European Spine Journal
https://doi.org/10.1007/s00586-020-06405-8

CASE REPORT

The posterior cervical transdural approach for retro-odontoid mass pseudotumor resection: report of three cases and discussion of the current literature

M. Schomacher[1] · F. Jiang[2,3] · M. Alrjoub[4] · C. D. Witiw[3] · P. Diamandis[4] · M. G. Fehlings[3,5]

Received: 29 May 2019 / Revised: 2 March 2020 / Accepted: 30 March 2020

Abstract

Objective The treatment of a retro-odontoid pseudotumor mass associated with severe spinal cord compression is challenging due to the complex regional anatomy. Here, we present an attractive treatment option involving a single-stage posterior transdural microsurgical resection followed by instrumented cervical reconstruction.

Methods We describe three patients presenting with clinical signs of cervical myelopathy and an imaging finding of mucoid and fibrous soft or semi-soft retro-odontoid pseudotumor mass with significant spinal cord compression at the C1/C2 level. Given the severity of the symptoms, surgical decompression was planned and fusion was necessitated by the severe degenerative osteoarthritis seen at the C1/C2 level with signs of instability. Using a standard posterior approach to the spine, a suboccipital decompression by craniectomy and laminectomy of C1, C2 and C3 was performed. The masses were visualized and confirmed with ultrasound imaging, and intraoperative neurosurgical monitoring was applied. The dura was then opened from the level of C0–C2. Exiting C2–C3 nerve roots were identified and protected throughout the procedure, and the dentate ligament was cut to facilitate access. Incision of the anterior dura provided easy access to the lesion for resection without any spinal cord retraction. Multiple intraoperative samples were sent to pathology for tissue diagnosis. The dura was closed with sutures and an overlay of fibrin sealant with collagen matrix sponge. The fusion procedures were performed using a standard occipital cervical plate and screws technique with contoured titanium rods.

Conclusions The posterior cervical transdural approach is a safe alternative procedure for mucoid and fibrous soft or semi-soft retro-odontoid pseudotumor mass removal. Preoperative CT scan can evaluate tissue characteristics and distinguish between a soft or ossified mass in front of the spinal cord. Local anatomical conditions facilitate less bleeding and adhesions, together with less spinal cord traction, in the intradural space. Cranio-cervical and suboccipital stabilization can be easily and safely performed with this exposure.

Keywords Retro-odontoid mass · Transdural approach · Cervical spine · Surgical technique · Posterior approach · Atlantoaxial region

✉ M. G. Fehlings
michael.fehlings@uhn.ca

[1] Vivantes Neurochirurgie, Klinikum Neukoelln, Rudower Str. 48, 12351 Berlin, Germany

[2] Division of Orthopaedic Surgery, Department of Surgery, Toronto Western Hospital, University Health Network, 399 Bathurst Street, Toronto, ON M5T 2S8, Canada

[3] Division of Neurosurgery, Department of Surgery, Toronto Western Hospital, University Health Network, 399 Bathurst Street, Toronto, ON M5T 2S8, Canada

[4] Department of Pathology, Laboratory Medicine Program, University Health Network, University of Toronto, 200 Elizabeth Street, Toronto, ON M5G2C4, Canada

[5] Department of Surgery, University of Toronto, 149 College Street, Toronto, ON M5T 1P5, Canada

Published online: 15 April 2020

Introduction

The resection of a retro-odontoid pseudotumor mass in the atlantoaxial region, with or without associated spinal cord compression, is challenging. Potential surgical interventions are limited by the complex surrounding anatomy, the nature of the articular surfaces, crucial ligamental structures, and inconsistent location of the vertebral artery [1, 2]. Multiple retro-odontoid pseudotumors have been previously reported including synovial cysts, herniated discs, ganglion cysts, damaged or degenerated transverse ligaments and pseudogout [3–7].

Surgical intervention is usually warranted either for diagnostic biopsy or when the imaging finding correlates with clear clinical signs and symptoms of spinal cord compression and cervical myelopathy [8]. Given the difficulty in accessing the lesion due to the anatomical location, operative resection remains a risky and challenging task. Despite this, several surgical options have been described in the literature, including the anterior transoral approach, the far-lateral cervical approach, and the posterior extradural approach [9–11]. However, these techniques are technically challenging and no clear consensus for an optimal approach currently exists [12].

