Accepted Manuscript

Submission Date: 2024-10-11
Accepted Date: 2025-10-17
Accepted Manuscript online: 2025-10-27

Journal of Neurological Surgery Part A: Central European Neurosurgery

Radiological and surgical findings of patients with intradiploic mass lesion: Case series and systematic review

Abdulkerim Gökoğlu, Hüseyin Yiğit, Merdan Orunoğlu, Turgut Tursem Toprak, Ayca Ersen Danyeli, Erdoğan Unur, AHMET SELCUKLU.

Affiliations below.

DOI: 10.1055/a-2731-4781

Please cite this article as: Gökoğlu A, Yiğit H, Orunoğlu M et al. Radiological and surgical findings of patients with intradiploic mass lesion: Case series and systematic review. Journal of Neurological Surgery Part A: Central European Neurosurgery 2025. doi: 10.1055/a-2731-4781

Conflict of Interest: The authors declare that they have no conflict of interest.

Abstract:
BACKGROUND AND OBJECTIVES: In this study, our goal is to examine the radiological findings and clinical outcomes of nine patients with intradiploic masses, who were treated at our clinic, along with a comprehensive review of the existing literature.
METHODS: The study includes a total of nine adult patients, who were under follow-up and treatment for intradiploic masses from 2015 to 2022. All patients included in the study provided signed informed consent forms. Exclusions from the study criteria comprised patients in the pediatric age group, those with a documented history of cancer, prior cranial surgery, active central nervous system infection, and acute head trauma resulting in cranial damage.
RESULTS: Our study comprised a total of 9 patients, with 6 (66.6%) females and 3 (33.3%) males, with a median age of 36 years (range: 18-76). Epidermoid cysts were identified in 2 patients, while others presented with cavernous hemangioma, arachnoid/leptomeningeal cyst, intradiploic lipoma, dermoid cyst, arachnoid cyst, fibrous dysplasia, and eosinophilic granuloma. Among the cohort, 8 patients presented with headaches. The patient with cavernous hemangioma underwent total resection and mini plate stabilization. Similarly, total resection was performed in cases of leptomeningeal cyst (n=1) and intradiploic lipoma (n=1). In a single patient, fibrous dysplasia was diagnosed through open biopsy. For the patient with eosinophilic granuloma, total mass excision and chemotherapy were undertaken. Notably, four patients (44.4%), including those with epidermoid cysts (n=2), dermoid cyst (n=1), and arachnoid cyst (n=1), were managed conservatively without surgical intervention.
CONCLUSIONS: The use of CT and MRI imaging in intradiploic lesions seems sufficient to differentiate the mass. However, it may be difficult to reach a definitive diagnosis in some patients without surgery. Therefore, based on the experience of clinical management, it is important to evaluate in detail the various radiological and clinical findings unique to the patient, regarding excision or nonoperative follow-up.

Corresponding Author:
Dr. Abdulkerim Gökoğlu, System Hospital, Neurosurgery, Gevher Nesibe Mahallesi , 38080 Kocasinan , Turkey, akerimg@hotmail.com

Affiliations:
Abdulkerim Gökoğlu, System Hospital, Neurosurgery, Kocasinan , Turkey
Abdulkerim Gökoğlu, Erciyes Universitesi, Anatomy, Talas, Turkey
Hüseyin Yiğit, Cappadocia University, Department of Medical Services and Techniques, Mustafapaşa, Turkey
[...]

AHMET SELCUKLU, Erciyes Universitesi Tip Fakultesi, Neurosurgery, Kayseri, Turkey

Original Research

Radiological and surgical findings of patients with intradiploic mass lesion: Case series and systematic review

Running Title: "Intradiploic masses: Case series and systematic review"

Abdulkerim Gökoğlu[a*], Hüseyin Yiğit[b], Merdan Orunoğlu[c], Turgut Tursem Tokmak[d], Ayça Erşen Danyeli[e], Erdoğan Unur[f], Ahmet Selçuklu[g]

[a]Department of Neurosurgery, Private System Hospital, Kayseri, Turkey

[b]Department of Medical Services and Techniques, Cappadocia University, Nevşehir, Turkey

[c]Department of Neurosurgery, Kayseri State Hospital, Kayseri, Turkey

[d]Department of Radiology, Kayseri Research and Training Hospital, Kayseri, Turkey

[e]Department of Pathology, Acıbadem MMA University, School of Medicine, Istanbul, Turkey

[f]Department of Anatomy, Faculty of Medicine, Erciyes University, Kayseri, Turkey

[g]Department of Neurosurgery, Erciyes University, School of Medicine, Kayseri, Turkey

Corresponding Author:*

Abdulkerim Gökoğlu

Department of Neurosurgery, Private System Hospital, Kayseri, Turkey

Gevher Nesibe Mah Gök Geçidi No: 15/1, Kocasinan, Kayseri, Turkey

Zip code: 38000

e-mail: gokogluak@erciyes.edu.tr

ORCID IDs:

Abdulkerim Gökoğlu: 0000-0001-8071-4078

Hüseyin Yiğit: 0000-0002-7739-9844

Merdan Orunoğlu: 0000-0001-8622-8038

Turgut Tursem Tokmak: 0000-0002-1952-9911

Ayça Erşen Danyeli: 0000-0001-8015-9916

Erdoğan Unur: 0000-0003-2033-4350

Ahmet Selçuklu: 0000-0001-6021-5060

Declarations

Funding: There is no funding in this study.

Competing interests: The authors declare no competing interests.

Ethics approval: This research was carried out in accordance with the Declaration of Helsinki. Institutional approvals for the conduct of the study were obtained from the Kayseri State Hospital Clinical Studies Ethics Committee (17.09.2021/43358).

Consent to participate: All authors have read and accepted the article's content; all authors consent to participate in the study.

Consent for publication: All authors have consent for the publication of this article.

Acknowledgements: The authors express their sincere gratitude to Dr. Alan Cohen (Prof. Dr, MD, FAANS, Chief of Pediatric Neurosurgery at Johns Hopkins Medical School) for his valuable contributions and insightful suggestions that significantly enhanced the quality of this manuscript.

Author Contributions

A.G., M.O., and T.T. contributed to the conceptualization, design, methodology, and writing and editing of the manuscript. A.G. and M.O. were responsible for formal analysis and provided administrative, technical, or material support. A.G., H.Y., M.O., A.E., E.U., and A.S. contributed to the methodology and supervision of the study. They also contributed to writing, reviewing, editing, and revision of the manuscript.

Introduction

Intradiploic lesions can originate from bony structures or result from the invasion of the calvari by scalp or brain lesions. Typically asymptomatic, calvarial lesions are often discovered incidentally during brain computed tomography (CT) or magnetic resonance imaging (MRI), or when evaluating local clinical symptoms or other diseases.[1-6] In some cases, these lesions may manifest visibly as a palpable or symptomatic swelling.[1,4] Key clinical factors, such as age and medical history, play a crucial role in guiding the radiologic diagnosis. While calvarial lesions can be either benign or malignant, the majority are benign tumors.[1-6]

Recognition of benign and malignant behaviour imaging features is important for diagnosis. In general, benign tumours have well-defined borders with a narrow transition zone; sclerotic margins are frequently present. However malignant tumours have poorly defined margins, a wide transition zone, aggressive periosteal reaction and often have a soft tissue component; these lesions cause dramatic bony destruction with intracranial or extracranial extension. Skull lesions can be lytic or sclerotic, single or multiple with varied composition.[7]

In contrast to cranial pathologies, intradural extramedullary tumors constitute approximately 40% of all spinal neoplasms, with nearly 90% of these lesions demonstrating benign characteristics. This represents a notable divergence from the prevalence of benign lesions observed in cranial pathologies. Consequently, the current study focuses on intradiploic lesions, aiming to elucidate their distinct features and clinical significance, thereby differentiating them from intradural pathologies affecting the brain and spine. The majority of these tumors are meningiomas and schwannomas, comprising 80%, while filum terminale ependymomas account for around 15%. Conversely, extradural tumors constitute approximately 55% of spinal masses and are predominantly metastatic and malignant.[8] These tumors either remain asymptomatic or are incidentally detected or they may present as a

palpable lump. They can erode the bone and involve the brain parenchyma due to their proximity to the brain. Radiological imaging is very helpful in accurate diagnosis of these lesions and in differentiating intradural from intradiploic lesions.[9] MRI is the most effective modality for assessing marrow involvement within the diploe, as well as evaluating associated soft tissue components and the invasion of nearby structures.[10]

This study focuses on reviewing the radiological findings and clinical outcomes of nine patients with intradiploic masses, who were treated at our clinic, accompanied by a comprehensive literature review.

