Turk Neurosurg 36(2):327-331, 2026
DOI: 10.5137/1019-5149.JTN.47293-24.4

Case Report

Received: 13.07.2024
Accepted: 16.05.2025
Published Online: 04.03.2026

Intracranial Mature Bone Formation: Report of Three Uncommon Cases and a Proposed Pathogenetic Mechanism

Ersin HACIYAKUPOGLU[1], Evren YUVRUK[2], Ayca Ersan DANYELI[3], Dervis Mansuri YILMAZ[4], Sebahattin HACIYAKUPOGLU[5]

[1]Heinrich-Braun-Klinikum Zwickau, Department of Neurosurgery, Zwickau, Germany
[2]VM Medical Park Maltepe, Department of Neurosurgery, Istanbul, Türkiye
[3]Acibadem University School of Medicine, Department of Medical Pathology, Istanbul, Türkiye
[4]Cukurova University, School of Medicine, Department of Neurosurgery, Adana, Türkiye
[5]Acibadem University School of Medicine, Department of Neurosurgery, Adana, Türkiye

Corresponding author: Ersin HACIYAKUPOGLU ✉ haciyakupoglu@yahoo.com

ABSTRACT

The formation of histologically mature bone within the intracranial compartment is an exceptionally rare phenomenon. Although intracranial calcifications are frequently encountered in clinical practice, true ossification culminating in the development of mature bone tissue remains poorly characterized. Herein, we report three cases of female patients presenting with intra- and extra-axial cranial masses, all histologically confirmed to comprise mature bone. We describe the associated radiologic features, surgical challenges, and histopathological findings. Furthermore, we propose a novel pathogenetic hypothesis implicating the intraoperative dispersion of bone dust as a potential etiologic factor in iatrogenic ossification. Our findings highlight the importance of surgical vigilance and meticulous intraoperative technique to mitigate this rare but avoidable complication.

KEYWORDS: Teratoma, Non-neoplastic calcifying pseudotumor, Mature bone, Hyperostosis, Cerebral calculi

ABBREVIATIONS: CSF: Cerebrospinal fluid, **MRI:** Magnetic resonance imaging, **CT:** Computed tomography, **H&E:** Hematoxylin and Eosin

INTRODUCTION

Intracranial calcifications are identified in up to 10% of neuroimaging studies and are most often incidental findings. These calcifications are typically dystrophic in nature, arising in regions of prior hemorrhage, inflammation, or necrosis. In contrast, true intracranial ossification—defined by the formation of mature lamellar bone, frequently containing bone marrow elements—is exceedingly rare (8-10). Such ossifications are usually confined to the skull base or meningeal structures and are generally attributed to congenital anomalies or post-inflammatory changes.

On rare occasions, mature bone may form within the brain parenchyma (intra-axially) or ventricular system. These lesions may radiographically and clinically mimic neoplastic or vascular pathologies, posing diagnostic challenges. Although ossified lesions such as mature teratomas, heavily calcified meningiomas, and calcifying pseudoneoplasms can account for certain presentations, the possibility of a distinct, under-recognized osteogenic mechanism warrants further investigation.

In this report, we present three cases of histologically confirmed intracranial mature bone in women of reproductive age, each with unique anatomical locations and clinical manifes-

Ersin HACIYAKUPOGLU : 0000-0002-9712-9913
Evren YUVRUK : 0000-0002-2945-743X
Ayca Ersan DANYELI : 0000-0001-8015-9916
Dervis Mansuri YILMAZ : 0000-0002-5137-4526
Sebahattin HACIYAKUPOGLU : 0000-0002-0700-7593

tations. Beyond characterizing the radiological, surgical, and pathological features, we propose a novel pathogenetic hypothesis: the intraoperative dissemination of bone dust, followed by osteogenic transformation, may serve as a potential mechanism for iatrogenic ossification within the cranial cavity.

Written informed consent was obtained from all patients included in this study.

CASE REPORT

Case 1

A 38-year-old female presented in 2008 with a several-month history of progressive headache, papilledema, and restricted upward gaze. Neurological examination revealed signs consistent with Parinaud's syndrome. Magnetic resonance imaging (MRI) demonstrated a heterogeneous mass measuring 6.0 × 4.5 × 2.7 cm in the pineal region, with susceptibility artifacts suggestive of calcification. The lesion compressed the third ventricle, resulting in obstructive hydrocephalus (Figure 1).

