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# Calvarial Tumors: A Retrospective Analysis and Clinical Experience

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## ABSTRACT

**AIM:** To elucidate the prognosis, frequency, and diverse nature of pathologies for calvarial tumors among different age groups.

**MATERIAL and METHODS:** Seventy-six patients who underwent surgery for calvarial lesions between January 2007 and March 2021 are included in this study. Clinical data obtained retrospectively from patients' electronic records. Radiological images and surgical notes are reviewed to determine extent of the tumor and resection.

**RESULTS:** Among 76 patients, 33 (43.4%) were male and 43 (56.6%) were female. The mean age was 36.0 years (range: 1–81 years) at the time of initial operation. Children consisted 28.9% (n=22) of the patients. In children, 59.1% (n=13) had tumor-like pathologies, while 27.3% (n=6) had benign pathologies, and 13.6% (n=3) had malignant tumors. In the adult population, 42.6% (n=23) had malignant tumors, 31.5% (n=17) had benign tumors, 16.7% (n=9) had tumor-like pathologies, and 9.2% (n=5) had intermediate-grade tumors. F-fluorodeoxyglucose positron emission tomography (FDG-PET) scan was performed in 16 patients, 10 cases underwent whole-body bone scintigraphy (WBBS), and 4 cases underwent both. Among these examinations, 16 (80%) of the FDG-PET scans and 5 (35.7%) of the WBBS scans revealed an extracranial pathological lesion. A calvarial tumor was diagnosed in 13 of 18 cases of metastatic lesions (72.2%) before the primary tumor detection.

**CONCLUSION:** Lesions of the calvarium include malignant tumors, intermediate grade tumors, tumor-like lesions, and benign tumors. These masses may be the first presentation in patients with underlying primary tumors. In our study, the malignant tumor rate in the calvaria was 34.2%, and 72.2% of the metastatic tumors were diagnosed with a calvarial resection before the primary tumor was found. Operating a calvarial lesion and making an early diagnosis are crucial for the treatment of the primary lesions.

**KEYWORDS:** Calvarial neoplasm, Surgical resection, Lesion variety

**ABBREVIATIONS: CT:** Computed tomography, **FDG-PET:** F-fluorodeoxyglucose positron emission tomography, **MRI:** Magnetic resonance imaging, **WBBS:** Whole-body bone scintigraphy

## INTRODUCTION

Tumors of the calvaria are very rare, comprising approximately 1% of all bone tumors (6). Metastasis of primary malignant tumors is thought to consist 12% of all calvarial lesions (1). However, most calvarial tumors are asymptomatic. Thus, the metastasis rate might be higher.

Patients with calvarial tumors usually present with a painless palpable mass, headache, and neurological deficit. Diagno-

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sis also occurs via incidental findings on a radiological examination or routine radiological examination of a patient with a primary malignancy (5). Radiological methods used in the diagnosis of calvarial tumors include direct roentgenograms, ultrasonography, contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI), CT-MRI angiography, and nuclear scintigraphy studies, such as F-fluorodeoxyglucose positron emission tomography (FDG-PET) and whole-body bone scintigraphy (WBBS) (7).

A limited number of studies have focused on the clinical implications of calvarial tumors. In this study, we aim to elucidate the prognosis, frequency, and diverse nature of pathologies for calvarial tumors among different age groups.

## MATERIAL and METHODS

Between January 2007 and March 2021, 76 patients underwent surgery for calvarial lesions. Lesions that didn't cause a bony structural pathology or bone erosions due to high intracranial pressure are excluded from this study. Retrospectively-obtained clinical data included age, gender, symptoms, type of primary tumor, other systemic metastases, neurological status before and after surgery, and complications. Radiological images were reviewed to determine the involvement of the cranium, scalp, and dura mater. The extent of resection was determined by reviews of postoperative CT or MRI scans and surgical notes. Ethical committee approval was obtained from local committee, numbered as 78017789/050.01.04/1931350.

## RESULTS

Seventy-six patients with calvarial lesions were retrospectively identified; 33 (43.4%) of the patients were male and 43 (56.6%) were female. The mean age was 36.0 years (range: 1–81 years) at the time of initial operation. Patients under the age of 18 were considered children, and 28.9% (n=22) of the patients were children. In children, 59.1% (n=13) had tumor-like pathologies, while 27.3% (n=6) had benign pathologies, and 13.6% (n=3) had malignant tumors (Figure 1). In the adult population, 42.6% (n=23) had malignant tumors (Figure 2), 31.5% (n=17) had benign tumors (Figure 3), 16.7% (n=9) had tumor-like pathologies (Figure 4) and, 9.2% (n=5) had intermediate-grade tumors (Figure 5). Histopathological diagnoses are summarized in Table I. Of the total patient population, 13.2% (n=10) had multiple lesions (Figure 6) and 86.8% (n=66) had solitary lesions.