Materials and methods

Clinical Case Selection

Patients diagnosed with intradiploic masses followed in our clinic were included in this study. Verbal and written consent was obtained from all patients participating in the study. The complaints of all patients were recorded in detail. Detailed physical examination and neurological tests were performed. CT and MRI scans of the patients were performed and interpreted by two separate radiologists, each 10 years of experience in neuroradiological imaging, blinded to the study.

All patients received treatment for intradiploic masses at our clinic from 2015 to 2022. Every patient included in the study provided a signed informed consent form.

The following patients were excluded from the study: children, those with a documented history of cancer, those with prior cranial surgery, those with an active central nervous system infection, and those withacute head trauma resulting in cranial damage.

Surgery

In the absence of vascular disorders, compression of neural tissues, or compromise of tissue integrity, conservative symptomatic treatment is generally preferred. Surgical intervention

was considered for lytic lesions (eosinophilic granulomas) or expansile mass effects (lipomas).

Systematic Literature Review

A systematic search was undertaken in PubMed and Embase databases from inception to May 10, 2024. Medical Subject Headings (MeSH) used for the search were as follows: “intradiploic masss” OR “epidermoid cyst” OR “dermoid cyst” AND (“MRI” OR “CT”). The following keywords were used with the MeSH terms: “intradiploic masss”, (“epidermoid cyst, dermoid cyst, skull, eosinophilic granuloma, headache, arachnoid cyst, malignant epidermoid”). Titles and abstracts identified were screened by both authors. A manual search of secondary sources included personal holdings, conference abstracts, and review of the references of identified articles. **Graphic 1** shows the study flow as recommended by the PRISMA 2020 updated guideline [11].

Screening and Data Extraction

Two authors trained in performing systematic reviews and database searching conducted the search strategy. In the first stage, the titles and abstracts of the articles were reviewed; in the next stage, two authors independently reviewed the full text of the articles. After preparing a list of titles and summaries of studies, articles were evaluated in terms of various methodological aspects, including sampling methods, reliability of the tools used and the objectives of the study. In case of confusion due to controversial literature findings, it was planned to include the studies in the research by reaching an expert consensus with the third independent author. Finally, a set of articles appropriate in terms of topic coverage and content structure was included in the article.

Results

Clinical Characteristics

Our study included a total of nine patients (66.6% females and 33.3% males) with a median age of 36 years (range: 18-76). The patients presented with various conditions, such as epidermoid cyst in 2 cases. Other cases included cavernous hemangioma, arachnoid/leptomeningeal cyst, intradiploic lipoma, dermoid cyst, arachnoid cyst, fibrous dysplasia, and eosinophilic granuloma. Table 1 provides a summary of the clinical and radiologic findings. Headache was a presenting symptom in 8 patients. Notably, the patient with cavernous hemangioma experienced a speech disorder, the patient with fibrous dysplasia had left eye proptosis, the patient with an arachnoid cyst presented with right parietal swelling, and the patient with an intradiploic lipoma had palpable swelling adjacent to the sagittal suture. MRI imaging was available for 8 patients. The diagnosis was confirmed by CT in one case. Patient-based clinical characteristics and treatment outcomes are summarized below (Table 1).

Case 1: A 25-year old woman presented to our outpatient clinic with a speech disorder and weakness on the right side. On physical examination, there was a slight effacement in left nasolabial sulcus and hypoactive deep tendon reflexes in upper extremity. On cerebral MR imaging, an ID cystic lesion (20*8*20 mm) was observed in the left frontal skull region, which showed hyper-intensity on T1- and T2-weighted images (Fig. 1a, 1b and 1c). The patient underwent total resection of the lesion with mini-plate stabilization. Neuronavigation was employed to delineate the surgical target and margins. A curvilinear skin incision was made to access the lesion. Using a high-speed drill, the bony margins were circumferentially addressed, and the lesion was completely excised. Histopathology was cavernous hemangioma. The patient experienced an uneventful postoperative course.

Case 2: A 32-year old woman presented with chronic headache and swelling (2 cm in size initially and reached up to 4 cm after 2 months) in the right parietal region. She had a history of head trauma due to a motor vehicle accident nearly four and half years ago. In skull

radiographs, a wide radiolucent area with sclerotic margins was observed at right parietal region (Fig. 2a, 2b). On cranial post-op coronal CT scan, there was internal table defect due to enlarged diploic space and thinned external table (Fig. 2c). On cranial MR imaging a round, cystic mass filled with cerebrospinal fluid (CSF) was observed in axial sections, which appeared hypo-intense on T1-weighted images and hyper-intense on T2-weighted images (Fig. 2d, 2e). Following a modified curvilinear skin incision, a skin flap was elevated, providing access to the lesion. Due to the lesion's gross size, neuronavigation was deemed unnecessary. During surgery, extremely thinned external table was observed when scalp flap was removed. Cystic content were drained during the craniotomy, exposing a thin membrane surrounding the cyst. Total resection was performed. Following resection of the mass, the resulting bony defect was repaired using Porous polyethylene (Medpor®). An optimal cranioplasty was achieved using synthetic grafting contoured to the cranial convexity (Fig. 2c). Histopathological examination showed an arachnoid/leptomeningeal cyst. There were no complications.

Case 3: A 26-year old woman presented with headache and a smooth swelling palpable at the midline of her head. On physical examination an oval, painful, soft mass was detected (3 cm in diameter) fixed to the skull at the vertex. Neurological examination was normal. On cerebral CT scan, there was a defect in the internal table with and enlarged diploic space and complete destruction of external table. In the diplooic space there was a hyper-intense in the right parasagittal region on coronal T1-weighted MR images (3a). A cystic mass was identified slightly compressing superior sagittal sinus on a T1-weighted MRI (3b). A hyper-intense lesion was noted in the right parasagittal region invading the external and internal tables of the calvaria- on coronal T2-weighted MRI (3c). Axial imagesshowed a round, lobulated, cystic lesion. The mass was surgically removed. The patient was positioned in a Mayfield skull clamp with the head flexed 15 degrees. Neuronavigational planning was

utilized to define the lesion and surgical margins. A midline parasagittal incision, centered over the lesion, was performed. Hemostasis was achieved and retractors were placed. Using a high-speed drill, the bony resection was carefully completed circumferentially around the lesion. Cranioplasty was performed by repairing the defect with acrylic synthetic cement. Lipid vacuoles were seen at the center on histopathological staining (Fig. 3g and 3h). Histopathological examination showed an ID lipoma. Postoperatively, all of the patient's symptoms resolved. No adverse events were observed.

Case 4: A 76-years old patient presented with headache. Neurological examination was normal. There was no palpable lesion in physical examination. CT and other imaging findings suggested an intradiploic epidermoid tumor located in the patient's right parietal region. However, radiological images did not reveal mass effect, which could directly explain the patient's headache or lead to periosteal tension. The tumor's relationship with the sinus was not consistent with increased intracranial pressure. Fundoscopic examination was normal. There was no neurological motor deficit. Therefore, the patient was placed under observation. In addition, a meningioma was detected in left parietal region. No surgery was performed as the patient had no clinical symptoms. A cystic mass lesion compressing the superior sagittal sinus was seen on aT1-weighted MRI (Fig. 4a).The cystic mass compressed the superior sagittal sinus on T1-weighted MRI (Fig. 4b). A hypodense cystic lesion was seen in the right parasagittal region on axial CT (Fig. 4c). A hyperintense, intradiploic lesion was seen in the right parasagittal region and a meningiomawas seen in the left frontal region on coronal T2-weighted MRI(Fig. 4d). No growth or progression of the patient's mass was observed during follow-up. Throughout the patient's follow-up period, no adverse events were observed.

Case 5: A 36-years old man presented with headache and a dysmorphic head appearance. The patient had history of tuberous sclerosis. The neurological examination was found to be

normal. In physical examination, there was skull deformation including swelling at frontal region of skull. Laboratory tests revealed a vitamin D level of 10.3 ng/mL, indicating vitamin D deficiency in the patient. In addition, the patient had pyoderma. A cystic lesion was detected in left frontal region on paranasal CT scan and cranial MRI. The lesion was interpreted as epidermoid cyst. Moreover, the patient had SEGA-intraventricular tumor in frontal horn of left lateral ventricle. An axial T2-weighted MRI demonstrated a mixed intradiploic mass in the left frontal region, with hypointense anterior portions and predominantly hyperintense components (Fig. 5a). An iso/hypointense intradiploic cystic mass lesion was noted in the left frontal region on axial T1-weighted MRI (Fig. 5b). An intradiploic, iso/hypointense cystic mass was seen in the left frontal region on coronal T1-weighted MR images (Fig. 5c). An intradiploic mass was seen in the left frontal region on axial diffusion-weighted, contrast-enhanced MRI (Fig. 5d). The patient expressed fear of surgery and declined to undergo the procedure. The patient exhibited no neurological deterioration. The patient was advised to seek surgical intervention should any neurological symptoms, hemorrhage, or infection develop. No progression of the mass was observed during a two-year follow-up period.

