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Case Report

A Rare Aneurysmal Bone Cyst Case that Rapidly Progressed from the Orbit to the Anterior Middle Cranial Fossa and Sinuses of a 14-Month-Old Boy

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Abstract

Introduction: Aneurysmal bone cyst is a vascular dilated bone lesion that most commonly arises in long bones. Only 2% occur in the head and neck. We describe a very rare case of aneurysmal bone cyst that showed very rapid extension from the orbit to the anterior middle cranial fossa and sinuses in a 14-month-old boy.

Case report: The patient suddenly developed exophthalmos and displacement of the right eye over a 1-month period. T1- and T2-weighted magnetic resonance imaging showed a lesion extending from the right orbit to the ethmoid sinus. The anterior cranial fossa showed expulsive and dilated shadows with formation of internal cysts that were visualized as slightly brighter than muscle. Biopsy initially led to a diagnosis of phosphaturic mesenchymal tumor, but giant cell reparative granuloma was later diagnosed. The tumor grew rapidly while the patient was awaiting surgery, and the right eye risked being blinded due to exclusion by the tumor. The patient underwent frontotemporal craniotomy and complete endoscopic resection of the mass via the nose. The final pathological diagnosis was aneurysmal bone cyst. No recurrence was observed 10 months postoperatively.

Conclusions: Aneurysmal bone cyst is a benign but rapidly progressive bone-destroying disease. Cranial nerve palsy symptoms may occur if the tumor involves the orbit and skull, as in this case. When the lesion spans multiple areas, prompt multidisciplinary treatment involving the cooperation of multiple departments is necessary. Complete surgical removal of the tumor is the gold standard, offering the lowest risk of recurrence.

Keywords: Aneurysmal bone cyst; Anterior skull base; Ethmoid; Orbit

Abbreviations: **ABC:** Aneurysmal Bone Cyst; **GCRG:** Giant Cell Reparative Granuloma; **MRI:** Magnetic Resonance Imaging; **CT:** Computed Tomography

Introduction

Aneurysmal bone cysts were first described in 1942 as "peculiar blood-containing cysts of large size" [1]. They are composed of blood-filled, anastomosing cavernous spaces, separated by cyst-like walls. Aneurysmal Bone Cyst (ABC) is a rare benign non-neoplastic lesion that expands and destroys surrounding bone. ABCs typically arise in the thorax, pelvis and metaphyses of the long bones, with only around 2% occurring in the head and neck region. Furthermore, most cases in the head and neck region affect the mandible [2]. Orbital ABC represents less than 0.25% of ABC cases [3]. Primary ABCs most commonly occur in the first and second decades of life, but are rare below 5 years of age [4]. To date, only four cases of ABC have been reported that showed progression to the orbit, anterior cranial fossa, and paranasal sinuses [5-8]. Among these, only two reports have described ABC in patients under 5 years of age, including this case [8]. We describe a very rare case of ABC in a 14-month-old boy who showed a very rapid increase in extent, from the orbit to the anterior middle cranial fossa and sinuses.

Case Presentation

This case involved a 14-month-old boy. The child had no relevant medical or family history, and no history of trauma. One month before visiting our hospital, his parents noticed that he showed right exophthalmos and visited the ophthalmology department of a general hospital. He underwent transorbital echography that identified a mass lesion in the right orbit. He was advised to undergo more detailed investigation and treatment at a specialized facility, and visited the Ophthalmic Plastic and Reconstructive Surgery department of our hospital a few days later. He was referred to the otolaryngology department that same day. At the first visit, ophthalmological examination revealed right exophthalmos and laterally downward displacement. In the examination, eyesight could not be measured, but the right eye showed normal light reflexes and no abnormalities of the optic disc. On palpation, the right eye was tense and upward vision was restricted.

From an otolaryngological perspective, the nasal cavity was narrow enough for insertion of a transnasal endoscope. No mass was identified in the nasal cavity. Magnetic Resonance Imaging (MRI) of the orbit revealed a well-defined mass shadow measuring about 30 × 26 mm, extending from the right ethmoid sinus to the orbit and frontal region. T1-weighted imaging showed a faint high signal (Figure 1a), and T2-weighted imaging showed a mild high signal. Cyst formation was observed in the mass (Figure 1b). The tumor also extended to the anterior skull base, and contrast enhancement showed a contrast effect along the dura mater (Figure 1c). Orbital Computed Tomography (CT) revealed lesions with internal calcification occupying the ethmoid sinus from the orbit, accompanied by destructive changes in the surrounding bone, causing displacement of the eyeball and optic nerve to the lower right (Figure 2a). Tumor biopsy was performed 4 days after the first visit under general anesthesia. The diagnosis was initially phosphate urinary mesenchymal tumor, but was later changed to Giant Cell Reparative Granuloma (GCRG).