The patient admission symptoms are summarized in Table 2. Lesions were located in the frontal bone (40.8%), parietal bone (19.7%), temporal bone (5.3%), and occipital bone (3.9%). In 23 patients (30.3%), either multiple calvarial lesions occurred or the lesions invaded more than one skull bone. Postoperative scans show that 65.8% (n=50) of the tumors

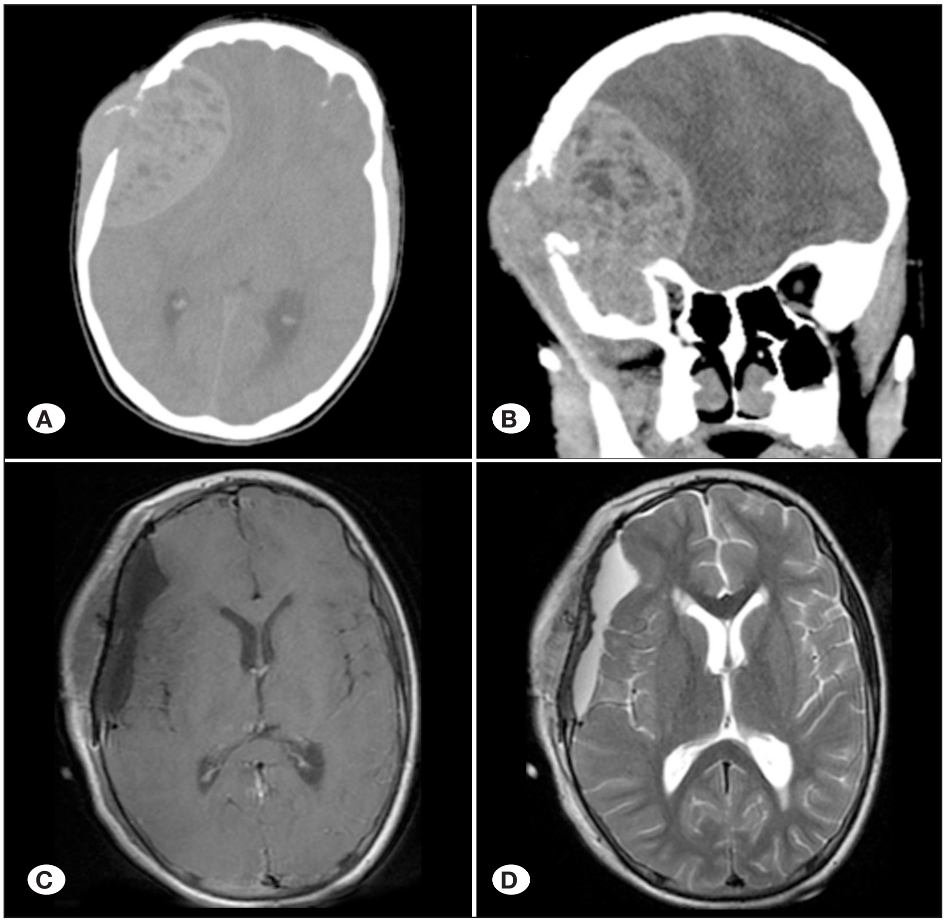


**Figure 1:** Pre-operative axial CT-scan **(A)**, coronal CT-scan **(B)** showing the metastatic Ewing sarcoma destructing right temporal bone. CT images show aggressive appearance of giant multicystic lesion. Post-operative axial T1-weighted, contrast enhanced MRI images **(C)** and post-operative axial T2-weighted MRI images **(D)** confirming the total resection of the metastatic lesion.

