

# Cranio cervical Pneumatization

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## ABSTRACT

Cranio cervical bony pneumatization is a rare finding, with limited numbers of cases reported in the literature. It is thought to be linked to Eustachian tube dysfunction and a ball valve mechanism, and has a link with recurrent Valsalva maneuvers. We report a case of pneumatization of the occiput, atlas (C1) and axis (C2) in a patient with extensive ENT (Ear, Nose and Throat) surgical history who presented following a fall. Plain film, CT and MRI images are presented.

## CASE REPORT

### CASE REPORT

A 45-year-old man presented following a fall while hill-walking. He had hyperextended his neck but had not injured his head. He complained of developing dysphagia and a sensation of throat swelling after the fall. He also had nausea with vomiting and pain in the left side of his neck and ear. On examination, no neurological deficit was elicited but he was noted to have new vocal hoarseness. His past medical history revealed an extensive previous ENT history. Over the previous 30 years he had recurrent problems with bilateral chronic suppurative otitis media and Eustachian tube dysfunction. Previous surgeries included a right tympanoplasty, right meatoplasty, left myringotomy and grommet insertion and left meatoplasty. Most recently two years ago, he had a tonsillectomy for recurrent tonsillitis and right quinsy.

Plain film radiographs of the cervical spine revealed pneumatization of the occiput, C1 and spinous process of C2, with a small amount of gas in the adjacent soft tissues (Figs. 1-2). No obvious fracture was identified. Multislice Computed Tomography (CT) of the skull base and cervical spine was performed using a GE Lightspeed VCT (64-slice). This showed extensive pneumatization of the occiput, C1 and posterior arch/spinous process of C2 (Figs. 3a-d). Continuous aeration was noted from the left mastoid air cells into the apex of the left petrous temporal bone and left clivus. Fluid density was identified in some areas of the pneumatized bone. An

apparent communication between the right occipital condyle and C1 was identified (Fig. 4). Multiple locules of gas were noted in the soft tissues adjacent to the occiput and posterior arch of C1. The marked cortical thinning secondary to the degree of pneumatization as well as slight cortical irregularity of the posterior arch of C1 made an underlying fracture a possibility (Fig. 5). A Magnetic Resonance Imaging (MRI) study was performed using a Philips Intera 1.5T. This revealed normal brain and cervical/upper thoracic spinal cord appearances. Fluid, corresponding to that seen in the CT, was identified within the occiput, posterior ring of C1 and spinous process of C2 (Figs. 6 a & b).

An ENT review revealed no acute abnormality on examination. The patient was discharged after a few days. He continued to complain of neck discomfort and a subsequent CT was performed 3 months after the initial presentation. This revealed a reduction in the fluid in the occiput, atlas and axis, with the fluid replaced by gas. No new fracture was found. The previously noted cortical irregularity had resolved. There remained an unchanged small amount of gas in the adjacent soft tissues. This was not considered clinically significant given the absence of underlying fracture.

## DISCUSSION

Human bony pneumatization occurs normally in the paranasal sinuses and middle ear. Bony pneumatization has been shown to be present as early as 24 weeks gestation [1], but radiographically is visible only after birth. There are three stages of pneumatization; infantile (birth to 2 years), transitional (from 2 to 5 years) and adult [2]. Once the adult stage has been reached, pneumatization should cease. Temporal bone pneumatization has been divided into 5 regions; the middle ear, mastoid, perilyabyrinthine, petrous apex and accessory [3]. The extent of the pneumatization of the temporal bone can vary greatly between individuals.

In this case report, we show an example of cranio cervical pneumatization. First reported in 1940 [4], hyperpneumatization of the occipital bone is a very rare condition with less than 20 cases in the literature to the best of our knowledge [5-16]. Even rarer is cranio cervical pneumatization, pneumatization of both the occiput and cervical vertebrae [5, 10-14, 17]. As in our case, cranio cervical pneumatization exhibits a male predominance in the reported cases.

Various theories have been proposed for the cause. The most commonly quoted is a ball valve mechanism where air forced up the Eustachian tube is trapped and gradually leads to enlargement of the sinuses with extension into the occiput [13, 15, 16]. Triggers for this include recurrent Valsalva maneuvers [5, 11, 13, 15, 16], excessive coughing [14] and recurrent high-altitude travel [8]. Our patient had an extensive ENT history although didn't describe any history of recurrent Valsalva maneuvers. In some of those cases with cranio cervical pneumatization, apparent communications are visualized between the pneumatized occipital condyles, atlas and axis [10, 11]. In our case, communication was seen between the right occipital condyle and medial aspect of the right lateral mass of C1. However, no communication was seen between the atlas and axis in our case, despite axis aeration.

