

Technical Notes & Surgical Techniques

Far-lateral trans-atlas extradural resection of retro-odontoid synovial cyst: Surgical technique and review of literature



Badih Adada (M.D.), Maria A. Vera Silva (M.D.)*, Houssein Darwish (M.D.), Elias Dakwar (M.D.)

Department of Neurosurgery, Cleveland Clinic Florida, 2950 Cleveland Clinic Blvd, Weston, FL 33331, United States of America

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ABSTRACT

Background and importance: Synovial cysts of the cranio-cervical junction constitute an uncommon pathology in neurosurgical practice. Different surgical approaches have been described for treating those lesions including trans-oral microsurgical approaches, endoscopic endo-nasal approaches and sub-occipital trans-dural approaches.

Objective: The purpose of this article is to describe a case of resection of a retro-odontoid synovial cyst through a modified far-lateral trans-atlas extradural approach. A detailed surgical plan with cadaveric dissection is presented as well as literature review of surgical approaches.

Methods: The authors describe an 86-year-old man presenting with gradual deterioration of his gait as well as upper and lower extremities weakness. He was found to have an odontoid pannus accompanied by midline retro-odontoid cyst on MRI. An anatomical cadaveric dissection describing the modified far-lateral trans-atlas extradural approach is described and then used to completely resect the cystic lesion, decompress the brain stem and perform a fusion of the cranio-cervical junction.

Result: This surgical technique allows for the decompression and fusion to be performed in the same operative time, avoids the contaminated surgical fields encountered during anterior approaches and prevents CSF leakage by avoiding dura opening.

Conclusion: Modified Far-Lateral Transatlas Approach offers several advantages when compared with the other options and can provide an alternative to treat these patients.

1. Introduction

Cysts of the atlantoaxial joint are an infrequent cause of cervico-medullary compression [1]. They usually present in older patients and those with rheumatoid arthritis [1]. In recent years, several cases have been reported [1]. They typically present with symptoms associated with a space occupying lesion in the cervical spine and consist of radiculopathy for the more lateral lesions and myelopathy when the spinal cord and the brainstem are compressed [2,3]. Occasionally some asymptomatic patients will develop sudden onset symptoms after an acute hemorrhage in the cyst or a marked increase in its size [4]. Although the natural history of synovial cysts is unpredictable, and some patients experience improvement or stabilization of their symptoms without surgery [3,5–7]. Early recognition and surgical resection of cysts involving the cranio-cervical junction are desirable to avoid sequelae resulting from compression of the brainstem [1]. Several surgical approaches have been described for resecting those cysts including anterior trans-oral/trans-nasal [8–11], trans-dural [12] through a

posterior sub-occipital craniotomy and finally far lateral approaches [13,14].

We reviewed the literature for described surgical approaches for resection of a retro-odontoid synovial cyst. A modified far-lateral trans-atlas extradural approach for resecting those cysts is reported. A detailed surgical plan with cadaveric dissection demonstrating the relevant surgical anatomy is presented.

1.1. Patient and method

An 86-year-old man with a past medical and surgical history positive for rheumatoid arthritis and hip replacement as well as lumbar decompression, was evaluated at our institution complaining of gradual deterioration of his balance, an unsteady gait, upper and lower extremities weakness and neck pain exacerbated by flexion. His physical examination demonstrated an unsteady gait requiring the use of a cane. Muscle strength was 4/5 in all major muscle groups in his upper and lower extremities and exaggerated deep tendon reflexes in his four

* Corresponding author.

E-mail address: VERASIM@CCF.ORG (M.A. Vera Silva).

