The Journal of Laryngology & Otology (2009), ***123***, *1114–1119.*

doi:10.1017/S0022215109990612

Main Article

Osteoradionecrosis of tympanic bone: reconstruction of outer ear canal with pedicled skin flap, combined with hyperbaric oxygen therapy, in five patients

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Abstract

Objective: To evaluate the results of one-stage surgical repair of the meatal skin defect in patients with long-lasting osteoradionecrosis of the outer ear canal, using a postauricular, inferiorly pedicled skin flap. All patients were also treated with hyperbaric oxygen both pre- and post-operatively.

Methods: A prospective study evaluating the results of a one-stage surgical procedure to repair the meatal skin defect in five patients with osteoradionecrosis of the outer ear canal. All patients were treated with hyperbaric oxygen both pre- and post-operatively.

Results: In four of the five patients, intact canal skin was achieved after surgery and hyperbaric oxygen therapy. One patient needed a second operation to cover a small remaining area of bare bone. In one patient, wound healing was unsatisfactory and an area of bare bone remained.

Conclusion: In cases of osteoradionecrosis of the outer ear canal, the skin defect can be repaired with an inferiorly pedicled skin flap. Although not yet scientifically proven, the peri-operative application of hyperbaric oxygen may be of additional value to improve wound healing in areas of compromised tissue.

Key words: External Ear Canal; Osteoradionecrosis; Hyperbaric Oxygenation; Otologic Surgical Procedures

Introduction

Radiotherapy is an essential treatment modality for a number of malignancies in the head and neck region, either as single therapy or combined with chemotherapy and/or surgery. However, one of its side effects is the potential for damage to adjacent tissues.

Osteoradionecrosis of the temporal bone is an uncommon, well documented side effect of radiotherapy to the head and neck region, with potentially lethal complications.[1] The bone of the ear canal is most often involved, for several possible reasons: the ear canal bone is protected only by the thin skin of the external meatus; its blood supply seems to be unfavourable; and there is direct communication with the (potentially infected) upper respiratory tract via the eustachian tube.[2]

Although modern radiotherapy techniques have diminished the incidence of osteoradionecrosis, it remains a well recognised complication of external beam radiotherapy.[3]

Osteoradionecrosis of the outer ear canal may take many years to develop, depending mainly on the pattern and dosage of irradiation. Trauma and infection are feared as provocative factors in the development of osteoradionecrosis. The age of the patient at the time of radiation may also be relevant.[2]

Ear canal osteoradionecrosis leads to necrosis of the ear canal skin. At otoscopy, an area of bare avital bone is seen, usually located at the floor and the posterior part of the ear canal, sometimes at the anterior meatal wall. Most patients suffer from protracted mild otalgia and otorrhoea.

There is no universally accepted treatment modality for osteoradionecrosis of the outer ear canal. Both conservative and surgical treatments have been described. In our clinic, we usually follow a conservative approach.

Conservative treatment results in spontaneous separation of a sequestrum of bone, after which the symptoms gradually decrease over years and the meatal skin defect disappears.[2]

A surgical reconstructive procedure has been described by Hill *et al.* in five patients.[4] Necrotic tissue was excised and the underlying avital bone drilled away. The defect of the external auditory canal skin was then covered with postauricular skin obtained from a rotational random flap.

Since osteoradionecrosis seems to be the result of hypoxic, hypovascular, hypocellular tissue,

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Accepted for publication: 23 March 2009. First published online 16 July 2009.

neovascularisation achieved with hyperbaric oxygen therapy might be expected to be an obvious treatment modality for this kind of chronic, non-healing wound. Several authors have reported their clinical experience with hyperbaric oxygen therapy as a supplementary treatment to surgery in cases of osteoradionecrosis of the jaw.[5–7]

In this paper, we report our clinical experience with a surgical reconstructive procedure for osteoradionecrosis of the external ear canal, used in combination with pre- and post-operative hyperbaric oxygen therapy. We applied this treatment regime to five patients with osteoradionecrosis of the outer ear canal who presented with protracted otorrhoea and mild external otitis.

