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Case Report

Osteoradionecrosis of the craniotomy flap: a rare complication of stereotactic radiosurgery

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Abstract

Osteoradionecrosis (ORN), ischemic necrosis of irradiated bone without evidence of persisting or recurrent tumor, is a known complication of radiation therapy. ORN of the skull has not been reported following stereotactic radiosurgery (SRS). We report two cases of ORN of the skull following SRS for recurrent meningiomas post-resection. Both patients developed ORN in their craniotomy flaps in areas that received high doses of radiation due to their proximity to the recurrent tumors. In each case, the ORN was asymptomatic and was detected on surveillance magnetic resonance imaging. Both patients were followed closely with imaging that ultimately revealed either stability or improvement in the ORN, confirming the diagnosis without the need for biopsy. The cases reveal a role for close imaging surveillance instead of immediate biopsy in patients with new enhancement involving bone in high-dose radiation treatment regions.

INTRODUCTION

Osteoradionecrosis (ORN), ischemic necrosis of irradiated bone without evidence of persisting or recurrent tumor, is a known complication of radiation therapy, particularly in patients with head and neck cancer. The exact mechanism is unknown; however, the proposed mechanism is that radiation-induced vascular changes result in diminished blood flow and ultimately in a hypocellular, hypovascular and hypoxic environment [1]. While often asymptomatic, symptoms and sequelae of ORN can vary in severity and include pain, fracture, chronic non-healing wounds and superimposed infections. To date, literature review did not reveal any reports of ORN of the calvarium following stereotactic radiosurgery (SRS). We present two cases of ORN of the calvarium following SRS for recurrent meningiomas after initial resection.

CASE REPORTS

Case 1

The first patient is a 50-year-old woman with history of a World Health Organization (WHO) Grade I meningioma in the parieto-occipital region, which was resected in 1999 with subsequent radiographic recurrence. Initial post-operative magnetic resonance imaging (MRI) did not reveal residual tumor and annual MRIs were stable for 7 years. She was then lost to follow-up until 2012 when an MRI revealed a 25-mm contrast-enhancing lesion at the resection cavity consistent with meningioma recurrence, and corresponding computed tomography (CT) revealed no evidence of adjacent bone erosion (Fig. 1A and B). The patient was treated with linear accelerator-based, framed SRS (14 Gy in one fraction) to the recurrent meningioma. She did well without issues for 5 years except for the interval development a 9 mm focus of enhancement within the surrounding brain parenchyma that resolved in ∼6 months without intervention and was ascribed to radiation treatment effect (RTE).

The patient's MRI at 5 years post-SRS revealed a new enhancing lesion immediately adjacent to the treated meningioma, which in retrospect may have begun developing 4 years post-SRS (Fig. 1C and D). This lesion involved the craniotomy bone flap, and a head CT confirmed a new 38-mm osteolytic focus involving that segment of the cranium (Fig. 1E). Perfusion MRI showed relative hypoperfusion at this site (Fig. 1F). After examination of all available images, including overlay of the SRS isodose cloud (Fig. 2A–D), the appearance was most consistent with ORN. Repeat brain MRIs and head CTs 6 months and 1.5 years later revealed the stability of this lytic lesion as well as the residual treated meningioma (Fig. 2E–H). The patient remained asymptomatic with the exception of rare episodes of minor focal scalp discomfort. Given the continued stability, this process was determined to be most consistent with ORN and biopsy was not pursued.