Commonly reported symptoms in patients with cranio cervical pneumatization include headache, vertigo, tinnitus, nausea, a feeling of fullness in the temporal region or a palpable swelling. Tinnitus has also been reported in patients with extensive temporal bone pneumatization [18]. Due to the cortical thinning associated with the pneumatization, patients are at increased risk of fractures from minor trauma [5, 6, 7]. Valsalva maneuver has also been reported as a cause of fracture [5, 11]. Fractures are reported as painless but it is the accumulation of gas in the soft tissues that can cause symptoms [5].

Some studies have shown regression of the pneumatization following treatment of the Eustachian tube dysfunction by tympanic drainage or asking the patient to reduce the number of Valsalva maneuvers they perform [11, 14, 16]. Follow-up CT examinations have shown healing of fractures and new bone formation and sclerosis, with pneumatization regression. At the sites of communication between the occipital condyles and lateral masses of C1, assimilation may be seen on the follow-up examinations [5].

In conclusion, cranio cervical pneumatization is a rare condition with few cases reported in the literature. Thought to be linked to Eustachian tube dysfunction and a ball valve mechanism, it has a link with recurrent Valsalva maneuvers and high-altitude travel.

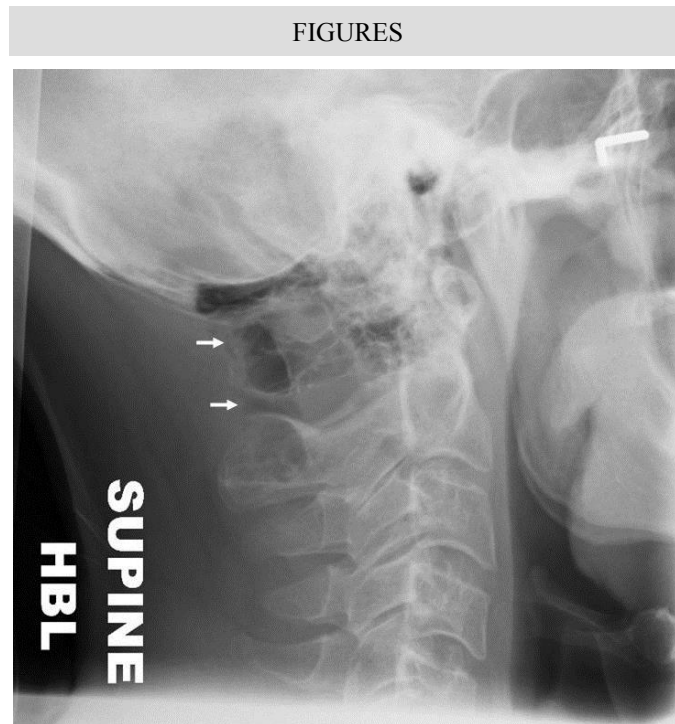
## TEACHING POINT

While a rare condition, a finding of cranio cervical pneumatization should alert the reporting radiologist to the possibility of Eustachian Tube dysfunction and a relevant ENT history should be sought. In a history of even only minor trauma, there is increased risk of fracture given the marked cortical thinning, and special care should be taken for subtle fractures when reporting.