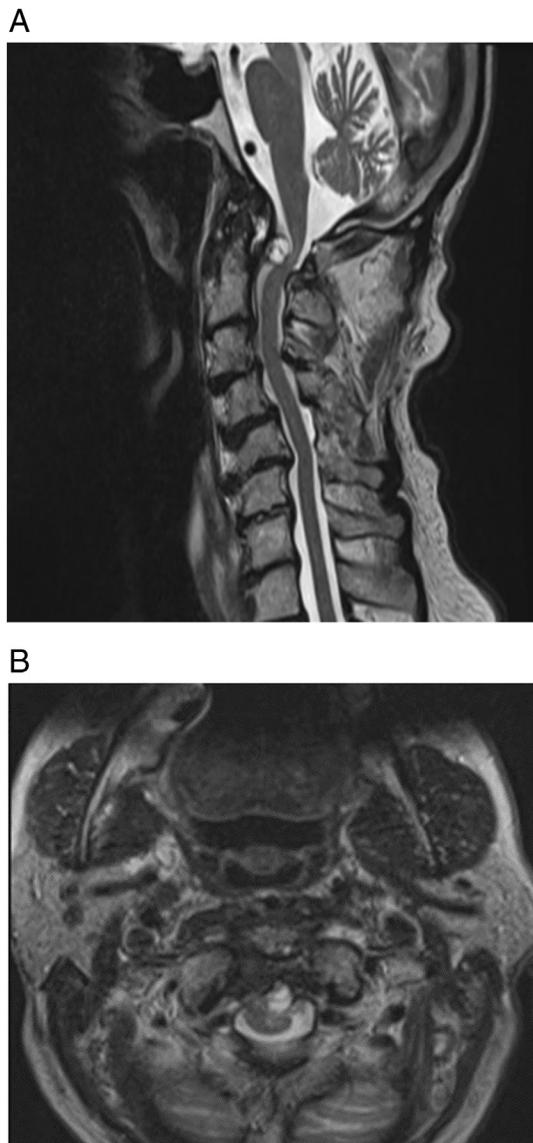


Fig. 1. Preoperative MRI showing the pannus and the retro-odontoid cyst severely compressing cervico-medullary junction in sagittal (A) and axial (B) T2 cuts.

extremities, his plantar reflex demonstrated an upward response of the toe bilaterally. An MRI of the cervical spine revealed an odontoid pannus formation accompanied by a midline retro-odontoid cyst causing significant mass effect on the cervico-medullary junction (Fig. 1). An X-ray of the cervical spine with flexion-extension views did not show any instability and demonstrated a normal anterior atlas to dens interval (AADI). Since the patient was presenting with a progressive myelopathy and significant cervico-medullary junction compression it was decided to surgically resect the cyst and to stabilize the cranio-cervical junction to stop the progression of the pannus and promote its resolution.

2. Results

2.1. Cadaveric dissection and relevant anatomy

A formalin-fixed, silicon-injected adult cadaveric head was analyzed, and specific attention was directed to the muscular, bony and ligamentous anatomy around the lateral aspect of the occipital condyle, lateral mass of C1 and C2 and the anterior aspect of the foramen

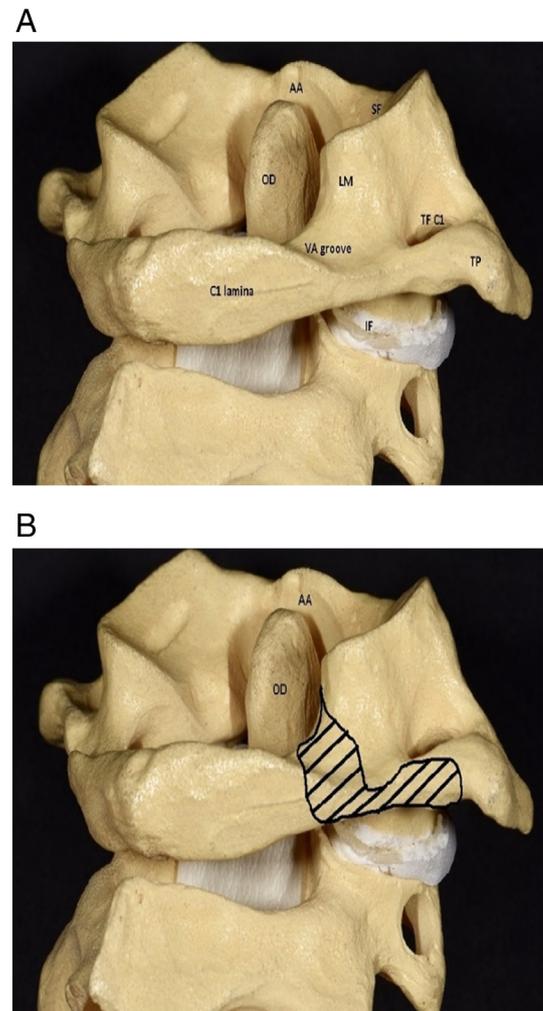


Fig. 2. Cervical spine model showing the bony elements of upper cervical vertebrae in oblique (A,B) views. Shaded area in (B) shows the bony segment that is drilled (VA groove in the C1 lamina, medial aspect of C1 lateral mass and the transverse process covering the vertebral artery). After drilling, there is direct access of the odontoid and the C1 anterior arch. AA, anterior arch; IF, inferior articular surface; LM, lateral mass; OD, odontoid; SF, superior articular surface; SP, spinous process; TP, transverse process; TF, transverse foramen; VA (vertebral artery).

magnum. A retro-auricular skin incision centered around the lateral mass of C1 was performed.