In this report, we present three cases of a retro-odontoid pseudotumor with significant spinal cord compression and symptoms of cervical myelopathy. We describe the successful treatment of these cases with posterior resection of the mass through a transdural approach, followed by cranio-cervical instrumentation and fusion.

Surgical technique

The surgery was performed with the patient in prone position. A stereotactic navigation imaging system was utilized for intra-operative referencing the C1/C2 region. Intraoperative neurophysiological monitoring was performed throughout the entire procedure.

The occipital and suboccipital region was exposed via a standard midline posterior approach. Prior to decompression, the trajectory and tracks for screws of the midline occipital plate, C1 lateral mass, C2 pedicle and subaxial lateral mass screws were prepared with the support of the navigation system.

With the aid of a surgical microscope (OPMI® PENTERO®), a suboccipital decompression by craniectomy and C1–C3 laminectomy was performed. Ultrasound images were obtained to localize the retro-odontoid mass.

Dura incision was then performed at the location found most optimal for accessing the lesion. Typically, this location corresponded to a line extending from the C3 level to the foramen magnum (Fig. 1a). After dural incision, tack-up sutures were placed to facilitate exposure as well as the later closure of the dura. The arachnoid was carefully opened and the retro-odontoid mass was identified along with exiting C2–C3 nerve roots (Fig. 1b). With the nerve roots directly visualized and protected, a linear length incision of the dura anterior to the cord was performed to reveal the retro-odontoid mass (Fig. 1c). The mass was carefully, without any retraction of the spinal cord, removed with the use of microsurgical curettes, rongeurs and ultrasonic suction (Fig. 1d). Specimens were collected and sent for quick section by pathologists.

The dura was closed with a combination of interrupted and continuous sutures, as well as fibrin sealant and collagen matrix sponge overlay to achieve watertight closure.

Finally, before wound closure, suboccipital instrumentation was done with the placement of hardware (contoured titanium rods) through the prepared tracts.

Case 1

An 80-year-old female patient presented with clinical signs of cervical myelopathy. Physical examination revealed moderate strength (motor grade 4 +/5) in her upper and lower limbs, bilateral positive Hoffman's sign, up-going plantar reflexes, and objective findings of gait imbalance. The mJOA score was found to be 16/18, and the VAS score was 8/10.

CT and CT myelography, instead of MRI-scan, were performed due to the presence of an active pacemaker. Imaging showed a large retro-odontoid pseudotumor mass with significant compression of the cervical medullary junction, evidence of atlas-occipitalization and C1/C2 instability (Fig. 2).

Given the severity of compression, clinical signs of myelopathy and the presence of occipitocervical instability, surgical intervention was recommended for the patient. We elected for posterior spinal C1–C3 laminectomy, transdural resection of the pseudotumor and instrumentation from occiput to C3.

The surgical procedure was performed as described in the technique section. Selected steps of the surgical procedure are shown in Fig. 3a–d. The location of the retro-odontoid mass was confirmed with high-resolution ultrasound images after suboccipital decompression by craniectomy and C1–C3 laminectomy (Fig. 4). Specimens taken from the mass were sent for histological examination. Neuromonitoring showed electrophysiological recordings over 50% of baseline levels at all points of the operation.

Postoperatively, the patient's neurological status remained consistent. Postoperative CT scans showed the accurate placement of instrumentation (Fig. 5). The postoperative course in the hospital was insignificant, and the patient was discharged to rehabilitation. At 8-week follow-up

