A Cystic Clival Chordoma with CT and MRI Unconventional Appearances

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Indian J Radiol Imaging

Abstract
We present the first case of clival cystic chordoma with extradural location, transdural transgression, and moderate bone involvement in a 10-year-old girl. Chordoma showed unconventional appearances on computed tomography (CT) and magnetic resonance imaging (MRI), due to cystic components, extradural space location with extensive intradural extension, moderate superficial bone involvement. Surgery confirmed the extradural location and histopathological examination revealed cystic chordoma. MRI and CT findings were not characteristic for a single lesion; differential diagnoses included cystic lesions such as epidermoid and dermoid cyst, ecchordosis physaliphora, and benign notochordal cell tumors.

Keywords
- chordoma
- CT
- cystic
- extradural
- MRI
- transdural

Introduction
A clival cystic chordoma is an extremely rare entity and represents a radiological challenge. If this already rare entity deviates from the classic computed tomography (CT) and magnetic resonance imaging (MRI) appearances of chordomas due to the disproportion between the large extraosseous soft tissue component and the moderate bone involvement, and also it deviates from the few reported cases of cystic intracranial chordoma due to the extradural location, an inappropriate differential pathway may be led down. We present a case of clival chordoma with CT and MRI unconventional appearances, such as cystic aspect, extradural location, and poor bone involvement.

Case Report
A 10-year-old girl was admitted to our institution after the radiological diagnosis of a mass of the clival region. The clinical history started several months before the admission with headache, pain on the right side of the head mainly raised by physical activity (especially sport). Because of this persisting symptom and because of the appearance of right palpebral spasms, the young girl underwent an
T1-weighted imaging (T1-WI) and very hyperintense signal on carotid arteries. The mass showed low signal intensity on T2-WI, and there was no evidence of contrast enhancement. CT, computed tomography; DWI, diffusion-weighted imaging; T1-WI, T1-weighted imaging; T2-WI, T2-weighted imaging.

The macroscopic appearance was the same as the previous two operations. As expected, the tumor was extradural and occupied the retroclival space. A gross debulking of the tumor through a retrosigmoid approach (craniotomy) to the right CP angle was performed under general anesthesia and with electrophysiological intraoperative monitoring. At surgery, the tumor appeared as a gelatinous mass, plastically growing into the CP angle cistern and extending into the adjacent cisterns. A marked encasement of the vessels and the cranial nerves by the tumor was evident. However, the dissection of the tumor from the neurovascular structures was facilitated by its soft aspect and by the absence of a significant peritumoral inflammatory reaction. The neoplasm was removed by a microsurgical technique and by suction. The neoplasm was followed and removed up to the junction between the posterior and the middle cranial fossae, where a detachment and perforation of the skull base dura mater was evident as well as the tumor passing from the middle to the posterior fossa. The postoperative course was uneventful. The mild motor deficit of the left lower limb quickly disappeared. The patient was readmitted 3 months after the first operation to allow her to finish the school time. No symptoms occurred in this period, and she was neurologically intact at the admission. MRI showed stable residual mass. The girl underwent a second surgery for the removal of the component of the tumor involving the anterior skull base though an endoscopically endonasal transphenoidal approach. As expected, the tumor was extradural and occupied the retroclival space. The macroscopic appearance was the same as the previous operation. The postoperative course was uneventful. The patient is now receiving proton radiotherapy on the residual tumor. On histopathological examination, the neurosurgical specimens were composed of mucinous material containing epithelial appearing tumor cells, with monomorphic relatively small round nuclei. The INI1 nuclear expression was retained (not shown). The cells did not display significant mitotic and/or proliferative activity (MIB1 immunostaining) (not shown).