Case 6: A 72-year old woman presented with headache. The neurological examination was normal. No marked abnormality was detected in physical examination. On cranial MRI, a dermoid cyst was detected filled with intense hair follicles at left frontal region. Cystic mass lesion at right frontal region which caused iso-intense mass effect on coronal T2-weighted MR images (6a). Cystic mass lesion compressing superior sagittal sinus on T2-wieghted MRI (6b). A hyper-dense cystic lesion was seen in the right frontal region on axial T1-weighted MR images (6c). An intradiploic, iso-intense lesion was seen in the right frontal region on axial diffusion-weighted MRI (6d). Post-operative axial CT imaging revealing total resection of left parietal dermoid cyst and cranioplasty with titanium miniplates and mini screws (6e).

The lesion was found to be fat-enriched. Tumor and surgical field planning were performed using neuronavigation. A curvilinear skin incision was made, and the skin was reflected. The tumor was totally resected with the aid of a high-speed drill and craniotomy. The procedure was completed with autograft cranioplasty using titanium microcrews and plates. The pathology result was reported as a dermoid cyst. The postoperative period and follow-ups were uneventful.

Case 7: A 70-year-old male patient applied with the complaint of headache and occipital soft swelling. The patient's neurological examination was normal. There was no obvious pathological finding in the physical examination. Cranial MRI revealed an arachnoid cyst in the left occipital diploe, without diffusion restriction and gadolinium contrast enhancement. A hyperintense cystic mass was seen in the left occipital region on axial T2-weighted MRI (Fig. 7a). An intradiploic, hypointense cystic mass was seen in theat left occipital region on axial T1-weighted MRI (Fig. 7b). A hypo-intense cystic lesion was seen in the left occipital region on axial ACD-Diffusion T2-weighted MR images (Fig. 7c). An intradiploic, hyperintense lesion without diffusion restriction was noted in the left occipital region on axial diffusion-weighted MR images (Fig. 7d). A hyperintense, non-contrast enhancing cystic lesion was noted in the occipital region on contrast-enhanced sagittal T1-weghted MR images (Fig. 7e). An intradiploic arachnoid cyst at was noted in the left occipital region on sagittal T2-weighted MRI (Fig. 7f). No enlargement of the cyst size was observed during the patient's follow-up. Cerebellar tests revealed no abnormalities. The patient's headaches resolved with medical treatment.

Case 8: A 46-year old woman presented with downward retraction of left eye, impaired vision, headache and swelling around left eye which led skull deformation. An open biopsy was performed in the diagnostic workshop. The mass was reported as fibrous dysplasia. An intradiploic lesion caused destruction in left orbit and zygomatic bone on axial cranial CT

scan (Fig. 8a, preoperative assessment). The intradiploic lesion caused destruction in the left orbit and zygomatic bone on coronal cranial CT scan (Fig. 8b). The intradiploic lesion caused destruction in left orbit and zygomatic bone on sagittal cranial CT scan (Fig. 8c). The orbital and zygomatic lesion site where the biopsy was performed was seen the on postoperative axial cranial CT scan (Fig. 8d, postoperative). The patient was advised to undergo orbital reconstruction. However, the patient declined.

Case 9: An 18-year old boy presented with persistent headache following head trauma which occurred 3 months ago. In another hospital, it was reported that a cystic lesion was developed. An intradiploic, iso-intense cystic mass was seen in theparietal region on coronal T2-weighted MR images (Fig. 9a).An intradiploic hyperintense mass was seen I the at right posterior parietal region on axial T1-weighted MR images (Fig. 9b). The intradiploic, iso/hyperintense cystic mass was noted in the right posterior parietal region on axial T2-weighted MR images (Fig. 9c). The intradiploic isointense mass was seen in the right posterior parietal region on axial FLAIR images (Fig. 9d). Intraoperative intradiploic mass (Fig. 9e). Excised intradiploic mass lesion (Fig. 9f). BURR-HOLE titanium reconstructionn of excision site (Fig. 9g). Excision site at right posterior parietal region on postoperative cranial CT scan (Fig. 9h). The patient underwent surgery; histopathological examination was reported as eosinophilic granuloma. Chemotherapy was initiated to the patient after surgery. A control CT scan was obtained, which revealed that there was no abnormality requiring surgery. At postoperative follow-up, no active drainage or wound infection was observed. The patient had normal neurological examination and stable vital signs. Thus, he was discharged. Chemotherapy was scheduled at oncology outpatient clinic.

Treatment Results

Treatment approaches varied, including total resection with mini-plate stabilization for the patient with a cavernous hemangioma (**Figure 1**), total resection for the leptomeningeal cyst

(n=1) (**Figure 2**) and intradiploic lipoma (n=1) (**Figure 3**), Notably, 4 patients (44.4%), including those with an epidermoid cyst (n=2) (**Figure 4** and **Figure 5**), dermoid cyst (n=1) (**Figure 6**), and arachnoid cyst (n=1) (**Figure 7**), were managed conservatively without surgery.

Open biopsy was performed for the fibrous dysplasia case (n=1) (**Figure 8**), and total mass excision with chemotherapy for the eosinophilic granuloma (n=1) (**Figure 9**).

Discussion

Intradiploic lesions can originate from various elements of bone, including osteogenic, chondrogenic, fibrogenic, vascular, and others.[12] Recognizing the imaging features that distinguish benign from malignant diploic masses is crucial for accurate radiologic diagnosis.[2] These lesions can manifest as lytic or sclerotic, single or multiple, each exhibiting distinct characteristics on imaging.[6] Generally, benign tumors present with well-defined borders and a narrow transition zone, often accompanied by sclerotic features. On the other hand, malignant tumors typically exhibit indistinct borders, a broad transitional zone, aggressive periosteal reaction, and may include soft tissue components.[1] Importantly, these lesions have the potential to cause significant bone damage with the possibility of intracranial or extracranial spread.[2]

Benign lesions encompass a variety of conditions, including fibrous dysplasia, osteoma, Langerhans cell histiocytosis, venous vascular malformation (cavernous hemangioma), leptomeningeal cyst, eosinophilic granuloma, epidermoid tumor, dermoid tumor, osteoblastoma, aneurysmal bone cyst, meningioma, Paget's disease, and other rare diseases. Malignant lesions that can impact the calvarium include metastases, multiple myeloma, osteosarcoma, chordoma, and chondrosarcoma. Additionally, systemic diseases such as chronic anemia, renal osteodystrophy, and osteopenia have the potential to affect the calvaria.[9]

Symptomatic intradiploic cysts may cause issues through mass effect or by inducing intracranial hypertension via epidural or subdural hemorrhage.[13] Consistent with findings in the existing literature, our study observed that intradiploic mass lesions were predominantly located in the parietal and temporal bones.[14-16] Notably, our study underscores that surgery may not be universally mandatory for all intradiploic mass lesions.

Table 2 systematically reviews intradiploic lesions reported in our study and the literature, detailing age, gender, location, diagnosis, pre-operative, intra-operative, and post-operative imaging (when available), complaints, physical examinations and treatment management strategies. Comparative analysis reveals that the treatment management reported in existing literature exhibits less comprehensive details than our series, notably lacking intra-operative and post-operative imaging and detailed histopathological data, particularly in lipoma cases. We posit that our study, by presenting detailed medical, follow-up, and surgical treatment modalities, along with post-operative outcomes, significantly contributes to the existing literature. While demographic and diagnostic distributions in our series align with those reported in previous studies, the inclusion of detailed surgical options, post-operative imaging, and the novel presentation of an intradiploic lipoma case represents a valuable addition to the current literature.