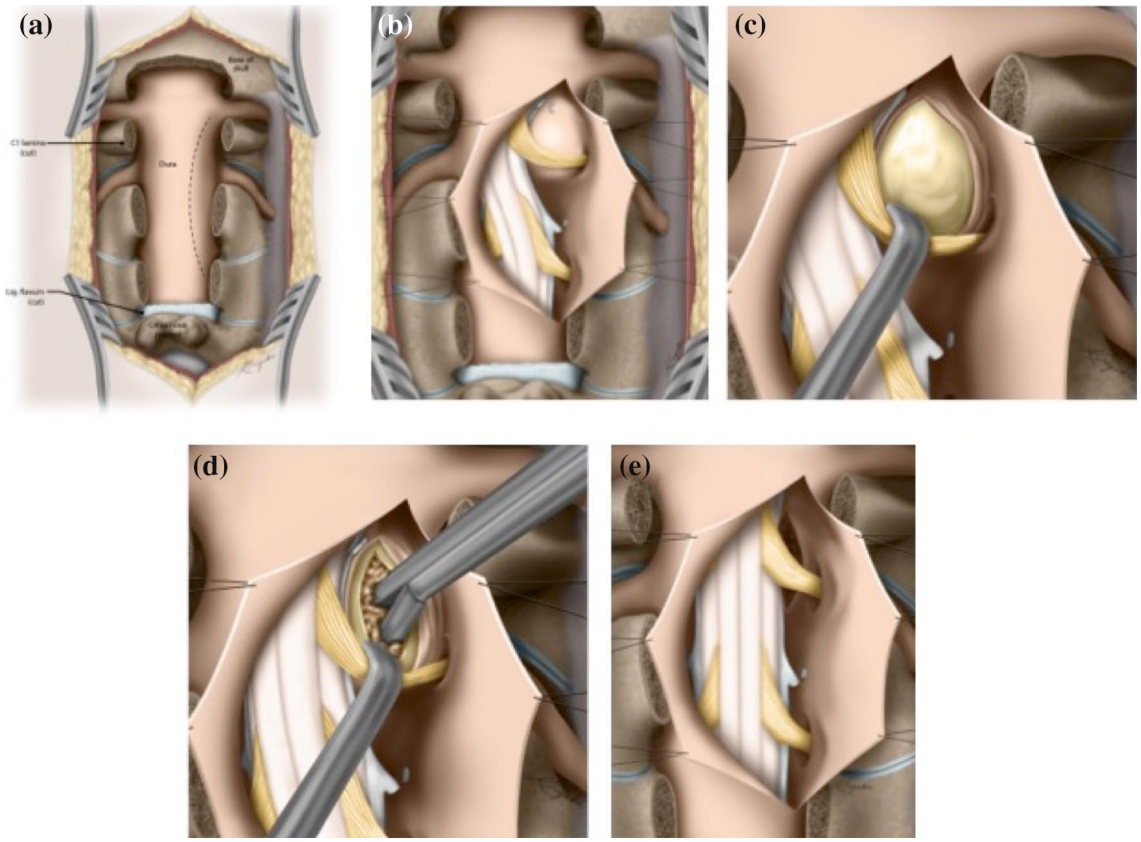

Fig. 1 An artistic depiction of the intraoperative surgical procedure. Conceptual design by the primary author, edits by the senior author and medical illustration by Diana Kryski (KryskiBiomedia). **a** C1–C3 laminectomy and planned incision line of the dorsal dura (dotted line). **b** The incision of the dorsal dura with dural tack-up sutures exposing the ventral retro-odontoid mass and displacing the spinal cord as well as nerve roots. **c** Anterior dura incised directly over the retro-odontoid mass while protecting the spinal cord and nerve roots. **d** Removal of the retro-odontoid mass with microsurgical curettes and rongeurs. **e** Adequate decompression of spinal cord and nerve roots after removal of the lesion

examination, the patient had no neck pain and was independently ambulating with full strength (motor grade 5/5) in all myotomes. The final pathology report of the intraoperative specimen described acellular eosinophilic material of fibro-connective tissue and cartilage, calcium pyrophosphate crystals and no evidence of inflammation or malignancy (Fig. 7a). At the 23-month follow-up examination, the patient was doing very well with no new complaints or neurological deficits.

Case 2

A 72-year-old woman presented with a 5-year history of mechanical neck pain as well as clinical signs of cervical myelopathy with progressive gait impairment, hand dysfunction and numbness. Physical examination found right-sided weakness and paresthesia, gait unsteadiness and altered hand dexterity. Additionally, the patient showed signs of hyperreflexia in all extremities along with a positive Hoffmann's sign bilaterally. The mJOA score was rated as 15/18.

Imaging studies (CT and MRI) showed a significantly large extradural retro-odontoid calcified pseudotumor mass with severe compression of the spinal cord at the C1/C2 level with dislocation of C1 facet joints. Given the findings, decompression at C1–C3, transdural resection of the pseudotumor, and instrumented fusion was planned.

