meatal wall until the defect is encountered. Slings are passed through the lateral canal wall to maintain forward traction on the pinna.

FIG. 3
The flap prior to placement in the canal wall. The distal half is epithelialized (white arrow), the proximal extent of which is shown by two marking dots made earlier at a trial placement. The rest of the flap, which will be buried, is de-epithelialized (dark arrow). The flap has narrowed following elevation, and now has dimensions of approximately 1 x 4 cm.

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A 67-year-old woman with non-insulin dependent diabetes mellitus underwent a right superficial parotidectomy. The histology reported malignancy within a pleomorphic adenoma. She subsequently received radiotherapy with 4MV photons to a dose of 56 Gy in 29 fractions of 1.9 Gy over 41 days. Ten years later she presented with a chronic irritation and a sense of blockage in the right ear canal. The canal was completely occluded with a large keratin plug, that was detached with some pain from an adherent plaque on the antero-inferior aspect of the ear canal. Further inspection after topical treatment showed that this quadrant of the canal was ulcerated all the way up to the annulus, and that the underlying bone was necrotic. There was also an associated small posterior tympanic perforation, which was dry. At the age of 78, four months after presentation, the defect was repaired with an inferiorly-based post-aural flap. An underlay myringoplasty was also performed. Follow-up in the subsequent two years has shown no further canal ulceration, and an intact tympanic membrane. Local wax accumulation has been cleared with use of drops only.

Case 2
A 67-year-old woman with non-insulin dependent diabetes mellitus underwent a right superficial parotidectomy. The histology reported malignancy within a pleomorphic adenoma. She subsequently received radiotherapy with 4MV photons to a dose of 56 Gy in 29 fractions of 1.9 Gy over 41 days. Ten years later she presented with a chronic irritation and a sense of blockage in the right ear canal. The canal was completely occluded with a large keratin plug, that was detached with some pain from an adherent plaque on the antero-inferior aspect of the ear canal. Further inspection after topical treatment showed that this quadrant of the canal was ulcerated all the way up to the annulus, and that the underlying bone was necrotic. There was also an associated small posterior tympanic perforation, which was dry. At the age of 78, four months after presentation, the defect was repaired with an inferiorly-based post-aural flap. An underlay myringoplasty was also performed. Follow-up in the subsequent two years has shown no further canal ulceration, and an intact tympanic membrane. Local wax accumulation has been cleared with use of drops only.

Case 3
A 38-year-old man had a right superficial parotidectomy for a mass which was reported to be a parotid lipoma. Five years later a locally recurrent plasty was not undertaken because this was the only hearing ear. Subsequent follow-up showed slight flap retraction, but no loss of epithelial cover. The patient continues to have CSOM, but has otherwise remained well in the six years since the repair.

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Case 4

A 43-year-old woman was diagnosed with a temporal lobe cystic astrocytoma, and underwent surgical debulking and radiotherapy. Treatment was with gamma irradiation from a cobalt-60 source to a total of 60 Gy in 30 fractions of 2 Gy delivered over 42 days. One year later residual tumour was removed at a further procedure, and she received six courses of procarbazine, cischloroethylnitrosourea, and vincristine (PCV) chemotherapy. Increasing problems with wax clearance, pain, and deafness in the left ear in the four years following the second procedure led to a consultation in which, after clearance of debris, an epithelial defect in the anterior wall and floor of the canal was recognized. There was a unilateral mild high frequency sensorineural hearing loss in the left ear. At the age of 48 years the patient underwent repair of the defect with an inferiorly based post-aural flap, and has been very pleased with the result in the subsequent nine months of follow-up.