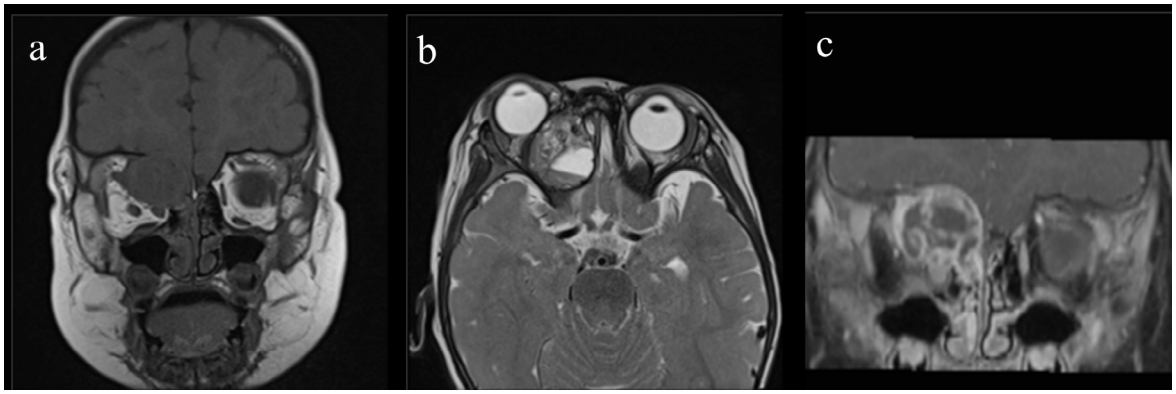

Figure 1: Initial Orbit magnetic resonance images. Initial orbital MRI revealed a well-defined mass of about 30 × 26 mm from the right ethmoid sinus to the right orbit. The right eyeball was protruding and excluded due to the exclusion due to the tumor. **a)** Coronal T1-weighted MRI showed that the tumor showed a faint hyperintensity mass shadow compared to muscle. **b)** Axial T2-weighted MRI showed mild high-intensity to high-intensity mass shadows, and cyst formation was observed in a part of the area. **c)** Coronal contrast-enhanced T1 MRI showed that the tumor extended to the anterior skull base and had a contrast-enhanced effect along the dura mater.

We scheduled surgery 1 month after the diagnosis was made. However, during the waiting time before surgery, the tumor grew and protrusion and displacement of the eyeball progressed. We asked the patient's parents to check the pupillary light reflex at home because the effect on the optic nerve was strengthened and the risk of blindness had to be considered. We were also preparing for emergency surgery if rapid progression of vision loss was identified. CT 2 days before surgery showed further growth of the orbital tumor and extension from the entirecranial fossa to the middle cranial fossa. The exclusion of the tumor into the optic nerve appeared to have increased (Figure 2b).

