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Lytic Bone Lesion of the Skull Vault as a Rare Presentation of Metachronous Metastasis from Kidney Carcinoma: A Case Report

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ABSTRACT

Background: We report a rare case of cranial vault metastasis from renal cell carcinoma occurring seven years after nephrectomy, with a late presentation and absence of symptoms. Osteolytic skull lesions are uncommon findings that are often incidental and are associated with a broad differential diagnosis, including both benign and malignant entities. This report reviews the features of metastases from renal cell carcinoma, with particular emphasis on the distinctive aspects of the present case, its radiological findings, and the associated clinical implications.

Case Presentation: We report the computed tomography (CT), angiographic, MR findings, and histopathological confirmation of a metachronous clear cell renal cell carcinoma (ccRCC) metastasis presenting as a solitary osteolytic lesion of the occipital bone with extensive bone destruction. The patient, a 77-year-old female, had undergone left radical nephrectomy seven years prior and presented with progressive retronuchal swelling over three months without associated pain or other symptoms. The article discusses the radiological and clinical features specific to this case.

Conclusions: Early recognition of bone lesions, including rare cranial vault metastases from renal tumors, enables prompt diagnosis and timely multidisciplinary management. Current guidelines support systemic therapy and, in selected cases, metastasectomy or stereotactic body radiotherapy (SBRT). Post-nephrectomy surveillance remains essential despite the rarity of late metastatic recurrence. Clinical context, including age and medical history, is key to accurate diagnosis and to guiding radiological interpretation. Early detection through vigilant follow-up is therefore crucial to optimize outcomes and quality of life.

INTRODUCTION

Calvarial osteolytic lesions are rare and may pose diagnostic challenges. They are frequently incidental and asymptomatic, predominantly benign. This report details CT imaging characteristics of a calvarial metastasis originating from renal carcinoma. The skull vault is formed by flat bones (frontal, parietal,

squamous temporal, and interparietal occipital). High-resolution CT depicts the inner and outer cortical tables (approximately 1.5 mm and 0.5 mm thick, respectively) and the intervening diploe. The outer table is covered by pericranium, while the inner table is lined by endosteum, a thin periosteal layer continuous with the outer dura mater. Osteolytic skull lesions may originate from the bone or result from invasion by contiguous structures or hematogenous dissemination. CT is the imaging modality with the highest diagnostic accuracy for detecting sclerotic or lytic bone lesions, capable of identifying sclerotic margins and calcifications. The skull vault has its own distinct spectrum of osteolytic lesions, each with characteristic CT patterns; recognizing these patterns helps clinicians in narrowing differential diagnoses and guiding management. As will be discussed, involvement of the cranial vault by a renal tumor many years after excision of the primary tumor represents an exceptional clinical condition.

CASE DESCRIPTION

We present the case of a 77-year-old female with a history of left radical nephrectomy for kidney cancer seven years earlier, who presented with a three-month history of a progressively enlarging occipital mass. The patient did not report redness around the mass or other signs of inflammation. The lesion was painless, without neurological deficits or systemic symptoms such as headache, dizziness, nausea, vomiting, fever, chills, weight loss, or fatigue. A history of trauma was excluded.

CT imaging revealed a well-defined, heterogeneous, 7 cm mass (56 x 67 x 70 mm) in the occipital region, destroying both the inner and outer tables of the occipital bone. The brain parenchyma was normal, and no additional calvarial lesions were identified. The rapidly growing lesion exerted a mass effect, causing slight compression of the occipital lobes and cerebellum. Tumor margins were regular and well delineated without peritumoral edema. Multiplanar reconstructions, after iodinated contrast administration, demonstrated compression of the sagittal sinus and confluence of sinuses (Figure 1A-C; Table 1A in the supplement; for related comparisons, see [1-3]).