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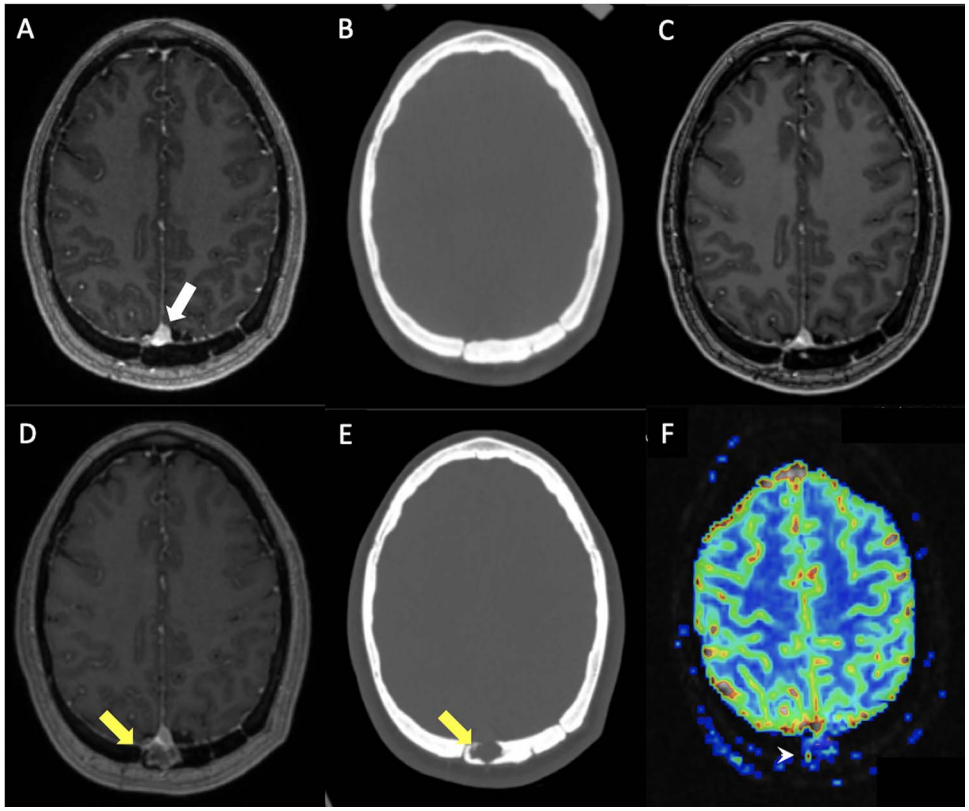

Figure 1. Case 1 prior to and at initial presentation of osteolytic lesion; (**A**) T1 post-contrast MRI axial slice obtained at the time of SRS showing the initial meningioma recurrence (white arrow) and (**B**) comparable axial CT slice also obtained at the time of SRS; (**C**) T1 post-contrast MRI 4 years post-SRS and (**D**) at the development of the lytic bone lesion 5 years post-SRS (denoted by yellow arrow); (**E**) CT at the time of development of the lytic bone lesion 5 years post-SRS (denoted by yellow arrow); (**F**) corresponding relative cerebral blood volume map (from dynamic susceptibility contrast perfusion imaging) reveals relative hypoperfusion of the enhancing lesion (denoted by white arrowhead; red = increased perfusion, blue = decreased perfusion).