A posterior transcallosal approach via occipital craniotomy was employed. Upon opening the splenium of the corpus callosum, a firm, mobile, bone-like mass encased in glial tissue and loosely tethered by fibrous bands was identified. The mass was fragmented and removed using a microrongeur. Postoperative recovery was uneventful, and the patient experienced resolution of papilledema.

Histopathological analysis confirmed the presence of mature lamellar bone containing normocellular marrow elements, consistent with a diagnosis of mature teratoma (1,11).

Case 2

A 46-year-old female presented with a 1-year history of progressive narrowing of the visual field and retro-orbital headache. Ophthalmological examination revealed decreased visual acuity and a nasal visual field defect in the right eye. MRI identified a 4.0 × 2.9 × 2.1-cm calcified mass involving the inner third of the right sphenoid wing (Figure 2), without evidence of invasion into the adjacent brain parenchyma.

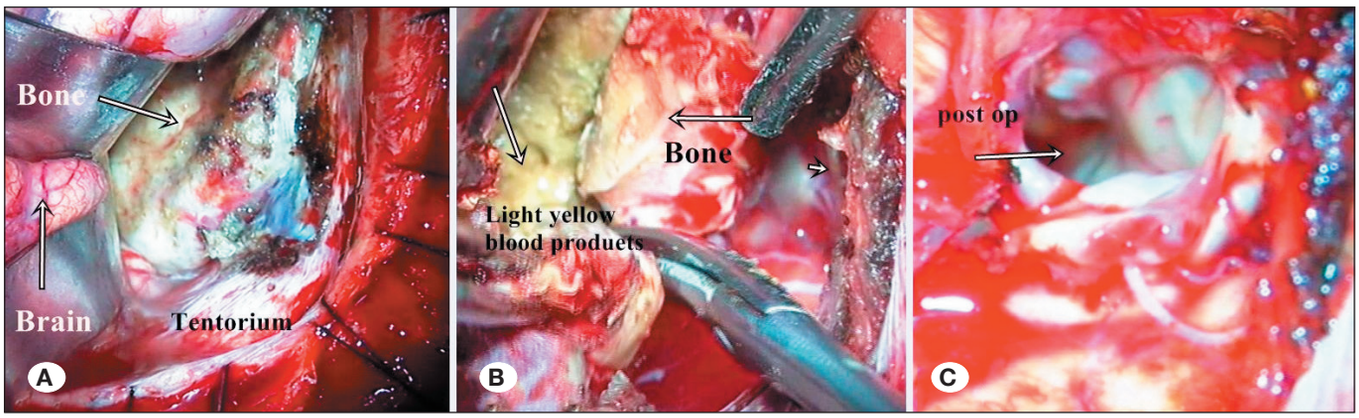

Figure 1: Intraoperative images of Patient #1. **A)** Upon splitting the splenium of the corpus callosum, a firm, heterogeneous mass was visualized. **B)** The lesion displayed irregular features consistent with mature lamellar bone, morphologically resembling calvarial bone. **C)** The mass was localized to the pineal region, causing compression of the third ventricle.