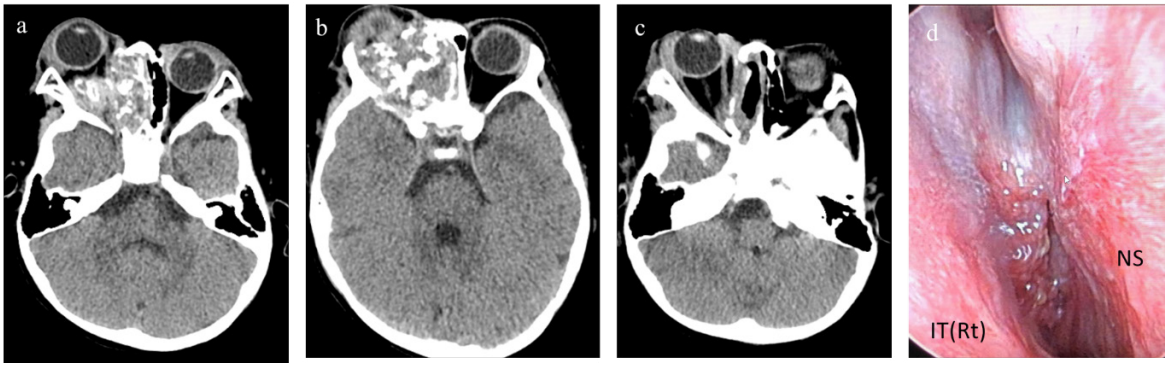

Figure 2: Changes in orbital CT findings over time and postoperative nasal endoscopic findings. **a)** Initial diagnosis Orbital horizontal section of CT scan revealed a tumor shadow with a clear boundary of about 30 × 26 mm, mainly from the right ethmoid sinus to the right orbit. The mass was accompanied by destructive changes in the surrounding bone, and the optic nerve was excluded to the lower right. **b)** Horizontal computed tomography 2 days before surgery showed that the tumor increased rapidly, and bone-destructive changes and internal calcification were conspicuous. **c)** No recurrence of the tumor is seen on horizontal CT 10 months after surgery. **d)** Nasal endoscopic finding 10 months after surgery. NS: Nasal Septal; IT(Rt): right inferior turbinate.

A multidisciplinary surgical conference was held the day before surgery. Due to the rapid growth of the tumor, the surgery plan was changed. We decided to make a slightly larger skin incision from the side to extend the surgical procedure from the anterior cranial fossa to the middle cranial fossa. The surgical plan was amended and the following procedure was applied. A frontal periosteal flap was raised, then the intraorbital tumor was debulked, the burden on the optic nerve was reduced, and the tumor was removed by anterior and middle fossa craniotomy and trans-nasal endoscopy (Figure 3a-d).

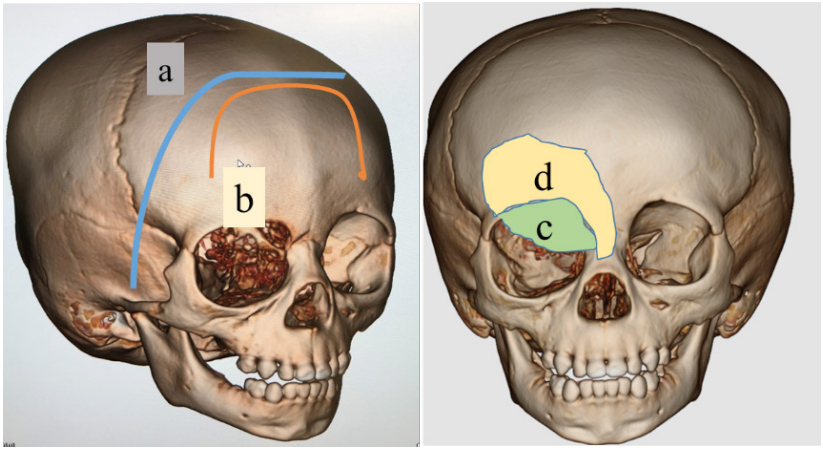

Figure 3: Preoperative simulation Surgical procedure. **a)** Skin incision;(Creation of surgical field from anterior to middle cranial fossa) An arcuate incision from the front of the right earlobe to the vicinity of the contralateral hairline projection **b)** Elevating a frontal periosteal flap. **c)** Relief of pressure on the optic nerve due to weight loss of intraorbital tumor. **d)** Removal of tumor by frontotemporal craniotomy and transnasal endoscopic surgery.

The operation was performed by a neurosurgeon, who made an arc-shaped skin incision from just before the right earlobe to the vicinity of the contralateral hair protrusion, then created a frontal periosteal flap. An ophthalmic plastic and reconstructive surgeon then reduced the dose of the intraorbital tumor from the supraorbital margin using a SONOPET® (Stryker, Kalamazoo, MI, USA) ultrasonic aspirator (Figure 4a). At this time, we confirmed that pressure on the optic nerve by the tumor was released by observing that the pupil that had shown mydriasis before the operation, was now miotic. The temporalis muscle was then incised along the temporal line to expose the pterion. After creating a Marcarty key hole, a burr hole was also drilled in the midline of the forehead, and a right frontotemporal craniotomy including an orbital bar was performed at the 2burr hole. After performing right frontal temporalis craniotomy, the tumor was excised from the dura mater of the frontal skull base. After the tumor in the orbit was detached from the nerve, the upper wall of the superior orbital fissure and the bone of the optic canal were removed to decompress the nerve (Figure 4b). After removing the tumor in the skull, lesions extending to the right ethmoid sinus, medial orbit, and maxillary sinus were completely resected through the skull base using a 3-Dimensional (3D) exoscope and endoscopically through the nose (Figure 4c,d).