Patients and methods

Five consecutive patients suffering from osteoradionecrosis of the external ear canal were selected for the surgical reconstruction procedure (figure 1). These patients required recurrent drainage, and visited our out-patient clinic regularly for removal of debris from the ear canal. Although some of the patients had been treated with external radiation on both sides of the neck, ear complaints were evident in only one ear in all five patients. Reconstruction was therefore carried out unilaterally. Relevant patient data are presented in Table I.

All patients were prepared for surgery by hyperbaric oxygen therapy. We intended to treat the patients with 30 pre-operative hyperbaric oxygen therapy sessions and 10 post-operative sessions. For various practical reasons, some patients' actual number of sessions was less than planned. The number of sessions for each patient is given in Table I. Patients received five hyperbaric oxygen treatments per week. During a hyperbaric oxygen therapy session, 100 per cent oxygen was breathed at an elevated ambient

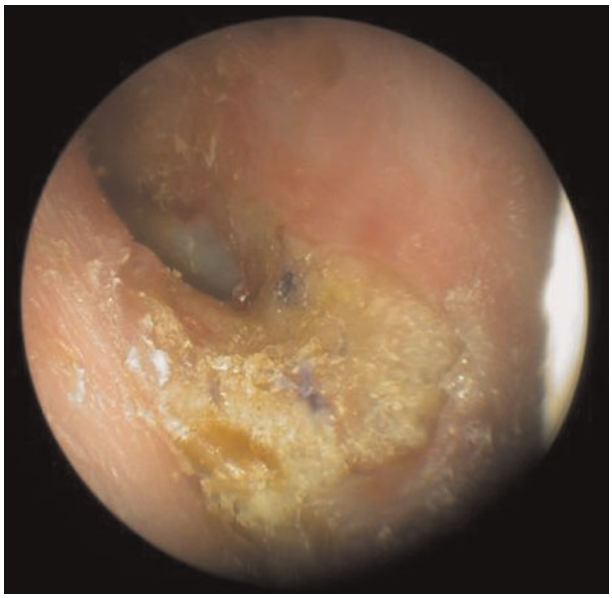

FIG. 1
Otoscopic view of pre-operative appearance (left ear).

TABLE I
PATIENTS' CLINICAL DETAILS

Pt no	Sex/age (yrs)	Tumour	Initial treatment	Cum RT dose (Gy)/ fractions (*n*)	Time RT to surgery (yrs)	Location/est % of skin defect	HBOT sessions pre-op/post-op (*n*)	Outcome	Follow up (yrs)
1	F/62	Adenoid cystic Ca External ear canal	RT + SR	70/35	9	Postero-inf/30%	24/10	Successful	3
2	M/68	SCC Nasopharynx	CT + RT	70/35	7	Inf/30%	30/10	Successful	1.5
3	M/63	Acinic cell tumour Parotid gland	RT + PD + ND	60/30	6	Antero-inf/35%	17/11	Unsuccessful	1
4	M/70	Lymph node metastasis Large cell Ca Unknown primary	RT	70/28	15	Inf/20%	28/12 +10*	Successful*	1
5	F/61	SCC Nasopharynx	RT	64/32	15	Inf/20%	30/10	Successful	0.5

*After second stage procedure. Pt no = patient number; yrs = years; cum = cumulative; RT = radiotherapy; est = estimated; HBOT = hyperbaric oxygen therapy; pre-op = pre-operative; post-op = post-operative; F = female; M = male; Ca = carcinoma; SCC = squamous cell Ca; SR = sleeve resection; CT = chemotherapy; PD = parotidectomy; ND = neck dissection; postero = posterior; inf = inferior; antero = anterior

https://doi.org/10.1017/S0022215109990612 Published online by Cambridge University Press

pressure of 2.5 ATA (atmosphere absolute) for a total of 80 minutes in a multiplace chamber, in periods of 20 minutes separated by 5 minute air breaks. All ears presented with an intact tympanic membrane. In four out of five patients, the middle-ear cavity was aerated. None of the patients needed middle-ear ventilation tubes.

