



Atypical Skull Base Metastasis from Pediatric Extremity Chondroblastic Osteosarcoma Detected by Surveillance ¹⁸F-FDG PET/CT: A Case Report with Focused Literature Review

Pediatric Ekstremitte Kondroblastik Osteosarkomunda Takip ¹⁸F-FDG PET/CT ile Saptanan Atipik Kafa Tabanı Metastazı: Olgu Sunumu ve Literatür Derlemesi

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Abstract

A 15-year-old girl who had previously undergone surgery and chemotherapy for non-metastatic chondroblastic osteosarcoma of the left fibula was evaluated with ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) during routine follow-up while in clinical remission. Imaging demonstrated a 36 × 17 mm hypermetabolic lesion in the right occipital condyle maximum standard uptake value [(SUV_{max}): 16.5], with adjacent bone and soft-tissue extension, together with a concurrent ¹⁸F-FDG-avid pulmonary nodule (SUV_{max}: 3.4). Shortly after imaging, the patient developed mild neck discomfort and right-sided tongue deviation, suggesting hypoglossal nerve involvement. Biopsy of the skull base lesion and histopathological evaluation of the pulmonary nodule confirmed metastatic chondroblastic osteosarcoma with concordant morphology and immunophenotype. The patient underwent biopsy of the occipital lesion, surgical excision, radiotherapy, and wedge resection of the pulmonary metastasis. Skull base involvement from osteosarcoma arising in the extremities is exceptional and is particularly rare in pediatric patients. This case highlights the complementary role of whole-body ¹⁸F-FDG PET/CT in detecting atypical metastatic sites that may not be routinely assessed by conventional surveillance strategies. In addition, the focused literature review underscores the exceptional rarity of skull base involvement in pediatric chondroblastic osteosarcoma and supports the need for heightened awareness of uncommon metastatic patterns.

Keywords: Chondroblastic osteosarcoma, pediatric osteosarcoma, skull base metastasis, ¹⁸F-FDG PET/CT, surveillance imaging

Öz

Daha önce sol fibulada non-metastatik kondroblastik osteosarkom nedeniyle cerrahi ve kemoterapi uygulanmış 15 yaşındaki kız hasta, klinik remisyonda iken rutin takip kapsamında ¹⁸F-florodeoksiglukoz pozitron emisyon tomografisi/bilgisayarlı tomografi (¹⁸F-FDG PET/CT) ile değerlendirildi. Görüntülemeye sağ oksipital kondilde, komşu kemik ve yumuşak dokuya uzanım gösteren, maksimum standart tutulum değeri [(SUV_{max}): 16,5], olan 36 × 17 mm boyutunda hipermetabolik bir lezyon ile eş zamanlı olarak ¹⁸F-FDG tutulumu gösteren bir pulmoner nodül (SUV_{max}: 3,4) saptandı. Görüntülemeden kısa süre sonra hastada hafif boyun rahatsızlığı ve sağa doğru dil deviasyonu gelişmesi hipoglossal sinir tutulumunu düşündürdü. Kafa tabanı lezyonundan alınan biyopsi ve pulmoner nodülün histopatolojik değerlendirmesi, uyumlu morfoloji ve

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immünofenotip ile metastatik kondroblastik osteosarkomu doğruladı. Hastaya oksipital lezyon biyopsisi, cerrahi eksizyon, radyoterapi ve pulmoner metastaza yönelik wedge rezeksiyon uygulandı. Ekstremité kökenli osteosarkomlarda kafa tabanı tutulumu son derece nadirdir ve özellikle pediatrik hastalarda oldukça seyrek. Bu olgu, konvansiyonel izlem stratejileriyle rutin olarak değerlendirilmeyebilecek atipik metastatik odakların saptanmasında tüm vücut ¹⁸F-FDG PET/BT'nin tamamlayıcı rolünü vurgulamaktadır. Ayrıca, odaklanmış literatür incelemesi pediatrik kondroblastik osteosarkomda kafa tabanı tutulumunun olağanüstü nadirliğini ortaya koymakta ve alışılmadık metastatik paternler konusunda farkındalığın artırılması gerektiğini desteklemektedir.