Following iodine contrast administration, the lesion demonstrated heterogeneous, progressive enhancement, with intensification over 15 minutes and associated discontinuous dural enhancement (Figure 1D). Angiographic imaging demonstrated marked arterial hypervascularization with hypertrophy of the occipital arteries (Figure 2A). On MR imaging, the lesion demonstrated a heterogeneous signal on both T1- and T2-weighted sequences, with mild enhancement following intravenous gadolinium administration. Diffusion-weighted imaging did not reveal any significant diffusion restriction. Post-contrast MR imaging demonstrated findings consistent with thrombosis of the superior sagittal sinus (Figure 2B). CT bone window images revealed destructive osteolysis with cortical breakthrough of the occipital squama. The lesion caused scalloping and thinning of the inner and outer tables, presenting as a punched-out intradiploic lesion measuring 50 x 49 mm, located about three centimeters behind the foramen magnum (Figure 3).

Key radiological findings

The present case highlights, first and foremost, the importance of being familiar with the spectrum of conditions that can produce focal osteolytic skull lesions and of identifying the general radiological features that can guide an initial differential diagnostic approach. A rapidly growing lesion of this kind requires early

diagnosis, because rapid infiltration of the surrounding structures markedly narrows the operative window, rendering the tumor inoperable within a short time. The skull vault's spectrum of osteolytic lesions exhibits distinct CT, MR, and angiographic imaging patterns, necessitating a structured radiological approach. In the present case, several typical features of an aggressive, rapidly growing lesion were identifiable: the lesion was solitary, involved the diploic space, caused cortical thinning and breakthrough, and expanded both skull tables. The osseous margins of the erosion were poorly defined, with no organized matrix or sclerotic areas, and no periosteal reaction could be identified (Supplementary Table 1; for related comparisons, see [3,4]).

The most commonly occurring lytic lesions of the calvarium are neoplastic (myeloma, lymphoma, hemangioma, and metastases from lung, breast, liver, and thyroid cancers) or inflammatory lesions (histiocytosis, osteomyelitis) (Supplementary Table 2).

Starting from the most evident CT finding, namely the heterogeneous spontaneous hyperdensity of the lesion (54–65 Hounsfield units), we summarize in Table 1B in the supplement the main differential diagnoses to consider in the initial assessment. Hyperdensity on non-contrast CT commonly reflects hypercellularity (meningioma, metastases, lymphoma), calcifications (meningioma, metastases), pigments, intratumoral hemorrhage, or high protein content (metastases). Meningiomas, which are hypercellular tumors frequently containing calcifications, typically appear hyperdense on non-contrast CT [6], and rare forms of locally aggressive meningiomas arising from the diploe have been described [7,8]. Although generally benign and slow-growing (WHO grades 1 and 2), a subset exhibits aggressive behavior (WHO grade 3) with bone destruction. The present case lacked typical meningioma features such as the "dural tail" sign, which is characterized by thickening and enhancement of the adjacent dura [9].

Histopathological examination of the biopsy specimen (Figure 4 A, B, C) confirmed metastatic clear cell renal cell carcinoma (ccRCC). RCC ranks as the 13th most common solid tumor globally [10] and accounts for approximately 3% of all malignancies. RCC remains aggressive even years after initial treatment [11], with 20–30% of localized cases developing local recurrence or distant metastases after curative surgery [12]. Once the biopsy had confirmed the radiological suspicion of an invasive, highly aggressive lesion—namely a metastasis from renal cell carcinoma—the definitive diagnosis of metastatic disease prompted further targeted evaluation. Although bone metastases from RCC are relatively frequent, the specific clinical features discussed below made the present case particularly unusual, as discussed in the Discussion section.

Clinical course and follow-up

Precise information regarding the patient's clinical course and follow-up between nephrectomy and the development of metastatic disease could not be obtained. At the time of hospitalization for diagnostic evaluation of the occipital lesion, the patient presented with multiple comorbidities, including atrial fibrillation on oral anticoagulant therapy, chronic kidney disease, valvular heart disease, coagulopathy associated with superior sagittal sinus thrombosis, anxiety-depressive disorder, and severe obesity. Staging investigations included contrast-enhanced whole-body CT scan, supplemented by head and neck CT angiography, brain magnetic resonance imaging, and diagnostic cerebral angiography. No further investigations were performed, mainly because