**Discussion**

Chordomas are rare and locally invasive malignant tumors that represent 1% of intracranial tumors and 4% of all primary bone tumors; they most commonly affect adults in their fourth and fifth decades of life, with male and whites predilection, while they are rare among children. Arising...
from embryonic remnants of the primitive notochord, chordomas can develop along the cranial (32%), spinal (32.8%), and sacral (29.2%) portions of the craniovertebral axis. Spheno-occipital synchondrosis is the most common site of origin of intracranial chordomas, arising from the upper third or along the caudal margin of the clivus. Occasionally, the extrusion of the notochord during the ossification can occur in aberrant locations, and notochord rests may persist into the extradural or intradural spaces. This would allow the chordomas to grow without bony involvement. There are three histological variants of chordoma: classical, chondroid chordomas, containing hyaline cartilage, and dedifferentiated chordoma. Dedifferentiated chordoma comprise <5% of all chordoma subtypes, and they are a particularly aggressive tumor with a predilection for the pediatric population with a much poorer prognosis. Chondroid variant often shows a less aggressive clinical behavior than classical chordoma.

Also, the degree of bone invasion and the integrity of dural are independent risk factors for the clinical prognosis of skull base chordoma patients. Recently, Wu et al\(^5\) classified clivus chordoma as endophytic (Type I) or exophytic (Type II) based on the degree of skull base bone invasion, and exploring the mechanisms of such bone invasion, they confirmed that the expression level of PTEN (phosphatase and tensin homolog) gene is associated with the degree of bone invasion, and the regulatory molecule transforming growth factor beta 1 may play an important role in bone invasion (Experimental Study on Differences in Clivus Chordoma Bone Invasion: An iTRAQ-Based Quantitative Proteomic Analysis). The classic appearance of intracranial chordoma at MRI is a well-circumscribed, expansile soft tissue mass, with high signal intensity on T2-WI, intermediate to low signal intensity on T1-WI, moderate to marked contrast enhancement. Variable intralesional dark areas on SWI (susceptibility weighted imaging) or GRE (gradient echo sequences) images are present due to intratumoral hemorrhages or calcifications; however, calcifications (bone sequestra or dystrophic calcifications) are better depicted by CT scan.

This clival chordoma did not conform to the typical CT and MRI appearances of intracranial chordoma, first due to the completely cystic appearance of the mass and the poor bone involvement in the face of a voluminous extrabone component. Based on cystic appearance, differential diagnosis included epidermoid cyst (EC), ecchordosis physaliphora (EP), and benign notochordal cell tumors (BNCTs), but considering also the location of the lesion, none of these lesions corresponded to our case (\textit{\textit{\textarrow{Table 1}}}). Although some MRI features were compatible with EC, such as T1 and T2 signal intensity and no contrast enhancement, ECs usually show restricted diffusion on DWI (bright hyperintensity), and they are usually intradural lesions (75%), which are not consistent with our case. EP is a congenital, often asymptomatic, benign lesion derived...
from intradural notochord remnants, usually located in the midline, such as in the dorsum of the clivus. However, EP usually arises from the intradural space, on the contrary, our case seems to be an extradural mass with secondary intradural invasion, a growth behavior that belongs to chordomas. Whether intradural chordomas arise from EP is still under debate; in literature, rare cases of symptomatic EP are described and malignant transformation to chordoma is also contemplated, but EP remains relatively small in size (2–3 cm) and only few cases of EP >3 cm have been reported in the literature, considering that "giant EP" is defined >6 cm³ in size. The substantially larger dimensions do not support the hypothesis that it could be a degenerated EP.

BNCTs are benign intraosseous lesions of notochordal cell origin reported to be found in 20% of autopsy series in the midline of clivus and vertebral bodies, with increasing frequency of their identification on MRI studies. BNCTs appear as well-defined intraosseous lesion, and as for EC and EP, signal intensity is low on T1-WI and high on T2-WI, without contrast enhancement, diffusion restriction, or soft tissue extension, but the location is extradural. We considered the hypothesis of cystic intracranial chordomas, but based on a review of the cases reported in the literature, while the lack of severe bone involvement resulted as a typical feature, the extradural location was never reported. Most of the intracranial cystic chordomas were intradural, in one case, the lesion was located in the right cavernous sinus and in another case, the authors were not completely sure of the location, which nevertheless seemed to be extradural (Table 2). Also, the patients’ age was not conclusive, only 4/11 patients were child or teenagers. Chondrosarcoma could be another possible differential diagnosis for midline chordomas with dural invasion in the presence of intratumoral calcification, but the absence of contrast enhancement did not support completely this hypothesis. Chondrosarcoma arises in the petroclival fissure, and therefore, it is usually located off midline. CT may show calcification of the tumor, often in characteristic “rings and arcs”