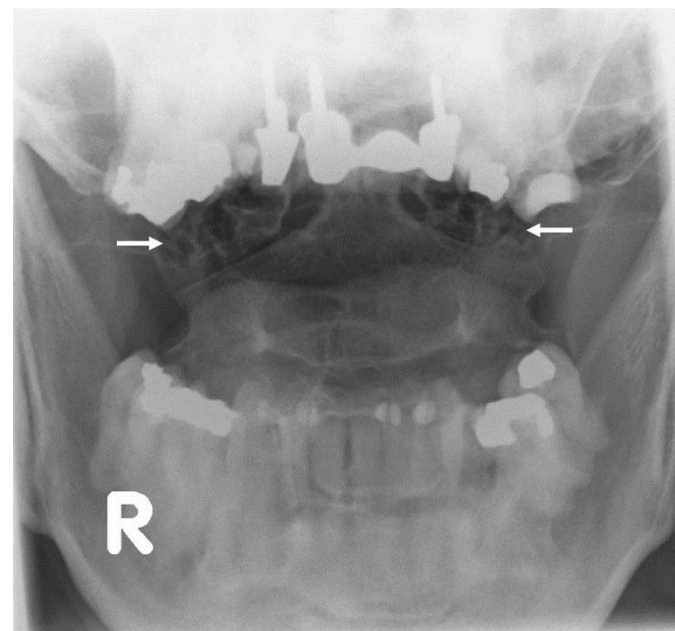
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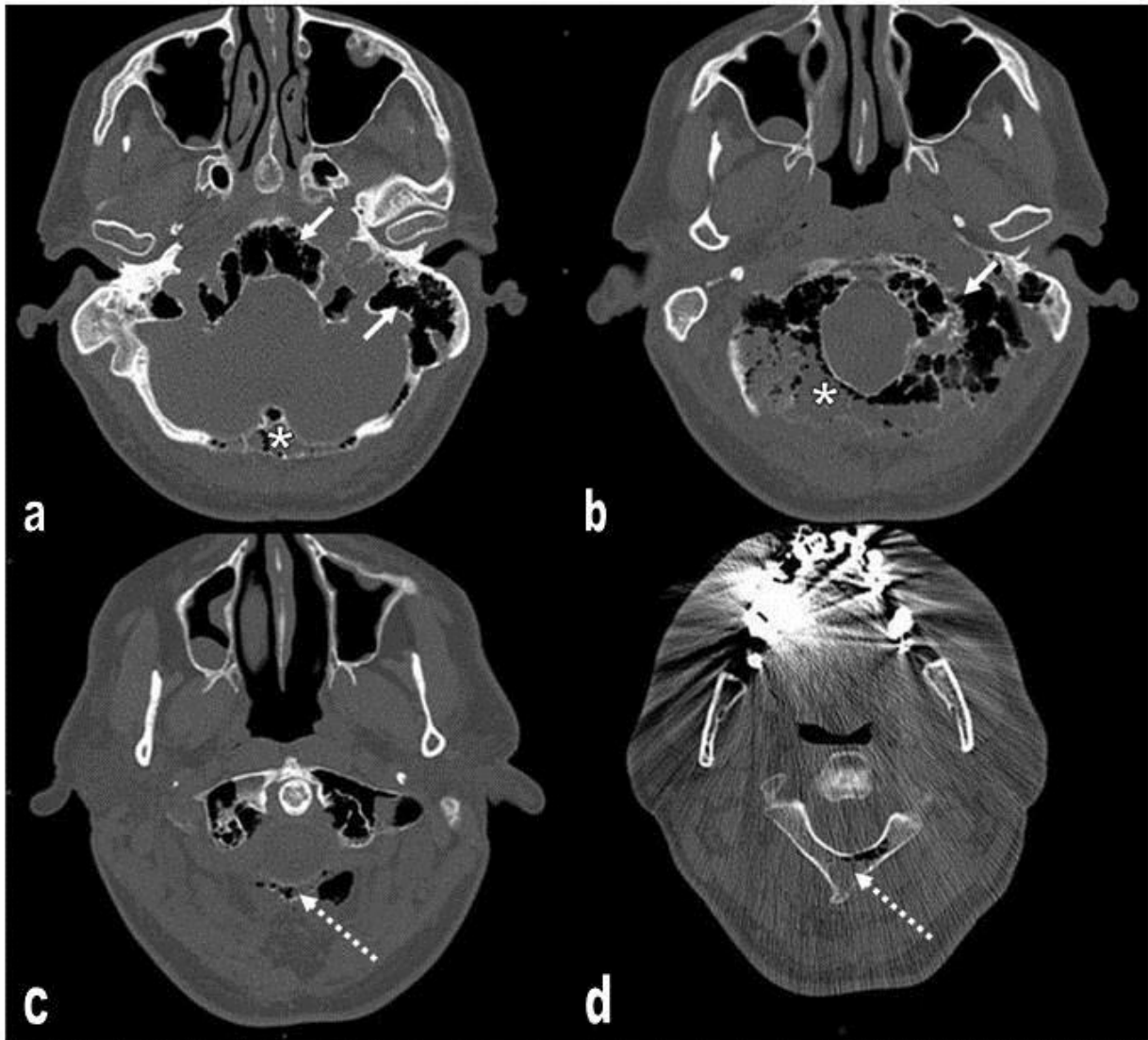
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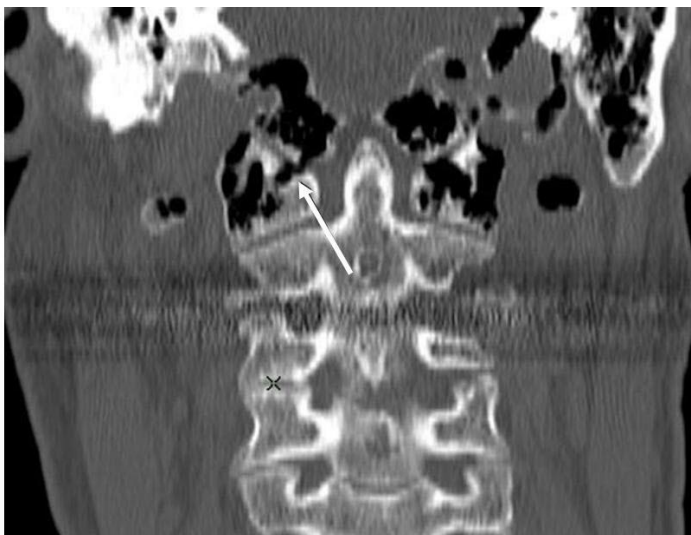
**Figure 1:** 45 year old male with craniocervical pneumatization. Lateral plain radiograph of the base of skull and upper cervical vertebral spine showing pneumatization of the occiput, C1 and spinous process of C2 with a small amount of adjacent soft tissue air (white arrows) (protocol: 73 kVp, 10 mAs).