of the patient's clinical condition and limited compliance with additional diagnostic procedures. Within the diagnostic limits of the investigations performed, no metastatic involvement of the thoracic or abdominal solid organs or the skeletal system was detected. The left renal fossa, corresponding to the site of the previous nephrectomy, showed no evidence of disease recurrence. Notably, administration of iodinated contrast medium resulted in worsening renal function, with serum creatinine levels increasing from 1.6 to 2.6 mg/dL. Following the open biopsy, which established the definitive diagnosis, the patient declined radical neurosurgical treatment and preoperative angiographic embolization. Upon discharge, she was referred for further evaluation at oncology, hematology, and cardiology centers. During the subsequent period, the patient's general condition rapidly deteriorated, mainly due to recurrent ulceration and hemorrhagic episodes involving the occipital lesion. Radiotherapy and immunotherapy, administered under the supervision of the oncology team, proved ineffective, largely because of difficulties in maintaining adherence to the recommended treatment.

DISCUSSION

The present case illustrates a rare and diagnostically challenging presentation of metastatic clear cell renal cell carcinoma (ccRCC). Although renal cell carcinoma can give rise to bone metastases at multiple sites, the incidence of metastatic involvement of the calvarium is very low. Metastases from RCC are relatively common in the head and neck region (approximately 15% of cases [13,14]), typically involving lymph nodes and certain osseous and soft-tissue sites such as the nasal cavity, paranasal sinuses, and oral cavity [13,14], whereas calvarial involvement is considered rare. Head and neck metastases are usually accompanied by involvement of other organ systems and only exceptionally present as an isolated site of disease (approximately 1% [15]).

When restricting the analysis to metachronous distant renal metastases—defined as those occurring more than three months after initial nephrectomy [16]—these develop in up to 7%–16% of patients with primary RCC within 5 and 10 years, respectively [16,17], predominantly involving the lung (54%), lymph nodes (22%), and bone (11.9%–20%) [16,18-21]. In a series of 671 patients with RCC, only one developed a metachronous distant metastasis to the skull vault [22]. We reviewed in the literature the cases most similar to our patient, in particular cases of late metastatic recurrence of the cranial vault (Table 2A in the supplement), and in most instances, bone involvement is accompanied by metastases in other anatomical sites. The case reported by Gaur in 2015 [5], similarly to our patient, showed isolated involvement of the cranial vault, without evidence of metastases in the other sites more commonly affected by renal cell carcinoma. In that case, the primary tumor had demonstrated early signs of local invasiveness, having infiltrated the perirenal fat at the time of surgery. In our case, however, the metachronous distant metastasis arose from a primary renal tumor that had shown no signs of local invasiveness or lymph node involvement.

We indeed retrospectively reviewed the features of our patient’s primary renal tumor, which had been removed approximately seven years earlier, in order to identify any elements that might, in retrospect, indicate an aggressive biological behavior. According to several studies, there are indeed features that correlate with the aggressiveness of renal tumors and the potential development of distant metastases. According to Yang et al. in 2025 [23], who used a radiomic approach, the most important features are arteriovenous thrombosis, necrosis, and

locoregional lymphadenopathy. The correlation between primary renal tumor size and the frequency of synchronous metastases is supported by some studies [23,24], whereas Ku et al. (2009) [25] identified a correlation between primary masses greater than or equal to 3 cm and the risk of metachronous distant metastases. Of particular note is the finding by Miyao et al. (2011) [21], who, in a multivariate analysis, showed that lymph node metastasis was the principal predictor of late recurrence. In our case, the primary lesion of the left kidney, whose G2 grade (WHO/ISUP) indicated a low-to-intermediate metastatic risk (see Table 2B in the supplement), measured 5.5 × 4.3 cm, exceeding the threshold proposed by Ku, and showed focal necrotic and hemorrhagic features, which Yang associated with metastatic risk. Conversely, other features highlighted by Yang and Miyao were absent, including venous thrombosis, locoregional invasiveness (capsule, renal vein, ureter), and, most importantly, locoregional lymphadenopathy. The prospective characterization of a renal tumor is currently the focus of new and promising lines of investigation. RCC is a neoplasm that can present with markedly heterogeneous clinical pictures, with the distinctive ability to recur at distant sites even many years later, in the form of late metastatic recurrence. Metachronous distant metastases have been the object of genetic and molecular studies aimed at identifying the features that confer the ability to colonize specific niches. Tumor subclones selected on the basis of specific genetic mutations remain quiescent until an immunological deficit allows their proliferation. A better understanding of these subtle mechanisms of gene regulation could pave the way for potential therapeutic targets in ccRCC, acting both on the proliferating tumor cells and on the defensive capacity of the immune system [26-30].