Cavernous Hemangioma

Calvarial hemangiomas represent a rare subset of osseous neoplasms, accounting for approximately 2% of all bone tumors.[17] Calvarial hemangiomas are predominantly classified as cavernous on a histological level, characterized by dilated blood vessels situated within the bone trabeculae.[18] This benign and slow-growing vascular bone tumor constitutes less than 1% of primary bone lesions and about 10% of benign calvarial tumors.[2]

Computed tomography features include an intra-diploic expansile lesion with trabeculations and spicules. Peripheral sclerosis may also be noted in some cases. There occurs expansion of outer table in most of the cases with sparing of inner table of the skull. [19,]

After the injection of contrast material, MRI depicts a uniform contrast enhancement. On MRI, osseous hemangioma appears isointense on T1-weighted images and hyperintense on T2-weighted images. It may exhibit hypo or hyperintense spots, indicative of the presence of fat or iron. Following gadolinium administration, the enhancement is initially focal and later diffuses. However, imaging is generally nonspecific, and there is the possibility of an aggressive course with soft tissue invasion. [7]

MRI reveals iso- to hypo-intense lesion on T1 weighted images, hyperintense on T2 and FLAIR images. Post-Gadolinium scans reveal avid, homogeneous enhancement in most of the cases and dull enhancement in some sclerosed lesions. The present case also displayed the similar features on MR images.[20]

Treatment is done in all cases unless specifically warranted. The indications for treatment include symptomatic mass effect on underlying brain, hemorrhage, esthetic improvement, and transformation to aggressive form.[21]

The primary mode of treatment is typically surgical, with the option of embolization before surgery. While radiotherapy can halt tumor progression, it does not lead to a reduction in tumor volume.[22] Embolization and intralesional steroid injection techniques have also been tried to treat the calvarial hemangiomas.[23] In our patient, the cavernous hemangioma was excised and mini-plate stabilization was achieved (**Case 1**).

Leptomeningeal Cyst

Leptomeningeal cysts are predominantly observed in pediatric age groups and often arise as a complication following trauma. Typically, they manifest in the fronto-parietal bone after calvarial fractures in children under 3 years of age. The development of leptomeningeal cysts

is associated with the enlargement of fractures and the formation of cysts due to cerebrospinal fluid pulsation in calvarial fractures.[24] On T1-weighted MRI images, these cysts appear hypointense, while on T2-weighted MRI images, they present as hyperintense. [25] Arachnoid cysts can be identified on CT imaging, exhibiting a hypodense intradiploic lesion with a normal CSF appearance. To differentiate these lesions from dermoid and epidermoid cysts, the addition of MRI imaging is recommended.[26] It's important to note that leptomeningeal cysts, which may develop after trauma, can occur at any age. In our study, one patient experienced the development of a leptomeningeal cyst after trauma, contrary to the common occurrence in younger individuals as reported in the literature. Typically, these cysts do not necessitate treatment unless they become symptomatic [27]. However, in our case (**Patient No: 1**), the leptomeningeal cyst, which caused headache and swelling in the parietal area, was surgically excised.

Intradiploic Lipoma

Intradiploic lipomas can manifest across a broad age range, spanning from 5 to 85 years, with the most common age of discovery typically occurring between the 4th and 5th decades of life. There is a slight male predominance, with a male-to-female ratio of approximately 1.3 to 1.[28] The primary symptom in 70% of cases is pain accompanied by palpable soft swelling of the calvarium. Interestingly, over 30% of intradiploic lipomas are incidentally discovered during imaging studies for various reasons. Histopathological examination reveals lipid vacuoles, and in the literature, intradiploic angiolipoma is frequently reported. On CT imaging, angiolipoma appears non-homogeneous and hypodense. [29] Generally, surgical intervention is not recommended unless intradiploic lipomas cause symptoms. [30] Our study included one patient (**Patient No: 3**) with an intradiploic lipoma. In this case, the lipoma was identified as a homogeneous and hyperdense lesion on a brain CT. Cranial MRI revealed homogeneity,

hypointensity on T1, and hyperintensity on T2 and FLAIR sequences. The patient underwent cyst excision and resection due to prominent headache symptoms.

Epidermoid Cyst

Epidermoid cysts, rare congenital lesions originating from the ectoderm, represent a small proportion, accounting for 0.3-1.8% of all intracranial tumors.[31] These cysts are believed to develop as a result of intradiploic congenital factors or posttraumatic epidermal or dermal folds. The primary manifestation in affected individuals is typically painless swelling of the scalp. Epidermoid cysts, lined with thin squamous epithelium, may harbor deposits of cholesterol and keratin.[32] Notably, the occurrence of epidermoid cysts is reported to be one times higher than that of dermoids.[13,33] The epidermoid cyst ratio in the intracranial compartment is 4:1. Intradiploic epidermoid cysts are rare, benign, and slow-growing tumors localized in the intertabular space of the cranial bones. They seldom necessitate surgical treatment.[34]

On CT scans, epidermoid cysts manifest as well-defined osteolytic lesions with a sclerotic wall, demonstrating an inclination to expand into both the inner and outer layers. They present as homogeneous and hypodense on CT images. In MRI, these cysts exhibit a smooth signal intensity on both T1 and T2 weighted images and show high signal intensity on Diffusion-Weighted Imaging (DWI). Typically, there is no contrast enhancement observed following gadolinium administration. The cyst appears isointense with cerebrospinal fluid (CSF) on T1-weighted sequences and hyperintense and heterogeneous on T2-weighted sequences. While it is rarely hyperintense on T1-weighted images compared to CSF due to its hemorrhagic and protein-rich content, the cyst suppresses CSF signals in Fluid Attenuated Inversion Recovery (FLAIR) sequences [34]. Notably, epidermoid cysts do not exhibit contrast enhancement; however, secondary contrast enhancement may be observed on CT and MRI, attributed to inflammation [35].

Given that epidermoid cysts are rich in keratin[7] and protein[36] upon histological examination, they can be expected to appear hyperintense in FLAIR images. In our study, two patients (**Patient No: 4 and 5**) exhibited hyperintensity compared to cerebrospinal fluid (CSF) on FLAIR sequences. One patient in our study presented with both an intradiploic epidermoid cyst in the left parietal region and a meningioma in the right parietal region simultaneously. This case underscores the possibility of intradiploic mass lesions coexisting with other intracranial lesions.

Another patient diagnosed with an epidermoid cyst (**Patient No: 5**) was found to have subependymal giant cell astrocytoma (SEGA) on cranial MRI.[37] Despite the absence of clinical findings suggestive of Tuberous Sclerosis in this patient, a close follow-up without surgery was planned. Malignant transformation is a rare occurrence in epidermoid cysts, with reported cases of squamous cell carcinoma originating from primary intradiploic epidermoid cysts in some case studies.[38,39] Surgical resection is typically undertaken to alleviate the mass effect on the intracranial structure, prevent abscess formation, and mitigate potential complications such as bleeding and malignant transformation.[40-42] In our study, as no radiologic features suggestive of malignant transformation were observed in the patients, a nonoperative follow-up was conducted.

Dermoid Cyst

Dermoid cysts are encapsulated by a thick epithelium and typically contain sebaceous and apocrine sweat glands, and occasionally, hair or teeth. These cysts are commonly detected in childhood or young adults, often apprearing along the midline, particularly near the anterior fontanelle.[43]

Diagnosing dermoid cysts is achievable through CT or MRI. On computed tomography, a dermoid cyst manifests as a hypodense, non-contrast intradiploic mass lesion.[44] Notably, the presence of fatty signal intensity on T1-weighted images and the prominence of a thick

peripheral capsule after gadolinium administration can be crucial findings.[1] In our study, the patient with a dermoid tumor (**Patient No: 6**) displayed hyperintensity on T1 and a non-homogeneous isointense appearance on T2, aligning with findings in the existing literature. Dermoid cysts have the potential to harbor remnants of hair, nails, and skin. Complications often arise due to cyst rupture, a phenomenon frequently observed in dermoid cysts [45]. However, the precise pathophysiology behind cyst rupture remains uncertain. Rupture may occur spontaneously or as a result of head trauma [46]. In the surgical approach, similar to dermoid cysts in various body regions[47], the cyst size and the potential for rupture and infection should be considered during surgical intervention. As previously delineated, the patient underwent surgical intervention tailored to the specific characteristics and dimensions of the cyst. Post-operative monitoring revealed an uneventful recovery, with no discernible complications or adverse events documented throughout the follow-up period.

