ISSN 2563-7142

CASE REPORT

Anatomical Variation of Dens Ankylosis in a 91-Year-Old Donor: A Case Report and Literature Review

2LT Justin Knapp[1], ENS Heather L MacEwen[1], 2LT Paige Mitchell[1], 2dLt Addison Stemmer[1], Gary Wind[2], Maria Ximena Leighton[2], Kerrie Lashley[3], Juan Jose Valenzuela-Fuenzalida[4], Guinevere Granite[2*]

Knapp J, MacEwen HL, Mitchell P et al. Anatomical Variation of Dens Ankylosis in a 91-Year-Old Donor: A Case Report and Literature Review. Int J Cadaver Stud Ant Var. 2026;7(1):06-14.

Abstract

This case highlights a previously undescribed lesion at the craniovertebral junction characterized by ankylosis of the dens to the anterior arch of the atlas (C1) and the anterior rim of the foramen magnum. This fusion was identified during donor dissection as part of a medical school neuroanatomy curriculum. Results of a thorough literature review are reported, confirming the novelty of the lesion described herein. Although a limited clinical history from our donor was available, the lesion may have influenced neurologic symptomatology. This case underscores the ongoing significance of human donor dissection in both the evolving field of anatomy and biomedical education.

Key Words: *Odontoid process; Craniovertebral junction; Ankylosis; Foramen magnum; Parkinson's disease*

Introduction

The Craniovertebral Junction (CVJ) is the transitional region between the skull base, the atlas (C1 vertebra), and the axis (C2 vertebra), providing most cervical flexion–extension and axial rotation while protecting the brainstem, upper spinal cord, and vertebral arteries [1]. The atlanto-occipital joint (C0-C1) permits primarily flexion–extension, whereas the atlanto-axial joint (C1-C2) accounts for up to 60% of cranial rotation [2]. The transverse ligament, alar ligaments, and the tectorial membrane (origin at C2) provide stability for the CVJ [3]. The odontoid process, or dens, serves as the central pivot of the CVJ, and pathology of the dens (e.g., ankylosis or calcification) can compromise joint mobility or impinge on adjacent neurovascular structures [4]. Many pathologies can interfere with CVJ function, including developmental and congenital variants or anomalies, benign

[1]F Edward Hebert School of Medicine, Uniformed Services University of Health Sciences, Bethesda, MD 20814, USA

Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD 20814, USA

[3]The Henry M Jackson Foundation for the Advancement of Military Medicine, Inc., Bethesda, MD 20814, USA

[4]Department of Morphology, Faculty of Medicine, Andrés Bello University, Santiago 8370146, Chile

[*]Corresponding author: Guinevere Granite, Assistant Professor, Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD 20814, USA, E-mail: guinevere.granite@usuhs.edu

Received: February 26, 2026, Accepted: March 29, 2026, Published: April 27, 2026

and malignant tumors, and inflammatory processes [4].

The term "ankylosing" is of Greek origin and is used to describe something as bent or crooked. Medically, "ankylosis" is typically used to describe the spine as stiff or rigid, and is commonly associated with fusion, adhesion, and surrounding inflammation. In the literature, descriptions of Ankylosing Spondylitis (AS) date back as early as 1500 B.C. in ancient Egypt [5].

However, while neck pain and older age at onset have been reported in women with AS, ankylosis of the dens in AS has not been described [6]. Herein, we present a novel case of an ankylosed dens without evidence of additional spinal pathology and report a thorough literature review that yielded descriptions of several lesions with varying similarity to ours, but none that matches it perfectly.

Case Description

A 91-year-old female donor (listed causes of death as Parkinson's disease, atrial fibrillation, and hypertension) was donated to the Maryland State Anatomy Board and subsequently transferred to the Uniformed Services University of the Health Sciences for donor dissection in the first-year medical school anatomy curriculum. After the brain was removed and the cranial cavity examined, ankylosis and enlargement of the dens involving the anterior part of the C1 ring and fusion to the anterior rim of the foramen magnum were observed (Figures 1-4). The initial dissection was performed by medical students, and assistance was provided by the anatomy faculty member when the abnormality was identified. In accordance with the policies of the Maryland State Anatomy Board, we were provided with no other medical or surgical history.