The management of patients with solitary calvarial metastasis is complex and requires a multidisciplinary approach. Although no standardized treatment protocol has been established, current guidelines for metastatic RCC recommend metastasectomy in selected patients, particularly in cases of systemic therapy resistance [12]. In a follow-up of 101 patients with metachronous distant metastases, Han et al. (2017) [16] estimated a median survival of 23.6 months after detection of the late metastatic recurrence. Although metastasectomy at many sites is recognized as a factor associated with improved prognosis [16,31], surgery for bone involvement has specific features for which detailed recommendations have not yet been issued [12,32-34]. At the time of initial diagnosis, our patient was considered a potential surgical candidate; however, she declined surgery and embolization. Following disease progression and the onset of critical clinical deterioration, characterized by heart failure, renal failure, and coagulopathy, together with limited adherence to subsequent therapy, the available management options became increasingly restricted. Our patient, stratified into a favorable prognosis group, according to the IMDC risk score [35] and MSKCC score (NCCN Guidelines 2.2026 [36]), has been considered, in accordance with ASCO guidelines (low IMDC score, a solitary bone metastasis, with a long interval between nephrectomy and the development of metastatic disease), for Stereotactic Body Radiation Therapy (SBRT), in addition to the first-line therapy (ICIs -Immune Checkpoint Inhibitors- and bone resorption inhibitor -RANKL inhibitor-) [37-39].

Conclusions

ccRCC is an aggressive malignancy that may recur years later as metachronous distant metastases. The calvarium is a rare site; new neurological symptoms or cranial swelling in patients with a history of RCC should prompt

immediate suspicion, even long after nephrectomy. The therapeutic window for radical treatment is limited due to rapid growth and local invasion [38]. In our case of solitary osteolytic calvarial metastasis from renal carcinoma, the patient remained clinically asymptomatic despite extensive bone destruction and early intracranial compression, thereby complicating management. Osteolytic skull lesions are heterogeneous and require a structured radiological approach for diagnosis. Although prognosis in late metastatic recurrence is generally poor, early detection may allow timely multidisciplinary treatment, including metastasectomy or stereotactic body radiotherapy (SBRT) alongside systemic therapy when indicated.

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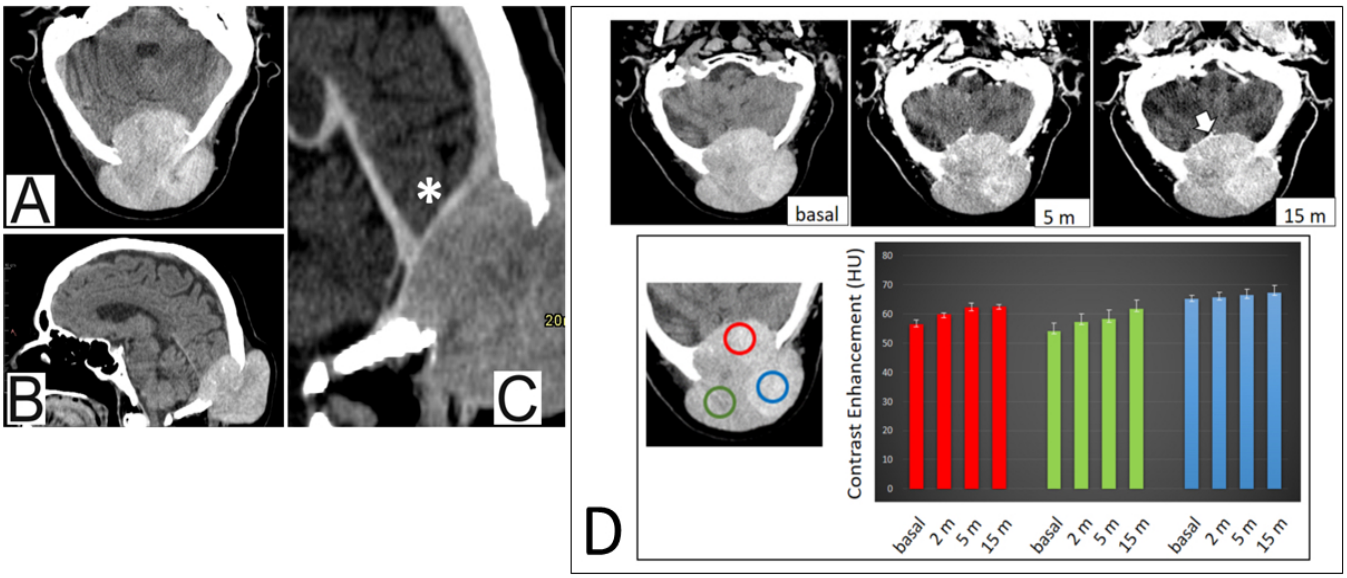