Once the skin and the sternocleidomastoid muscle were reclin ed anteriorly the splenius capitis attaching to the occipital bone between the superior and inferior nuchal lines was identified. The next muscular layer consists of the semispinalis and longissimus capitis; the occipital artery runs through the digastric groove and superior to this muscular layer. Below this layer is the sub-occipital triangle consisting of the superior and inferior obliques and the rectus capitis posterior major. The superior oblique inserts on the lateral tip of the transverse process of the atlas and runs towards the occipital bone at the level of the inferior nuchal line. The inferior oblique attaches to the inferior aspect of the transverse process of C1 and goes towards the spinous process of C2. Once the muscles of the sub-occipital triangle were elevated from the underlying bony structures, the occipital condyle, lateral mass of C1 and lateral mass of C2 came into view. The vertebral artery was seen exiting the transverse foramen of C1 and running postero-medially along the vertebral groove of the posterior arch of C1. Once the vertebral artery was mobilized from its groove and the lateral mass of C1 was drilled and the lateral aspect of the posterior arch of the atlas was

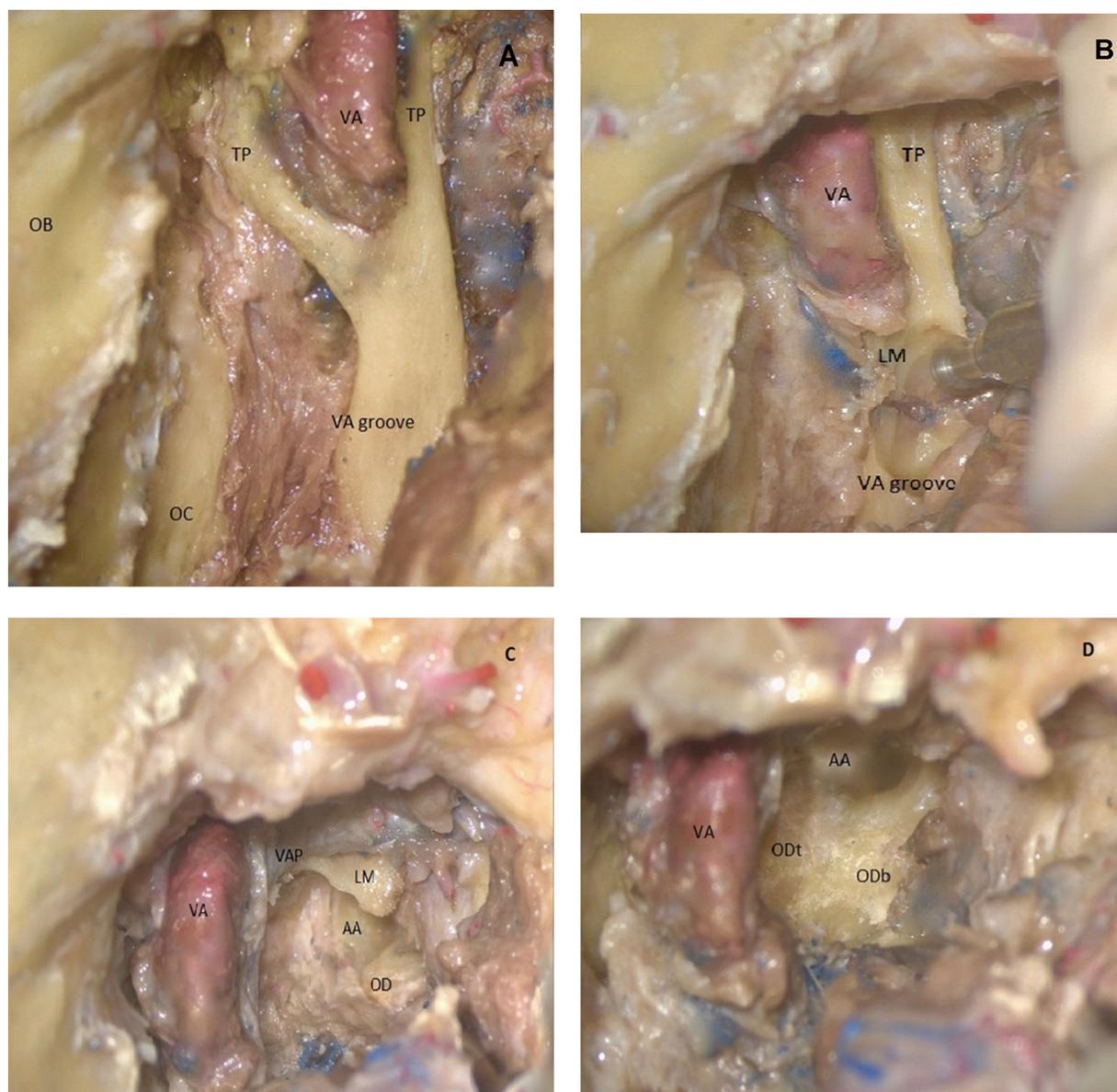


Fig. 3. Cadaveric demonstration under microscope. Head in lateral position, right sided approach, before drilling of the transverse process, lateral mass of C1 and the C1 VA groove (A), Drilling of the transverse process of C1 and exposure of the vertebral artery as well as the VA C1 groove and partial drilling of the medial aspect of C1 lateral mass (B), exposure of the odontoid as well as the anterior arch of C1 (C), and a more magnified view of the odontoid from base to tip as well as the anterior arch of C1 (D). AA, anterior arch; LM, lateral mass; OB, occipital bone; OC, occipital condyle; OD, odontoid; ODb, odontoid base; ODt, odontoid tip; TP, transverse process; VA, vertebral artery; VAP, vertebral artery venous plexus.