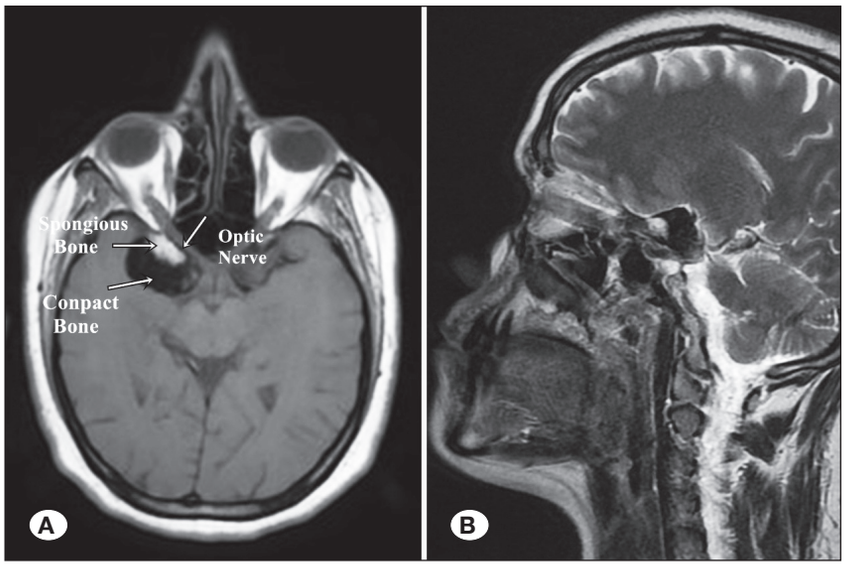

Figure 2: Preoperative magnetic resonance imagings (MRIs) of Patient #2 demonstrating a densely calcified lesion. **A)** Axial T1-weighted image showing a well-defined mass within the inner third of the right sphenoid wing. **B)** Sagittal T2-weighted contrast-enhanced image revealing peripheral enhancement consistent with ossified tissue.

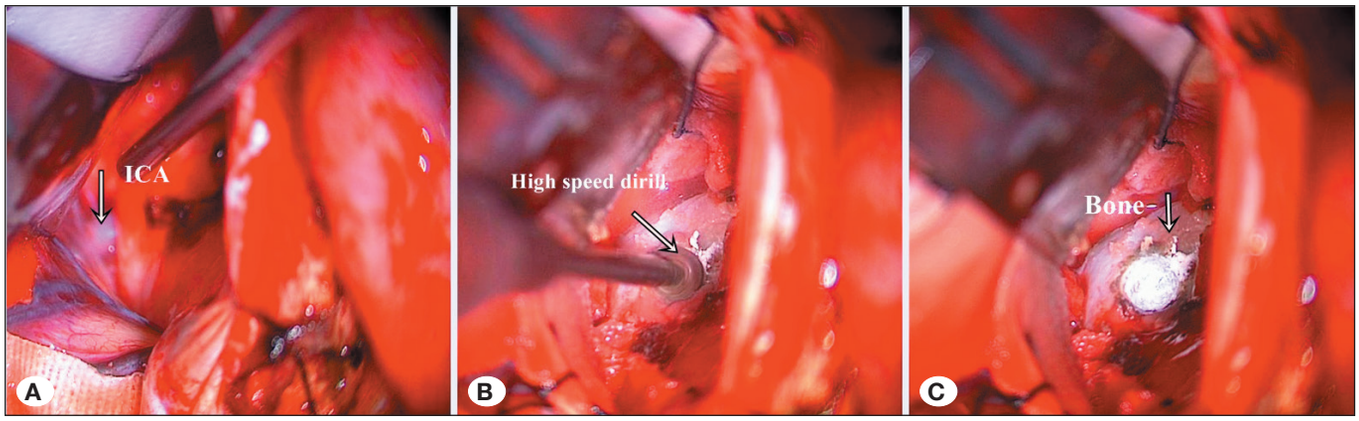

Figure 3: Intraoperative views of Patient #2. **A)** Pterional craniotoy revealing a hard, highly vascularised mass, **B)** High speed drill used to reduce the mass, **C)** Showing bone tissue after drilling

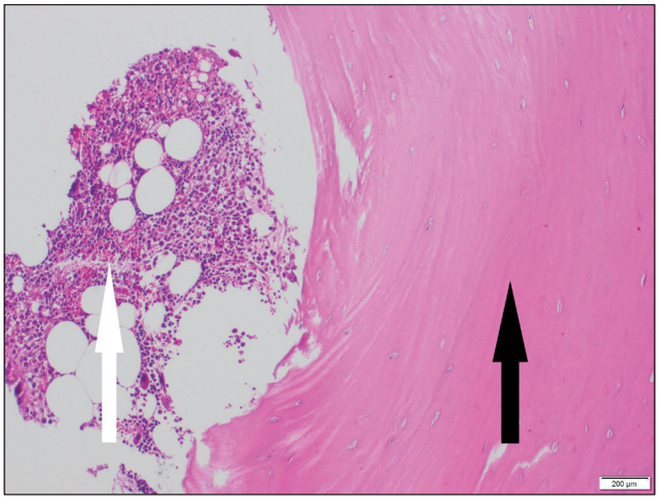

Figure 4: Histopathological analysis of excised tissue from Patient #2. Dense sclerotic lamellar bone fragments (black arrow). Intervening bone marrow elements (white arrow) confirm the presence of mature bone tissue, consistent with a non-neoplastic ossified pseudotumor (Haematoxylin and Eosin, x200).