Figure 1. 77-year-old woman was referred with a rapidly progressive swelling at the back of the neck. Head computed tomography examination revealed a well-defined, 7 cm heterogeneous occipital mass (56 x 67 x 70 mm), destroying the inner and outer tables of the squamous part of the occipital bone, extending into both the intracranial and extracranial compartments. The brain was normal, and there were no other calvarial lesions. A, B) CT scan, axial and sagittal reconstructions. C) CT scan after iodinated contrast medium injection demonstrating compression of the sagittal sinus and confluence of sinuses (*). GE Revolution EVO 64 CT scanner. D) Contrast Enhancement. CT scan axial sections before (basal) and after (5 minutes; 15 minutes later) iodinated contrast medium injection demonstrate an occipital lytic bone lesion characterized by progressive, heterogeneous fill-in of contrast enhancement, especially in the intracranial region (+10%) and in the right extracranial region (+14%). Graph showing density measurements in three different areas of the mass at baseline and after contrast medium injection (2 minutes, 5 minutes, 15 minutes), as detailed below. There was a subtle rim-enhancement extending along the dural surface (white arrow). Three different areas were randomly selected and marked with three different colors to highlight the heterogeneity of the lesion; the graph shows the quantification in Hounsfield Units (HU) of the three regions of interest (ROIs), before and after iodinated contrast administration at different time points, demonstrating different values across different regions of the lesion. GE Revolution EVO 64 CT scanner.

