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Surgical management of temporal bone osteoradionecrosis: Single surgeon experience of 47 cases☆

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ABSTRACT

Purpose: To report the outcomes of 47 patients with temporal bone osteoradionecrosis treated primarily with surgical resection in order to analyze whether flap type and hyperbaric oxygen use affect wound breakdown.
Materials and methods: Between January 1998 and January 2016, 47 patients were treated for temporal bone osteoradionecrosis with surgery. Some patients were also treated with hyperbaric oxygen. Resection of grossly necrotic temporal bone was followed by immediate reconstruction with local, regional, or free flaps. Minimum follow-up was 6 months. If patients had breakdown of their initial reconstructions, secondary reconstruction was performed with either a regional or free flap. During the post-operative period, wound breakdown, flap complications, and patient survival were noted.
Results: 30 patients developed ORN from primary radiotherapy while 17 had post-operative radiation. It was found that wound breakdown was significantly associated with type of flap reconstruction ($p = 0.02$) with local flap reconstruction portending a poorer prognosis. Hyperbaric oxygen was not associated with decreased wound breakdown ($p = 0.5$).
Conclusions: Surgical treatment can be an effective treatment for temporal bone osteoradionecrosis, without hyperbaric oxygen providing any additional benefit. Reconstruction with regional or free flaps may be a more reliable method to resurface defects compared to local flaps.

1. Introduction

Osteoradionecrosis (ORN) is a rare yet well-studied complication of radiation therapy in the management of head and neck cancer. In the past half-century, both use of external beam radiation and survival of patients with head and neck malignancy have greatly increased. This in turn, has increased the incidence of ORN and other post-radiation sequelae. A wealth of literature exists regarding ORN of the mandible; however, ORN of the temporal bone (ORNTB) has become of greater interest in recent years. ORN is caused by the inclusion of osseous structures within the radiation field of an aero digestive malignancy. This undue exposure is thought to cause endarteritis and inflammation that eventually leads to periosteal hypoxemia leading to tissue necrosis. Multiple factors predispose the temporal bone to ORN, including its position within the skull base, thin overlying soft tissue, and a tenuous vascular supply [1–4].

ORNTB has been associated with treatment of parotid, oropharynx, nasopharynx, and brain malignancies [5–6]. Exposure to high doses of external beam radiation can result in multiple sequalae, all of which can fall under the umbrella of ORNTB. These late stage complications can also be divided into soft tissue and bony sequalae, or localized and diffuse [2]. Soft tissue complications include external canal stenosis or ulceration, otitis externa, sensorineural hearing loss, and cholesteatoma [5,7]. In addition, ORNTB predisposes patients to middle ear space infections which can have a coupling effect to worsen ORNTB [8]. Intracranial complications of ORNTB include abscesses, sigmoid sinus thrombosis, meningitis, malignant otitis externa, skull base osteomyelitis, internal carotid aneurysm, and death [9].

Treatment options of ORNTB can be categorized into conservative and surgical. Conservative management includes regular canal cleaning, otic drops (peroxide vs antibiotics for purulent otorrhea), systemic antibiotics, and minor sequestrectomies/debridement. Surgical intervention also has a range; mastoidectomy, subtotal petrosectomy, and variations of lateral temporal bone resections (LTB) [8]. There has been mention of hyperbaric oxygen in the literature but with few studies demonstrating efficacy.

LTB represent a complicated challenge for the reconstructive surgeon. The temporal bone has an intricate role in the skull base,

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separating CSF and intracranial contents from the aero digestive tract and external environment. Moving up the reconstructive ladder, local flap and free flap reconstruction are the few options flexible enough to properly reconstruct LTB defects. With advances in free flap reconstruction, the goals of defect management have moved from simple coverage to functional outcomes and cosmesis [10–11].

In this study, the management and outcomes of 47 patients treated for ORNTB by a single surgeon practice are reported. While conservative management is often the initial option for patients, the goal of this study was to demonstrate the favorable outcomes in patients treated with primary surgical intervention.

2. Patients and methods

Prior to beginning this study, Institutional Review Board (IRB) approval was gained from JPS Hospital.

This study was a retrospective analysis of a single surgeon's experience with primary surgical treatment for temporal bone osteoradionecrosis (ORN) from January 1998 to January 2016 at a tertiary referral private practice in Fort Worth, Texas. The study sought to report outcomes, namely patient survival and flap loss, following resection of necrotic temporal bone followed by reconstruction with either locoregional flaps or microvascular free tissue transfer.