Anahtar Kelimeler: Kondroblastik osteosarkom, pediatrik osteosarkom, kafa tabanı metastazi, ¹⁸F-FDG PET/BT, takip görüntüleme

Introduction

Osteosarcoma is the most common primary malignant bone tumor in children and adolescents, typically arising in the metaphyseal regions of long bones such as the distal femur, proximal tibia, and proximal humerus. Chondroblastic osteosarcoma, a histologic subtype characterized by the production of cartilaginous matrix in addition to malignant osteoid, accounts for a minority of cases and generally shares a clinical behavior similar to conventional osteosarcoma.

Osteosarcoma is characterized by hematogenous dissemination, with the lungs representing the predominant site of metastasis, whereas extrapulmonary spread is distinctly less frequent. Accordingly, standard surveillance strategies primarily focus on local limb magnetic resonance imaging (MRI) and chest computed tomography (CT) to detect local recurrence and pulmonary metastases. These protocols are designed to monitor the most common patterns of relapse and are not routinely intended to evaluate anatomically distant or clinically silent skeletal sites (1).

Although primary craniofacial osteosarcomas may involve the skull base through direct local extension, these tumors arise from the craniofacial skeleton itself and constitute a distinct clinical entity. In contrast, metastatic spread from an extremity osteosarcoma to the skull base is exceptionally uncommon, particularly in pediatric patients (2). Because the skull base is not considered a routine surveillance region in extremity osteosarcoma, metastatic involvement of this anatomically complex area may remain clinically unsuspected, particularly when early symptoms are minimal or nonspecific.

Whole-body ¹⁸F-fluorodeoxyglucose positron emission tomography (¹⁸F-FDG PET)/CT offers the advantage of comprehensive metabolic assessment, enabling simultaneous evaluation of both common and unexpected sites of disease involvement within a single examination. In this context, we present a pediatric case of chondroblastic osteosarcoma of the fibula with unexpected metastatic involvement of the occipital condyle detected on routine

surveillance PET/CT prior to the development of significant neurological symptoms. By illustrating a rare metastatic pattern outside conventional follow-up fields, this case suggests the complementary role of whole-body metabolic imaging in selected clinical contexts.

Case Report

A 15-year-old female with a history of non-metastatic chondroblastic osteosarcoma of the left proximal fibula was initially diagnosed in 2021. At presentation, the tumor measured approximately 6.5 cm in greatest dimension and showed cortical destruction with soft-tissue extension; surgical margins were intact. She underwent neoadjuvant chemotherapy followed by surgical resection and completed adjuvant treatment in August 2022, achieving clinical remission, after which she was followed with routine surveillance.

In December 2023, during routine oncologic surveillance, whole-body ¹⁸F-FDG PET/CT was performed for restaging. The examination demonstrated a 36 × 17 mm hypermetabolic lesion in the right occipital condyle maximum standard uptake value (SUV_{max}: 16.5) (Figure 1), extending to the clivus and right hemi-C1 vertebra with adjacent soft-tissue infiltration. In the same study, a solitary ¹⁸F-FDG-avid pulmonary nodule was identified in the anterior basal segment of the right lower lobe (SUV_{max}: 3.4), suggestive of concurrent metastatic disease.

At the time of PET/CT, the patient had no significant focal neurological deficit. Shortly thereafter, she developed mild neck discomfort and rightward deviation of the tongue on examination, consistent with hypoglossal nerve involvement. Cranial MRI was subsequently performed for detailed anatomical assessment. Contrast-enhanced T1-weighted sequences confirmed a heterogeneously enhancing mass centered in the right occipital condyle with destructive osseous changes, extension into the prevertebral and paravertebral soft tissues, and partial involvement of the right hypoglossal canal. Diffusion-weighted imaging demonstrated restricted diffusion with corresponding low ADC values, consistent with high tumor cellularity (Figure 2).