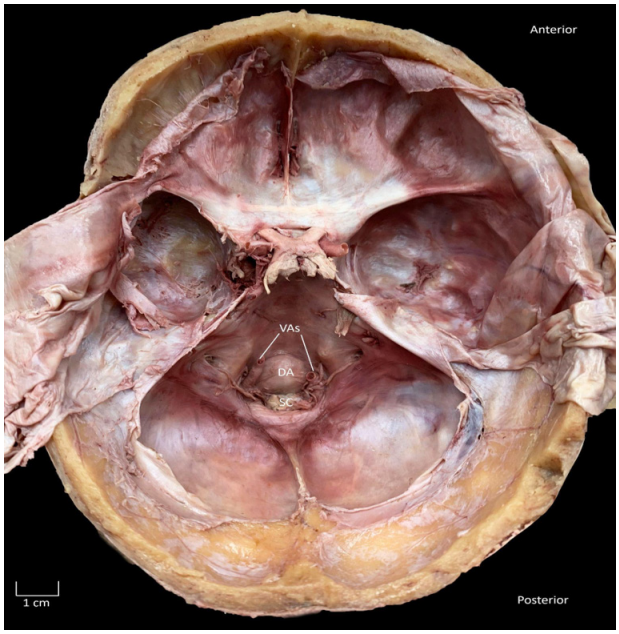

Figure 1) *Image of the craniotomy between the calvaria and the cranial base. DA=Dens Ankylosis; SC=Spinal Cord; VAs=Vertebral Arteries.*

Methodology

The dens ankylosis was identified during the dissection component of the neuroanatomy module. Subsequent examination of the brain and cranium was performed, including midbrain sections. A craniotomy was initially attempted using a Ridgid 12V Job Max Power Base equipped with a 1-1/8" Wood Plunge Cutting Blade and a Multi-Tool Head Saw. Our goal was to circumferentially cut through the external bony lamina at the broadest part of the skull; however, the blade was unable to fully penetrate the skull's thickness. To proceed, we utilized Robox stainless steel chisels and a Miltex stainless steel post-mortem hammer to break through the internal bony lamina. This approach ultimately allowed us to remove the calvaria successfully. Examination of the posterior cranial fossa revealed the enlarged dens at the level of the foramen magnum (Figure 2). An incision was performed along the midline of the dens ankylosis during the initial evaluation of this finding (Figure 3). The cranium was then hemisected using a Milwaukee Orbital Super Sawzall oscillating saw, which confirmed fusion

of the dens to the C1 ring and foramen magnum when viewed in the sagittal plane.

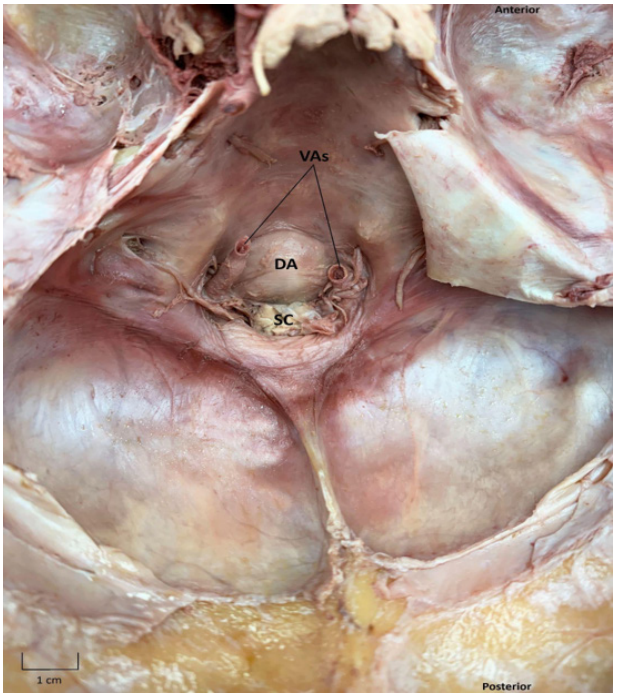

Figure 2) *Image of the craniotomy between the calvaria and the cranial base. DA=Dens Ankylosis; SC=Spinal Cord; VAs=Vertebral Arteries.*