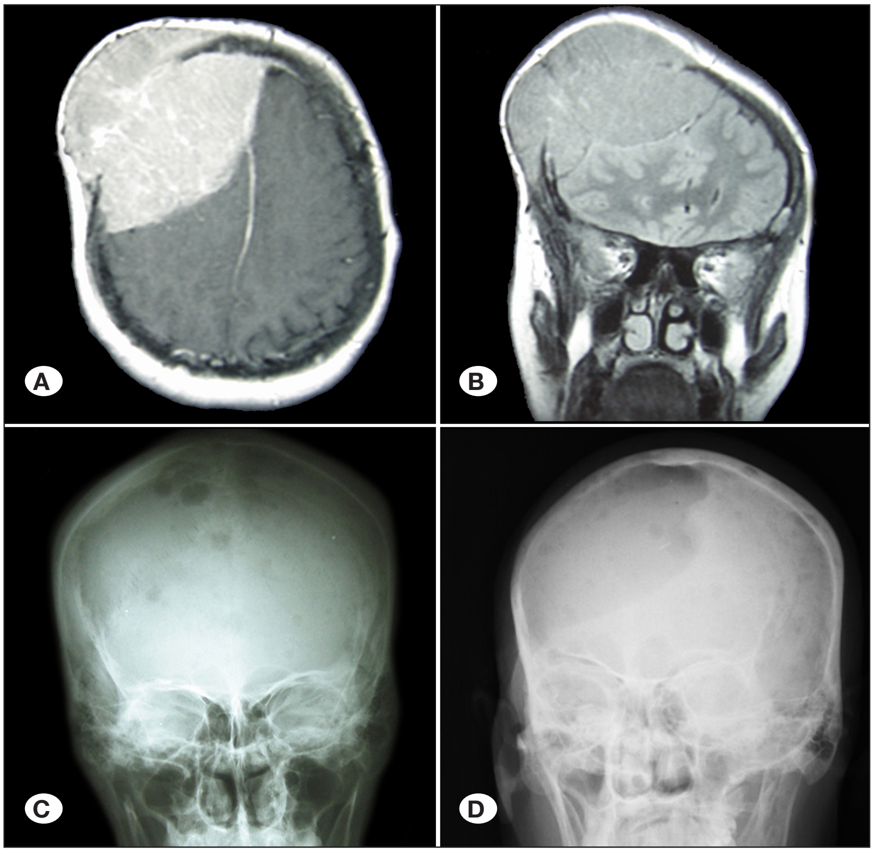


**Figure 2:** Pre-operative axial T1-weighted contrast enhanced MRI **(A)** and coronal T2-weighted MRI **(B)** depicting massive multiple myeloma invading right frontal bone. Pre-operative **(C)** anteroposterior direct roentgenogram showing beaten brass sign. Gross total excision can be seen on post-operative anteroposterior direct roentgenogram **(D)**.