Patients developing ORN following treatment with either post-operative or primary radiotherapy for head and neck malignancies during January 2008 to January 2016 were included in the study. Osteoradionecrosis was defined by exposure of greater than 1 cm of bone in patients who failed conservative treatment, namely antibiotic therapy and wound care consisting of xeroform and bactroban. All patients were offered hyperbaric oxygen (HBO) therapy, at a 20/10 standard dive protocol but not all patients were able to undergo treatment due to patient refusal or socioeconomic factors. Patients with persistent cancer in addition to ORN were excluded along with patients with primary temporal bone malignancy treated surgically. Patients with ORN underwent debridement without en bloc excision until clinically healthy bleeding bone was encountered. All patients were reconstructed with locoregional or free flaps. Following surgery, all patients were kept on 6 weeks of antibiotics while being managed by an infectious disease specialist. The majority of these patients received 6 weeks of intravenous antibiotics, either ampicillin-sulbactam as monotherapy or a combination of levaquin-clindamycin. A minority of patients with poor kidney function had alternate regimen and occasionally received oral antibiotics if they could not tolerate intravenous. Patients were followed for a minimum of 6 months unless they died prior to the follow-up time.

In order to adequately report the findings, patient cases were retrospectively analyzed for location of malignancy, compliance with hyperbaric oxygen therapy, flap failures and/or salvage, medical complications, and death. Patients were also stratified based on whether they were primarily or post-operatively treated with radiation. To compare whether rates of wound breakdown was related to type of reconstruction or hyperbaric oxygen therapy, chi square analysis was performed.

3. Results

Following exclusion of patients not appropriate for the study, 47 patients were found to meet the inclusion criteria. There were 37 males and 9 females, with a combined average age of 66.2 years.

Table 1 represents patient outcomes from those developing temporal bone ORN following primary external beam radiation. 30 patients developed temporal bone ORN following primary radiation therapy, all of which were resected and reconstructed. 12 patients had squamous cell carcinoma (SCC) of the conchal bowl. Following resection, 8 had local scalp and rotational flaps of which 6 completed hyperbaric oxygen therapy. In this subset of patients, 4 had recurrence of ORN and underwent 1 supraclavicular flap, 2 radial forearm free flaps, and 1 anterolateral thigh free flap. These patients healed well and had no further complications. 2 patients in this group did not have hyperbaric oxygen but did well without any issues. 1 patient died from a stroke 9-weeks post-operatively. 3 of the 12 patients had free tissue transfer, 1 rectus flap and 2 radial forearm flaps, of which 2 had hyperbaric oxygen. All of these patients healed well, but one patient passed from heart disease 6 weeks following surgery. 1 patient had a rotational latissimus dorsi flap and did not receive hyperbaric oxygen, but did well without any flap failure.

Table 1
Reconstruction and treatment outcomes of patients developing temporal osteoradionecrosis after receiving primary external beam radiation therapy.

	Local flap	Free flap	Regional flap
Total primary EBRT patients	16	10	4
Hyperbaric oxygen therapy	14	7	2
Wound breakdown or flap complications in HBO group	7	0	1
Death in HBO group	0	1	0
No hyperbaric oxygen therapy	2	3	2
Wound breakdown or flap complications in no HBO group	0	1	0
Death in no HBO group	1	1	0

Of the 30 patients treated with primary radiation therapy, 6 also had post-auricular sulcus or scalp SCC. 5 of these patients had hyperbaric oxygen therapy and all were reconstructed with local flaps from the scalp or neck. 2 of these patients had a recurrence of ORN and following resection, were salvaged with a pectoralis flap. One again recurred and was salvaged with a radial forearm free flap. 1 patient with post-auricular SCC did not have HBO but had resection with an anterolateral thigh free flap, and went on to do well without any further complications.

4 patients had conchal bowl basal cell carcinoma, 3 of which received HBO and were covered with local flaps. One patient recurred and had a second local flap, which did well. The one patient that did not have HBO was reconstructed with a supraclavicular flap and went on to do well without any complication.

Lastly in the group receiving primary RT, 8 patients had external auditory canal (EAC) SCC without any temporal bone involvement. 6 of these patients had coverage with free flaps, 2 rectus abdominis, 1 latissimus, and 3 radial forearm. 5 of these patients had HBO and did well, while 1 did not have HBO and had a recurrence of ORN leading to second resection and coverage with a local flap. One patient died of a pulmonary embolism 3.5 months post-operatively. 2 patients with EAC SCC had a pec flap (both had HBO). 1 patient had flap breakdown and had repeat local flap reconstruction. The same patient had another flap breakdown and was reconstructed the final time with an anterolateral thigh free flap.

Table 2 represents patients developing ORN following post-operative radiation treatment. In the next group of patients, 17 developed temporal bone ORN following post-operative external beam radiation following initial resection of their head and neck malignancy.12 patients had an auriculectomy and partial temporal bone excision reconstructed with local flaps from the scalp or neck. 9 of these patients

Table 2
Reconstruction and treatment outcomes of patients developing temporal osteoradionecrosis after receiving post-operative external beam radiation therapy.