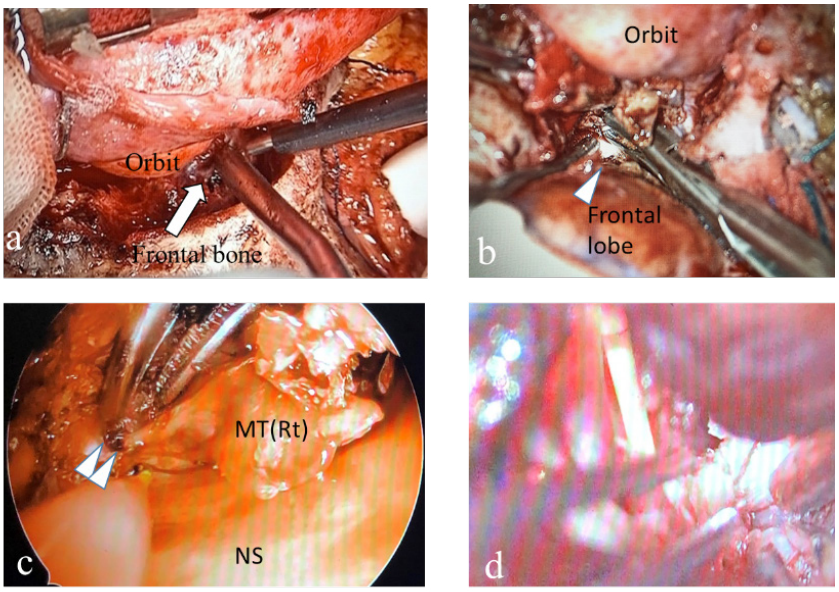

Figure 4: Intraoperative findings**. a)** The tumor in the orbit is aspirated and resected with a sonopet to reduce the volume of the tumor (arrow). **b)** The intraorbital tumor is detached from the superior orbital fissure tissue, and the bone above the superior orbital fissure is removed and decompressed (arrowhead). **c)** Transnasal endoscopy operation findings. **d)** Intracranial 3-dimensional (D) exoscope operation findings. The tumor in the paranasal sinuses is excised from the base of the right middle turbinate (double arrowhead) by simultaneous surgery of c) and d). MT(Rt): right middle turbinate, NS: nasal septum.

The dura mater had not been invaded, but the cerebrospinal fluid showed slight presence of bleeding, so the surface was reinforced with DuraGen® (Integra Life Sciences Corp., Princeton, NJ, USA) and closed. The dura was reinforced with fibrin glue, then lifted to the bone window. Defects in the right lamina cribrosa, ethmoid sinus canopy, and sphenoid sinus were reconstructed with a frontal periosteal flap and also covered from the nasal side with a septal mucosal flap and free mucosa of the inferior turbinate. The craniotomy bone fragment was fixed with a bioabsorbable plate. The operation time was 6 h, and intraoperative blood loss during the operation was 89 ml. Postoperative pathological examination initially diagnosed GCRG (Figure 5), but Fluorescence *in situ* Hybridization (FISH) analysis yielded positive results for USP6 gene rearrangement, resulting in a final diagnosis of ABC. As of the time of writing, 10 months postoperatively, no recurrences have been identified from sinus CT or transnasal endoscopic findings (Figure 2c, d). Protrusion of the right eye has improved, but some displacement remains.

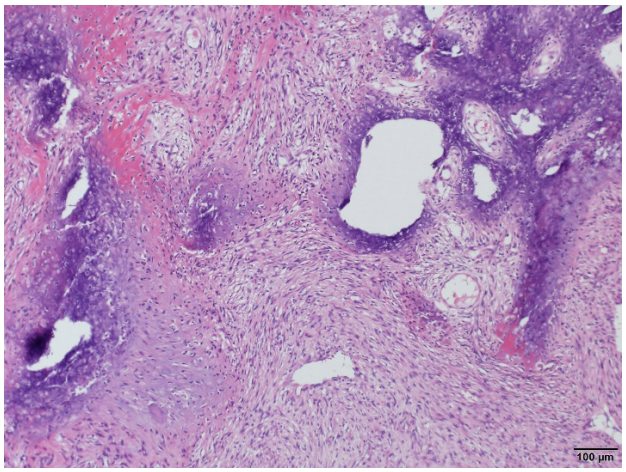

Figure 5: Histochemical staining. Photomicrograph shows osteoid formation, calcified lesions, and osteoclast-like polynuclear giant cells in the lesion. There are findings that the distribution of giant cells is locally unevenly distributed (hematoxylin and eosin, ´100).