All surgical procedures were performed under general anaesthesia. The operating site was sterilised and the skin incisions were indicated (Figure 2). For local haemostasis, the retroauricular skin was infiltrated with Xylocaine 1 per cent plus adrenaline 1:100 000.

The first incision was placed directly behind the auricle and extended from the apex to the mastoid tip (Figure 3). Using sharp dissection in the anterior direction, the outer ear canal was identified including the skin defect and the underlying avascular bone. The middle-ear cavity remained unopened in all procedures. The avascular bone of the meatal ring was drilled with a diamond burr until vital bone was identified by its different colour and the occurrence of some bleeding. Care was taken not to open the mastoid cavity or to enter the glenoid fossa. Facial nerve monitoring was not used in any of the surgical procedures.

A second skin incision was made posterior to the initial one and a full-thickness skin flap was mobilised from the mastoid planum (Figure 4). The ratio of the flap was kept to a maximum of 5:1 after excision of the tip of the flap. Hair follicles were removed from the distal area, as this was intended to cover the ear canal at the end of the procedure. The size and location of the part of the flap that was to be buried under the conchal cartilage was estimated, and the skin was removed from this area (Figure 5). By doing so, a second stage procedure to remove the pedicle was avoided.

Next, the flap was positioned in the ear canal (Figure 6). A meatoplasty was performed, with excision of a large piece of conchal cartilage. When the dimensions of the distal area of the transposed skin were measured, the flap was sutured to the adjacent skin (Figure 7) so that the tip of the flap reached to the tympanic membrane. The ear canal was packed with Gelfoam and a cotton strip with an antibiotic dressing (hydrocortisone–oxytetracycline–polymyxin

FIG. 2
Marking of the incisions on the retroauricular skin (left ear).

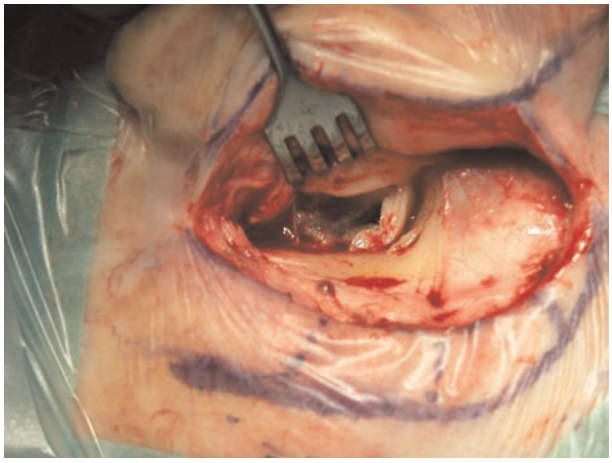

FIG. 3
The external meatus showing the anterior incision and palva flap.

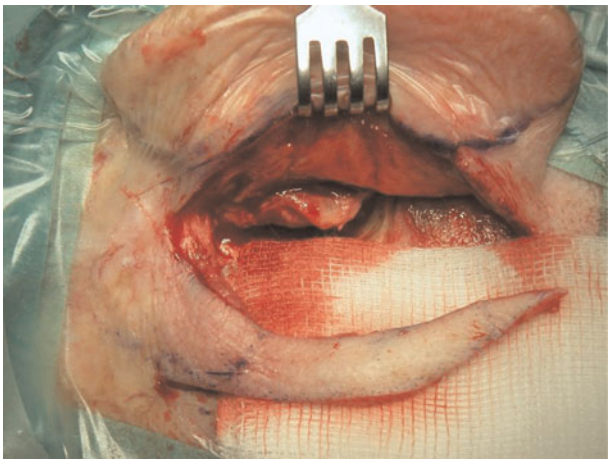

FIG. 4
Preparation of the skin flap.