A right pterional craniotomy was performed, revealing a rock-hard, highly vascularized mass (Figure 3). The optic nerve and internal carotid artery were decompressed with meticulous dissection. Intraoperative bleeding was controlled using fibrin sealant and hemostatic agents. The patient recovered without neurological deficits.

Histopathology showed densely sclerotic lamellar bone with focal areas of bone marrow (Figure 4), consistent with a diagnosis of non-neoplastic calcifying pseudotumor (10,12).

Case 3

A 43-year-old female with a 20-year history of chronic headaches and progressive swelling on the left side of the head initially declined an MRI due to claustrophobia. Four months later, she presented to the emergency department in respiratory arrest. Computed tomography revealed a calcified mass within the fourth ventricle associated with obstructive hydrocephalus. An emergency external ventricular drain was placed, followed by MRI, which confirmed a 5.0 × 4.3 × 2.7-cm mass in the fourth ventricle and a coexisting frontal osteoma exerting mass effect on adjacent brain tissue (Figure 5).

During posterior fossa exploration, a firm, vascular, mobile bony mass adherent to surrounding neural structures via fibrous bands was encountered. Ultrasonic aspiration proved ineffective, and the lesion was ultimately removed using a surgical rasp. Despite initial stabilization, the patient died on postoperative day 2.

Histopathological examination demonstrated mature lamellar bone with normocellular marrow (Figure 6), confirming the lesion as a mature ossified mass.

DISCUSSION

Intracranial ossification presents a rare and diagnostically challenging phenomenon due to its diverse etiologies and atypical presentation. Several pathogenetic mechanisms have been proposed: 1) congenital teratomas with mesodermal differentiation into osseous tissue; 2) reactive metaplasia secondary to chronic inflammation, trauma, or hemorrhage; and 3) exogenous introduction and subsequent osteogenic transformation of bone fragments or bone dust.

The first mechanism is well-documented in midline intracranial teratomas, in which pluripotent germ cells differentiate into mature tissue types, including bone, cartilage, or dental structures. This etiology most plausibly accounts for the lesion observed in our first case (1,11). Reactive ossification due to chronic inflammation or degenerative changes, as seen in calcifying pseudotumors and postinflammatory meningeal ossification, has been reported in the skull base and dura mater (2,10,12); this mechanism aligns with the findings in our second patient.

The third mechanism—iatrogenic dissemination of bone dust—deserves greater scrutiny (13,14). High-speed drilling during craniotomy generates fine osseous particles that can

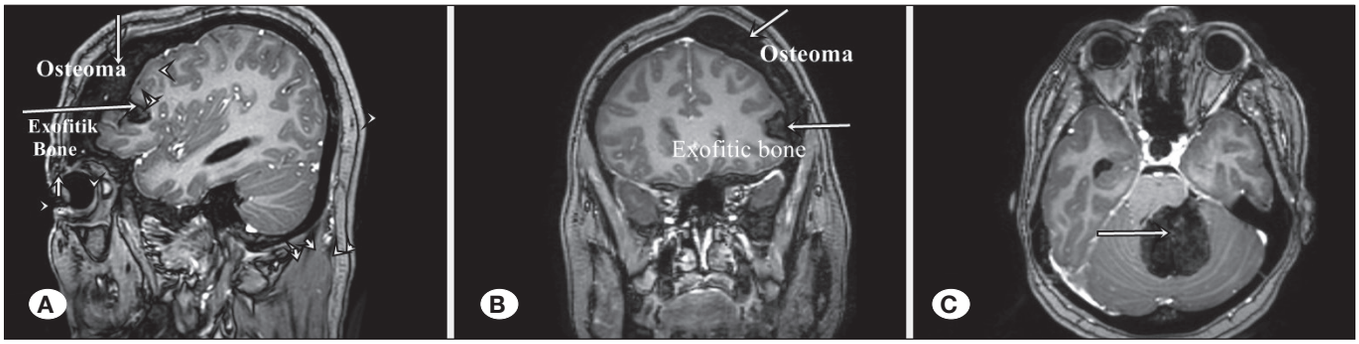

Figure 5: Magnetic resonance imaging (MRI) findings in Patient #3. Sagittal **(A),** and coronal **(B)** T1-weighted contrast enhanced images show exophytic osseous growths arising from the calvarium, impinging on the adjacent cerebral parenchyma. **C)** Axial T1-weighted contrast enhanced image demonstrates large, heterogeneous mass occupying the fourth ventricle, with signal intensity characteristics identical to cortical bone, causing obstructive hydrocephalus.