Discussion

ABC is a locally aggressive benign tumor of uncertain pathogenesis. This entity is postulated to arise from a local circulatory disturbance leading to increased venous pressure and subsequent production of hemorrhage in the bone [9]. This hemorrhage is thought to lead to osteolysis. The osteolysis, in turn, causes further hemorrhage, leading to exponential tumor growth. This theory might explain why ABCs are uncommon in the calvarium and bones of the facial skeleton, where the venous pressure is low. On the other hand, ABCs are more common in long bones, where the venous pressure is higher and the marrow content is greater [10]. ABCs are classified into primary and secondary types, with the former characterized by a lack of any history of trauma or pre-existing lesion and the latter by fibrous dysplasia, giant cell tumors, chondroblastoma, chondromyxoid fibroma, non-ossifying fibroma, fibrous histiocytoma, osteoblastoma, and osteosarcoma, among others [8].

Pre-existing arteriovenous malformations of the primary type and are seen in children. A history of accompanying lesion or trauma is not present in children. However, in adults, a history of trauma is typically present. The secondary type is accompanied by cysts, tumors, and degeneration of the fibro-osseous lesion. [11]. Eighty-five percent of cases are in those under 20 years of age. The tumor is very rarely seen in patients under 5 years or over 50 years of age, because it appears in bones that continue growing. Primary ABC (65%) is seen in children and adolescents.[12] According to the literature, the mean age of patients with ABC of the calcaneus is 24 years [12].

Radiologically, ABCs are described as well-defined osteolytic and destructive lesions. Typically, they show expanded, remodeled and ballooned contour of the bone. The fluid-fluid levels frequently encountered are secondary to the hemorrhagic components. CT with bone window can illustrate the expansile multi-cystic features of the lesion [12].

ABC on MRI usually exhibits multi-cystic cavities with different intensity and fluid-fluid levels within these cystic cavities [13-16]. However, diagnostic imaging in this case showed marked calcification inside the tumor on the sinus CT, which gave the impression of slight difference from ABC, which is characterized by calcification at the rim of the bone. T2-weighted MRI showed partial cyst formation, but numerous, scattered low-intensity sites due to calcification. Infiltration findings were strong, and malignant tumor was strongly suspected from imaging findings alone. Similar calcified lesions of the intramedullary space or associated extraosseous soft tissue mass have been reported in small cell osteosarcoma. Such calcification has been explained to result from the dystrophic processes of necrotic tumors or expansion of the periosteal reaction [17].

Diagnosis of ABC from imaging alone is difficult, and histopathologic examination is essential. Histologically, ABC shows cystic spaces filled with blood surrounded by osteoclast-like multinucleated giant cells. However, few cystic spaces filled with blood were seen in our case. In addition, the presence of multiple giant cells that were also seen in our case on histological examination may cause difficulty in differentiating the lesion histologically from osteoclastoma, fibrous dysplasia, ossifying hematoma and cavernous hemangioma of bone [18]. In this case, pathological distinction between GCRG and ABC was not possible, so pathological diagnosis by fluorescence *in situ* hybridization (FISH) was performed. As GCRG and solid ABC cannot be distinguished morphologically, FISH for *USP6* break-apart is a useful ancillary tool in the diagnosis of primary ABCs and for distinguishing them from GCRGs and other morphologically similar lesions [19,20]. Oliveira et al. stated that primary ABC is a mesenchymal neoplastic disease characterized by spindle cell proliferation, exhibiting USP6 rearrangements in most cases. Secondary ABC is a morphological mimic of primary ABC, but lacks the hallmark USP6 rearrangements of primary ABC, and likely represents a common endpoint of differentiation in various non-ABC bone tumors [21]. In this case, FISH for USP6 break apart was observed, and the final diagnosis was thus primary ABC.

ABC is a benign tumor, but has the characteristic of slowly growing (several months) before progressing rapidly within a short period of time [22]. When the tumor develops in the frontal bone, various types of cranial nerve palsy may appear due to exclusion by the tumor. In this case, blindness was possible due to optic neuropathy and exclusion of nerves in the superior orbital fissure, resulting in symptoms involving the oculomotor, trigeminal, trochlear, and abducens nerves. Preoperative preparations and systems were required to enable operation in response to rapid

exacerbation of the tumor. Furthermore, in this case, distinguishing between benign and malignant tumors before surgery was necessary. If the tumor turned out to be benign, division and removal would be to some extent unavoidable, but preservation of the functions of the cranial nerves and the like would be necessary. In the case of a malignant tumor, removal of the tumor en bloc would have been necessary, including surrounding healthy tissues such as the eyeball. The rapid growth of the tumor before surgery was strongly suggestive of malignant tumor, but before surgery, we repeatedly confirmed the pathological results with a pathologist, and decided to treat the entity as a benign tumor. However, the patient was considered likely to lose his eyesight before the surgery, so the three departments were ready to perform the surgery on an urgent basis.