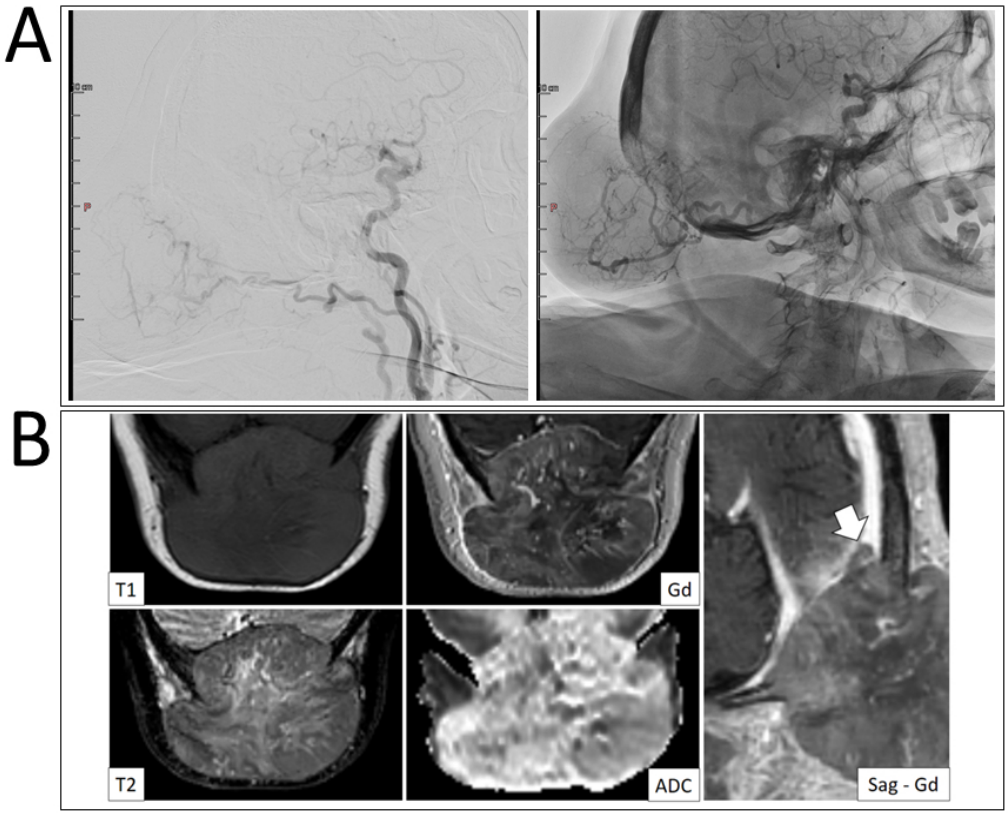

Figure 2. A) Angiographic image showing the rich arterial vascularization of the occipital neoplasm and the hypertrophy of the occipital arteries. Technical notes: using a right transfemoral catheterization with a 5-F introducer, a selective study of the internal carotids, external carotids, and vertebral arteries was performed. The study demonstrated significant contributions to the lesion from the occipital arteries on both sides. Siemens Artis Zee angiography system. B) MR imaging (axial T1 Spin Echo (T1-SE) before and after injection of gadolinium (Gd); axial T2 Fast Spin Echo (T2-FSE); Apparent Diffusion Coefficient (ADC)). Occipital mass, heterogeneously hypointense in T1 and hyperintense in T2, characterized by moderate heterogeneous contrast enhancement. No significant diffuse restriction was detected by diffusion-weighted imaging (ADC map). On the sagittal plane, post-gadolinium T1-weighted imaging (Sag T1-Gd) demonstrated findings consistent with thrombosis of the superior sagittal sinus (white arrow). Technical notes: MRI was performed using a Philips Achieva T-Stream 1.5T system.