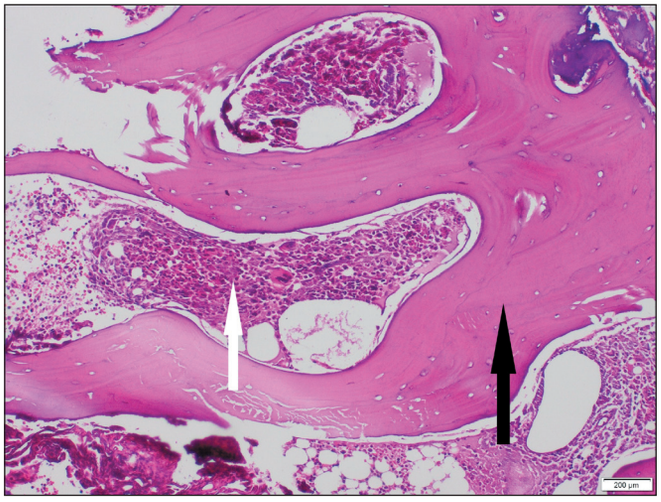

Figure 6: Histopathological findings in Patient #3. Sections reveal mature trabecular bone (black arrow) with normocellular marrow. Marrow elements (white arrow) are present between trabeculae, confirming the diagnosis of mature intraventricular ossification (Haematoxylin and Eosin, X200).

be dispersed via irrigation fluids and inadvertently introduced into cerebrospinal fluid (CSF) spaces. These microfragments may become embedded in vascularized areas such as the choroid plexus, where local osteoinductive factors, including osteoprogenitor cells, inflammatory cytokines, and growth factors, may facilitate ectopic bone formation (5,6,14). This process is believed to involve activation of the Wnt/β-catenin signaling pathway, induction of osteoblastic differentiation, secretion of osteoid matrix, and subsequent mineralization (3,9).

The hormonal milieu may further influence ossification (7). Estrogen, parathyroid hormone, and vitamin D are known regulators of bone turnover and osteoblastic activity. All three patients in our series were premenopausal women, suggesting a possible hormonal predisposition that may have contributed to enhanced osteogenesis (3,7,8,15). Furthermore, the presence of neovascularized, CSF-rich environments may support the survival, integration, and maturation of ectopic bone tissue.

In the third case, the patient's 25-year history of an untreated frontal osteoma near the dura suggests prolonged cortical erosion and dissemination of bone fragments into the ventricular system. This observation supports our hypothesis that delayed intraventricular ossification may result from chronic, subclinical migration of bone debris (14).

Surgical Implications and Prevention

The surgical management of intracranial mature bone is technically demanding. The dense, lamellar architecture of mature bone resists fragmentation by conventional aspiration techniques. In our cases, ultrasonic aspirators were ineffective, necessitating the use of microrongeurs and surgical rasps for adequate debulking and removal.

To minimize the risk of iatrogenic ossification, we recommend the following intraoperative strategies:

- Continuous irrigation and suction during bony drilling to promptly remove bone dust
- Placement of moist cottonoids around the operative field to localize particulate debris
- Meticulous sealing of any breach into the ventricular system or subarachnoid space to prevent contamination
- Prophylactic application of bone wax or fibrin sealant over drilled surfaces, particularly near CSF pathways, as suggested by previous studies (4,6).

Additionally, surgeons should consider resecting asymptomatic exophytic bone lesions located adjacent to CSF compartments, as these may serve as a source of osseous debris with delayed consequences.

This case series highlights three distinct presentations of intracranial mature bone formation, each with a different underlying etiology: a midline mature teratoma, a reactive calcifying pseudotumor, and a suspected case of iatrogenic ossification due to bone dust migration. Notably, the third case provides compelling circumstantial support for a novel pathophysiolog-

ical mechanism involving the chronic introduction and osteogenic transformation of bone dust within the fourth ventricle.

CONCLUSION

These findings underscore the need for heightened intraoperative vigilance during cranial drilling, particularly in procedures involving proximity to CSF spaces. Preventive strategies aimed at minimizing particulate dissemination should be incorporated as standard practice to reduce the risk of delayed, ectopic bone formation. Given the potential for such lesions to mimic neoplastic or vascular pathology, neurosurgeons must remain aware of this rare but clinically significant phenomenon during diagnosis, surgical planning, and postoperative follow-up.