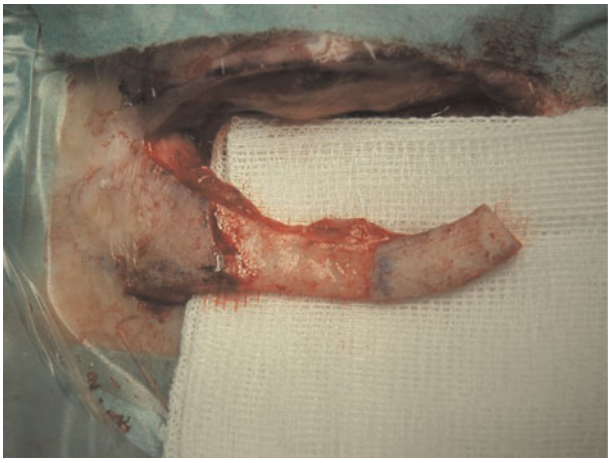

FIG. 5
Removal of the tip of the flap, and removal of the epidermis from the pedicle.

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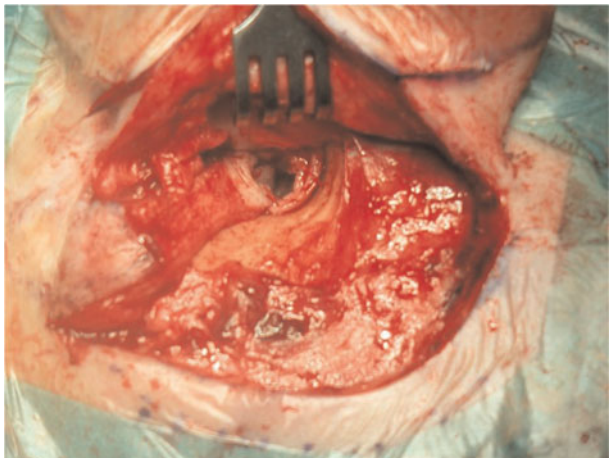

FIG. 6
Positioning of the flap in the meatus, after circumferential removal of avital bone.

B ointment). The retroauricular skin was mobilised from the dermis by splitting it from the subcutis in a posterior direction. This was necessary to diminish the tension of both sides of the wound (Figure 8).

Systemic antibiotics (amoxicillin–clavulanic acid) were given for one week post-operatively.

Hyperbaric oxygen therapy was recommenced two or three days post-operatively.

One week after surgery, the packing was removed from the ear canal and the remaining sutures were cut. Frequent wound care was conducted in the first two months after the surgery, until the return of healthy meatal skin was confirmed (Figure 9).

Results

No facial weakness was seen either pre- or post-operatively.

The duration of follow up varied between seven and 36 months.

The main outcomes were absence of bare bone in the ear canal and reduced complaints after surgery and wound healing. On average, it took approximately three months to obtain intact canal skin after surgery. This was longer than the healing period for non-irradiated patients undergoing comparable surgery. After a period of three to four months, three of the five patients reported far fewer ear complaints, and dry canal skin was seen at otoscopy. These cases were regarded as successful.

In one patient, a small area of bare bone persisted at the inferior part of the external ear canal. At follow up, no signs of coverage by the adjacent skin were observed, and the ear canal required frequent cleaning. Therefore, a second stage procedure was carried out, six months after the first operation, in which the defect was covered by a small piece of temporalis fascia. In addition, 10 sessions of hyperbaric oxygen therapy were administered after this second procedure. The fascia was replaced with normal skin in approximately eight weeks. After additional treatment, this case was regarded as successful.

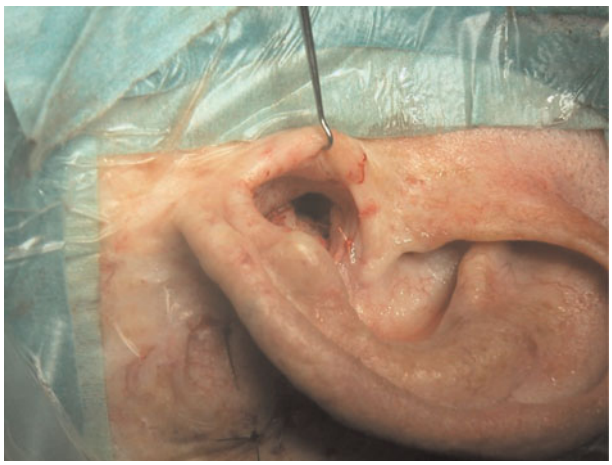

FIG. 7
The transposed skin viewed externally.