Case 5

A 27-year-old woman had excision of a left parotid mass which was reported to be a mucoepidermoid carcinoma with positive margins. She underwent two further surgical clearances in the next few months, culminating in radical parotidectomy with reconstruction with a free latissimus dorsi flap. She then received radiotherapy with cobalt-60 to a total of 60 Gy in 33 fractions of 1.8 Gy over 47 days. A three-field plan was used because an extended area of tissue needed to be treated. Two years following her initial surgery she had developed a pinhole meatus which, after failure of conservative treatments, was enlarged using a superiorly based post-aural rota-
tional flap inserted without subcutaneous burial into the roof of the canal. This was successful at enlarging the meatus, but six years later an episode of cellulitis of the scalp drew attention to an accumulation of debris in the ear which overlay a postero-inferior lateral defect of the canal. The tympanic membrane was intact, and the hearing normal except for a mild unilateral high frequency hearing loss. At the age of 35 the patient had a repair of the defect with an inferiorly based post-aural flap. Follow-up has been less than three months to date, but no complications have been encountered so far.

Procedure of canal wall repair with post-aural flap

The external ear canal is cleaned, and the skin margins of the ulcer freshened. Histological confirmation of benign pathology may be desirable. A post-aural incision is made just posterior to the sulcus, extending from the mastoid tip inferiorly to just below the apex to the pinna superiorly. A second incision is made posterior to this, tapering towards the apex of the first, and a long, narrow post-aural skin flap, inferiorly based, is raised superficial to the peristomeum of the mastoid. The ratio of the flap is variable, up to a ratio of 3:1. The pinna is reflected forward, and with sharp dissection the tympanic ring is identified. The soft-tissues of the walls of the ear canal are raised until the ulcerative defect is reached medially, and the underlying necrotic bone is drilled away until viable bleeding bone is encountered. The flap is then passed through this tunnel, and ink dots are used to mark the proximal extent of the full thickness flap which is needed to repair the defect. The flap is then retrieved, and the area proximal to the dots is de-epithelialized to allow it to be buried. The flap is then passed back to its definitive new position, and, if convenient, a pair of absorbable sutures may be used to secure the epithelialized portion of the flap to the freshened edges of the ulceration. The sutures are not necessary to maintain the position of the flap. The donor site is then closed directly, avoiding tension at the inferior extent where the proximal portion of the flap lies buried underneath. The newly fashioned canal is then packed with a topical antibiotic dressing, such as chloramphenicol ointment on ribbon gauze or BIPP, for a week. Patients have also been given oral antibiotics for a week. Subsequent follow-up is routine, and wax clearance can usually be achieved with the use of topical drops alone.

Discussion

We present a simple and effective procedure to excise and reconstruct an area of skin and bone necrosis in patients who have received radiotherapy to the parotid region. The canal defect is reconstructed with a rotational skin flap from a territory which has itself been irradiated. Although the introduced skin lacks the specialized characteristics of meatal skin, such as wax production and keratinocyte migration, all patients have done well. In particular, none have had chronically discharging ears due to the build-up of keratinous debris.

Radiotherapy has a number of recognized side effects in relation to the ear. Effects have been noted in relation to the canal, ossicles, temporal bone, and inner ear (Gyorkey and Pollock, 1960; Schuknecht and Karmody, 1966; Ramsden et al., 1975; Adler et al., 1985). A prospective trial showed megavoltage irradiation to a dose of 60–70 Gy to be associated with the development of both conductive and sensorineural deafness (Anteunis et al., 1994). None of the patients were reported to have develop canal necrosis or CSOM over the five years of the study. The experimental and now discredited technique of fast neutron therapy was reported to be cause of a seventh nerve palsy in some patients with parotid malignancy (Rampling and Catterall, 1984).

Acute soft tissue lesions of the canal, such as dermatitis and desquamation were always seen in the era of orthovoltage radiation (Schuknecht and Karmody, 1966). Acute reactions may be less marked with modern megavoltage techniques. However, the skin-sparing qualities of megavoltage irradiation may be lessened around the ear by oblique incidence of the beam, and the spacing, or build-up effect, of the pinna, wax, and beam-directing shell. A more recent paper has looked at pathological findings at long-term (one to 21 years) in 13 temporal bones removed from patients long after their treatment (Adler et al., 1985). All patients had received treatment with a cobalt-60 source. Bone changes were of radiation osteitis, with bone resorption, fibrosis, and loss of marrow. Osteoradionecrosis was present in approximately half of these bones, and involved the tympanic ring in all such cases except one. Soft tissue changes noted include epithelial hyperplasia, atrophy of ceruminous glands, fibrosis of the dermis, and in one case, loss of epithelium with fibrosis. The clinical correlates of these findings were not presented.