	Local flap	Free flap	Regional flap
Total primary EBRT patients	4	13	0
Hyperbaric oxygen therapy	3	10	0
Wound breakdown or flap complications in HBO group	2	0	0
Death in HBO group	1	0	0
No hyperbaric oxygen therapy	1	3	0
Wound breakdown or flap complications in no HBO group	0	1	0
Death in no HBO group	0	0	0

had HBO, 7 of which were reconstructed with free flaps (2 rectus, 1 anterolateral thigh, 4 radial forearm), all of which survived. 2 of the patients receiving HBO in this group were reconstructed with local flaps, broke down, and were again repaired with local flaps. One of these patients broke down again and was repaired with a pectoralis flap and continued to do well after surgery. 1 of those patients was repaired with a radial forearm free flap and died of a myocardial infarction 5 weeks post-operatively. 3 of the 12 patients did not have HBO, 2 of whom had radial forearm free flaps and 1 had a local flap. All of those patients had an uneventful post-operative course.

4 of the 17 patients receiving post-operative radiation had an auriculectomy and partial temporal bone resection with regional flaps (2 supraclavicular and 2 pectoralis). 3 of these patients had HBO and were reconstructed with a radial forearm free flap and did not have any complications following. 1 of the patients did not have HBO and was also reconstructed with a radial forearm free flap; however, this patient developed delayed flap loss from infection at post-operative day 18 and was salvaged with a second radial forearm free flap after which no further complications occurred.

Lastly, 1 patient of the 30 was treated with auriculectomy and subtotal temporal bone resection and reconstructed with a radial forearm free flap. This patient had HBO and subsequently broke down, after which the patient was salvaged with small local flaps without further complication.

In order to compare rates of breakdown with different types of flap coverage, all of the patients, whether receiving primary RT or post-operative RT, were placed together (Table 3) and analyzed using a chi-square test and $\alpha = 0.05$ (Table 3). Comparison of flap breakdown as related to type of flap (Table 4) used yielded a chi statistic of 7.4164 ($p = 0.024522$), suggesting a significant difference in outcome depending on flap type used, with greatest breakdown associated with local flaps. Next, flap breakdown was analyzed between patients receiving and not receiving hyperbaric oxygen. Again, using a chi square test, the chi statistic was found to be 0.4081 ($p = 0.522957$), suggesting no significant difference in outcome when hyperbaric oxygen was used (Table 5).

4. Discussion

The data reported in this paper represents the largest single surgeon experience of surgical treatment for temporal bone osteoradionecrosis. Based on a review of 47 cases, resection and flap reconstruction of necrotic temporal bone could be a viable option in comparison to pure conservative management. Surgically treated patients in this report obtained good symptomatic relief and long-term control of ORN. As local flap reconstruction tended to break down more often ($p = 0.02$), regional and free flap reconstruction appeared to be a more robust method of resurfacing these defects. Moreover, there did not appear to be a trend in poorer outcome in patients not receiving HBO ($p = 0.52$) suggesting a negligible contribution of HBO when these patients are managed surgically. With the exception of those patients passing prior to the minimum follow-up period, other patients went on to do well past the 6-month follow-up period. Given the short minimum time frame and number of confounding variables, it is important to understand that these are simply the experiences from one institution and should be taken as generalized recommendations. As hyperbaric oxygen therapy and modality of radiation were not standardized, a true head-to-head comparison was unable to be performed accurately and thus, no statistical impact is tied to these results.

Although surgical management of temporal bone ORN is one treatment option, the outcomes are sparsely reported and conservative therapy has traditionally been the more accepted form of treatment. In a study by Phillips et al. in 2015, 23 patients with temporal bone ORN were treated with antibiotics and in-office debridement as necessary. None of the patients required temporal bone resection and tolerated non-surgical treatment without incident [1]. Many reports of surgical treatment do not exist; however, Kammeijer and colleagues reported their experience with 49 patients with temporal ORN, 14 of whom were treated with surgery as a primary option. Only 1 patient having primary surgical treatment, subtotal petrosectomy, was noted to have failure requiring revision surgery [8]. The authors from the aforementioned study concluded that surgery could be a viable treatment option, but should be reserved for select patients with advanced findings, and especially so in patients with non-serviceable hearing. Despite encouraging results, many continue to support the use of surgery as a salvage option for patients failing conservative management. In a 2014 study, 18 out of 33 patients had failed conservative treatment and went on to require surgical treatment due to intractable pain, infection, or development of cholesteatoma [4]. Not only does this suggest that there may be a large degree of treatment failure inherent in conservative management, but also that surgical treatment may represent definitive care for this challenging population.