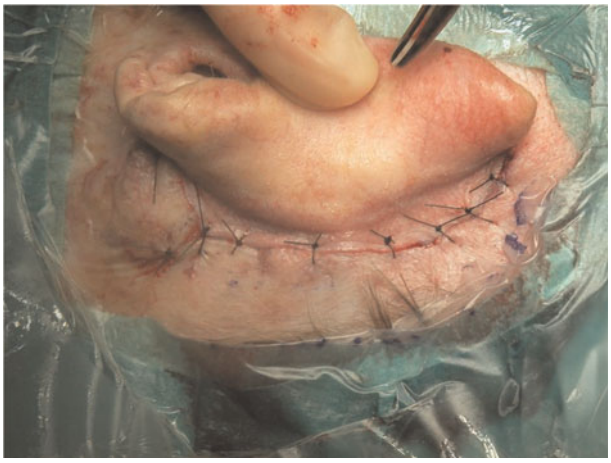

FIG. 8
Closure of the skin.

FIG. 9
Otoscopic view of the post-operative result after one year of follow up (left ear).

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In another patient, the ear canal showed no signs of healing after several months of follow up, despite frequent wound care and cleaning. In addition, a slowly progressive chondronecrosis of the helix of the auricle, already present before surgery, continued to progress after surgery. Additional hyperbaric oxygen therapy was proposed, but was refused by the patient. The outcome of this case was deemed unsuccessful.

No instances of meatal stenosis were encountered during follow up. After the period of wound healing, patients with a successful reconstruction were seen every three to four months for routine cleaning of the ear canal.

Discussion

The prevalence of osteoradionecrosis of the temporal bone has been studied by Wang and Doppke in patients with carcinoma of the auditory canal and chemodectoma.[3] They concluded that, in order to avoid osteoradionecrosis of the temporal bone, the cumulative irradiation dosage should be limited to 60–65 Gy and to 2 Gy per fraction, with a maximum of five fractions per week. Although the irradiation regimes of two of our five patients complied with these recommendations, these patients still developed osteoradionecrosis. The other three patients received barely larger doses.

Our surgical reconstruction technique has previously been published by Hill *et al.*, who applied it in five cases of radiation-induced necrosis of the outer ear canal.[4] The technique is somewhat similar to a procedure with two flaps which has been used for reconstruction of the outer ear canal in patients with acquired atresia.[8] The authors Dhooge & Vermeersch described an inferiorly based postauricular flap and an anterior, cranially based flap. They did not de-epithelialise the pedicle of the posterior flap, but removed it in a second stage procedure under local anaesthesia. As described by Hill *et al.*, we performed a single stage procedure, with removal of the skin from the pedicle of the flap.

The postauricular flap is suitable for repair of postero-inferior defects in the canal wall. Two of our five patients presented with bony dehiscence of the anterior part of the ear canal, although the overlying skin was intact. This was indicated preoperatively by protrusion of the anterior part of the skin into the lumen of the ear canal during movement of the mandible. Nevertheless, we were able to perform postauricular skin flap reconstruction in all five patients. Hill *et al.* also reported skin defects in the anterior part of the ear canal in some of their patients.[4] However, it cannot be deduced from their description whether they also encountered bony defects of the anterior osseous canal. A cranially based, anterior flap, as described by Dhooge and Vermeersch, could be suitable for the repair of purely antero-superior defects, although we could find no reports of the use of this flap for patients with osteoradionecrosis.[8]

Two different problems might be expected with the technique we used in our category of patients. The first one concerns the quality of the transposed skin, which lacked special features unique to meatal skin, such as earwax production and epithelial cell migration. We performed a meatoplasty in combination with the reconstructive procedure, in order to obtain an ear canal that would be easily accessible for cleaning. The second problem related to wound healing, as the repair of the external ear canal defect used a skin flap taken from an irradiated area. It was for this reason that we applied hyperbaric oxygen therapy prior to surgery.