The recurrence rate of ABC is reportedly high with curettage alone, and the recurrence rate of ABC cases occurring in the skull after curettage is 21-50% [23]. Complete removal is required to cure ABC [5,24,25]. However, blindness may result from damage to the optic nerve caused by the tumor-removing surgery. At the pre-surgery conference jointly conducted by multiple departments, the surgical procedures each department was responsible for were carefully simulated using 3D models in advance, and the surgical images were shared. The SONOPET® ultrasonic aspirator was used to aspirate and reduce the tumor to avoid damage to the ophthalmic nerve group of the optic nerve and superior orbital fissure. During the intraorbital operation, the anterior scalp flap was returned many times, and the operation was continued while confirming the dilated state of the pupil and checking for damage to the optic nerve. Furthermore, tumor clinging to the optic nerve was carefully peeled off to release pressure on the optic nerve. By carefully exfoliating the tumor around the superior orbital fissure, the nerves running through the superior orbital fissure (cranial nerves III to VI) were also preserved. By removing the bone above the optic canal and superior orbital fissure, pressure on the cranial nerves was relieved. Furthermore, all soft tissues that seemed to be part of the tumor attached to the frontal bone and dura mater were carefully removed.

In this case, the preoperative diagnosis was GCRG. However, the final pathological diagnosis was ABC. Similar to GCRG, ABC requires complete removal of the tumor, and the treatment based on this judgment was correct from the perspective of preventing tumor recurrence. In this case, unlike previous reports of ABC, the tumor showed rapid growth. Terkawi et al. also reported a case of ABC in the paranasal sinuses showing a rapid increase in extent similar to this case, in which the affected eye was already blind at the time of the first visit [26]. Since this disease sometimes increases in extent rapidly and may cause neurological symptoms by expulsion and destruction of surrounding tissues, prompt and accurate diagnosis and formation of a treatment policy are necessary. The orbital area was operated on by an ophthalmic plastic and reconstructive surgeon, while the posterior orbital optic nerve and superior orbital fissure and frontal and temporal regions were operated on by a skull base brain surgeon.

Finally the part from the lamina cribrosa to the maxillary sinus, the sphenopalatine sinus, and the sphenopalatine foramen was operated on by a head and neck surgeon and a nasal endoscopist, with each performing surgery in a separate surgical area. In addition, the situation and status of the surgery was shared using an endoscope for the surgery on the intracranial site and displaying the resulting images to all staff involved in the surgery. For multidisciplinary treatment of a tumor such as in this case, multiple departments need to jointly cooperate. To date, 5 cases of ABC (including this case) have been reported to spread to three areas of the orbit, anterior cranial fossa, and paranasal sinuses (Table 1) [5-8]. Of the 4 cases besides the present case, there were 3 cases which underwent neurosurgery alone, and 1 case which underwent joint surgery with neurosurgery and plastic surgery. Our hospital has one of Japan's leading skull base centers, admitting cases for neurosurgery, otolaryngology, ophthalmic plastic and reconstructive surgery, and plastic surgery, and these head and neck diseases are treated in a multidisciplinary manner.

Reference	Age/ gender	Symtoms	Location	Treatment	Surgical approach	Follow up	recurrence
Tamini et al.2005 [5]	14 years /F	headache visual loss	Sphenoid sinus, orbit anterior and middle cranial fossa	resection	Frontotemporal craniotomy, Orbitozygomatic osteotomy	undefined	no
Bozbuga et al. 2009 [6]	9 years /F	nasal obstruction, headache	sphenoid,ethmoid and maxillary sinuses orbit, Clivus, sinus cavernous	embolization. followed by surgical resection.	extended frontal approach	22 months	no
Hnenny et al. 2015 [7]	29 years /F	Ptosis diplopia	sphemoid,ethmoid and maxillary sinuses, orbut, anterior cranial fossa	resection	anterior craniotomy	3 months	no
Elias et al. 2019 [8]	15 months /F	exophthalmous, epistaxis	ethmoid sinus orbit, anterior cranial fossa	resection	anterior craniotomy, transnasal endoscopic surgery	6 months	no
Our case 2021	14 months /M	exophthalmous	ehmoid sinus,orbit anterior and middle cranial fossa	resection	frontotemporal craniotomy, transnsal endoscopic surgery	10 months	no

Table 1: Clinical features of aneurysmal bone cyst case that progressed to three areas: orbit, intracranial, and paranasal sinuses.