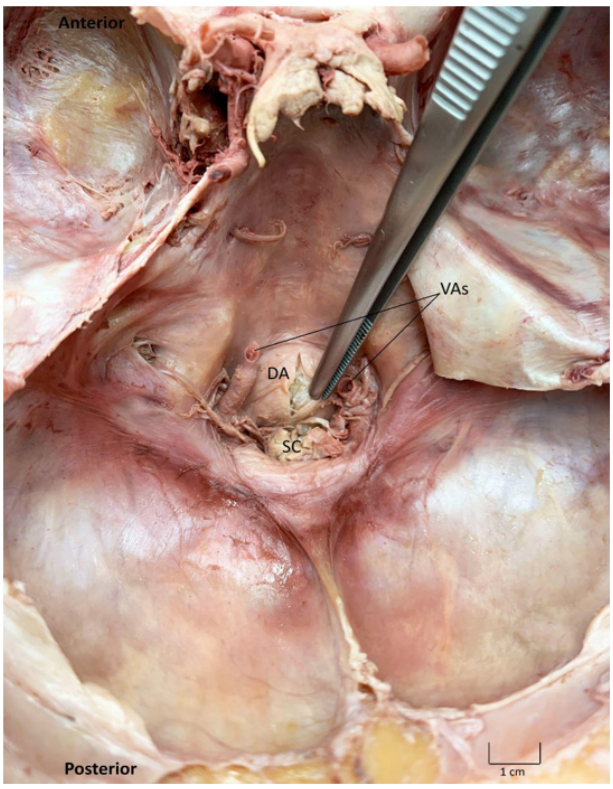

Figure 3) *The image shows a midline incision on the dens ankylosis. DA=Dens Ankylosis; SC=Spinal Cord; VAs=Vertebral Arteries.*

Odontoid process (Dens)

The primary anatomical variation observed was the ankylosis of the dens. The dens, measuring 3 cm in length, was fused to the anterior arch of the atlas (C1) and the anterior rim of the foramen magnum (Figure 4). The dens ankylosis may have contributed to neurologic dysfunction due to its compression of the brainstem as it traversed through the foramen magnum.

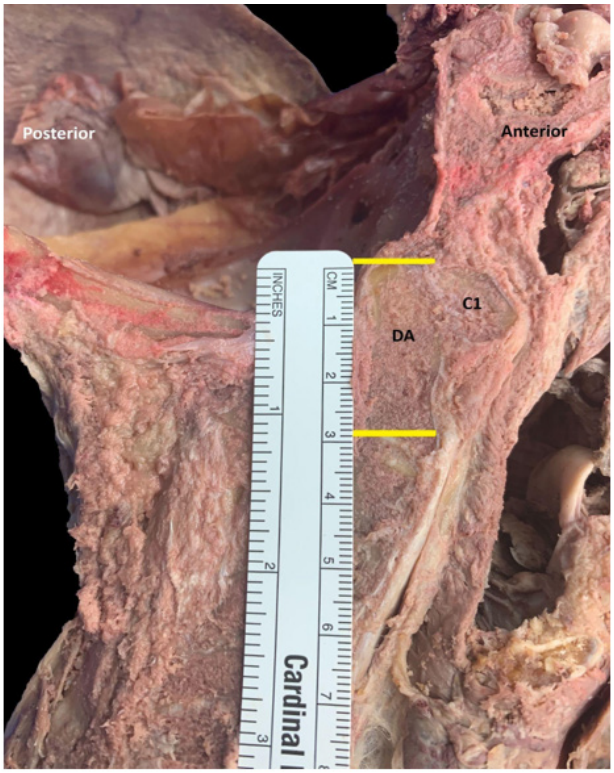

Figure 4) *The image shows the donor after hemisection, demonstrating fusion of the dens to the C1 ring and foramen magnum, with the dens ankylosis measuring 3 cm.*