The need for an ample oxygen supply in areas of healing tissue is fundamental. This may be especially true for irradiated tissue. The one unsuccessful result in our series concerned a patient who had initially objected to pre-operative hyperbaric oxygen therapy, and who consequently underwent only 17 of the intended 30 sessions of hyperbaric oxygen therapy. He was also a smoker, and cigarette smoking is known to cause tissue hypoxia and to attenuate the reparative processes of wound healing.[9–11] In contrast to our other patients, who did not smoke during therapy or had never smoked, this patient continued smoking during therapy. These two factors may have contributed to the unfavourable outcome.

In the head and neck area, hyperbaric oxygen therapy is frequently used to treat osteoradionecrosis as part of a 'sandwich therapy' with surgery according to the Marx protocol, or to prevent osteoradionecrosis of the mandible when surgical intervention is indicated.[12] We intended to apply this regime to our patients, in order to achieve maximum tissue oxygenation before surgery and in the first two weeks of wound healing. Increased plasma and tissue oxygen concentration is believed to improve wound healing by initiating and accelerating angiogenesis and revascularisation.[13–15]

Although the literature is not always consistent, hyperbaric oxygen therapy is generally a well accepted modality for the prevention or treatment of radiation-induced wound healing problems. The effect of hyperbaric oxygen therapy as an adjunctive treatment with radical surgery for osteoradionecrosis of the jaw has been reported in a series of 18 patients, with satisfactory results.[5] Complete healing was achieved in 14 patients, after unsuccessful conservative treatment involving antimicrobial therapy, rinsing with antiseptics and removal of small sequestra for a mean period of more than 15 months. The combination of hyperbaric oxygen therapy and surgery has also been described by Peleg and Lopez, who have reported use of this treatment for osteoradionecrosis of the jaw.[7]

Different levels of evidence can be distinguished for the clinical effect of hyperbaric oxygen therapy as an adjuvant treatment modality for osteoradionecrosis in the head and neck region. The highest level of evidence is the randomised, controlled trial. Currently, there are no such studies available to support the use of hyperbaric oxygen therapy. In fact, the only randomised, controlled trial in the literature showed a worse outcome for the hyperbaric oxygen therapy group, and this treatment was therefore terminated prematurely.[16] However, this study provoked serious criticism internationally.[17–20] One of the points of

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debate was the application of an incorrect protocol. Hyperbaric oxygen therapy was given twice daily to 'improve patient compliance'. However, giving double the daily dose of a treatment such as hyperbaric oxygen so that the treatment period can be shortened does not necessarily have the same effect, and could even become toxic. Nevertheless, we can conclude from a large number of animal and clinical studies that hyperbaric oxygen therapy combined with surgery for osteoradionecrosis is a useful treatment modality, based on a good level of evidence.[21] The same goes for the effect of hyperbaric oxygen therapy on random skin flaps. There are no well controlled, randomised, clinical or laboratory trials suggesting a beneficial effect of hyperbaric oxygen therapy on skin flap survival.[22] To date, the additional value of peri-operative administration of hyperbaric oxygen in cases of osteoradionecrosis has not been sufficiently proven.

- **Osteoradionecrosis of the external ear canal is a well recognised complication of external beam radiotherapy**
- **Most patients with this condition suffer from chronic mild otalgia and otorrhoea**
- **Therapy is usually conservative, consisting of prolonged and frequent cleaning of the ear canal**
- **This paper describes experience with a surgical procedure to remove necrotic bone and to repair the skin defect with an inferiorly pedicled skin flap**
- **To maximise the success rate of the reconstruction, hyperbaric oxygen therapy was administered both pre- and post-operatively**

Skin defects in the outer ear canal resulting from osteoradionecrosis can be repaired with a pedicled skin flap. Although not yet scientifically proven, the addition of peri-operative hyperbaric oxygen therapy may be of value in improving wound healing in areas of compromised tissue.

Conclusion

In patients with osteoradionecrosis of the outer ear canal, the skin defect can be repaired with an inferiorly pedicled skin flap. Although not scientifically proven, the addition of peri-operative hyperbaric oxygen therapy may be of value in improving wound healing in areas of compromised tissue.

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Dr M Metselaar takes responsibility for the integrity of the content of the paper.
Competing interests: None declared