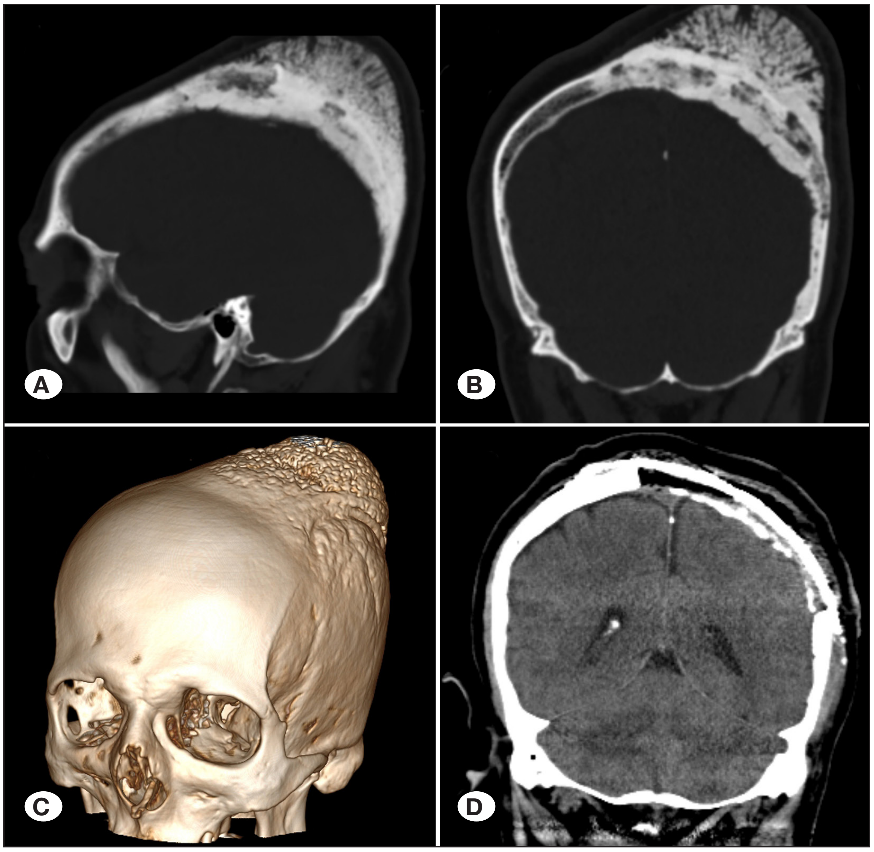


**Figure 3:** Pre-operative cranial sagittal **(A)** and coronal **(B)** CT scans showing giant intraosseous meningothelial meningioma causing diffuse sclerosis with bone expansion in left parietal bone. **C)** Pre-operative 3D-CT reconstruction of the mass lesion. **D)** Post-operative coronal CT scan displaying total excision of the lesion.

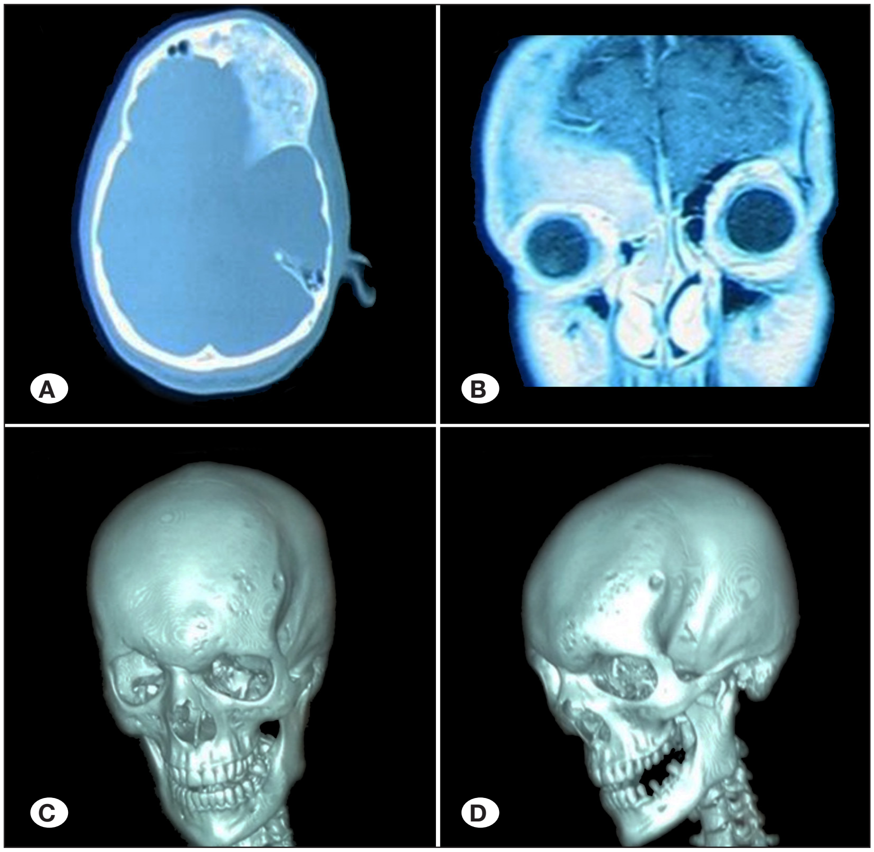


**Figure 4: A)** Pre-operative axial CT scans depicting left craniofacial fibrous dysplasia. Expansive bone lesion with intact cortex is seen. **B)** Pre-operative coronal T1-weighted contrast enhanced MRI showing left sided orbital rim deformity. **C, D)** Pre-operative 3D-CT reconstruction of the lesion.