Contemporary discussion of the clinical findings in osteoradionecrosis of the temporal bone and canal proceeds from the key paper of Ramsden et al. (1975) which proposed a classification of patients into two major groups: ‘localized necrosis’, and ‘diffuse necrosis’. Patients with localized necrosis presented with otorrhoea and a necrotic canal floor through which dead bone was visible. The 18 patients in this group had received irradiation of various head and neck or intracranial tumours, and of these, eight had received megavoltage treatment, the rest orthovoltage. Patients with localized necrosis were treated conservatively, with spontaneous separation of a sequestrum in nine. All were reported to heal satisfactorily, although this took a period of one to four years. None were offered a surgical procedure to repair the local defect. By contrast, nearly all of the 11 patients with diffuse osteoradionecrosis had been irradiated for middle ear malignancy, and presented with significant symptoms such as vertigo, total deafness, cutaneous fistulas, and intracranial complications. Nine required a major surgical procedure to produce a safe ear. The authors suggested that there was an inverse correlation between age at irradiation and
onset of osteoradionecrosis, although the number of patients in their series was not large enough for statistical validity. Further series of patients with osteoradionecrosis of the temporal bone have since been reported, sometimes with catastrophic manifestations (Ma and Fagan, 1988; Guida et al., 1990; John et al., 1993; Yuen and Wei, 1994). In the largest series, that of Yuen and Wei, 16 patients with temporal bone osteoradionecrosis following treatment for nasopharyngeal carcinoma were reported, of whom seven had localized canal necrosis. These latter patients were treated with simple skin debridement only, without reconstruction. This was satisfactory in four, but in three patients the abnormality failed to heal and this group later underwent total extirpation of the tympanic plate and modified radical mastoidectomy (Yuen and Wei, 1994). In this paper we report five patients who have developed localized osteoradionecrosis of the canal following megavoltage irradiation of the parotid, or adjacent organs. In each case we used an established simple surgical procedure using a local flap to repair successfully the canal defect (Stauch et al., 1982). The use of the post-aural flap has not been reported before for radiotherapy-induced canal necrosis.

Local flaps on the face are usually robust. Indeed the concept of the axial flap, with its secure blood supply and predictable anatomical landmarks, was largely developed in the reconstruction of the face (Esser, 1936). The blood supply to the pinna is potentially vast for an organ of its size, and can be increased above baseline very quickly, as anyone who has been embarrassed or angry in the past will testify. The local arteries are the superficial temporal, the posterior auricular, and the occipital, all named and direct branches of the external carotid artery. Most of the supply to the pinna derives from the posterior auricular and occipital arteries (Ma and Fagan, 1988). These arteries also supply the inferiorly based post-aural flap, although it is not an axial flap. The superficial temporal and posterior auricular arteries form an Anastomotic loop which allows retrograde filling of the post-aural flap if it is superiorly based (Stauch et al., 1982).

In our patients a post-aural flap was used to repair the canal wall defect. The post-aural flap has been recorded since at least the 1940s, and it was initially used to correct congenital canal stenosis (Siirala, 1949; Renard, 1981). It was also used to correct post-traumatic canal stenosis, which was a typical problem in patients injured by windscreens in unrestrein- tained car crashes. Pre-auricular flaps were used for similar indications (Macomber et al., 1958; Owens, 1959; Pennisi et al., 1965), one author reporting that the pre-auricular flap was viable even if used at a ratio of 5:1. Unfortunately none of the papers above reported on the long-term viability of the flaps in these patients. The post-aural flap as described here is essentially a random flap, and we have not used it at a ratio greater than 1:3. However, no long-term problems with viability have been encountered in our patients, despite the fact that all our patients have received radiotherapy to the donor site, and some of the patients are quite elderly. There were also no problems with incorporation of post-aural skin into the canal, and no need for regular dewaxing removal in out-patients. We believe that the procedure we describe offers an excellent long-term solution to the unusual problem of post-radiotherapy localized necrosis of the external ear canal.

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References


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