Declarations

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

Ethical statement and consent for publication: This case report series did not require formal Institutional Review Board approval; written informed consents were obtained from all patients.

AUTHORSHIP CONTRIBUTION

Study conception and design: EH, AED, SH
Data collection: EH, DMY, SH
Analysis and interpretation of results: EH, EY, DMY
Draft manuscript preparation: EH, EY, SH
Critical revision of the article: AED, DMY, SH
Other (study supervision, fundings, materials, etc...): EH
All authors (EH, EY, AED, DMY, SH) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Abdelmuhdi AS, Almazam AE, Dissi NA, Albastaki UM, Pierre-Jerome C: Intracranial teratoma: Imaging, intraoperative, and pathologic features: AIRP best cases in radiologic-pathologic correlation. Radiographics 37:1506-1511, 2017. https://doi.org/10.1148/rg.2017160202
2. Bertoni F, Unni KK, Dahlin DC, Beabout JW, Onofrio BM: Calcifying pseudoneoplasms of the neural axis. J Neurosurg 72:42-48, 1990. https://doi.org/10.3171/jns.1990.72.1.0042
3. Buckwalter JA, Glimcher MJ, Cooper RR, Recker R: Bone biology. J Bone Joint Surg Am 77:1256-1270, 1995. https://doi.org/10.2106/00004623-199508000-00019
4. De Los Reyes FVA, Rivera ID, Santos HM, Carlos RM: Mature teratoma of the pineal region in the paediatric age group: A case report and review of the literature. Malays J Pathol 40:175-183, 2018.
5. Jaiswal PA, Vilanilam GC, Rajalakshmi P, Kumar KK, Abraham M: Intracranial migrating bone dust: Innocuous or evil? Neurol India 67:534-536, 2019. https://doi.org/10.4103/0028-3886.258041
6. Kafadar A, Abuzayed B, Kucukyuruk B, Cetin E, Gazioglu N: Intracranial migration of bone dust after intraventricular neuroendoscopy complicating acute hydrocephalus and removal of bone dust: Case report. Neurosurgery 67:E503-E504, 2010. https://doi.org/10.1227/01.NEU.0000371975.21566.7D
7. Kronenberg HM: Developmental regulation of the growth plate. Nature 423:332-336, 2003. https://doi.org/10.1038/nature01657
8. Pansuriya TC, Kroon HM, Bovée JVMG: Enchondromatosis: Insights on the different subtypes. Int J Clin Exp Pathol 3:557-569, 2010.
9. Rebolledo JB, Moya-Angeler J, Lane JM: Bone and calcium metabolism. In: Grauer JN (ed), Orthopaedic Knowledge Update 12 (OKU 12). American Academy of Orthopaedic Surgeons, 2017: Chapter 6.
10. Rhodes RH, Davis RL: An unusual fibro-osseous component in intracranial lesions. Hum Pathol 9:309-319, 1978. https://doi.org/10.1016/S0046-8177(78)80088-4
11. Romero LR, Chen BY, Guzman MA, Zhou Y, Lai JP, Chen F: Ruptured intracranial teratoma: A case report and literature review. Clin Med Rev Case Rep 2:029, 2015. https://doi.org/10.23937/2378-3656/1410029
12. Tatke M, Singh AK, Gupta V: Calcifying pseudoneoplasm of the CNS. Br J Neurosurg 15:521-523, 2001. https://doi.org/10.1080/02688690120097741
13. Thomson S, Tyagi AK, Chumas PD: Intracranial hypertrophic calcification complicating neuroendoscopy: Report of three cases. J Neurosurg 98:186-189, 2003. https://doi.org/10.3171/jns.2003.98.1.0186
14. Turhan T, Ersahin Y: Intraventricular migration of the bone dust. Is a second operation for removal necessary? Case report and review of the literature. Childs Nerv Syst 27:719-722, 2011. https://doi.org/10.1007/s00381-010-1339-z
15. Yanagisawa S, Okamoto K, Yamaguchi S, Tamai Y, Fujitani M, Inoue M, Hara T: Intracranial growing teratoma syndrome observed at 44 months after initial treatment; a case presentation and literature review. Childs Nerv Syst 36:865-868, 2020. https://doi.org/10.1007/s00381-019-04443-2