In this case, the pediatrician and anesthesiologist were asked to manage the general treatment of the patient after the operation. The pathologist was required to confirm the pathological diagnosis before the operation. Since the patient was a 1-year-old infant, tolerance to surgery had to be considered. Even what would be considered a small amount of bleeding in adults, puts a heavy strain on the circulatory system in infants. The operation time also needed to be shortened. In this case, the operation time was 6 h and the amount of bleeding was 89 ml. The surgery was completed extremely smoothly, and surgical invasion of the patient was minimized.

Skull base surgery (anterior craniotomy) is often performed in ABC cases on the orbital and sinus sides [4,6,7,27], and surgery by transnasal endoscopy or external incision is often reported in ABC cases on the nasal and sinus sides [18,28,29]. Tumors that extend to the paranasal sinuses and skull are often treated with craniofacial resection or a combined subcranial-midfacial degloving approach [2,5,30]. In this case, skull base surgery and transnasal endoscopic surgery were used in combination, as described by Elias et al., [8]. Furthermore, as a device in this case, in addition to orbitomy using Sonopet®, an endoscope was used in the skull base surgery. The SONOPET® ultrasonic aspirator is a handheld surgical instrument that provides access to small surgical fields such as the orbit [31]. The device does not involve traction or sharp stimulation, allowing its use near the dura mater without damaging adjacent nerve tissue [32].

The use of a 3D exoscope is very useful in skull base surgery and combined surgery under an endoscopic approach from the nasal cavity, as in this case. Compared to a microscope, an endoscope opens up the area in the center of surgery, providing a better view of the entire operating room and a better view of the surgical field. As a result, the entire surgery proceeds more smoothly because the surgeons can easily understand each other in simultaneous surgeries by multiple departments, as in this case.

Conclusion

ABC is a benign but rapidly progressive bone-destroying disease. Symptoms of cranial nerve palsy can arise when they occur in the orbit and skull, as in this case. If the lesion spans multiple areas, multiple departments need to cooperate to make a rapid diagnosis and provide multidisciplinary treatment. Complete surgical resection of the tumor is the gold standard with the lowest risk of recurrence.