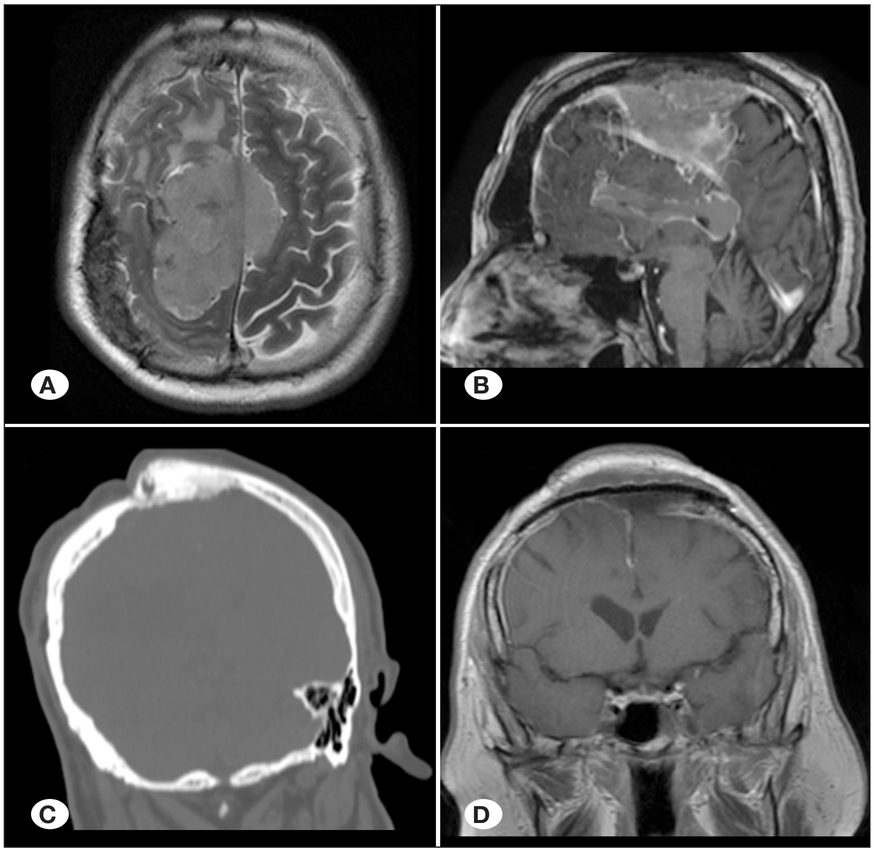


**Figure 5:** Pre-operative T1 weighted contrast enhanced axial **(A)** and sagittal **(B)** MRI showing the atypical meningioma occluding superior sagittal sinus. **C)** Pre-operative coronal CT scan displaying thickening of the parietal bone. **D)** Total resection is seen in post-operative coronal T1-weighted contrast enhanced MRI images.

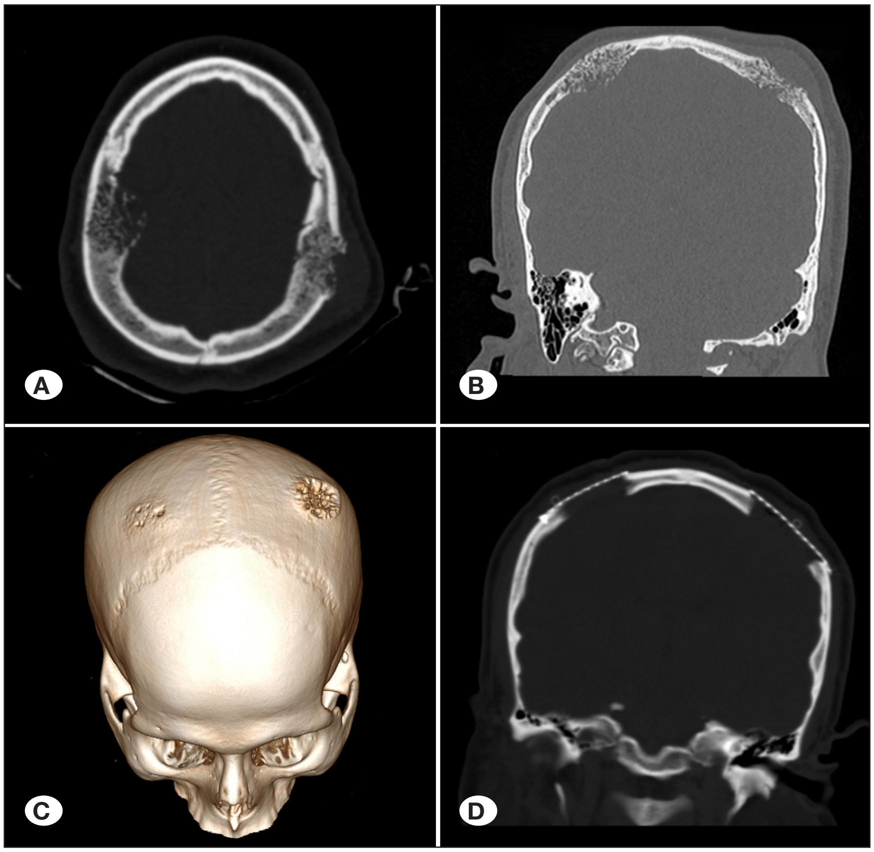


**Figure 6:** Pre-operative cranial axial **(A)** and coronal **(B)** CT scans showing bilateral intraosseous hemangioma in parietal bones with sunburst pattern. **C)** Pre-operative 3D-CT reconstruction of the lesions. **D)** Post-operative coronal CT scan depicting total excision and titanium mesh placement.

were totally resected, 22.4% (n=17) of the tumors were resected as gross total, and 11.8% (n=9) of the tumors were subtotally resected. Due to recurrence of the tumor or residual tumors, 9 patients were operated more than once.