Cranial base

On gross inspection of the cranial base, the structures beneath the tentorium cerebelli appeared symmetric (Figures 5 and 6).

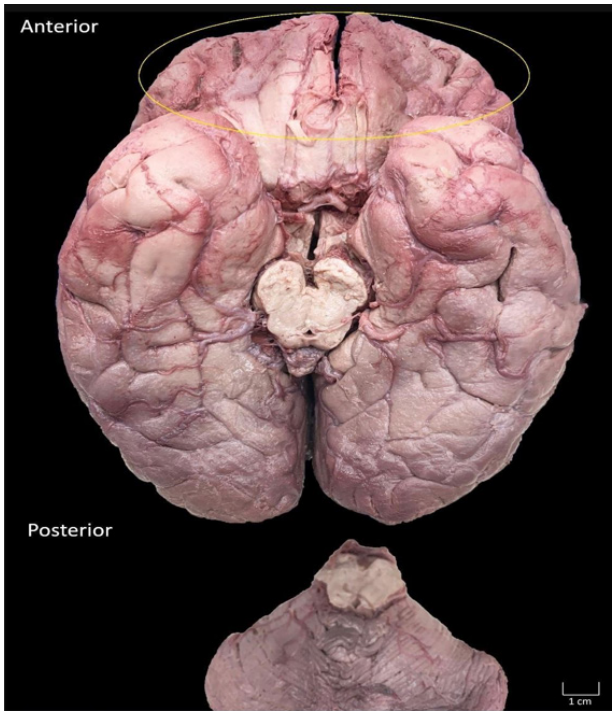

Figure 5) *Inferior view of the brain with the cerebellum (below) separated from the hemispheres (above). Image highlighting the inferior frontal lobe surface demonstrating loss of brain mass. These findings are likely due to post-mortem brain shrinkage.*

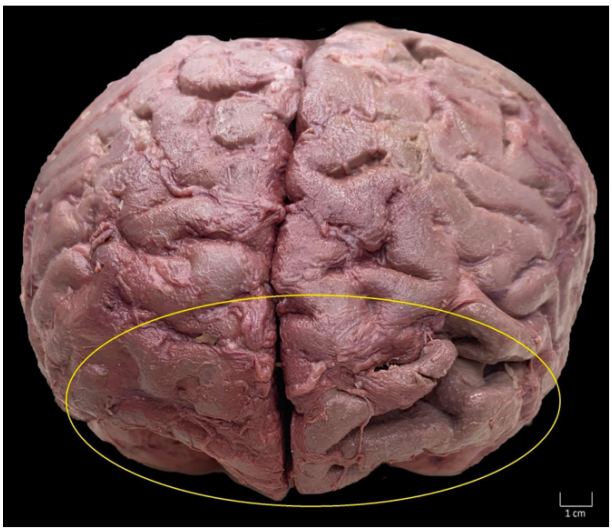

Figure 6) *Anterior view of the brain, highlighting the anterior frontal lobe surface, demonstrating loss of brain mass. In particular, note the large spaces between the superior and middle frontal gyri on the left frontal lobe. These findings are likely due to post-mortem brain shrinkage.*

Literature Review

A formal literature review searching for descriptions of bony anomalies of the foramen magnum, C1, and C2 vertebrae yielded a small number of similar findings. PubMed, EMBASE, and Web of Science were queried with the following terms:

PubMed

osteophytic OR bony OR calculus OR calicif OR ankylosis OR dens-ankylosis OR ankylosis-of-the-dens OR skeletal-fusion OR skeletal-anatomic*) AND (anatomical-variations OR "Anatomic Variation"[Mesh] OR growth OR protuberance OR tumor OR "Bone Neoplasms"[Mesh] OR "Brain Stem Neoplasms"[Mesh] OR "Skull Base Neoplasms"[Mesh]) AND (foramen-magnum OR "Foramen Magnum"[Mesh] OR "Cervical Atlas"[Mesh] OR "Brain Stem"[Mesh] OR "Medulla Oblongata"[Mesh])*

EMBASE

('osteophytic' OR 'bony' OR 'calculus' OR 'calicif' OR 'ankylosis' OR 'dens-ankylosis' OR 'ankylosis-of-the-dens' OR 'skeletal-fusion' OR 'skeletal-anatomic*') AND ('anatomical-variations' OR 'anatomical variation'/exp OR 'growth' OR 'protuberance' OR 'tumor' OR 'bone tumor'/exp OR 'brain stem tumor'/exp OR 'skull base tumor'/exp) AND ('foramen-magnum' OR 'foramen magnum'/exp OR 'first cervical vertebra'/exp OR 'brain stem'/exp OR 'medulla oblongata'/exp)*

Web of science

ALL=(osteophytic OR bony OR calculus OR calicif OR ankylosis OR dens-ankylosis OR ankylosis-of-the-dens OR skeletal-fusion OR skeletal-anatomic*) AND ALL=(anatomical-variations OR growth OR protuberance OR tumor OR Neoplasm) AND ALL=(foramen-magnum OR Cervical-Atlas OR Brain-Stem OR Medulla-Oblongata)*

On the date of retrieval (March 20, 2025), these terms yielded 156 results from PubMed, 203 results from Embase, and 76 results from Web of Science. Titles and abstracts were screened

for relevance, and the remaining articles were reviewed in full.

The articles remaining after final exclusions described various anatomical anomalies and tumors of the skull base, C1, and C2, none of which was a perfect match for the lesion found in our specimen. These cases are briefly summarized below.

Discussion

Common developmental variants of C1 and C2 include those of the posterior bridge and vertebral foramen, transverse vertebral foramen, dorsal foramen, C1 arches, and C1 superior articular fossa [7]. None of the variants of these structures encroaches on the foramen magnum or spinal canal, as the anomaly in our specimen did. Shoja et al. (2018) described many developmental anomalies and osseous variations of the skull base [8]. Similarly, none of these variations as described was similar to our anomaly. Additionally, Avci et al. (2011) and McRae (1969) described several skull base anomalies, none of which encroached on the foramen magnum or spinal canal [9,10].

Specific common congenital anomalies of the craniocervical junction were considered. Os Odontoideum (OO) is an ossicle adjacent to the dens [11]. Still, unlike our specimen's lesion, OO is detached from the dens, rather than fused to it, and features continuous cortical margins [12-13]. Persistent ossiculum terminale, another congenital anomaly, is often found incidentally on imaging and radiographically mimics a dens fracture [14]. However, it is not described as an enlargement of the dens, nor is it known to encroach on the spinal cord, as the lesion in our specimen did.

Several investigators reported chondromas, enchondromas, and osteochondromas in the area [15-18]. None of those pathologies arose from the dens, however, or presented in the anterior foramen magnum. These lesions are composed of mature bone and cartilaginous tissue, and have been described grossly as yellow-reddish, rubbery masses, whereas our specimen was rigid and bony [15].

Chordomas have also been reported around the CVJ [19-21]. These tumors, however, were described as much more heterogeneous than the one found in our donor. They often contain mucinous, fibrotic, and cystic areas, and display gross multi-hued coloring, unlike our donor, whose lesion consisted of homogenous bone.