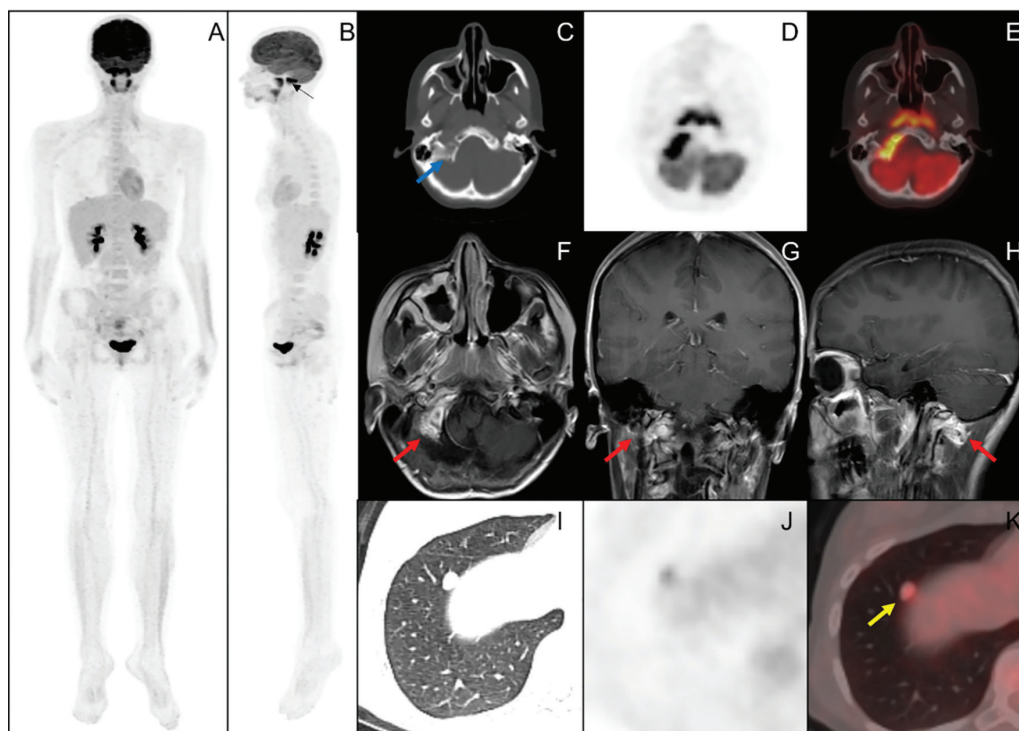


Figure 1. ^{18}F -FDG PET/CT and MRI of a 15-year-old girl with metastatic chondroblastic osteosarcoma

(A, B) MIP images show a hypermetabolic occipital condyle lesion (SUV_{max} : 16.5). (C-E) Axial CT (C, blue arrow), PET (D), and fused PET/CT (E) demonstrate the destructive skull base lesion. (F-H) Post-contrast T1-weighted MRI (red arrows) demonstrates a heterogeneously enhancing mass centered in the right occipital condyle, extending into prevertebral soft tissues and partially involving the hypoglossal canal, correlating with osseous destruction demonstrated on CT. (I-K) CT (I), PET (J), and fused PET/CT (K, yellow arrow) show an ^{18}F -FDG-avid right lower lobe pulmonary metastasis (SUV_{max} : 3.4)

MIP: Maximum intensity projection, SUV_{max} : Maximum standardized uptake value, CT: Computed tomography. PET: Positron emission tomography, MRI: Magnetic resonance imaging, ^{18}F -FDG: ^{18}F -Fluorodeoxyglucose

Following multidisciplinary evaluation, surgical management was planned and preceded by a diagnostic biopsy of the skull base lesion, which histopathologically confirmed metastatic chondroblastic osteosarcoma. Definitive surgical excision of the occipital condyle mass was subsequently performed in March 2024. Adjuvant radiotherapy was administered to the skull base region following surgery as part of local disease control. In April 2024, the patient underwent wedge resection of the right lower lobe pulmonary metastasis. Histopathological examination of the primary fibular tumor had demonstrated neoplastic osteoid formation with prominent cartilaginous matrix production. Immunohistochemistry showed SATB2 positivity, low p53 expression, and a Ki-67 proliferation index of approximately 10%. Analysis of paraffin blocks from the occipital lesion confirmed metastatic chondroblastic osteosarcoma with identical morphology and immunophenotype (Figure 3). The pulmonary nodule exhibited concordant histopathological features, confirming systemic metastatic dissemination. At the latest follow-up, 26 months after

detection of metastatic relapse, the patient remained without evidence of disease.