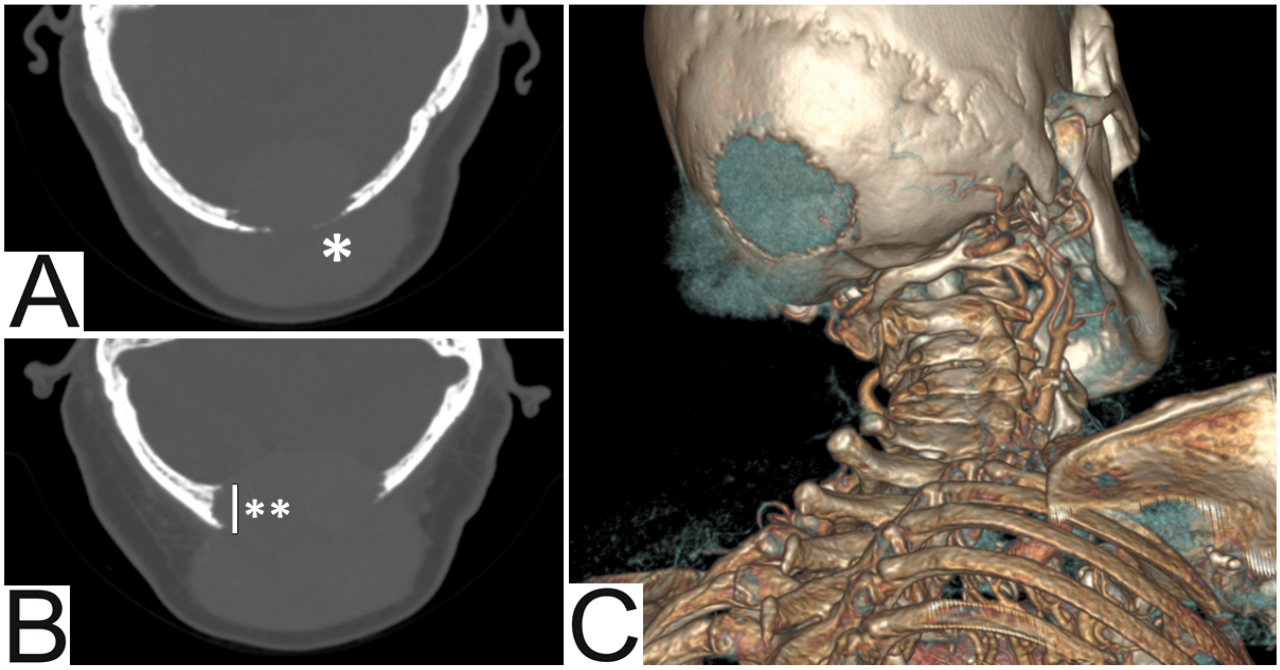

Figure 3. CT scan demonstrating trabecular and cortical osteolysis. A, B) Axial images from a non-contrast CT scan using bone algorithm. Destructive osteolysis with cortical breakthrough at the occipital squama. Axial computed tomography (CT) scan with bone window depicts inner and outer table scalloping, thinning and interruption (*). The " punched-out" lesion expands the intradiploic diameter at the bone margins (**), suggesting intradiploic origin. C) CT MPR 3D reconstruction showing the defect in the occipital bone, located about three centimeters behind the foramen magnum. GE Revolution EVO 64 CT scanner.

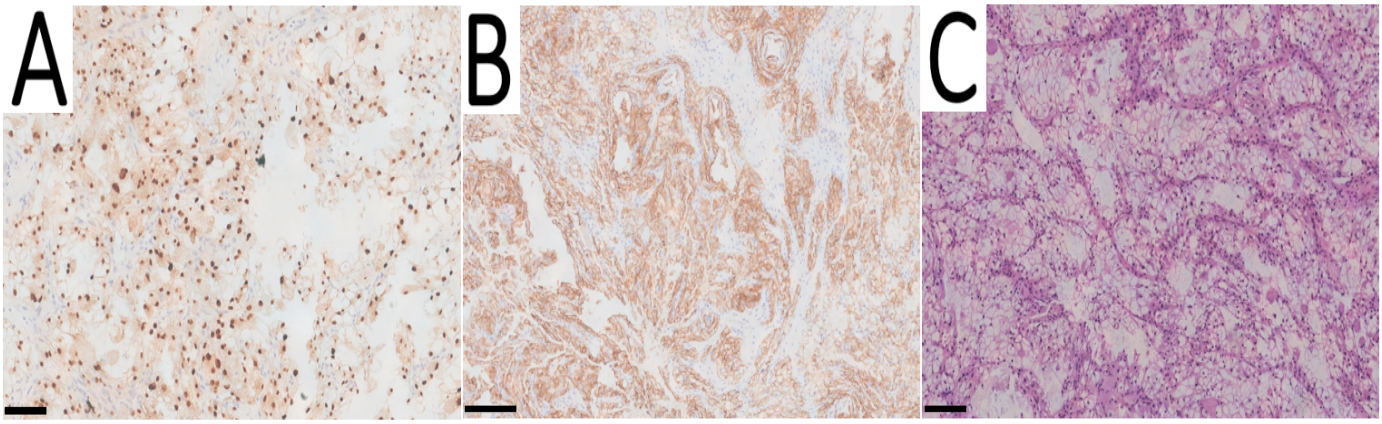

Figure 4. A) PAX8 (20x): nuclear immunoreactivity for PAX8 in the clear cell renal cell carcinoma (scale bar 150 micrometers). B) CAIX (20x): extensive membranous immunoreactivity in the clear cell renal cell carcinoma cells. CAIX (Carbonic Anhydrase IX) is a transmembrane enzyme that plays a crucial role in regulating intracellular pH. It is overexpressed in hypoxic cells (scale bar 250 micrometers). C) Hematoxylin and Eosin (20x): a fragment of metastatic clear cell renal cell carcinoma composed of cells with abundant optically clear cytoplasm, resulting from lipids dissolved during histological processing. The cells are arranged in nests and surrounded by a delicate network of branching capillaries (scale bar 100 micrometers).