removed the horizontal aspect of the cruciform ligament that attaches the lateral mass of C1 was identified (Fig. 2). A synovial joint between the cruciform ligament and the dens was identified. Posterior to the cruciform ligament is the tectorial membrane, a continuation of the posterior longitudinal ligament of the cervical spine. Attached to the dens are the allar and apical ligaments. Once the dens were drilled and removed a synovial joint between the anterior aspect of the dens and the atlas was identified (Figs. 3,4).

2.2. Surgical technique

Under general anesthesia, endotracheal intubation, the patient was positioned in a sitting position. The head was kept neutral. Intraoperative somatosensory evoked potentials (SSEP) and motor evoked potentials were obtained. A C-shaped incision starting above the ear pavilion, curving posteriorly and inferiorly was performed. The skin flap was elevated sub-galeally and reclined anteriorly. The

ligamentum nuchae was incised and the sub-occipital muscles including the splenius capitis and the semi-spinalis capitis were elevated subperiosteally, the occipital artery running through the digastric groove was isolated and divided, the muscle flap was reclined postero-inferiorly. The occipital squama as well as the posterior arch of C1 were exposed. At this point the microscope was introduced to the surgical field and the rest of procedure was continued using micro surgical techniques. The inferior and superior obliques were elevated off the occiput and C1 and a sub-periosteal dissection along the posterior arch of C1 was continued exposing the vertebral artery groove and the transverse foramen. The vertebral artery at the groove of C1 was mobilized subperiosteally superiorly allowing us to drill the lateral posterior arch of C1 as well as open the transverse foramen. A 4-0 nylon was placed on the areolar tissue surrounding the vertebral artery and used to suspend it superiorly expanding the space below the artery, allowing us to continue drilling the lateral mass of the atlas all the way towards the odontoid. The odontoid and the pannus around it were