The surgical procedure performed was similar to the previous case. However in this case, following microscope surgical dura opening, the dentate ligament was cut, and C1 and C2 nerves were mobilized before mass excision.

The operation was uncomplicated, the postoperative course was unremarkable, and the patient was discharged to a rehabilitation facility. At the 8-week follow-up examination, the patient was doing well and ambulating independently. The cervical spine X-ray showed good alignment and stable fixation. At six-month follow-up, routine MRI was obtained and showed excellent decompression of the spinal canal in comparison with the preoperative MRI, without signs of recurrence (Fig. 6). The final pathology report described necrotic tissue with bone fragments, calcifications,

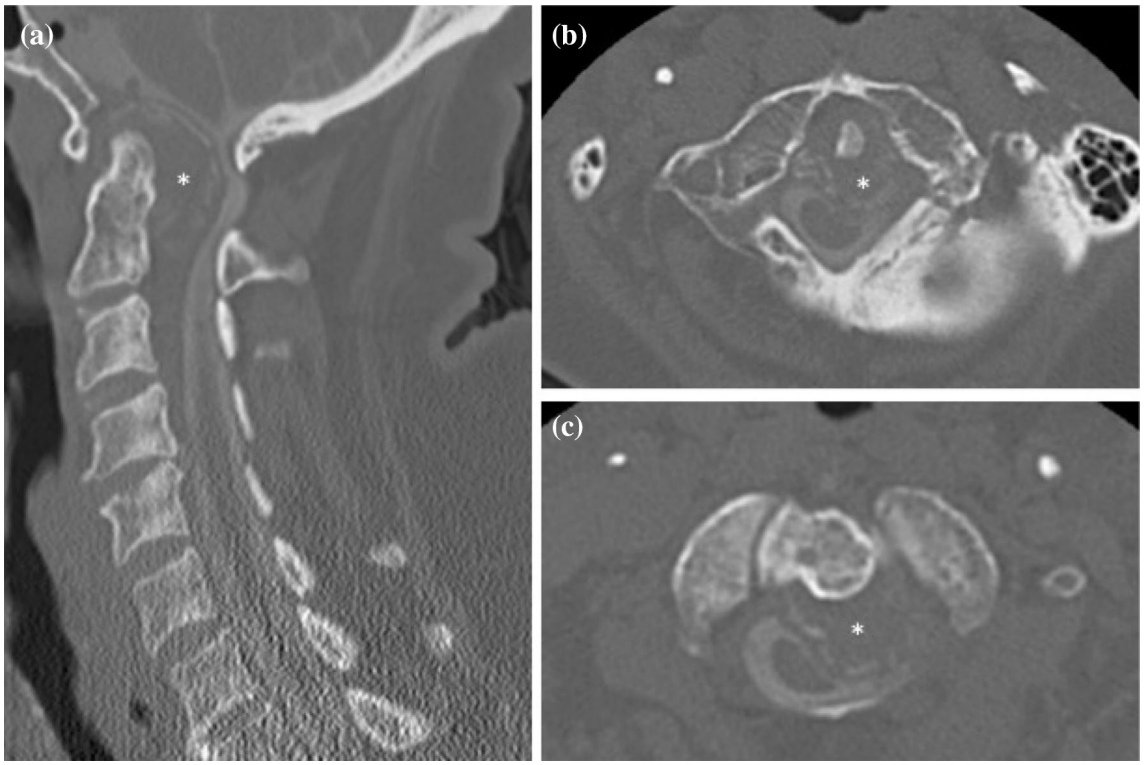

Fig. 2 Case 1: Preoperative CT myelography revealed a sizeable retro-odontoid pseudotumor (*). Selective **a** sagittal and **b**, **c** axial images showing the mass effect of the lesion causing significant compression of the spinal cord at the cervical medullary junction

lymphohistiocytic inflammation and focal crystal deposition, but no signs of malignancy (Fig. 7b). The 22-month follow-up examination showed stable post-surgical conditions, and the patient was doing well without signs of neurological deficits.