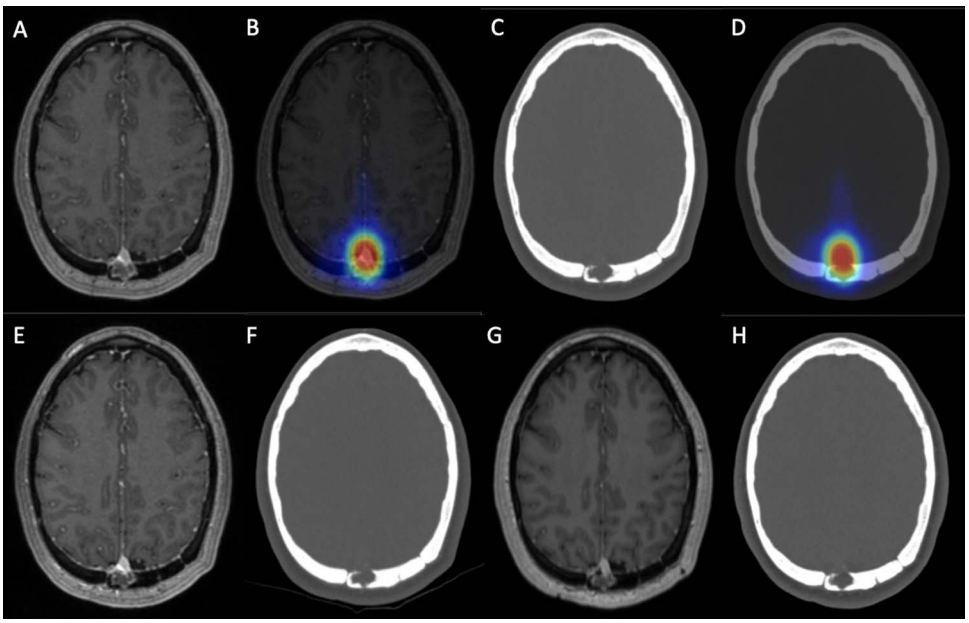

Figure 2. Case 1 at initial presentation and subsequent follow-up of osteolytic lesion. Identical serial T1 post-contrast MRI axial slices obtained (**A**, **B**) at the time of the development of the lytic bone lesion 5 years post-SRS, with (B) showing the radiation isodose overlay (red corresponds to higher dose, blue to lower dose); identical CT head axial slices (**C**, **D**) at the time of the development of the lytic bone lesion 5 years post-SRS, with (D) showing the radiation isodose overlay revealing that the lesion is in the high-dose region; (**E**) T1 post-contrast MRI 6 months after the development of the lytic bone lesion and (**F**) comparable CT at the same timepoint; (**G**) T1 post-contrast MRI 1.5 years after the development of the lytic bone lesion and (**H**) comparable CT slice at the same timepoint.

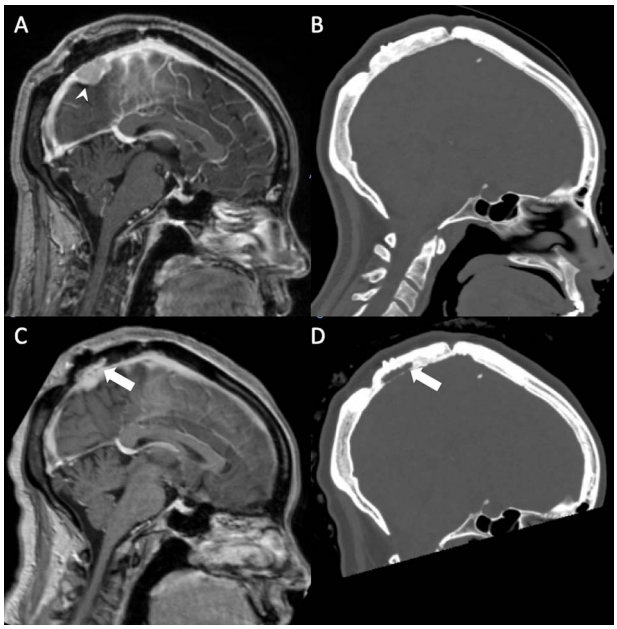

Figure 3. Case 2 prior to and at initial presentation of osteolytic lesion; (**A**) T1 post-contrast MRI sagittal slice obtained in 2017 at the time of SRS showing the initial meningioma recurrence (denoted by arrowhead) and (**B**) comparable head CT sagittal slice windowed for bone at that same timepoint; (**C**) T1 post-contrast MRI sagittal slice obtained at the time of development of an enhancing lesion involving bone at 1-year post-SRS (denoted by arrow) and (**D**) comparable head CT sagittal slice obtained at the that same timepoint revealing the lytic bone lesion at this site (denoted by arrow).

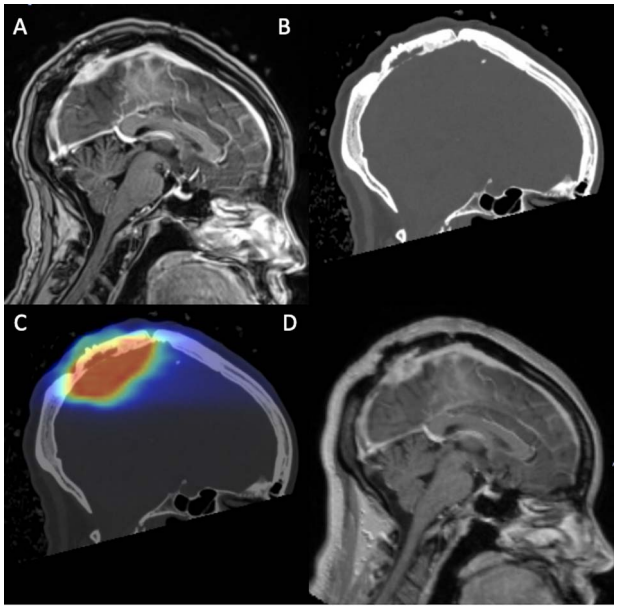

Figure 4. Case 2 at initial presentation and subsequent follow-up of osteolytic lesion; (**A**) T1 post-contrast MRI and (**B**) comparable CT sagittal slices obtained 3 months after the development of the lytic bone lesion; (**C**) the radiation isodose is overlayed on the preceding CT showing that the high-dose region (red) corresponds to the location of the osteolytic lesion (presumed ORN) in this case; (**D**) sagittal T1 post-contrast MRI slice at 9 months after the development of the lytic bone lesion.