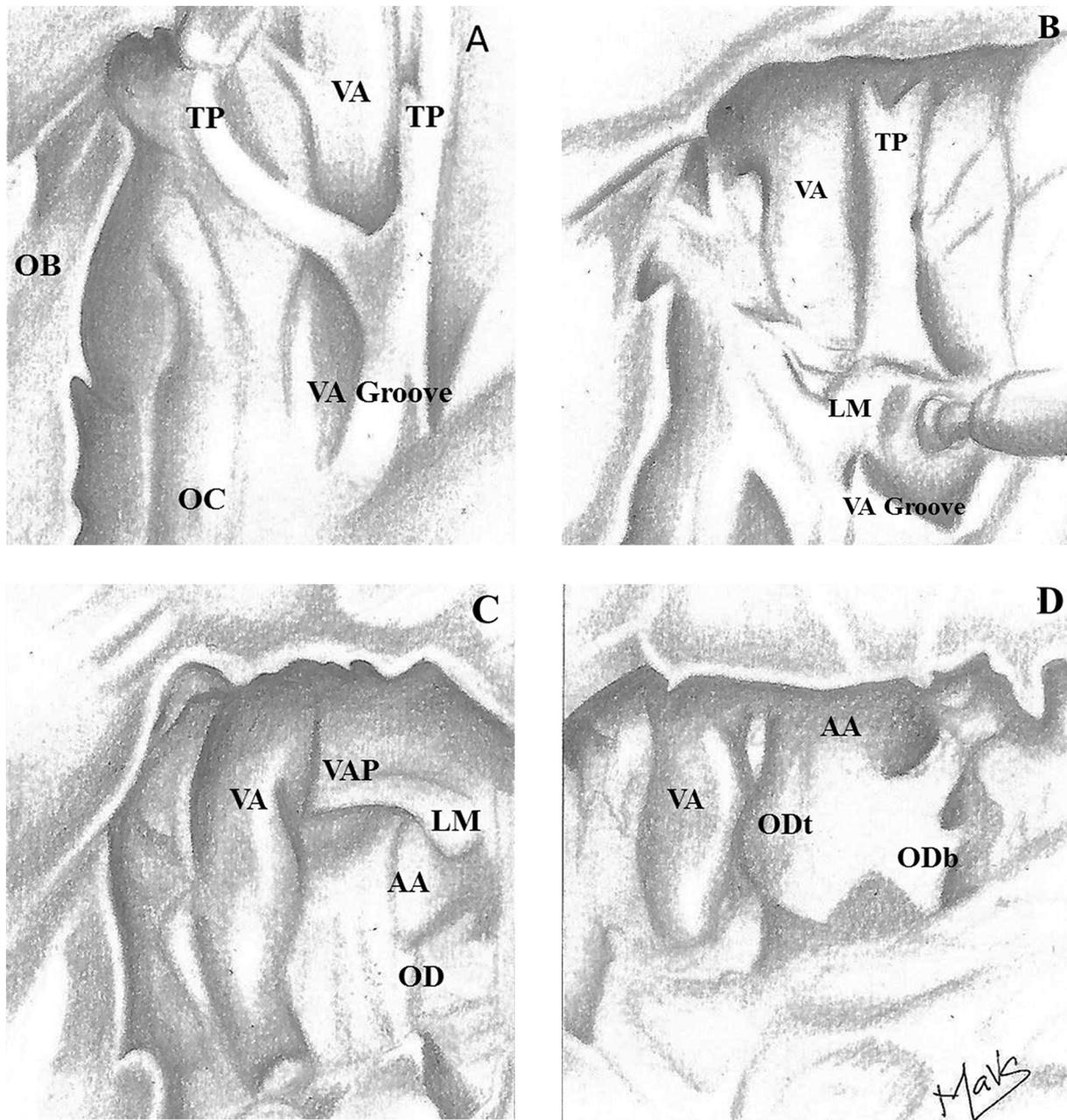


Fig. 4. Artist's rendition of the cadaveric demonstration. Head in lateral position, before drilling of the transverse process, lateral mass of C1 and the C1 VA groove (A), Drilling of the transverse process of C1 and exposure of the vertebral artery as well as the VA C1 groove and partial drilling of the medial aspect of C1 lateral mass (B), exposure of the odontoid as well as the anterior arch of C1 (C), and a more magnified view of the odontoid from base to tip as well as the anterior arch of C1 (D). AA, anterior arch; LM, lateral mass; OB, occipital bone; OC, occipital condyle; OD, odontoid; ODb, odontoid base; ODt, odontoid tip; TP, transverse process; VA, vertebral artery; VAP, vertebral artery venous plexus.

identified. Partial resection of the pannus was performed decompressing the ventral aspect of the spinal cord. The cyst was visualized between the odontoid and the dura and then resected. At this point proceed with performing an occiput to C2 fusion. A C2 pedicle screw was first placed. We initially started with a high-speed drill performing a pilot hole. We then used a guided drill bit and drill a pedicle screw tract approximately 20 mm in length. The tract was palpated with a ball-ended tip for integrity. A favored-angled 4.0 mm × 20 mm screw was inserted. An occipital plate overlying the left side of the occiput was then placed. Since the patient's occipital squama was found to be very thin, small bi-cortical 6 mm occipital screws were placed. Four screws were placed in total. A contoured titanium rod was then placed into the Tulip heads connecting with the occipital plate to the C2 pedicle screw.

2.3. Postoperative course

The patient's postoperative course was uneventful and neurological examination revealed improvement in his gait as well as strength of the patient's extremities. A postoperative MRI of the cervical spine showed complete resection of the cyst and good decompression of the cranio-cervical junction (Fig. 5). The pathology was consistent with a synovial cyst associated with a pannus. One month after surgery, the patient underwent an MRI which revealed total resection of the cyst with decompression of the cervical spinal cord.