Arachnoid Cyst

Arachnoid cysts, typically benign pathologies, are commonly observed in the intracranial region. However, their occurrence within the intradiploic area is rare, and the term 'intradiploic arachnoid cyst' was first coined by Weinand et al.[48] These cysts arise from small defects in the dura mater, eroding the inner layer of the folded extensions of the arachnoid membrane. They expand into the diploe, causing damage to the outer layer of the skull. Dunkser and McCreary termed these cysts, 'leptomeningeal cysts'.[49] Originating from the inner surface of the related bone, these cysts may lead to the rupture of the dura mater, resulting in the accumulation of cerebrospinal fluid (CSF) covered with arachnoid membrane in the diploic space. It's important to note that CSF accumulation in the diploic space is exceedingly rare.[27,50]

In the MRI imaging of one of our patients (**Patient No: 7**) diagnosed with an arachnoid cyst, a cystic lesion in the left occipital region was observed. The lesion appeared T1-weighted

Diffusion-Weighted Imaging (DWI) Hypointense and T2-weighted Diffusion-Weighted Imaging (DAG) Hyperintense. These characteristics were further highlighted in contrast-enhanced sagittal T1-weighted MRI images. The patient is currently being monitored and surgery is not being considered.

Fibrous Dysplasia

Fibrous dysplasia is an exceptionally rare bone disease typically occurring within the first 20 years of life [51,52]. Resulting from a non-hereditary genetic mutation, this condition leads to abnormal differentiation and maturation of osteoblasts, causing the progressive replacement of normal bone with immature woven bone. Bone involvement can be focal or multifocal, with a hemicranial predominance when extensive. The frontal bone is the most commonly affected, followed by the sphenoid bone, ethmoidal bone, parietal bone, temporal bone, and occipital bone [51]. Fibrous dysplasia is a fibro-osseous lesion that alters bone structure and may involve the cranial bones. It can lead to expansion and distortion of the affected bones. [53]. Intradiploic masses are located within the diploë. Although fibrous dysplasia is a rare occurrence in the craniofacial region[54] and is not typically classified as an intradiploic mass, it was included in this study due to its involvement of the bone structure in the present case. For diagnosis, CT is the preferred imaging modality, capable of revealing the characteristic ground-glass appearance (70-130 HU) in all or part of the lesion [55]. Intralesional calcifications may also be present. Medical treatment often involves the use of bisphosphonates. Surgical decompression is considered in cases with a severe mass effect.[12] In our study, the patient with fibrous dysplasia underwent clinical follow-up after an open biopsy due to symptoms such as proptosis in the left eye, headache, and skull deformity around the left eye (**Patient No: 8**).

Eosinophilic Granuloma

Langerhans cell histiocytosis (LCH) encompasses three idiopathic diseases characterized by the proliferation of Langerhans cells.[56] When the lesion is solitary and monostotic, as is often

the case, it is termed eosinophilic granuloma.[57] LCH is most prevalent in children and adolescents, and its severity tends to be inversely proportional to the age of onset.[58] The calvaria is the most common site affected by LCH, with the parietal bones being the most commonly involved.[59] Typically, the lesion is well-defined, lytic with non-sclerotic borders, and it extends across all three layers of the skull[60].

Eosinophilic granuloma is a subtype of Langerhans cell histiocytosis (LCH), constituting a rare entity that accounts for less than 1% of all bone tumors [61]. It is more commonly found in the calvarium, mandible, ribs, ilium, or long bones, presenting with symptoms such as swelling, deformation, and tenderness.[57] In cases where there is no definite surgical indication, close follow-up is recommended, as these lesions may become symptomatic (e.g., hematoma due to cyst perforation or bleeding).[60] In our study, the patient with eosinophilic granuloma in the left parietal area (**Patient No: 9**) underwent chemotherapy after mass excision due to symptomatic headaches, and the pathological evaluation revealed eosinophilic granuloma.

This study acknowledges several limitations. Firstly, the generalizability of our findings is constrained by the limited sample size and the heterogeneity of diagnoses within our patient cohort. However, it is important to emphasize that intradiploic masses are rare entities, which inherently poses challenges to the design of large-scale, comparative studies. Secondly, the absence of systematic, long-term clinical and imaging follow-up represents a notable shortcoming. Due to the asymptomatic nature of some patients, routine follow-up imaging was not uniformly pursued, and subsequent evaluations were primarily guided by clinical presentation. Nevertheless, this study possesses several strengths. Notably, it provides detailed radiological and surgical characterization of rare disease subtypes. Furthermore, the expert neuroradiological interpretations presented herein contribute valuable insights to clinical practice.

Due to the relative rarity of benign lesions of the skull and the similarity of some imaging findings, they are easily confused with one another or misdiagnosed at the time of diagnosis. It is important for radiologists to understand the imaging appearances and characteristics of these diseases in order to make an accurate diagnosis based on a patient's clinical history and laboratory tests.[62]

There are a number of benign slow-growing tumors in the brain known as intraradiploic masses, though they are relatively uncommon. With detailed clinical and radiological evaluations, the majority of patients can be followed up without surgery [36,63].

Conclusions: Intradiploic lesions are uncommon entities, posing diagnostic and therapeutic challenges. While CT and MRI are valuable tools for characterizing these masses, achieving a definitive diagnosis often necessitates histopathological evaluation.[29,34] Surgical excision, followed by thorough pathological examination, remains the gold standard for establishing a conclusive diagnosis. Current best practices emphasize a tailored approach to management, considering the patient's unique radiological and clinical presentation. In cases where surgery is deemed necessary, complete excision is the ideal treatment. However, for asymptomatic patients or those with lesions suggestive of benign etiology, a conservative approach involving close clinical and radiological monitoring may be warranted. Ultimately, a multidisciplinary assessment, integrating radiological findings, clinical symptoms, and surgical expertise, is crucial for optimizing patient outcomes.

Ethics Approval

This research was carried out in accordance with the Declaration of Helsinki. Institutional approvals for the conduct of the study were obtained from the Local Ethical Committe.

Funding

Conflict of Interest

None declared

References

1. Lloret I, Server A, Taksdal I. Calvarial lesions: a radiological approach to diagnosis. *Acta radiologica (Stockholm, Sweden : 1987)*. Jun 2009;50(5):531-42. doi:10.1080/02841850902795274

2. Colas L, Caron S, Cotten AJAJoR. Skull vault lesions: a review. 2015;205(4):840-847.

3. Garfinkle J, Melançon D, Cortes M, Tampieri DJSr. Imaging pattern of calvarial lesions in adults. 2011;40:1261-1273.

4. Arana E, Martí-Bonmatí LJAAjor. CT and MR imaging of focal calvarial lesions. 1999;172(6):1683-1688.

5. Yim Y, Moon W-J, An HS, Cho J, Rho MH. Imaging Findings of Various Calvarial Bone Lesions with a Focus on Osteolytic Lesions. 2016;74(1):43-54.

6. Yalcin O, Yildirim T, Kizilkilic O, et al. CT and MRI findings in calvarial non-infectious lesions. 2007;13(2):68.

7. Krupp W, Heckert A, Holland H, Meixensberger J, Fritzsch DJJoMCR. Giant intradiploic epidermoid cyst with large osteolytic lesions of the skull: a case report. 2012;6:1-5.

8. Schiffman JD, Fisher PG, Gibbs PJASoCOEB. Early detection of cancer: past, present, and future. 2015;35(1):57-65.

9. Khodarahmi I, Alizai H, Chalian M, et al. Imaging spectrum of calvarial abnormalities. 2021;41(4):1144-1163.

10. Ledbetter LN, Leever JDJRC. Imaging of intraspinal tumors. 2019;57(2):341-357.

11. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. 2021;372

12. Gomez CK, Schiffman SR, Bhatt AA. Radiological review of skull lesions. *Insights into imaging*. Oct 2018;9(5):857-882. doi:10.1007/s13244-018-0643-0

13. Moreira-Holguin J, Medélez-Borbonio R, Quintero-Lopez E, García-González U, Gómez-Amador JJIJoSCR. Intradiploic epidermoid cyst with intracranial hypertension syndrome: Report of two cases and literature review. 2015;16:81-86.

14. Ţica O, Ţica OA, Roşca E, et al. Intradiploic epidermoid cysts - a series of three cases and our experience with literature data. *Romanian journal of morphology and embryology = Revue roumaine de morphologie et embryologie*. Jul-Sep 2020;61(3):889-894. doi:10.47162/rjme.61.3.27

15. Lee DH. Intradiploic epidermoid cyst of the temporal bone: is it the same as or different from cholesteatoma? *The Journal of craniofacial surgery.* Sep 2011;22(5):1973-5. doi:10.1097/SCS.0b013e31822eaa52

16. Mehra S, Chandra GU, Kumar S. Intradiploic epidermoid tumor of temporal bone X-ray, CT, MR Imaging. 2012;18(2):98-102. doi:10.4103/0971-7749.100738

17. Khanam H, Lipper MH, Wolff CL, Lopes MBS. Calvarial hemangiomas: report of two cases and review of the literature. *Surgical Neurology.* 2001/01/01/ 2001;55(1):63-67. doi:https://doi.org/10.1016/S0090-3019(00)00268-8

18. Bantan NAA, Abouissa AH, Saeed M, et al. A unique case of multiple calvarial hemangiomas with one large symplastic hemangioma. 2021;21:1-12.