Because of the cranial defects, 72.4% (n=55) of patients underwent reconstruction with titanium mesh, 10.5% (n=8) underwent reconstruction with medpor porous polyethylene implant, and 2.6% (n=2) underwent reconstruction with methyl methacrylate. No reconstruction was performed in 14.5% (n=11) of the patients. FDG-PET scan was performed in 16 patients, 10 cases underwent WBBS, and 4 cases underwent both. Among these examinations, 16 (80%) of the FDG-PET scans and 5 (35.7%) of the WBBS scans revealed an extracranial pathological lesion.

The most common postoperative complication was epileptic seizures (n=3). Wound infection (n=2), irritation of titanium mesh (n=1), and abscesses (n=1) also occurred. All patients with benign pathologies are still alive. Sixteen of the 26 patients (61.5%) with malignant tumors died. The mean length of survival was 33.3 months among the deceased patients and 4 patients (15.4%) with malignant tumors died within the post-operative 3 months. The dura mater was invaded by the tumors in 34 (44.7%) patients. Dural invasion was observed in 16 (61.5%) malignant tumors, which was the highest rate among all pathologies. Calvarial metastatic lesion rate was 23.7% (n=18) and a calvarial tumor was diagnosed in 13 of 18 cases of metastatic lesions (72.2%) before the primary tumor detection.

## DISCUSSION

Calvarial tumors comprise 0.8%–1% of all the bone tumors but the frequency reaches up to 4% in some studies (6). Calvarial tumors are usually divided into three groups in the literature (2,11-14), and only a few studies grouped these lesions into four categories, consisting of malignant, intermediate, tumor-like, and benign groups (6). We also grouped the calvarial lesions into four categories in our study. In present study, the most common type of benign lesions were meningiomas, osteomas, and intraosseous hemangiomas. Tumor-like lesions of the calvarium mostly consisted of two pathologies, fibrous dysplasia and Langerhans cell histiocytosis. These results are in accordance with previous publications and these pathologies usually occur at younger ages (2,10). In our study, the mean age of patients with tumor-like lesions was 17.3 years.

Metastasis of the primary tumor to the calvaria usually suggests advanced stages of the tumor (2). In a radiological study, Mitsuya et al. reported that the most common primary tumor that metastasizes to calvaria were breast cancer (55%), lung cancer (14%), prostate cancer (6%), and others (25%) (9). In our study, calvarial metastatic lesion rate was 23.7%, and the most common metastatic lesion was lung cancer (22%), followed by thyroid follicular carcinoma (16%) and breast cancer (16%). The most common primary malignant tumor was anaplastic meningioma followed by multiple myeloma. Furthermore, 61.5% of patients with malignant calvarial tumors died and the mean length of survival for the deceased patients was 33.3 months. The early mortality rate within post-