Discussion

Osteosarcoma is the most common primary malignant bone tumor in childhood and adolescence, with pulmonary metastases representing the predominant pattern of dissemination. In contrast, cranial or skull base involvement is distinctly uncommon and is more frequently described in the setting of primary craniofacial osteosarcomas rather than metastatic disease.

Most published reports of chondroblastic osteosarcoma involving the skull describe primary tumors arising from cranial bones or maxillofacial structures. Uysal et al. (3) reported a pediatric craniofacial chondroblastic osteosarcoma involving the maxillary, ethmoid, and sphenoid bones, emphasizing diagnostic challenges but again describing a primary cranial origin rather than metastatic spread. Similarly, Vasquez et al. (4) reported

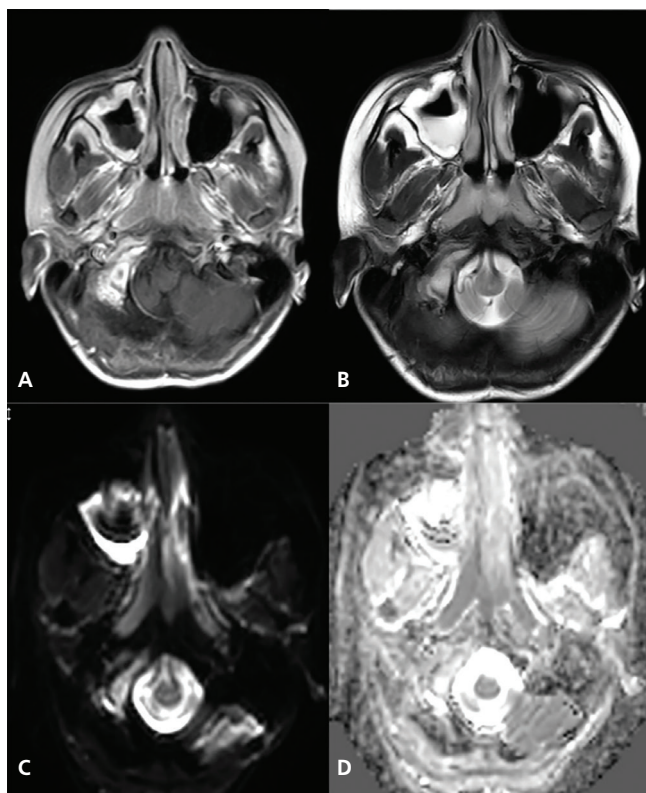


Figure 2. Axial MRI sequences of the right skull base lesion

(A) Contrast-enhanced T1-weighted image demonstrates a heterogeneously enhancing mass centered in the right occipital condyle, with cortical disruption and replacement of normal marrow signal. (B) T2-weighted image shows heterogeneous high signal intensity within the lesion. (C) Diffusion-weighted imaging (b800) reveals focal hyperintensity within the solid portions of the mass. (D) Corresponding apparent diffusion coefficient map demonstrates low signal intensity in the same region, confirming true diffusion restriction consistent with hypercellular malignant tissue

MRI: Magnetic resonance imaging

a pediatric primary skull osteosarcoma presenting as a parieto-occipital lesion without distant metastasis at presentation. He et al. (5) detailed imaging characteristics of primary occipital chondroblastic osteosarcoma with CT and MRI correlation, also without evidence of distant primary disease. Mamachan et al. (6) reported an anterior maxillary chondroblastic osteosarcoma limited to the craniofacial region without systemic dissemination. Almeida et al. (7) reported a rapidly progressive primary maxillary chondroblastic osteosarcoma in a young adult patient, further reinforcing the predominance of craniofacial origin in skull-related presentations. Adwani et al. (8) described a massive recurrent chondroblastic osteosarcoma of the maxilla in an adolescent patient, highlighting the aggressive behavior of primary maxillary tumors but not metastatic dissemination from an appendicular source.