19. Mehra S, Chandra GU, Kumar SJIJoO. Intradiploic epidermoid tumor of temporal bone X-ray, CT, MR Imaging. 2012;18(2):98-102.

20. Ţica O, Ţica OA, Roşca E, et al. Intradiploic epidermoid cysts–a series of three cases and our experience with literature data. 2021;61(3):889.

21. Pop MM, Bouros D, Klimko A, Florian IA, Florian ISJSR. Intracranial epidermoid cysts: benign entities with malignant behavior: experience with 36 cases. 2023;13(1):6474.

22. Tyagi DK, Balasubramaniam S, Sawant HVJJoNiRP. Giant primary ossified cavernous hemangioma of the skull in an adult: a rare calvarial tumor. 2011;2(2):174.

23. Ilyas M, Shah SA, Gojwari T, Rafiq S, Ellahi I, Ganaie KH. Classic imaging features of calvarial hemangioma-a case report. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2018/09/01/ 2018;49(3):663-665. doi:https://doi.org/10.1016/j.ejrnm.2018.04.010

24. Meier JD, Dublin AB, Strong EBJSB. Leptomeningeal cyst of the orbital roof in an adult: case report and literature review. 2009;19(03):231-235.

25. Kim H, Jo KW. Treatment of a traumatic leptomeningeal cyst in an adult with fibrinogen-based collagen. *Journal of Korean Neurosurgical Society*. May 2013;53(5):300-2. doi:10.3340/jkns.2013.53.5.300

26. Garg K, Sinha S, Kale SS, Kumar R, Sharma BSJNI. A rare case of non-traumatic intradiploic arachnoid cyst. 2013;61(4):446-447.

27. Kumar R, Chandra SP, Sharma BSJJoNP. Giant intradiploic pseudomeningocele of occipital bone: case report. 2012;9(1):82-85.

28. Kolb L, Yarrarapu SNS, Ameer MA, Rosario-Collazo JA. Lipoma. 2018;

29. Amirjamshidi A, Ghasemi B, Abbasioun KJSNI. Giant Intradiploic Angiolipoma of the skull. Report of the first case with MR and histopathological characteristics reported in the literature and a review. 2014;5:50.

30. Barnett RR, Piazza MG, Elton SW. Pediatric Neurosurgery in Primary Care: Masses of the Scalp and Skull in Children. *Pediatric Clinics of North America*. 2021/08/01/ 2021;68(4):743-757. doi:https://doi.org/10.1016/j.pcl.2021.04.003

31. Hasturk AE, Basmaci M, Yilmaz ER, Kertmen H, Gurer B, Atilgan AO. Giant intradiploic epidermoid cyst presenting as solitary skull mass with intracranial extension. *The Journal of craniofacial surgery*. Nov 2013;24(6):2169-71. doi:10.1097/SCS.0b013e3182a2d820

32. Zito P, Scharf R. Cyst, epidermoid (sebaceous cyst). StatPearls. StatPearls Publishing; 2020.

33. Chou Y-W, Tien C-H, Lee J-S, Chuang M-TJJoCS. Intradiploic epidermoid cyst in the skull. 2015;26(7):e662-e663.

34. Turk O, Ozdemir NG, Demirel N, Atci IB, Kanat A, Yolas CJJoCS. Nontraumatic intradiploic epidermoid cyst and older age: association or causality? 2018;29(2):e143-e146.

35. Serrallach BL, Orman G, Hicks MJ, Desai N, Kralik S, Huisman TAJTNJ. Conventional and advanced MR imaging findings in a cohort of pathology-proven dermoid cysts of the pediatric scalp and skull. 2022;35(4):497-503.

36. Narlawar R, Nagar A, Hira P, Raut AJJopm. Intradiploic epidermoid cyst. 2002;48(3):213-214.

37. Recinos PF, Roonprapunt C, Jallo GIJJoNP. Intrinsic brainstem epidermoid cyst: Case report and review of the literature. 2006;104(4):285-289.

38. Sattar S, Akhunzada NZ, Javed G, Uddin Z, Khan YAJSNI. Pilocytic astrocytoma: A rare presentation as intraventricular tumor. 2017;8:116.

39. Palma L, Guidetti BJJon. Cystic pilocytic astrocytomas of the cerebral hemispheres: Surgical experience with 51 cases and long-term results. 1985;62(6):811-815.

40. Ball JR, Hurlbert RJ, Winn HR. *Youmans neurological surgery*. Elsevier; 2011.

41. Fox BD, Smitherman SM, Amhaz H, et al. A supratentorial, hemorrhagic, intraparenchymal epidermoid cyst. 2009;16(8):1101-1105.

42. Chen C-Y, Wong J-S, Hsieh S-C, Chu J-S, Chan WPJAjon. Intracranial epidermoid cyst with hemorrhage: MR imaging findings. 2006;27(2):427-429.

43. Reissis D, Pfaff MJ, Patel A, Steinbacher DM. Craniofacial dermoid cysts: histological analysis and inter-site comparison. *The Yale journal of biology and medicine*. Sep 2014;87(3):349-57.

44. Özgüral O, Mammadkhanlı O, Doğan İ, Eroğlu Ü, Okçu AH, Ünlü A. Three rare localizations of intracranial dermoid tumors. 2018;

45. Jain P, Aggarwal A, Jain SG, Jain SJNI. Ruptured Intracranial Dermoid Cyst–Unusual Cause of Obstructive Hydrocephalus. 2022;70(4):1712-1713.

46. Koh Y-C, Choi J, Moon W-J, Roh H, Park HJAJoN. Intracranial dermoid cyst ruptured into the membranous labyrinth causing sudden sensorineural hearing loss: CT and MR imaging findings. 2012;33(5):E69-E71.

47. Koçak M, Dilbaz B, Ozturk N, et al. Laparoscopic management of ovarian dermoid cysts: a review of 47 cases. *Annals of Saudi medicine*. Sep-Oct 2004;24(5):357-60. doi:10.5144/0256-4947.2004.357

48. Weinand ME, Rengachary SS, McGregor DH, Watanabe IJJon. Intradiploic arachnoid cysts: report of two cases. 1989;70(6):954-958.

49. Nemoto S, Hoffman HJJJon. Leptomeningeal cyst of the posterior fossa: case report. 1986;65(5):704-705.

50. Bava J, Bansal A, Patil SB, Kale KA, Joshi ARJCrir. Posttraumatic intradiploic leptomeningeal cyst: A Rare complication of head trauma. 2015;2015(1):395380.

51. Szymczuk V, Taylor J, Boyce AMJCor. Craniofacial fibrous dysplasia: clinical and therapeutic implications. 2023;21(2):147-153.

52. Burke A, Collins MT, Boyce AMJOd. Fibrous dysplasia of bone: craniofacial and dental implications. 2017;23(6):697-708.

53. Tafti D, Cecava ND. Fibrous dysplasia. 2018;

54. Khan A, Mirza TM, Slehria AUR. An Unfamiliar Complication of Frontoethmoid Sinus Fibrous Dysplasia: Intradiploic CSF Cyst. *Journal of the College of Physicians and Surgeons--Pakistan : JCPSP*. Jun 2018;28(6):S72-s74. doi:10.29271/jcpsp.2018.06.S72

55. Atalar MH, Salk I, Savas R, Uysal IO, Egilmez HJPJoR. CT and MR imaging in a large series of patients with craniofacial fibrous dysplasia. 2015;80:232.

56. Schalper JA. CHAPTER 29 - Pediatric Tumors. In: Bibbo M, Wilbur D, eds. *Comprehensive Cytopathology (Third Edition)*. W.B. Saunders; 2008:915-950.