Case 3

An 84-year-old female with known history of rheumatoid arthritis presented to the emergency department with progressive tetraparesis and an inability to ambulate. On initial examination, it was found that she had 4/5 motor power on the right upper and lower extremities, while only 3/5 motor power on the left side. She had features of hyperreflexia and up-going toes bilaterally with the plantar response.

Urgent MRI was obtained and revealed a large retro-odontoid extradural mass, confirming a pseudotumor causing severe compression of the spinal cord. The patient was taken to the OR for an urgent C1–C3 laminectomy and transdural microsurgical resection of the pseudotumor.

The surgical procedure was performed as described in the technique section. Intraoperative ultrasound was utilized after laminectomy to localize the retro-odontoid mass.

The surgical procedure was uncomplicated. Postoperatively, the patient was discharged to a rehabilitation centre after a period of hospitalization. At 3-month follow-up, the patient was still using a wheelchair; however, her strength was improving significantly. At 9-month follow-up, the patient had recovered the ability to walk with assistive devices. The final pathology report from the intraoperative specimen indicated fibrocartilaginous tissue with hyalinized cartilage, which appeared to represent an exuberant reactive process (Fig. 7c).

Discussion

Retro-odontoid pseudotumor masses are rare lesions that can cause significant cervicomedullary compression with clinical signs of myelopathy. Although theories exist, the exact etiology of these lesions remains unclear [4, 13, 14]. Therefore, it is imperative that tissue samples are obtained for diagnostic purposes. Several surgical procedures have been described, including atlantoaxial fusion techniques, C1 laminectomy, C1 laminoplasty and direct transdural tumor resection [15–17]. To our knowledge, the majority of articles in the literature describe the use of transdural pseudotumor resection without fusion, except for one small case series (Table 1).