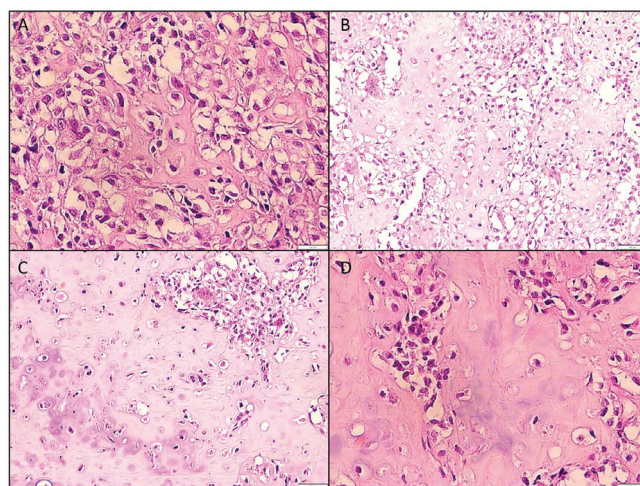


Figure 3. Histopathologic features of the occipital lesion

(A) Highly atypical polyhedral and spindle cells producing immature osteoid in a lace-like pattern (H&E, $\times 200$). (B) Chondroid matrix blending into eosinophilic osteoid with hyperchromatic oval to spindle cells and scattered multinucleated giant cells (H&E, $\times 100$). (C) High-grade malignant cartilage admixed with atypical oval to spindle cells and multinucleated giant cells (H&E, $\times 100$). (D) Cartilaginous component with high-grade stromal cells in areas with relatively scant osteoid production (H&E, $\times 200$) H&E: Hematoxylin and eosin

In contrast, Dumpala et al. (9) documented a rare case of mandibular gingival metastasis from a rib chondroblastic osteosarcoma; however, the metastatic involvement was limited to the oral cavity and did not extend to the skull base. Meningeal chondroblastic osteosarcoma represents an even rarer entity, typically presenting as a dura-based mass mimicking meningioma (10) (Table 1).

Importantly, across these reports, skull involvement consistently represents a primary cranial tumor rather than metastatic dissemination from an appendicular skeleton origin. To our knowledge, skull base metastasis arising from a pediatric extremity chondroblastic osteosarcoma has not been previously documented in the available literature.

The biological basis of atypical metastatic patterns in osteosarcoma remains incompletely understood. Although hematogenous dissemination explains the predominance of pulmonary metastases, the mechanisms underlying rare extrapulmonary skeletal involvement, particularly at the skull base, remain uncertain. In the present case, the unusual site of relapse is best interpreted as an uncommon manifestation of metastatic spread rather than evidence of a distinct biological pathway.

From an imaging standpoint, ^{18}F -FDG PET/CT plays an established role in staging, response assessment, and selected surveillance settings in osteosarcoma. Although most osteosarcomas demonstrate high ^{18}F -FDG avidity,