**Figure 2:** 45 year old male with craniocervical pneumatization. Odontoid process plain AP radiograph showing pneumatization of C1 lateral masses (white arrows) (protocol: 70 kVp, 8 mAs).



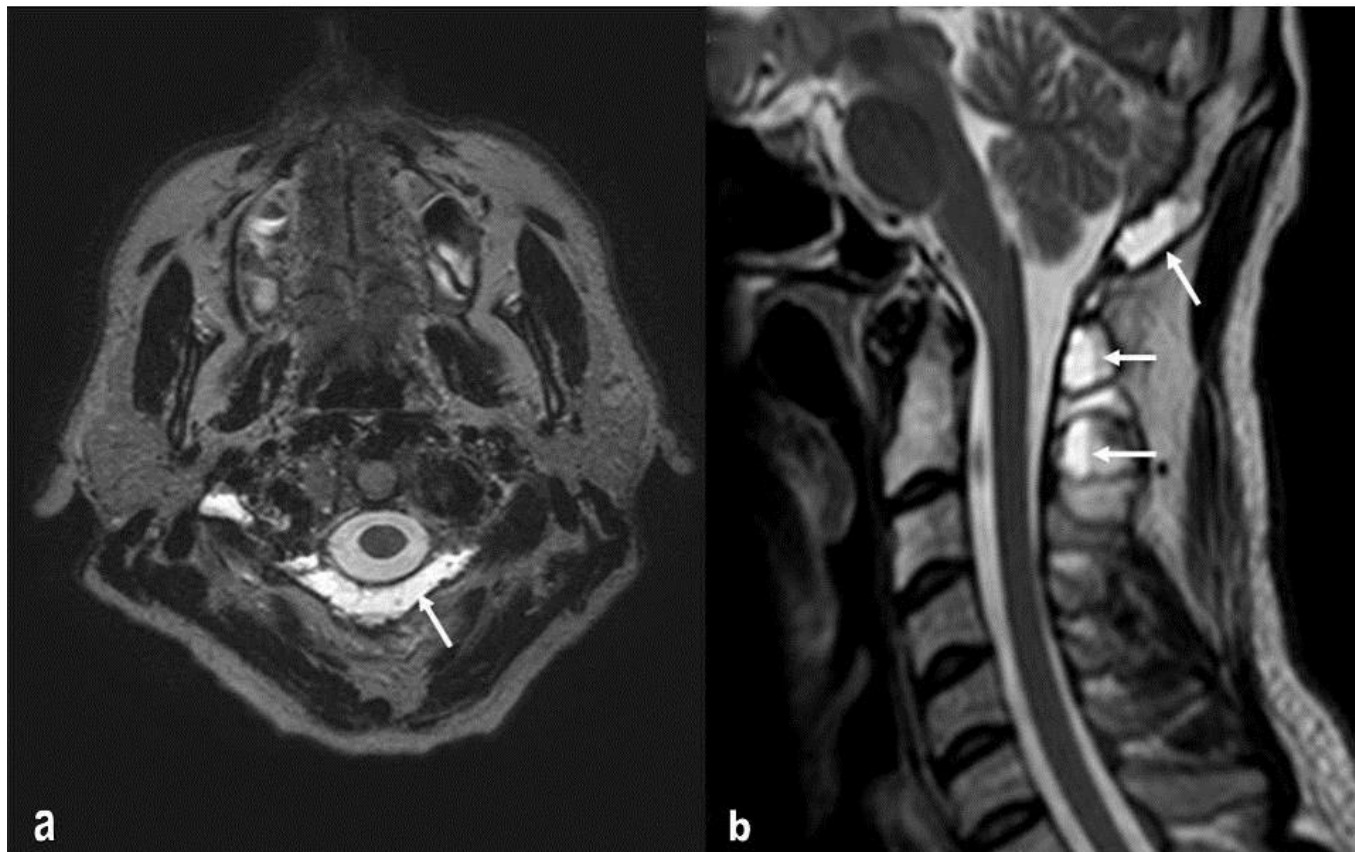
**Figure 3:** 45 year old male with craniocervical pneumatization. Series of axial non-contrast CT images (GE Lightspeed VCT, protocol: 120kV, 1mAs, 1.25mm slices, non-contrast, dose 506mGy) showing the extensive pneumatization of the occiput, C1 and posterior arch of C2. Continuous aeration from the left mastoid air cells into the apex of the left petrous temporal bone and left clivus can be seen (white arrows in 3a & 3b). Areas of fluid attenuation are seen within the pneumatized occiput (asterisks in 3a & 3b) and cervical vertebrae (broken white arrows in 3c & 3d).