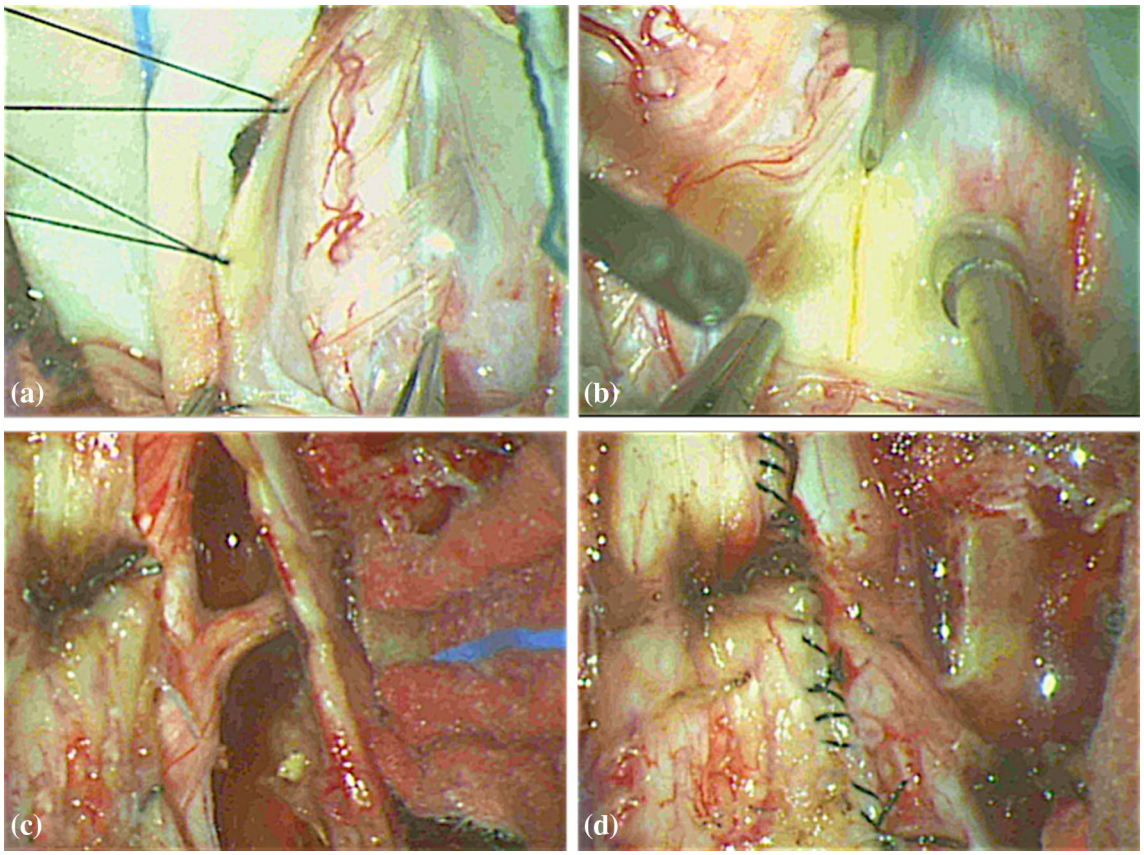

Fig. 3 Case 1: Selected intraoperative photographs of a transdural approach for resection of a retro-odontoid pseudotumor. **a** Placement of dural tack-up sutures and exposure of the arachnoid membrane after suboccipital decompression with laminectomy of C1, C2 and C3 and left-sided dura incision. **b** After identifying the location of the retro-odontoid pseudotumor, a linear length incision of the anterior dura was performed directly over the mass lesion while protecting the spinal cord and nerve roots. **c** Excellent decompression of the spinal cord and nerve roots was achieved after the removal of the pseudotumor. **d** Repair of the dorsal dura with interrupted and continuous sutures

Chikuda et al. [18] reported that approximately two-thirds of retro-odontoid pseudotumor cases in the literature showed signs of atlantoaxial instability. For these cases, a fusion procedure is recommended. However, controversies arise when a massive pseudotumor is present, without apparent instability [16]. Although good results have been reported with both techniques, all of our patients underwent a posterior fusion procedure. Post-surgery and in follow-up exams, no signs of hardware failure or changes in the cranio-cervical alignment were registered. Therefore, we recommend that cervical laminectomies should be accompanied by instrumented fusion to reduce the risk of instability and kyphosis.

Taylor et al. [19], described intradural spinal procedures for resection of a ventral intradural lesion by using a unilateral hemilaminectomy. The same approach was later extended by Stookey et al. [20], for a transdural resection of ventral extradural "chondroma". Fox and Onofrio [21] reported the use of cervical transdural discectomy with laminectomy.

Fujimoto et al. [22] published a series of 30 patients with cervical myelopathy or radiculomyelopathy who had undergone microscopic transdural cervical discectomy with a laminoplasty. The authors recommended it as a valid option for paracentral and paracentroforaminal cervical disc herniation. Tanaka et al. [23] reported ten-year follow-up of the procedure and showed a stable clinical course with no recurrence or postoperative kyphosis.

Fujiwara et al. [24] performed transdural resection of a retro-odontoid pseudotumor via a C1 laminectomy without suboccipital craniotomy and fusion. The authors reported no recurrence or signs of instability at 1-year follow-up [24].

Madhavan et al. [25] recently published a small case series of three elderly patients with progressive myelopathy secondary to a retro-odontoid cyst. The authors suggested that the transdural approach should be considered since it could avoid some of the morbidities related to ventral procedures (wound infection, CSF leak, longer operative time and frequent need for posterior instrumented stabilization). In two of the three cases, the authors