Table 1. Summary of reported cases of skull chondroblastic osteosarcoma

Author-year	Age-sex	Pediatric	Primary vs metastatic	Location	Imaging modality	PET/CT	Treatment	Outcome
Uysal et al. (3)	17-M	Y	Primary	Maxilla/ethmoid/sphenoid	Cranial X-ray, CT, MRI	N	Surgery + RT	No relapse (46 months)
Romeo et al. (10)	51-M	N	Primary	Meningeal	CT, MRI, cerebral angiography	N	Pre-operative embolization + surgery + ChT + RT	No relapse (43 months)
Dumpala et al. (9)	24-M	N	Metastatic (4 th rib)	Mandibular gingiva	CT, OPG	N	Surgery + ChT + RT	Poor outcome
Adwani et al. (8)	17-M	Y	Primary (recurrent)	Maxilla	CT	N	Surgery + ChT + RT	Deceased
Almeida et al. (7)	27-F	N	Primary	Maxilla	Panoramic radiography, CT	N	NACT	Not reported (short follow-up)
He et al. (5)	9-M	Y	Primary	Occipital	CT, MRI (CE + DWI)	N	Surgery (subtotal) + RT + ChT	Deceased (6 months after local recurrence)
Orunmuyi et al. (11)	32-M	N	Primary	Frontal	¹⁸ F-FDG PET/CT, ⁶⁸ Ga-RGD PET/CT	Y	Surgery + RT + ChT	Recurrent setting
Mamachan et al. (6)	58-M	N	Primary	Anterior maxilla	CT, ¹⁸ F-FDG PET/CT	Y	Surgery	No recurrence (asymptomatic at 1 year)
Mamachan et al. (6)	17-M	Y	Primary	Parietal-occipital	MRI, CT, bone scan	N	NACT + surgery + RT	Deceased (15 months)
Present Case - 2026	15-F	Y	Metastatic	Occipital	¹⁸ F-FDG PET/CT, CT, MRI	Y	Surgery + RT + ChT	No relapse; NED at 26 months follow-up

CT: Computed tomography, MRI: Magnetic resonance imaging, RT: Radiotherapy, ChT: Chemotherapy, OPG: Orthopantomography, NACT: Neoadjuvant chemotherapy, CE: Contrast-enhanced, DWI: Diffusion-weighted imaging, ¹⁸F-FDG PET/CT: ¹⁸F-Fluorodeoxyglucose positron emission tomography/computed tomography, ⁶⁸Ga-RGD PET/CT: Gallium-68-labeled arginine-glycine-aspartic acid PET/CT

variability in metabolic behavior has been reported. In a skull chondroblastic osteosarcoma case, ¹⁸F-FDG PET failed to demonstrate uptake while Gallium-68-labeled arginine-glycine-aspartic acid PET provided superior tumor visualization (11). In contrast to that report, our case demonstrated marked hypermetabolic activity within the occipital condyle on routine surveillance ¹⁸F-FDG PET/CT, enabling detection of a clinically occult skull base relapse prior to the development of significant neurological deficits.

Standard surveillance strategies for extremity osteosarcoma are primarily structured to detect local recurrence and pulmonary metastases, typically through limb MRI and chest CT. As a result, anatomically complex skeletal regions such as the skull base are not systematically evaluated in the absence of focal neurological symptoms. In the present case, routine surveillance with whole-body ¹⁸F-FDG PET/CT enabled simultaneous identification of both pulmonary and skull base metastatic sites within a single examination,

revealing an unexpected pattern of relapse that would not have been encompassed by conventional follow-up imaging fields.

Although this single case does not warrant modification of established surveillance algorithms, it illustrates that metastatic dissemination in osteosarcoma may occasionally extend beyond anticipated anatomical territories. By documenting skull base involvement arising from a pediatric extremity chondroblastic osteosarcoma, this report adds to the limited literature on atypical metastatic presentations and suggests that whole-body ¹⁸F-FDG PET/CT may help identify clinically unsuspected relapse in selected patients.

Conclusion

This case illustrates the potential utility of whole-body ¹⁸F-FDG PET/CT for identifying both typical and atypical relapse sites within a single examination and suggests

a complementary role for metabolic imaging beyond conventional surveillance protocols in selected clinical settings.

Ethics

Informed Consent: Written informed consent was obtained from the patient's legal guardian for publication of this case and accompanying images.

Availability of Data and Material: All data and materials are available from the corresponding author upon reasonable request.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.B., Concept: S.B., E.A., Design: S.B., H.G.S., İ.K., E.A., Data Collection or Processing: S.B., H.G.S., İ.K., U.Y., Analysis or Interpretation: S.B., H.G.S., İ.K., U.Y., Literature Search: S.B., H.G.S., Writing: S.B., U.Y., E.A.

Conflict of Interest: No conflicts of interest were declared by the authors.

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