**Figure 4 (left):** 45 year old male with craniocervical pneumatization. Non-contrast CT (GE Lightspeed VCT, protocol: 120kV, 1mAs, 2mm coronal reformats, non-contrast, dose 506mGy) showing pneumatization of C1 and the occiput with an apparent communication between the right occipital condyle and medial aspect of the right lateral mass of C1 (white arrow).



**Figure 5 (left):** 45 year old male with craniocervical pneumatization. Axial non-contrast CT image images (GE Lightspeed VCT, protocol: 120kV, 1mAs, 1.25mm slices, non-contrast, dose 506mGy) showing air in the soft tissues adjacent to the posterior arch of C1 on the left side (white arrows), with cortical irregularity of the posterior arch indicating a possible fracture.



**Figure 6:** 45 year old male with craniocervical pneumatization. MRI Axial (6a) & Sagittal (6b) T2 sequences (Philips Intera 1.5T, TR = 3658, TE = 120, slice thickness 3mm, non-contrast) of the base of skull, cervical spine and upper thoracic spine. Areas of increased T2 signal in the occiput and spinous processes of C1 and C2 in keeping with fluid within the areas of pneumatization (white arrows). Normal visualized spinal cord.

<b>Etiology</b>	Ball-valve mechanism: air is forced up the Eustachian tube and trapped, leading to air extension from the sinuses into the occiput, C1 & C2
<b>Incidence</b>	Very rare; only 7 cases of craniocervical pneumatisation have been reported, with 20 cases of occipital pneumatization
<b>Gender Ratio</b>	More common in men
<b>Age predilection</b>	None
<b>Risk Factors</b>	Recurrent Valsalva manoeuvres, excessive coughing, recurrent high altitude travel
<b>Treatment</b>	Treatment of unstable fractures, but otherwise conservative management: reduction in number of Valsalva manoeuvres, tympanic drainage, avoid flying
<b>Prognosis</b>	Some cases report spontaneous regression with conservative management
<b>Imaging findings</b>	<p>X-ray:</p> <ul style="list-style-type: none"> <li>• Increased lucency of occiput, C1 &amp; C2</li> <li>• Possible pathological fracture</li> <li>• Areas of soft tissue air</li> </ul> <p>CT:</p> <ul style="list-style-type: none"> <li>• Aeration of occiput, C1 &amp; C2</li> <li>• Communication between occiput, C1 &amp; C2</li> <li>• Cortical thinning with possible pathological fracture</li> <li>• Areas of fluid density within pneumatised bone</li> </ul> <p>MRI:</p> <ul style="list-style-type: none"> <li>• Complete loss of normal bone marrow signal on T1</li> <li>• Fluid signal (high T2/low T1) within pneumatised bone</li> </ul>