As the current study dealt only with patients receiving surgical therapy as a primary treatment modality with or without HBO, it is difficult to compare outcomes with reported data in the literature. In order to provide more standardized treatment recommendations, this study should be replicated across multiple institutions and also compared directly with a similar cohort of patients treated conservatively to determine the rate of treatment failures and post-treatment sequelae. It is well known to the authors that variables such as radiation dose, duration of HBO, presence of infection, and concurrent comorbidities may heavily influence healing in these patients and as such, larger more standardized trials would serve to corroborate the findings presented here.

This study of 47 patients suggests a strong role for surgery as a primary and definitive treatment option in the care of patients with temporal bone ORN and should be a consideration in these circumstances. The reader is encouraged to carefully validate the outcomes of this study in the context of his/her own institution but is cautioned to understand that these outcomes may be dependent on multiple confounding variables and surgeon technical skill.

Table 3
Reconstruction and treatment outcomes of all patients developing temporal osteoradionecrosis.

	Local flap	Free flap	Regional flap
Total primary EBRT patients	20	23	4
Hyperbaric oxygen therapy	17	17	2
Wound breakdown or flap complications in HBO group	9	0	1
Death in HBO group	1	1	0
No hyperbaric oxygen therapy	3	6	2
Wound breakdown or flap complications in no HBO group	0	2	0
Death in no HBO group	1	1	0

Table 4
Chi square table comparing association between wound breakdown and flap type.

	Local flap	Free flap	Regional flap
Wound breakdown	9	2	1
Healthy tissue survival	11	21	3

Chi square statistic = 7.4164 ($p = 0.024522$) significant association.

Table 5
Chi square table comparing association between wound breakdown and HBO therapy.

	Hyperbaric oxygen	No hyperbaric oxygen
Wound breakdown	10	2
Healthy tissue survival	26	9

Chi square statistic = 0.4081 ($p = 0.522957$) association not significant.

5. Conclusion

Analysis of these 47 cases of temporal bone ORN from a single surgeon experience demonstrates that surgical excision is a viable solution for treatment and the use of hyperbaric oxygen may not provide a substantial contribution in the face of primary surgical treatment. It appears that reconstruction with regional flaps or free tissue transfer may be a more reliable method compared to local flap coverage.

References

[1] Phillips D, Njoku I, Brown K, et al. Radiation-induced necrosis of the temporal bone. Otol Neurotol 2015;36(8):1374–7. http://dx.doi.org/10.1097/mao.0000000000000812.
[2] Ramsden R, Bulman C, Lorigan B. Osteoradionecrosis of the temporal bone. J Laryngol Otol 1975;89(09):941–55. http://dx.doi.org/10.1017/s0022215100081226.
[3] Birzgalis A, Ramsden R, Farrington W, et al. Severe radionecrosis of the temporal bone. J Laryngol Otol 1993;107(03):183–7. http://dx.doi.org/10.1017/s0022215100122583.
[4] Sharon J, Khwaja S, Drescher A, et al. Osteoradionecrosis of the temporal bone. Otol Neurotol 2014;1. http://dx.doi.org/10.1097/mao.0000000000000321.
[5] Lambert E, Gunn G, Gidley P. Effects of radiation on the temporal bone in patients with head and neck cancer. Head Neck 2016;38(9):1428–35. http://dx.doi.org/10.1002/hed.24267.
[6] Mou Y, Sai K, Wang Z, et al. Surgical management of radiation-induced temporal lobe necrosis in patients with nasopharyngeal carcinoma: report of 14 cases. Head Neck 2010;33(10):1493–500. http://dx.doi.org/10.1002/hed.21639.
[7] Smouha EE, Karmody CS. Non-osteitic complications of therapeutic radiation to the temporal bone. Am J Otol 1995;16:83Y7.
[8] Kammeijer Q, van Spronsen E, Mirck P, et al. Treatment outcomes of temporal bone osteoradionecrosis. Otolaryngol Head Neck Surg 2015;152(4):718–23. http://dx.doi.org/10.1177/0194599814564536.
[9] Leonetti JP, Origitano T, Anderson D, et al. Intracranial complications of temporal bone osteoradionecrosis. Am J Otol 1997;18:223Y8.
[10] O'Connell D, Teng M, Mendez E, et al. Microvascular free tissue transfer in the reconstruction of scalp and lateral temporal bone defects. Craniomaxillofac Trauma Reconstr 2011;4(04):179–88. http://dx.doi.org/10.1055/s-0031-1286119.
[11] Richmon J, Yarlagadda B, Wax M, et al. Locoregional and free flap reconstruction of the lateral skull base. Head Neck 2014;37(9):1387–91. http://dx.doi.org/10.1002/hed.23725.