57. Jha SK, De Jesus O. Eosinophilic granuloma. 2020;

58. Krooks J, Minkov M, Weatherall AG. Langerhans cell histiocytosis in children: History, classification, pathobiology, clinical manifestations, and prognosis. *Journal of the American Academy of Dermatology.* 2018/06/01/ 2018;78(6):1035-1044. doi:https://doi.org/10.1016/j.jaad.2017.05.059

59. Choudhary G, Udayasankar U, Saade C, Winegar B, Maroun G, Chokr J. A systematic approach in the diagnosis of paediatric skull lesions: what radiologists need to know. *Polish journal of radiology.* 2019;84:e92-e111. doi:10.5114/pjr.2019.83101

60. Dukmak ON, Abualia SMS, Meqbil YJI, Emar M, Basal SI, Itaidek S. Eosinophilic granuloma affecting the parietal bone of the skull: A case report and literature review. *International journal of surgery case reports*. Jul 2022;96:107371. doi:10.1016/j.ijscr.2022.107371

61. Tawashi K, Khattab K. Langerhans cell histiocytosis of the frontal bone with unexpected manifestations: Rare case report. *International journal of surgery case reports*. 07/01 2023;109:108580. doi:10.1016/j.ijscr.2023.108580

62. Ugga L, Cuocolo R, Cocozza S, et al. Spectrum of lytic lesions of the skull: a pictorial essay. *Insights into imaging*. Oct 2018;9(5):845-856. doi:10.1007/s13244-018-0653-y

63. Guadalupi P, Gessi M, Massimi L, Caldarelli M, Gaudino S. A Cystic Clival Chordoma with CT and MRI Unconventional Appearances. *The Indian journal of radiology & imaging*. Mar 2022;32(1):127-131. doi:10.1055/s-0041-1741044

Legends of Tables

Table 1. Summary of the clinical and radiological findings of the patients

Table 2. Demographic and clinical features of patients with intradiploic lesions: A literature review. Abbreviations: *NA*, not available; *Y*, yes; *N*, no; *M*, male; *F*, female.

Legend of Graphic

Graphic 1. PRISMA flow diagram for systematic literature review

Legends of Figures

Fig. 1 A hyper-intense intradiploic cavernous hemangioma (20x8x20 mm) localized in the left frontal skull region on T2-weighted MRI (1a). A hyper-intense intradiploic cavernous hemangioma localized at left frontal region on sagittal T1-weighted MRI (1b). A hyper-intense intradiploic cavernous hemangioma localized at left frontal region on axial T1-weighted MRI (1c).

Fig. 2 Radiolucent image on right parasagittal region on A-P skull radiograph (2a). Radiolucent image adjacent to vertex on lateral skull radiograph (2b). Postoperative coronal CT image revealing treatment of a leptomeningeal cyst leading bone destruction which localized at right parietal region with syntetic porous polyethylene grafting for cranioplasty (2c, white arrow). A hypointense Intradiploic leptomeningeal cyst (40x14x40 mm) localized at parasagittal region in right parietal bone on T1-weighted coronal MR images (2d). A hypointense intradiploic leptomeningeal cyst at right parasgitall region compresiing superior sagittal sinus on T1-weighted sagittal MR images (2e). A hyperintense Intradiploic arachnoid cyst at right parietal region on axial T2-weighted MRI (2f).

Fig. 3 Intradiploic, hyper-intense lesion (26x12x20 mm) at right parasagittal region on coronal T1-weighted MR images (3a). A hyperintense cystic mass lesion compressing sinus sagittalis superior on sagittal T1-weighted MR image (3b). Intradiploic, hyperintense lesion at right parasagittal region on coronal T2-weighted MR images (3c). Parasagittal mass lesion not causing restricted diffusion at right vertex on diffusion MR images (3d). Postoperative on coronal CT image revealing traetment of bone destruction of Intradiploic lipoma at right

parasagittal region with synthetic (3e). Postoperative on sagittal CT image revealing traetment of bony destruction of intradiploic lipoma at right parasagittal region with synthetic polymethymethacrylate grafting for cranipolasty at vertex level (3f). Lipid vacuoles at center in histopathological staining (3g and 3h, red arrow).

Fig. 4 A cystic hypodense mass lesion (18x9x13 mm)compressing sinus sagittalis superior on sagittal CT image (4a). A hyperintense cystic mass lesion compressing sinus sagittalis superior on sagittal T1-weighted MR image (4b). A hypo-dense cystic lesion at right parasagittal region on axial CT image (4c). A hyper-intense, intradiploic lesion at right parasagittal region and meningioma at left frontal region on coronal T2-weighted MR images (4d). A hyper-intense , cystic lesion at right parasagittal region on axial T2-weighted MR images (4e). A hyper-intense cystic lesion at right parasagittal region on diffusion-weighted MR images (4f).

Fig. 5 A hyperintense intradiploic cystic mass lesion (41x26x22 mm) at left frontal region on axial T2-weighted MR images (5a). A iso-hypointense intradiploic cystic mass lesion at left frontal region on axial T1-weighted MR images (5b). An intradiploic, iso-hypointense cystic mass lesion at left frontal region on coronal T1-weighted MR images (5c). A hyperintense intradiploic mass lesion at left frontal region on axial diffusion-weighted MR images (5d). A iso-hypointense mass lesion with contrast-enhancement at right frontal region and SEGA intraventricular tumor with contrast-enhancement at left frontal anterior horn on axial contrast-enhanced T1-weighted MR images (5e) A hypodense intradiploic cystic lesion at right frontal region on axial cerebral CT scan (5f). A hypodense intradiploic cystic lesion at right frontal region on coronal paranasal CT scan (5g). A hypodense intradiploic cystic lesion at right frontal region on sagittal paranasal CT scan (5h).

Fig. 6 A 72-years old woman presented with headache. The neurological examination was normal. No marked abnormality was detected in physical examination. On cranial MRI, a

dermoid cyst was detected filled with intense hair follicles at left frontal region. Cystic mass lesion at right frontal region which caused iso-intense mass effect on coronal T2-weighted MR images (6a). Cystic mass lesion compressing sinus sagittalis superior on sagittal T2-wieghted MR images (6b). Hyper-dense cystic lesion at right frontal region on axial T1-weighted MR images (6c). Intradiploic, iso-intense lesion at right frontal region on axial diffusion-weighted MR images (6d). The lesion was found to be fat-enriched. Tumor and surgical field planning were performed using neuronavigation. A curvilinear skin incision was made, and the skin was reflected. The tumor was totally resected with the aid of a high-speed drill and craniotomy. Post-operative axial CT imaging revealing total resection of left parietal dermoid cyst and cranioplasty with titanium miniplates and mini screws (6e).

Fig. 7 A hyperintense (10x6x7 mm) cystic mass lesion at left occipital region on axial T2-weighted MR images (7a). An intradiploic, hypo-intense cystic mass lesion at left occipital region on axial T1-weighted MR images (7b). A hypo-intense cystic lesion at left occipital region on axial ACD-Diffusion T2-weighted MR images (7c). An intradiploic, hyper-intense lesion without diffusion restriction at left occipital region on axial diffusion-weighted MR images (7d). A hyper-intense , non-contrast enhancement cystic lesion at occipital region on contrast-enhanced sagittal T1-weghted MR images (7e). An intradiploic arachnoid cyst at left occipital region on sagittal T2-weighted MR images (7f), (white circle).

Fig. 8 An intradiploic hyperdense lesion (42x32x26 mm) caused destruction in left orbit and zygomatic bone on axial cranial CT scan (8a). An intradiploic hyperdense lesion caused destruction in left orbit and zygomatic bone on coronal cranial CT scan (8b). An intradiploic hyperdense lesion caused destruction in left orbit and zygomatic bone on sagittal cranial CT scan (8c). Orbital and zygomatic lesion site where biopsy performed on postoperative axial cranial CT scan (8d), (white circle).

Fig. 9 An intradiploic, iso-intense cystic mass (12x11x9 mm) lesion at parietal region on coronal T2-weighted MR images (9a). An intradiploic hyperintense mass lesion at right posterior parietal region on axial T1-weighted MR images (9b). An intradiploic, iso-hyperintense cystic mass lesion at right posterior parietal region on axial T2-weighted MR images (9c). An intradiploic isointense mass at right posterior parietal region on axial FLAIR images (9d). Image of intraoperative intradiploic mass (9e). Excised intradiploic mass lesion with surrounding normal calvarium fragments via utlization of high speed drilling (9f). BURR-HOLE titanium reconstruction of excision site (9g). Excision site at right posterior parietal region on postoperative cranial CT scan (9h), (white circle).