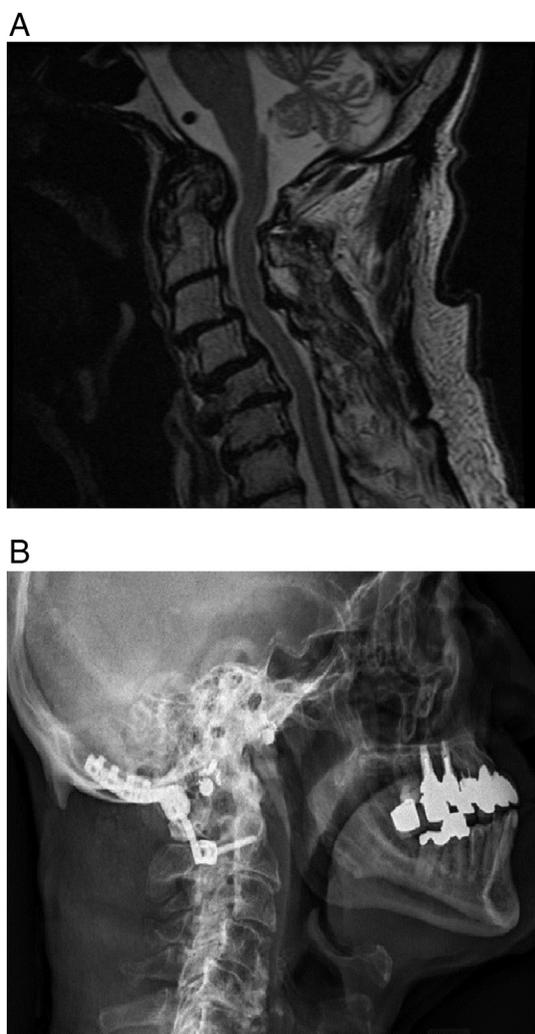


Fig. 5. Post-operative MRI shows decompression of the cord with partial pannus and total retro-odontoid cyst resection (A) and postoperative lateral X-ray shows the unilateral occipito-cervical fusion (B).

2.4. Systematic review

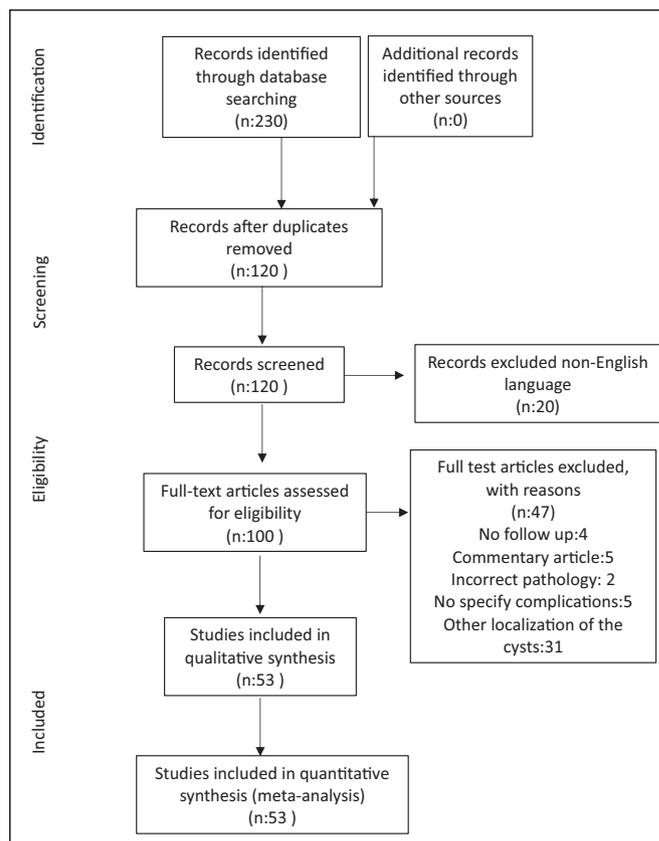
Our PubMed search yielded 230 articles related to the topic. After applying the exclusion criteria (Table 1), we obtained 52 articles of retro-odontoid cysts. Number of patients, approaches, resection and complications are listed in Table 2.

This study does not have IRB approval because individual medical history was kept confidential and was not used in reporting the result of the study. HIPAA rules were followed in maintaining patient privacy. No changes were made to the routine patient care process and a data monitoring committee was not required. This study does not require a consent, because we reviewed medical records and the patient privacy was respected.

3. Discussion

Several non-neoplastic, space occupying lesions occur at the cranio-cervical junction [5,15–20]. Among them are pseudo-tumors, composed of amorphous degenerative fibrocartilaginous material developing as a result of ligamentous repeated injury and micro-bleeding [15,16]. Thickening of the transvers ligament [12] and pannus formation [17] as a result of an inflammatory response [21–25] seen in the setting of rheumatoid arthritis is another [26]. Finally, synovial cysts occurring at the atlantoaxial joints [13] located between the lateral masses of the

Table 1
Study selection using an order outlined by the PRISMA group.



atlas and axis, or between the odontoid process and the cruciform ligament can present as non-neoplastic space occupying lesions [21]. It is hypothesized that synovial fluid extrusion from the joint capsule caused by increased motion at the joint leads to synovial cysts formation [27]. Mechanically stressed joints [28] undergo an up regulation of inflammatory factors [21–25] resulting in further joint degeneration and cyst formation with latent growth and metaplasia of synovial tissue [4,8].