**Table I:** Epidemiology and Characteristics of Histopathological Types

| Tumors | Case Numbers | Age Mean (Range) | Male: Female | Involvement of Skull Bones | Dural Invasion | Resection Rate |
|---|---|---|---|---|---|---|
| **Malignant Tumors** | **26** | **49.1 (9-81)** | **11:15** | **Multiple (10)**<br>**Solitary (16)**<br>Parietal (6)<br>Frontal (7)<br>Occipital (2)<br>Temporal (1) | **16** | **Total (18)**<br>**Gross Total (2)**<br>**Subtotal (5)** |
| Folliculer Carcinoma of Thyroid | 3 | 68.3 (56-81) | 0:3 | Occipital (1)<br>Frontal (1)<br>Parietal (1) | 2 | Total (2)<br>Subtotal (1) |
| Anaplastic Meningioma | 3 | 46,6<br>(32-58) | 0:3 | Multiple (2)<br>Parieta l (1) | 3 | Tota l(3) |
| Ewing Sarcoma | 2 | 22 (12-32) | 1:1 | Multiple (1)<br>Temporal (1) | 1 | Total (1)<br>Gross Total (1) |
| Adenocarcinoma of Lung | 2 | 69.5 (62-77) | 1:1 | Multiple (1)<br>Frontal (1) | 1 | Total (1)<br>Subtotal (1) |
| Invasive Ductal Carcinoma | 2 | 46 (39-53) | 1:1 | Parietal (1)<br>Frontal (1) | 2 | Total (1)<br>Subtotal (1) |
| Multiple Myeloma | 2 | 49.5 (41-58) | 0:2 | Multiple (1)<br>Frontal (1) | 0 | Total (1)<br>Gross Total (1) |
| Squamos Cell Carcinoma | 2 | 67.5 (62-73) | 1:1 | Parietal (1)<br>Occipital (1) | 1 | Total (1)<br>Subtotal (1) |
| Malign Epithelial Tumor | 2 | 58 (50-66) | 1:1 | Multiple (1)<br>Frontal (1) | 2 | Total (1)<br>Subtotal (1) |
| Prostate Cancer | 1 | 50 | 1:0 | Frontal (1) | 0 | Total (1) |
| Non-Small Cell Malign Epithelial Tumor | 1 | 57 | 1:0 | Multiple (1) | 1 | Total (1) |
| Adenoid Cystic Carcinoma | 1 | 38 | 0:1 | Multipl (1) | 0 | Gross Total (1) |
| Renal Cell Carcinoma | 1 | 38 | 1:0 | Multiple (1) | 1 | Total (1) |
| Medulloblastoma | 1 | 13 | 1:0 | Frontal (1) | 0 | Total (1) |
| Chloroma | 1 | 9 | 0:1 | Multiple (1) | 0 | Total (1) |
| Plasmacytoma | 1 | 38 | 1:0 | Parietal (1) | 0 | Total (1) |
| Basal Cell Carcinoma | 1 | 65 | 1:0 | Parietal (1) | 1 | Total (1) |
| **Intermediate Tumors** | | | | | | |
| Atypical Meningioma | 5 | 56.4 (40-66) | 4:1 | **Multiple (3)**<br>**Solitary (2)**<br>Parietal (2) | 5 | Total (3)<br>Gross Total (2) |
| **Benign Tumors** | **23** | **34.7 (1-75)** | **10:13** | **Multiple (9)**<br>**Solitary (14)**<br>Frontal (8)<br>Parietal (3)<br>Occipital (1)<br>Temporal (2) | **10** | **Total (17)**<br>**Gross Total (4)**<br>**Subtotal (2)** |
| Meningioma | 9 | 51.6 (30-75) | 4:5 | Multiple (7)<br>Temporal (1)<br>Frontal (1) | 9 | Total (3)<br>Gross Total (4)<br>Subtotal (2) |

**Table I:** Cont.

| Tumors | Case Numbers | Age Mean (Range) | Male: Female | Involvement of Skull Bones | Dural Invasion | Resection Rate |
|---|---|---|---|---|---|---|
| Osteoma | 6 | 25.1 (17-39) | 2:4 | Frontal (3)<br>Parietal (2)<br>Occipital (1) | 0 | Total (6) |
| Intraosseous Hemangioma | 4 | 40.5 (21-50) | 3:1 | Multiple (1)<br>Parietal (1)<br>Frontal (1)<br>Temporal (1) | 1 | Total (4) |
| Dermoid Cyst | 2 | 1 (1-1) | 1:1 | Multiple (1)<br>Frontal (1) | 0 | Total (2) |
| Epidermoid Cyst | 2 | 9.5 (5-14) | 0:2 | Frontal (2) | 0 | Total (2) |
| **Tumor-like Lesions** | **22** | **17.3 (3-47)** | **11:11** | **Multiple (1)**<br>**Solitary (21)**<br>Frontal (16)<br>Parietal (4)<br>Temporal (1) | **3** | **Total (13)**<br>**Gross Total (7)**<br>**Subtotal (2)** |
| Fibrous Dysplasia | 10 | 15.7 (6-28) | 5:5 | Frontal (8)<br>Parietal (1)<br>Temporal (1) | 0 | Gross Total (8)<br>Subtotal (2) |
| Langerhans Cell Histiocytosis (Eosinophilic Granuloma) | 9 | 15.2 (3-47) | 5:4 | Multiple (1)<br>Frontal (5)<br>Parietal (3) | 2 | Total (9) |
| Simple Bone Cyst | 3 | 29 (23-36) | 1:2 | Frontal (3) | 1 | Total (3) |

**Table II:** Symptom Presentation

| Symptoms | n |
|---|---|
| Palpable mass | 37 |
| Headache | 17 |
| Neurological deficits | 5 |
| Proptosis | 4 |
| Visual field defect and/or vision loss | 4 |
| Incidental finding on radiological evaluation of unrelated cause | 3 |
| Epileptic seizures | 3 |
| Routine radiological examinations during primary tumour treatment | 2 |
| Nystagmus | 1 |
| Tinnitus | 1 |
| Skin lesion | 1 |

operative 3 months among patients with malignant tumors was 4%. We grouped atypical meningiomas as intermediate-grade tumors because they cannot be described as either benign or malignant tumors. In this study, 6.6% of lesions were intermediate-grade tumors.