Oohori et al. (2004) described a case of resection of a retro-odontoid pseudotumor, a common complication of rheumatoid arthritis [22]. While our donor exhibited many characteristic findings of rheumatoid arthritis, Oohori et al. (2004) described the resected lesion as yellow and irregular, unlike the growth in our donor, which was osseous in origin [22].

Muzumdar et al. (2010) described a case of pediatric osteoblastoma in the area [23]. The description and anatomical photographs of the lesion were similar to those of our donor; however, it was much larger. Osteoblastoma is classically described as a painful lesion that does not respond to analgesics. We cannot know if our lesion caused this kind of pain due to the limited information provided by the Maryland State Anatomy Board.

Sen and Sekhar (1991) enumerated some of the most common neoplasms of the anterior foramen magnum [24]. Their list included meningiomas, neurilemmomas, and metastases. The appearance and gross characteristics of our donor's dens ankylosis did not fit the characteristics of any of these, and the data attached to our donor did not include a cancer diagnosis from which our lesion may have metastasized.

The remainder of the relevant literature dealt with individual case reports and unusual presentations of lesions at the craniovertebral junction. Feldman et al. (1979) described a case of Paget's disease of bone causing encroachment of the dens into the posterior fossa, which stretched the brainstem, much like the lesion in our donor [25]. Our donor, however, showed no other signs of Paget's disease, and the bony growth of the dens displayed none of the classical characteristics associated with Paget's disease, such as a woven structure. Slavotinek (1991) described a bony exostosis of the C1 vertebra causing cranial nerve XII palsy; however, the lesion did not encroach on the foramen magnum and was found to the left of the midline [26]. Vergne et al. (1966) described synovial and ganglion cysts in the region, but these contained fluid or gelatinous material, and did not present as bony growths [27]. Finally, Goel and Shah [2010] described a case of post-traumatic bony growth of the clivus and odontoid process in a 19-year-old [28]. The lesion was described as softer than normal bone upon resection, while the specimen in our donor was not soft.

This case presents a previously uncharacterized anomaly of the craniovertebral junction, distinct from other lesions in that region described in the literature, and likely represents a novel condition. Our donor's fusion at the CVJ and resultant compression of the brainstem likely resulted in restricted craniocervical mobility and may have affected brainstem function [29]. For this donor, whose medical history included Parkinson's disease, brainstem compression may have exacerbated or mimicked symptoms of Parkinson's by affecting postural instability, autonomic dysregulation, or neurodegenerative progression.

While this case illustrates a potentially novel anomaly of the CVJ, our report is not without limitations. Due to the rules governing Maryland tissue donations, very little information was available about our donor's medical history. It was, therefore, impossible to probe the patient's history or clinical presentation for signs and symptoms that may have been related to the lesion, and our conjectures are purely hypothetical. Histopathological analysis was impossible due to the condition of the tissue and formalin fixation, so our observations were limited to gross analysis. Another constraint of the donation rules prohibits radiologic imaging of specimens. We can, therefore, only speculate on what radiologic findings may have been present. A thorough radiologic differential diagnosis for any such osseous lesion must include consideration of congenital anomalies (like *os odontoideum* and persistent *ossiculum terminale*), chronic inflammatory processes (such as rheumatoid arthritis pseudotumor), and various bone neoplasms (including chordoma or osteoblastoma) before a novel variant is confirmed.

Clinically, awareness of such anatomical variants is crucial for accurate radiological interpretation and surgical planning, particularly in procedures involving the skull base or superior cervical spine. While this anomaly may be rare, its potential to influence neurological status highlights the importance of including structural anomalies in differential diagnoses involving unexplained brainstem or cervical spinal cord symptoms.

Finally, this case illustrates the enduring educational value of human donor dissection. Beyond reinforcing classical anatomical relationships, it provides future clinicians with exposure to rare but clinically significant anomalies. Continued documentation and analysis of such variants will enhance our understanding of their prevalence, clinical impact, and diagnostic recognition in both anatomical and medical practice.