Table 1 Imaging characteristics of our case and differential diagnosis

<table>
<thead>
<tr>
<th></th>
<th>T1-WI</th>
<th>T2-WI</th>
<th>DWI/ADC</th>
<th>Contrast enhancement</th>
<th>Bone erosion</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our case</td>
<td>Low</td>
<td>High</td>
<td>No restriction (ADC: 1.400 × 10⁻⁶ mm²/s)</td>
<td>No</td>
<td>Mildly</td>
<td>Extradural, secondary intradural</td>
</tr>
<tr>
<td>EC</td>
<td>Low</td>
<td>High</td>
<td>Restriction</td>
<td>No</td>
<td>No</td>
<td>Intradural</td>
</tr>
<tr>
<td>EP</td>
<td>Low</td>
<td>High</td>
<td>No restriction</td>
<td>No</td>
<td>No</td>
<td>Intradural</td>
</tr>
<tr>
<td>BNCTs</td>
<td>Low</td>
<td>High</td>
<td>No restriction</td>
<td>No</td>
<td>No</td>
<td>Intraosseous</td>
</tr>
<tr>
<td>Chondrosarcoma of the skull base</td>
<td>Low/intermediate</td>
<td>High</td>
<td>No restriction (&gt; mean ADC value: 2,051 ± 261 × 10⁻⁶ mm²/s)</td>
<td>Yes</td>
<td>Yes “ring-and-arc” calcification</td>
<td>Extradural off midline</td>
</tr>
</tbody>
</table>

Table 2 Case reports of cystic chordomas reported in literature

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Age/sex</th>
<th>T1-WI</th>
<th>T2-WI</th>
<th>DWI</th>
<th>CE</th>
<th>Bone erosion</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciarpaglini et al (2009)¹⁶</td>
<td>60/M</td>
<td>Hypo</td>
<td>Hyper</td>
<td>–</td>
<td>No</td>
<td>No</td>
<td>Retroc. Intrad.</td>
</tr>
<tr>
<td>Kim et al, 2018²²</td>
<td>27/M</td>
<td>Hypo</td>
<td>Hyper</td>
<td>Hyper</td>
<td>No</td>
<td>No</td>
<td>Retroc. Intrad.</td>
</tr>
<tr>
<td>Sathe et al (2019)²³</td>
<td>26/M</td>
<td>Hypo</td>
<td>Hyper</td>
<td>No RD</td>
<td>No</td>
<td>Mild</td>
<td>Cavernous sinus</td>
</tr>
</tbody>
</table>

Abbreviations: ADC, apparent diffusion coefficient; BNCTs, benign notochordal cell tumors; DWI, diffusion-weighted imaging; EC, epidermoid cyst; EP, echondrosiophysalhora; T1-WI, T1-weighted imaging; T2-WI, T2-weighted imaging.
(chondroid matrix mineralization). Furthermore, recent studies demonstrate that DWI may be helpful in the differential diagnosis between chordoma and chondrosarcoma, with chondrosarcoma having a higher average ADC than chordoma.

**Conclusion**

Cystic chordoma is an extremely rare entity that should be considered in the differential diagnosis of cystic lesions of the clival region. But in our case, cystic chordoma not only demonstrated unconventional appearance on CT and MRI with respect to intracranial chordoma, and yet it did not conform to reported radiological appearance of intracranial cystic chordoma.

**Declaration of Patient Consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Financial Support and Sponsorship**

Nil.

**Conflict of Interest**

None declared.

**References**