Case 2

The second patient is a 44-year-old woman, with a right posterior parasagittal WHO Grade II meningioma who underwent gross total resection in 2014 with post-operative imaging revealing no residual disease. No adjuvant therapy was pursued. She did well until a brain MRI in 2017 demonstrated a 2.1-cm recurrence along the superior sagittal sinus with no adjacent bone erosion on CT (Fig. 3A and B). She was asymptomatic and was treated with linear-accelerator-based, hypofractionated frameless SRS (30 Gy in five fractions) to the recurrent tumor. The patient did well for the next 2 years with significant tumor response except for the development of RTE in a small region of surrounding brain, which resolved without intervention.

On serial imaging, an MRI 1-year post-SRS showed a new adjacent enhancing lesion that was associated with some bone lysis seen on CT without apparent growth of the treated meningioma (Fig. 3C and D). T1 post-contrast MRI and non-contrast head CT 3 months later revealed mild enlargement of the lesion (Fig. 4A and B). At this point, the differential diagnosis included ORN versus tumor progression. After discussion at tumor board, her case was felt to more likely represent ORN as the lytic lesion was within the high-dose region, as demonstrated on the isodose overlay (Fig. 4C). Further close interval monitoring was recommended. The next brain MRI 9 months after the development of the lytic lesion revealed stability of both the treated meningioma and the adjacent enhancing lesion (Fig. 4D), supporting the diagnosis of ORN.

DISCUSSION

To our knowledge, these are the first reported cases of ORN of the skull following SRS. ORN is a known complication of radiation therapy most frequently reported following radiation to the head and neck. ORN can range in severity from being asymptomatic to causing pain, fractures, superimposed infection and chronic wounds [2]. Management includes vitamin E and pentoxifylline for mild cases and hyperbaric oxygen and surgical resection for more severe cases [2–4].

The mechanism of ORN is thought to involve inflammation and fibrosis of the periosteal vessels, resulting in ischemia and avascular necrosis [5]. The mandible is particularly susceptible due to its relatively low vascularity [4], but ORN can affect other bones such as ribs [6], maxilla [3, 4] and vertebra [7]. These two patients developed ORN in their craniotomy flaps after SRS to adjacent recurrent meningiomas.

After careful review in a multidisciplinary setting, the decision was made to follow the patients closely with imaging as opposed to proceeding with biopsy due to the high clinical suspicion for ORN. In each case, the craniotomy flap was within the high-dose region (Figs 2 and 4). The risk of ORN increases with increasing dose to the affected bone [2, 8]. It is likely that post-surgical disruption of blood flow to these flaps was confounded

by vascular changes secondary to high-dose radiation leading to ORN.

Diagnostic considerations in such cases include ORN and tumor recurrence. The definitive way to make a diagnosis is through pathology review; however, an invasive procedure can often be avoided using serial imaging in asymptomatic patients. Stability of the lesion without intervention favors a diagnosis of ORN over tumor recurrence. Perfusion imaging can distinguish between malignancy and radiation necrosis in the brain [9, 10]. Radiation necrosis displays hypoperfusion, as was illustrated in the first case of ORN above, whereas malignancy displays hyperperfusion. While a biopsy may ultimately be necessary to make the diagnosis, these cases demonstrate that, in patients with indolent courses, it is generally prudent to closely observe with imaging. In such cases, serial imaging revealing stability or improvement of the lesion(s) in question can solidify a diagnosis of ORN, avoiding an invasive procedure.

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CONFLICT OF INTEREST STATEMENT

None declared.

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ETHICAL APPROVAL

None required.

CONSENT

Consent was obtained from patients in both cases.

GUARANTOR

Ashley Schlafstein.

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