Conclusion

This case report describes a previously unreported ankylosis of the dens to both the anterior arch of C1 and the anterior rim of the foramen magnum. Unlike previously documented anomalies of the CVJ, this lesion was osseous, rigid, and directly encroached upon the cervicomedullary junction. Although no direct clinical inferences can be made as to the lesion's contribution to any underlying pathophysiology, its location and compression on the brainstem could conceivably have contributed to a wide array of neurological signs and symptoms. This case underscores the importance of considering structural anomalies in the clinical context of unexplained brainstem or cervical symptoms. From an educational perspective, the finding highlights the enduring value of human donor dissection in exposing learners to rare lesions and variations with potential clinical significance. Continued documentation of such cases can expand our understanding of their prevalence, their possible contributions to neurologic findings, and whether they merit consideration in clinical and surgical practice.

Author Contributions

Conceptualization, J.K., P.M., H.M., A.S., G.G.; methodology, H.M., G.G.; validation, J.K., G.G.; formal analysis, J.K., P.M., H.M., A.S.; investigation, J.K., P.M., H.M., A.S.; resources, J.K., P.M., H.M., A.S., G.G.; data curation, J.K.; writing—original draft preparation, J.K., P.M., H.M., A.S., G.G.; writing - review and editing, G.W., E.M., M.X.L., K.L, J.J.V.-F., G.G.; visualization, G.W., G.G; supervision, G.G.; project administration, G.G. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement

This article and its contents were approved by the Human Anatomic Board Research Committee of the Uniformed Services University of the Health Sciences (April 25th, 2025).

Acknowledgment

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.29 We would also like to thank Dr. Gary Wind for his artistic contribution to the article's schematic. More of his artwork can be found on his educational website at http://www.vesalius.com. Additionally, we would like to thank Mr. Paul Levett from the Uniformed Services University Learning Resource Center for his assistance with compiling the search terms and facilitating our literature review.

Disclaimer

The contents of this presentation are the sole responsibility of the author(s) and do not necessarily reflect the views, opinions or policies of Uniformed Services University of the Health Sciences (USUHS), The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., the Department of Defense (DoD) or the Departments of the Army, Navy, or Air Force. Mention of trade names, commercial products, or organizations does not imply endorsement by the U.S. Government.