Differentiating these degenerative lesions from neoplastic pathologies occurring at the cranio-cervical junction has been facilitated by the widespread use of CT and MRI [29]. Flexion extension X-rays of the cervical spine in the setting of these pathologies are important to obtain as the atlanto-axial ligaments are often damaged resulting in mechanical instability [30].

Surgical resection of retro-odontoid synovial cysts presenting with myelopathy is the cornerstone of treatment [12]. Several approaches have been described to deal with these lesions (Table 2) [1,5,8–17,21,23–25,27,31–65]. They are divided into anterior approaches: microsurgical (trans-oral) or endoscopic (endo-nasal), posterior trans-dural approaches [12], and finally lateral extradural approaches [1].

A two-staged anterior approach [66] followed or preceded by a posterior fusion has been the procedure most commonly used to treat atlantoaxial synovial cysts [34,37,38,43,51,52,55,56,67,68]. This approach provides versatile and direct access to extradural midline lesions and it has been used for many years [51]. The trans-oral decompression is limited by a deep, narrow and contaminated surgical field [69]. It has several associated morbidities including the risk of developing a CSF fistula, higher risk of infection because of the nature of the surgical field, problems with speech and swallowing [1,62,68,70]. The incidence of postoperative sepsis, cervical infection, respiratory or cardiac complications was reported in up to 8.3% of patients [12].

Table 2
Approach and complications in patients with retroodontoid synovial cysts.

First Author	Year	# of patients	Approach	Resection	Complications
Onofrio and Mih [27]	1988	10	Laminectomy; C1–2	Complete	None
Miller et al. [31]	1989	9	Laminectomy, C1–2	Complete	None
Quaghebeur et al. [32]	1992	8	Laminectomy C1–2	Complete	None
Goffin et al. [33]	1992	7	Laminectomy; C1–2	Subtotal resection	None
Choe et al. [34]	1993	6	Transoral; C1–C2 fusion	Complete	None
Kaufmann et al. [35]	1996	1	Transoral odontoidectomy and decompression	Complete	None
Vergne et al. [36]	1996	1	C1 laminectomy	Biopsy	None
Zünkele et al. [37]	1996	21	15 Transoral transpalatopharyngeal 6 posterior fusion	Complete	Pneumonia
Birch et al. [38]	1996	5	2 Transoral decompression and fusion, 2 laminectomy, 1 observation	Complete	None
Fransen et al. [39]	1997	1	Postero-lateral approach, partial drilling of the condyle + C1 and C2 hemilaminectomy	Complete	None
Akiyama et al. [40]	1999	1	Laminectomy, transcondylar resection, lateral suboccipital craniotomy, posterior instrumented fusion.	Complete	None
Aksoy and Gomori [41]	2000	1	C1–2 Laminectomy with anterior fusion	No	None
Ito et al. [42]	2000	1	Posterior C1–C2 transarticular fusion	Complete	None
Chang et al. [24]	2000	1	Posterior C1–2 wiring and fusion	No	None
Cai et al. [43]	2001	2	Transoral decompression + posterior craniocervical fusion	Complete	Wound infection
Isono et al. [44]	2001	1	C1 laminectomy		Initial aggravation of symptoms followed by improvement
Zorzon et al. [1]	2001	2	Postero-lateral approach with C1–C2 Hemilaminectomy	Subtotal resection	None
Frempong et al. [11]	2002	1	Endoscopic transoral	Complete	None
Takahashi et al. [45]	2003	1	MR- guided percutaneous fenestration	No	None
Eustacchio et al. [46]	2003	1	C1 hemilaminectomy, suboccipital craniotomy	Subtotal resection	None
Okamoto et al. [23]	2004	1	Right hemilaminectomy, posterior fusion	Subtotal resection	None
Sagiuchi et al. [47]	2006	1	Philadelphia collar, later C1–2	No	None
Matsumoto et al. [48]	2006	1	Removal of posterior arch of atlas, occiput-C6		None
Suetsuna et al. [49]	2006	3	C1 laminoplasty w/o fusion	Complete	None
Cihanek et al. [50]	2008	1	C1–C2 transarticular fixation	No	None
Fenoy et al. [51]	2008	21	5Transoral-transpalatopharyngeal. 16 posterior fusion	Complete	Palatal wound dehiscence. Pneumonia
Cecchi et al. [25]	2008	1	Philadelphia collar + NSAIDs and corticosteroids	No	None
Velan et al. [21]	2008	1	Percutaneous cyst aspiration.	Subtotal resection	Recurrence
Kirk et al. [52]	2009	1	Transoral decompression, posterior instrumented fusion	Complete	None
Marbacher et al. [8]	2009	1	Transoral decompression, Fusion with transarticular screws	Complete	Atlantoaxial instability
Ogata et al. [16]	2009	1	Posterior C1–3 hooks, fusion	No	None
Aizawa et al. [53]	2010	1	Hemilaminectomy, foramen magnum craniectomy	Subtotal resection	None
Harries et al. [13]	2010	1	Far-lateral excision	Subtotal resection	None
Weng et al. [54]	2010	1	Posterior decompression, posterior instrumented fusion (craniocervical)	No	None
Lütjens et al. [14]	2011	1	Modified lateral approach	Complete	None
Van Gompel et al. [55]	2011	10	9 Transoral decompression + posterior craniocervical fusion. 5 posterior decompression.	Complete	None
Takeuchi et al. [15]	2011	1	Surgical decompression with atlantoaxial fixation	Subtotal resection	None
Lyons and Birch [56]	2011	11	Transoral decompression + posterior fusion	Complete	None
Parks et al. [57]	2013	1	Posterior decompression, posterior instrumented fusion (craniocervical) with transarticular screws		None
Kakutani et al. [17]	2013	7	C1 laminectomy with or without laminoplasty	Reduction	None
Sameshima et al. [58]	2013	1	Hemilaminotomy, transcondylar resection	Complete	None
Ikegami et al. [59]	2013	1	Lateral atlantoaxial joint puncture, arthrography	No	None
Barbagallo et al. [60]	2013	5	5 C1-C2 fixation, 2 Occipitocervical fusion	Complete	None
Lee et al. [61]	2013	3	Anterior decompression and resection, posterior fusion	Complete	None
Puffer et al. [10]	2013	3	Transoral decompression + posterior occiput-C3 fusion, Posterior occiput C3 fusion and laminectomy with posterior occiput C2 fusion.	Subtotal resection	None
Klineberg et al. [9]	2014	1	Transoral aspiration	Complete	Respiratory distress and intubation
Ohnishi et al. [62]	2015	1	Anterolateral approach with C1 posterior arch and C1 lateral mass resection.	Complete	None
Hartmann et al. [63]	2016	1	C1 Laminectomy	Complete	None
Theodotou et al. [5]	2016	1	C1 partial laminectomy	Complete	None
Manhas et al. [64]	2016	1	C-1 laminectomy and far-lateral craniotomy	Complete	Recurrence
Shah et al. [65]	2016	2	C1–2 fusion only	Complete	None
Madhavan et al. [12]	2018	3	Posterior transdural with occipitalcervical fusion in 2 pts.	Complete	CSF leak