**Table 1:** Summary table for craniocervical pneumatization

	X-ray	CT	MRI	Post-Contrast
<b>Lytic bone metastases</b>	<ul style="list-style-type: none"> <li>Lytic areas in the vertebral bodies</li> <li>Absent pedicles on the AP view</li> <li>Smaller lesions are often missed</li> </ul>	<ul style="list-style-type: none"> <li>Lytic irregular areas of soft-tissue attenuation</li> <li>Cortical breach with invasion of adjacent structures</li> <li>Vertebral body collapse (pathological fracture)</li> </ul>	<ul style="list-style-type: none"> <li>T1: Intermediate to low signal intensity</li> <li>T2: Intermediate to high signal intensity</li> </ul>	<ul style="list-style-type: none"> <li>Enhancement of the metastatic deposit on T1</li> </ul>
<b>Multiple myeloma</b>	<ul style="list-style-type: none"> <li>Generalized osteopenia</li> <li>Well-defined 'punched-out' lytic lesions</li> <li>Endosteal scalloping</li> </ul>	<ul style="list-style-type: none"> <li>Diffuse osteopenia</li> <li>'Punched-out' lytic lesions</li> <li>Expansile lesions with soft tissue masses</li> <li>Pathological fractures</li> </ul>	<ul style="list-style-type: none"> <li>T1: Multiple focal low signal areas</li> <li>T2: Multiple focal high signal areas</li> </ul>	<ul style="list-style-type: none"> <li>Enhancement of focal or diffuse disease on T1</li> </ul>
<b>Spinal Infection (Osteomyelitis)</b>	<ul style="list-style-type: none"> <li>Initially normal</li> <li>Disc-space narrowing with end-plate irregularity</li> <li>Bone lucency which may progress to sclerosis if untreated</li> </ul>	<ul style="list-style-type: none"> <li>Bone lucency detected earlier than on plain film</li> <li>Intramedullary gas</li> <li>Disc-space narrowing</li> <li>Adjacent soft-tissue swelling or collection</li> </ul>	<ul style="list-style-type: none"> <li>T1: Hypointense (fluid and bone marrow oedema)</li> <li>T2: Hyperintense (fluid, bone marrow oedema, paravertebral soft tissues/collection)</li> </ul>	<ul style="list-style-type: none"> <li>Endplate enhancement</li> <li>Fluid collections peripherally enhance</li> <li>Paravertebral soft tissues also show enhancement</li> </ul>
<b>Intraosseous vertebral hemangioma</b>	<ul style="list-style-type: none"> <li>Lucent vertebral body lesion with prominent sclerotic vertical trabeculae</li> <li>Mainly lower thoracic and upper lumbar vertebrae</li> </ul>	<ul style="list-style-type: none"> <li>Lucent vertebral body lesion with prominent sclerotic vertical trabeculae (Corduroy sign on sagittal view; Polka-dot sign on axial view)</li> <li>Bulge of posterior cortex</li> <li>Extraosseous extension</li> </ul>	<ul style="list-style-type: none"> <li>T1: Hyperintense (high fat content) unless fat-poor hemangiomas (intermediate to low T1)</li> <li>T2: Hyperintense</li> <li>Extraosseous extension may cause neural impingement</li> </ul>	<ul style="list-style-type: none"> <li>Usually enhances</li> </ul>
<b>Intraosseous pneumatocyst [19]</b>	<ul style="list-style-type: none"> <li>Small radiolucent area</li> <li>Thin sclerotic rim</li> <li>Vertebral body</li> </ul>	<ul style="list-style-type: none"> <li>Well-defined lucent lesion</li> <li>Gas attenuation</li> <li>+/- gas in the adjacent intervertebral disc</li> </ul>	<ul style="list-style-type: none"> <li>T1: Hypointense</li> <li>T2: Hypointense</li> </ul>	<ul style="list-style-type: none"> <li>No enhancement</li> </ul>

**Table 2:** Differential diagnosis table for craniocervical pneumatization

**ABBREVIATIONS**

CT = Computed tomography  
 ENT = Ear, Nose and Throat

**KEYWORDS**

Cranio cervical Pneumatization; Eustachian Tube Dysfunction; Occiput; Cervical Spine

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