In the literature, the most common symptoms for calvarial tumors are palpable mass and headache followed by exophthalmos, visual defects, and loss of consciousness (2, 12). In this study, the most common admission symptoms were palpable mass, headache, and neurological deficits (Table II). As the tumors are often asymptomatic and found during routine radiological evaluations or manifest with minor symptoms, the incidence of calvarial tumors might increase with improvements in radiological diagnostic techniques (3). CT scan and MRI are beneficial for assessing different aspects of the lesions and are complementary to each other. A lesion in the diploic space of the bone can be detected with MRI before it moves to the bony structure. In addition, involvement of the adjacent tissue, such as scalp or dura, is shown better in MRI. In this study, 44.7% of tumors invaded the dura mater, and dural invasion was seen in 61.5% of malignant tumors, which is the highest rate among all pathologies. Contrast-enhanced MRI is the gold standard for detecting calvarial metastases. However, structural changes in the calvarium, lesion margins, and whether the lesion is sclerotic or lytic are shown better in CT scans (8, 9). Radionuclide bone scintigraphy is used for detecting bone metastasis and FDG-PET is used for detecting far organ metastasis of primary tumors. Even though the results are comparable, bone scintigraphy has low sensitivity when detecting osteolytic bone lesions, whereas FDG-PET has higher sensitivity (4). In our study, 16 (80%) of the FDG-PET scans and 5 (35.7%) of WBBS scans showed extracranial pathological lesions. While benign and malign pathologies can cause similar symptoms, the nature of the tumor is very different. Although calvarial metastasis is usually seen in the late stages of the primary tumor, removing the calvarial lesion and diagnosing the pathology earlier are very important for the treatment of primary lesions (13). In our study, a calvarial lesion was detected in 72.2% of patients before the primary tumor was diagnosed in metastatic tumors.

When removing a calvarial lesion, a surgeon's aim should always be total excision of the mass, independent of whether the tumor is malign or benign. Because of adjacent tissue invasion and the nature of the tumor, total excision might not always be possible. We have totally resected 65.8% of the tumors, 22.4% were gross totally resected, and only 11.8% of the tumors were subtotally resected. Due to a residual tumor or tumor recurrence, 10.5% of patients needed to be operated more than once. All of the patients that needed to be operated again had either malign or intermediate-grade lesions.

The gold standard for cranioplasty is autologous grafts (12). However, synthetic materials, such as titanium mesh, porous polyethylene implants, and methyl methacrylate, can also be used. In our series, cranial defects were reconstructed most commonly with titanium mesh (72.4%). Only 14.5% of patients did not need reconstruction due to the size of the defect. No autologous grafts were used due to the discomfort of another incision.

## CONCLUSION

Lesions of the calvarium include malignant tumors, intermediate grade tumors, tumor-like lesions, and benign tumors. Due to the wide variety of pathologies involving the cranium, diagnosis of calvarial tumors with only preoperative radiological evaluations is difficult. A calvarial mass may be the first presentation in patients with underlying primary tumors. Thus, these tumors should be evaluated seriously and patients should be thoroughly examined due to the high rate of malignant tumor involvement in the calvaria. In our study, the malignant tumor rate in the calvaria was 34.2%, and 72.2% of the metastatic tumors were diagnosed with a calvarial resection before the primary tumor was found. Operating a calvarial lesion and making an early diagnosis are crucial for the treatment of the primary lesions. These findings suggest that calvarial lesions should not be disregarded at any age group, even if they present with benign symptoms.

**AUTHORSHIP CONTRIBUTION**

Study conception and design: DA, HK
Data collection: SU, ITB
Analysis and interpretation of results: AD, SU
Draft manuscript preparation: HS, DK
Critical revision of the article: AD, EA, DK
All authors (DK, SU, HK, HS, ITB, AD, EA) reviewed the results and approved the final version of the manuscript.

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