Table 1. Summary of the clinical and radiological findings of the patients

Patient No	Age	Gender	Complaints and Findings	Imaging	Preoperative Image	Postoperative Image	Affected Localisation	Procedure performed	Diagnosis
1	25	Female	Speech disorder, right lateral weakness, left nasolabial sulcus erasure, DTR hypoactive	T1 and T2 DWI Hyperintense	Y	N	Left frontal	Total resection, mini plate stabilization	Cavernous hemangioma
2	33	Female	Headache, right parietal swelling, history of traffic accident	T1 DWI Hypointense, T2 DWI Hyperintense	Y	Y	Right parietal and right parasagittal	Cystectomy, total resection	Leptomeningeal cyst
3	26	Female	Headache, palpable soft swelling in the midline of the head, oval, painful, soft mass fixed to the calvarium at the vertex	T1 DWI Homogeneous, T2 and FLAIR hyperintense	Y	Y	Right parietal and right parasagittal	Cystectomy, total resection	Intradiploic lipoma
4	76	Female	Headache	T1 hypointense and T2 FLAIR hyperintense	Y	N	Right parietal and right parasagittal	Non-surgical follow-up	Epidermoid cyst
5	36	Male	Headache, swelling, deformation in the frontal area	T1 hypointense and T2 hyperintense fine contrast enhancement in the periphery	Y	N	Left frontal	Non-surgical follow-up	Epidermoid cyst
6	72	Female	Headache	T1 hyperintense, T2 iso-intense, DWI iso-intense	Y	Y	Right frontal	Non-surgical follow-up	Dermoid cyst
7	70	Male	Headache	T1 DWI Hypointense, T2 DAG Hyperintense, non-contrast enhancing cystic lesion in occipital region on contrast enhanced sagittal T1-weighted MRI images	Y	N	Left occipital	Non-surgical follow-up	Arachnoid cyst
8	46	Female	Proptosis of the left eye, headache, skull deformity around the left eye	Intradiploic lesion causing destruction of the left parietal and zygomatic bone on axial cranial CT scan	Y	Y	Left orbital and zygomatic	Open biopsy	Fibrous dysplasia
9	18	Male	Persistent headache after trauma	T2 & FLAIR hyperintense and T1 isointense intradiploic lesion	Y	Y	Right parietal bone	Excision	Eosinophilic granuloma

Abbreviations: *Y*, yes; *N*, no;

Table 2. Demographic and clinical features of patients with intradiploic lesions: A literature review.

References	Age	Gender	Clinical Presentation	Localization	Pre-op Imaging - x-Ray	Pre-op Imaging - CTI	Pre-op Imaging - MRI	Post-op imaging	Diagnosis	Management
(Lloret, Server, & Taksdal, 2009)	14 days	F	NA	parietal, parasagittal	N	N	Y	NA	atretic cephalocele	NA
	56 years	F	NA	left frontal	N	Y	Y	NA	epidermoid cyst	NA
	1 year	M	NA	parietal, parasagittal	N	Y	Y	NA	dermoid cyst	NA
	2 years	M	NA	left parietal	N	Y	Y	NA	leptomeningeal cyst	NA
	27 years	F	NA	left parietal	N	Y	Y	NA	eosinophilic granuloma	NA
	36 years	M	NA	left frontal	N	Y	Y	NA	oessous hemangioma	NA
	20 years	M	NA	left frontal	N	Y	Y	NA	fibrous dysplasia	NA
	48 years	F	NA	left orbitozygomatic	N	Y	Y	NA	meningioma	NA
	38 years	M	NA	right parietal	N	Y	Y	NA	osteosarcoma	NA
	84 years	F	NA	left parietal	N	Y	Y	NA	angiosarcoma	NA
(Colas, Caron, & Cotten, 2015)	75 years	F	NA	parietal, parasagittal	N	Y	Y	NA	solitary calvarial metastasis of breast cancer	NA

	8 years	F	NA	left frontoparietal	Y	Y	N	NA	Langerhans hystiocytosis	NA
	52 years	F	NA	left parietal,parasagittal	N	Y	Y	NA	intraosseous meningioma	NA
	47 years	F	NA	left parietal	N	N	Y	NA	osseous hemangioma	NA
	26 years	F	NA	right parietal	N	N	Y	NA	epidermoid cyst	NA
	10 years	M	NA	parietal, parasagittal	N	N	Y	NA	dermoid cyst	NA
	30 years	M	NA	forntal,parasagittal	N	N	Y	NA	aneurysmal bone cyst	NA
	62 years	M	NA	left frontal	N	Y	Y	NA	fibrous dysplasia	NA
(Garfinkle, Melançon, Cortes, & Tampieri, 2011)	21 years	M	NA	left frontal	Y	Y	Y	CTI	Langerhans hystiocytosis	surgical excision
	78 years	F	NA	parietal, parasagittal	N	Y	N	NA	epidermoid cyst	NA
	32 years	M	NA	left orbitofrontal	N	N	Y	NA	dermoid cyst	NA
	30 years	F	headache, blurred vision, right proptosis	right frontal	Y	Y	Y	NA	hemangioma	NA
	43 years	F	NA	parietal, parasagittal	N	Y	Y	NA	typical plaque meningioma	NA
	48 years	F	NA	left occipital	N	Y	Y	NA	hemagiopericytoma	NA

	27 years	F	NA	right frontal	Y	Y	Y	NA	fibrous dysplasia	NA
	68 years	F	NA	right temporal	Y	Y	N	NA	osteoma	NA
	18 years	F	NA	left frontal	N	Y	Y	NA	osteoblastic osteosarcoma	NA
(Arana & Martí-Bonmatí, 1999)	27 years	F	tenderness in occipital area	right occipital	N	Y	N	NA	eosinophilic granuloma	NA
	17 years	F	bone swelling	left frontal	N	Y	Y	NA	eosinophilic granuloma	surgical excision
	63 yeras	F	NA	left frontal	N	Y	Y	NA	epidermoid cyst	NA
	43 years	M	NA	occipital, midline	N	Y	N	NA	dermoid cyst	NA
	61 years	F	gait disorder	right frontal	N	Y	Y	NA	frontal bone meningioma	NA
	65 years	M	headache,palpable mass	left frontal	N	Y	Y	NA	meningioma	NA
	47 years	M	palpable mass	left parietal	N	Y	Y	NA	intraosseous meningioma	NA
	42 years	F	palpable mass	left parietal	N	Y	Y	NA	hemangioma	NA
	28 years	F	NA	right frontal	N	Y	N	NA	fibrous dysplasia	NA
	32 years	F	palpable mass	left occipital,parasagittal	N	Y	Y	NA	fibrous dysplasia	NA
(Yim,	4	F	NA	right frontal	Y	Y	Y	NA	Langerhans	NA

Moon, An, Cho, & Rho, 2016)	years								hystiocytosis	
	45 years	M	NA	right parietal, parasagittal	Y	N	Y	NA	osseous hemangioma	NA
	13 years	M	NA	right parietal	Y	Y	Y	NA	epidermoid cyst	NA
	58 years	F	NA	right parietal	Y	Y	Y	NA	intracalvarial meningioma	NA
	35 yeras	M	NA	occipital,midline	N	Y	Y	NA	fibrous dysplasia	NA
	1 year	F	NA	right frontoparietal	N	Y	Y	NA	desmoplastic fibroma	NA
	45 years	M	NA	parietal, parasagittal	Y	N	Y	NA	atretic cephalocele and presistent falcine sinus	NA
(Yalcin et al., 2007)	19 yerar s	F	NA	right frontal	Y	Y	Y	NA	eosinophilic granuloma	NA
	63 years	M	NA	left parietal	N	Y	Y	NA	leptomeningeal cyst	NA
	24 years	F	NA	right temporal	Y	Y	Y	NA	fibrous dysplasia	NA
	45 years	F	NA	left frontoparietal	N	Y	N	NA	sclerotic intraosseus meningioma	NA
	28 years	F	NA	right orbitozygomatic	N	Y	N	NA	osteosarcoma	NA
(Khodarah	24	M	seizures,	left	Y	N	Y	NA	leptomeningeal	NA

mi et al., 2021)	years		hsitory of fall at 3years age	parietotemporal					cyst	
	9 months	F	NA	parietal,parasagittal	N	Y	N	NA	epidermoid cyst	NA
	4 years	M	NA	parietal,parasagittal	N	N	Y	NA	atretic cephalocele	NA
	18 years	M	NA	frontoparietal	Y	N	N	NA	dermoid cyst	NA
	55 years	M	NA	right parietal	Y	N	Y	NA	fibrous dysplasia	NA
	29 years	M	NA	right frontal	N	Y	N	NA	fibrous dysplasia	NA
	50 years	F	NA	left orbitozygomatic	N	Y	N	NA	primary intraosseus memningioma	NA
	52 years	M	NA	frontal, midline	Y	Y	Y	NA	hemangioma	NA
	11 years	F	painful bump on forehead	left frontal	Y	Y	Y	NA	Langerhans hystiocytosis	NA

Abbreviations: *NA*, not available; *Y*, yes; *N*, no; *M*, male; *F*, female.