Although endoscopic anterior approaches may have less of the complications seen with the anterior trans-oral approach, it is typically reserved for lesions located above the level of the hard palate [11]. All anterior approaches will require a second stage to perform a posterior fusion [67]. This two-stage approach can be a cause of neurological deterioration and other medical morbidities [66].

The posterior approach through a sub-occipital craniotomy requires opening the dura to get to the anterior aspect of the foramen magnum [12]. It does allow the resection of cystic lesions that are para-median [70], however lesions that are truly midline as seen in our patient cannot be addressed using this approach. It is also difficult to address more solid lesions associated with those cysts, such as pannus or ligamentous thickening, through this route. Because of its trans-dural nature this approach has been associated with CSF leakage [12]. In those cases, surgery could result in undue brainstem retraction, higher rates of subtotal resection, and postoperative morbidity, due to inadequate exposure [70].

The lateral approach is extradural [70]. By removing the vertebral artery groove of the C1 lamina and partial drilling the medial aspect of the lateral mass of C1, allows a wide exposure of the dens including the associated pannus and synovial cyst. This was achieved without any traction on the dura. The occipito-cervical fusion treating and prevent any instability was performed during the same surgical approach.

The lateral trans-atlas approach offers several distinct advantages when compared to the other options [43]. The risk of postoperative infection, wound infection [43] or CSF leakage is lower when compared with the trans-oral approach, and it is best tolerated by elderly patients or those with medical co-morbidities [3,38]. The far lateral approach obviates the need for any spinal cord retraction and still provides a sufficient working space [14]. With this, technique the lower cranial nerves are not exposed and no incident of dysfunction associated with these nerves have been reported [69]. The risk of iatrogenic of spinal cord neurological deficits is decreased [69].

4. Conclusion

This far-lateral approach to the odontoid has several advantages including being extradural, allowing wide exposure of the odontoid, avoiding the contaminated oral fields and the morbidity associated with the trans-oral approach and finally allowing the completion of the fusion during the same surgical procedure.

Conflict of interest

None.

Disclosure of funding

None.

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