References

1. Offiah CE, Day E. The craniocervical junction: embryology, anatomy, biomechanics and imaging in blunt trauma. Insights Imaging. 2017;8:29-47.
2. Lopez AJ, Scheer JK, Leibl KE, et al. Anatomy and biomechanics of the craniovertebral junction. Neurosurg Focus. 2015;38:E2.
3. Tubbs RS, Hallock JD, Radcliff V, et al. Ligaments of the craniocervical junction. J Neurosurg Spine. 2011;14:697-709.
4. Menezes AH. Craniovertebral junction anomalies: diagnosis and management. Semin Pediatr Neurol. 1997;4:209-23.
5. Murphy SN, Nguyen BA, Singh R, et al. A brief human history of ankylosing spondylitis: a scoping review of pathogenesis, diagnosis, and treatment. Surg Neurol Int. 2022;13:297.
6. Roussou E, Sultana S. Spondyloarthritis in women: differences in disease onset, clinical presentation, and Bath Ankylosing Spondylitis Disease Activity and Functional Indices (BASDAI and BASFI) between men and women with spondyloarthritides. Clin Rheumatol. 2011;30:121-7.
7. Wysocki J, Bubrowski M, Reymond J, et al. Anatomical variants of the cervical vertebrae and the first thoracic vertebra in man. Folia Morphol. 2003;62:357-63.
8. Shoja MM, Ramdhan R, Jensen CJ, et al. Embryology of the craniocervical junction and posterior cranial fossa, part I: development of the upper vertebrae and skull. Clin Anat. 2018;31:466-87.
9. Avci E, Dagtekin A, Ozturk AH, et al. Anatomical variations of the foramen magnum, occipital condyle and jugular tubercle. Turk Neurosurg. 2011;21:181-90.
10. McRae DL. Bony abnormalities at the cranio-spinal junction: Chapter XVIII. Neurosurg. 1969;16:356-75.
11. Cho S, Shlobin NA, Dahdaleh NS. Os odontoideum: a comprehensive review. J Craniovertebr Junction Spine. 2022;13:256-64.
12. Ogut E, Şekerci R, Şen H, et al. Anatomo-radiological importance and the incidence of os odontoideum in Turkish subjects: a retrospective study. Surg Radiol Anat. 2020;42:701-10.
13. Ogut E. Anatomical variability, morphofunctional characteristics, and clinical relevance of accessory ossicles of the back: implications for spinal pathophysiology and differential diagnosis. J Orthop Surg Res. 2025;20:240.
14. O'Brien WT Sr, Shen P, Lee P. The dens: normal development, developmental variants and anomalies, and traumatic injuries. J Clin Imaging Sci. 2015;5:38.
15. Inoue T, Ohara Y, Niiro T, et al. Cervical periosteal chondroma causing spinal cord or nerve compression: 2 case reports and literature review. World Neurosurg. 2018;114:99-105.
16. Lotfinia I, Vahedi P, Tubbs RS, et al. Basioccipital bone osteochondroma growing into the foramen magnum. Surg Neurol Int. 2012;3:21.
17. Miyakoshi N, Hongo M, Kasukawa Y, et al. Cervical myelopathy caused by atlas osteochondroma and pseudoarthrosis between the osteochondroma and lamina of the axis: case report. Neurol Med Chir. 2010;50:346-9.
18. Wani AA, Zargar JI, Ramzan AU, et al. Isolated enchondroma of atlas. Turk Neurosurg. 2011;21:226-9.

19. Goodarzi A, Toussi A, Lechpammer M, et al. Intradural chordoma of cerebellopontine angle: case report and review. World Neurosurg. 2017;107:1052-e11.

20. Ozek E, Bolukbasi FH, Baskan O, et al. Prepontine chordoma presenting with MRI features of an epidermoid cyst: case presentation and a mini-review. Curr Med Imaging Rev. 2018;14:147-50.

21. Tamaki M, Aoyagi M, Kuroiwa T, et al. Clinical course and autopsy findings of a patient with clival chordoma who underwent multiple surgeries and radiation during a 10-year period. Skull Base. 2007;17:331-40.

22. Oohori Y, Seichi A, Kawaguchi H, et al. Retroodontoid pseudotumor resected by a high cervical lateral approach in a rheumatoid arthritis patient: a case report. J Orthop Sci. 2004;9:90-3.

23. Muzumdar D, Balasubramaniam S, Jhawar S, et al. Massive benign osteoblastoma of the suboccipital bone and foramen magnum region. Pediatr Neurosurg. 2010;46:232-7.

24. Sen CN, Sekhar LN. Surgical management of anteriorly placed lesions at the craniocervical junction-an alternative approach. Acta Neurochir. 1991;108:70-7.

25. Feldman RG, Culebras A, Schmidek HH. Paget's disease and the nervous system. J Am Geriatr Soc. 1979;27:1-8.

26. Slavotinek JP, Brophy BP, Sage MR. Bony exostosis of the atlas with resultant cranial nerve palsy. Neuroradiol. 1991;33:453-4.

27. Vergne P, Bonnet C, Zabraniecki L, et al. Synovial cyst at the C1-C2 junction and spondyloarthropathy. J Rheumatol. 1996;23:1438-40.

28. Goel A, Shah A. Unusual bone formation in the anterior rim of foramen magnum: cause, effect and treatment. Eur Spine J. 2010;19:162-4.

29. Iwanaga J, Singh V, Ohtsuka A, et al. Acknowledging the use of human cadaveric tissues in research papers: recommendations from anatomical journal editors. Clin Anat. 2021;34:2-4.