References

1. Jaffe HL, Lichtenstein L (1942) Solitary unicameral bone cyst with emphasis on the roentgen picture, the pathologic appearance, and the pathogenesis. Arch Surg 44: 1004-1025.
2. Guilemany JM, Alobid I, Blanch JL, Ballesteros F, Alós L, et al. (2004) Orbitoethmoid aneurysmal bone cyst. Case report and literature review. Rhinology 42: 164-166.
3. Hunter JV, Yokoyama C, Moseley IF, Wright JE (1990) Aneurysmal bone cyst of the sphenoid with orbital involvement. Br J Ophthalmol 74: 505-508.
4. Sanghvi DA, Iyer VR, Chagla AS, Shenoy A (2010) Intradiploic frontal bone aneurysmal bone cyst in a child: a case report. Dentomaxillofac Radiol 39: 252-255.
5. Tamimi AF, Nimri C, Huseini M, Abu-Elrub M, Kharazi K, et al. (2005) Aneurysmal bone cyst of the sphenoid bone as an intracranial and orbital space-occupying lesion. Pediatr Neurosurg 41: 280-282.
6. Bozbuğa M, Turan Süslü H (2009) Aneurysmal bone cyst of the sphenoid bone extending into the ethmoid sinus, nasal cavity and orbita in a child. Turk Neurosurg 19: 172-176.
7. Hnenny L, Roundy N, Zherebitskiy V (2015) Giant aneurysmal bone cyst of the anterior cranial fossa and paranasal sinuses presenting in pregnancy: case report and literature review. J Neurol Surg Rep 76: 216-221.
8. Elias R, Youssef El SA, Antoine N, Joya H, Ibrahim S, et al. (2019) Aneurysmal bone cyst of the ethmoid sinus in a fifteen-month old girl: a rare entity. EC Clinical and Medical Case Reports 2: 46-50.
9. Lau AW, Pringle LM, Quick L, Riquelme DN, Ye Y, et al. (2010) TRE17/ubiquitin-specific protease 6 (USP6) oncogene translocated in aneurysmal bone cyst blocks osteoblastic maturation via an autocrine mechanism involving bone morphogenetic protein dysregulation. J Biol Chem 285: 111-120.
10. Boyd RC (1979) Aneurysmal bone cysts of the jaws. Br J Oral Surg 16: 248-253.
11. Çobanoğlu U, Kösem M, Altýndal E, Arslan H (2010) Costa originated giant aneurysmal bone cyst. Erciyes Med J 32: 295-300.
12. Kransdorf MJ, Sweet DE (1995) Aneurysmal bone cyst: concept, controversy, clinical presentation, and imaging. AJR Am J Roentgenol 164: 573-580.
13. Martinez V, Sissons HA (1998) Aneurysmal bone cyst: a review of 123 cases including primary lesions and those secondary to other bone pathology. Cancer 61: 2291-2304.
14. Barnes R (1956) Aneurysmal bone cyst. J Bone Joint Surg 38: 301-311.
15. Biesecker JL, Marcove RC, Huvos AG, Miké V (1970) Aneurysmal bone cysts: a clinicopathologic study of 66 cases. Cancer 26: 615-625.
16. Ruiter DJ, Van Rijssel TG, Van Der Velde EA (1977) Aneurysmal bone cysts: a clinicopathological study of 105 cases. Cancer 39: 2331-2339.
17. Edeiken J, Raymond AK, Ayala AG, Benjamin RS, Murray JA, et al (1987) Small-cell osteosarcoma. Skeletal Radiol 16: 621-628.
18. Yadav JS, Gupta AK, Kakkar N (2011) Aneurysmal bone cyst of the paranasal sinuses: a rare entity. Clinical Rhinology: An International Journal 4: 93-95.
19. Agaram NP, LeLoarer FV, Zhang L, Hwang S, Athanasian EA, et al. (2014) usp6 gene rearrangements occur preferentially in giant cell reparative granulomas of the hands and feet but not in gnathic location. Hum Pathol 45: 1147-1152.
20. Li L, Bui MM, Zhang M, Sun X, Han G, et al. (2019) Validation of fluorescence *in situ* hybridization testing of USP6 gene rearrangement for diagnosis of primary aneurysmal bone cyst. Ann Clin Lab Sci 49: 590-597.
21. Oliveira AM, Perez-Atayde AR, Inwards CY, Medeiros F, Derr V, et al. (2004) USP6 and CDH11 oncogenes identify the neoplastic cell in primary aneurysmal bone cysts and are absent in so-called secondary aneurysmal bone cysts. Am J Pathol 165: 1773-1780.
22. Hunter JV, Yokoyama C, Moseley IF, Wright JE (1990) Aneurysmal bone cyst of the sphenoid with orbital involvement. Br J Ophthalmol 74: 505-508.
23. Purohit A, Chopra S, Sinha VD, Dhanker SR (2002) Aneurysmal bone cyst of the temporal bone: case report. Neurology India 50: 511-513.
24. de Minteguiaga C, Portier F, Guichard JP, Racy E, Heitzmann P, et al. (2001) Aneurysmal bone cyst in sphenoid bone: treatment with minimally invasive surgery. Ann Otol Rhinol Laryngol 110: 331-334.
25. Kimmelman CP, Potsic WP, Schut L (1982) Aneurysmal bone cyst of the sphenoid in a child. Ann Otol Rhinol Laryngol 91: 339-341.
26. Terkawi AS, Al-Qahtani KH, Baksh E, Soualmi L, Mohamed Ael-B, et al. (2011) Fibrous dysplasia and aneurysmal bone cyst of the skull base presenting with blindness: a report of a rare locally aggressive example. Head Neck Oncol 3:15.
27. Nadkarni T, Goel A, Desai K, Aiyer P, Shenoy A (2001) Massive aneurysmal bone cyst of the anterior cranial fossa floor--case report. Neurol Med Chir (Tokyo) 41: 615-619.
28. Hashemi SM, Heidarpour M, Eshaghian A, Ansari P, Hashemi MS, et al. (2015) A rare case of aneurysmal bone cyst in the paranasal sinus. Iran J Otorhinolaryngol 27: 395-399.
29. Składzieriń J, Olés K, Zagólski O, Moskała M, Sztuka M, et al. (2008) A giant cranial aneurysmal bone cyst associated with fibrous dysplasia. B-ENT 4: 29-33.
30. Arocho-Quinones EV, Self S, Suchi M, Zwagerman NT, Lew SM (2018) Spheno-orbital aneurysmal bone cyst in a 10-month-old infant. World Neurosurg 117: 371-376.
31. Kim K, Isu T, Matsumoto R, Isobe M, Kogure K (2006) Surgical pitfalls of an ultrasonic bone curette (SONOPET) in spinal surgery, Neurosurgery 59: ONS390-ONS393.
32. Bengoa-González Á, Mencía-Gutiérrez E, Alonso-Martín B, Laslău BM, Salvador E, et al. (2021) Giant cell reparative granuloma of the orbit: clinicopathological characteristics and treatment. Case Rep Ophthalmol Med 2021: 7.