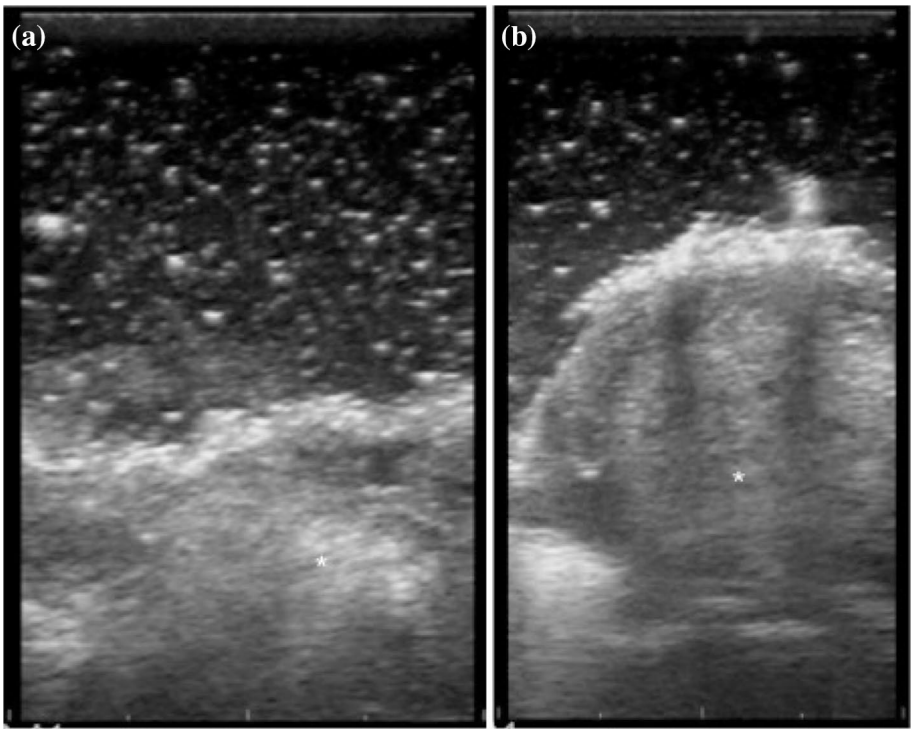

Fig. 4 Case 1: Intraoperative ultrasound imaging demonstrating compression and displacement of the spinal cord by the retro-odontoid pseudotumor (*) in sagittal (**a**) and axial (**b**) views

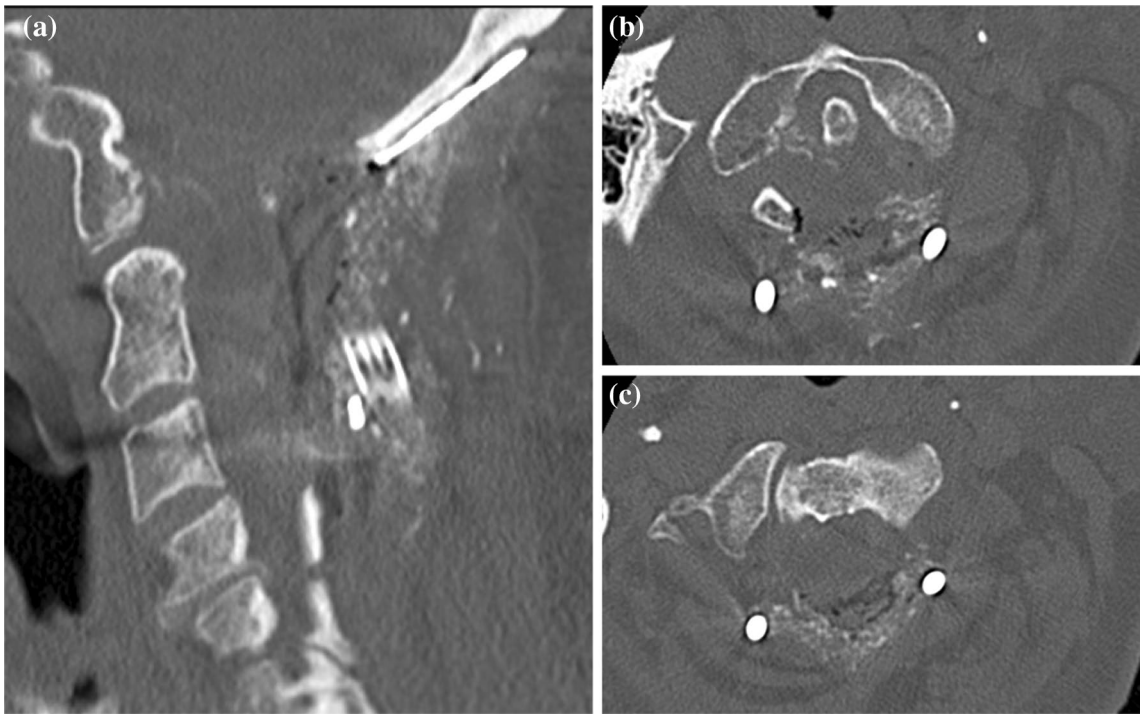

Fig. 5 Case 1: Selective **a** sagittal and **b**, **c** axial images of the postoperative CT imaging of the cervical spine showing resection of the retro-odontoid pseudotumor and excellent decompression of the spinal cord

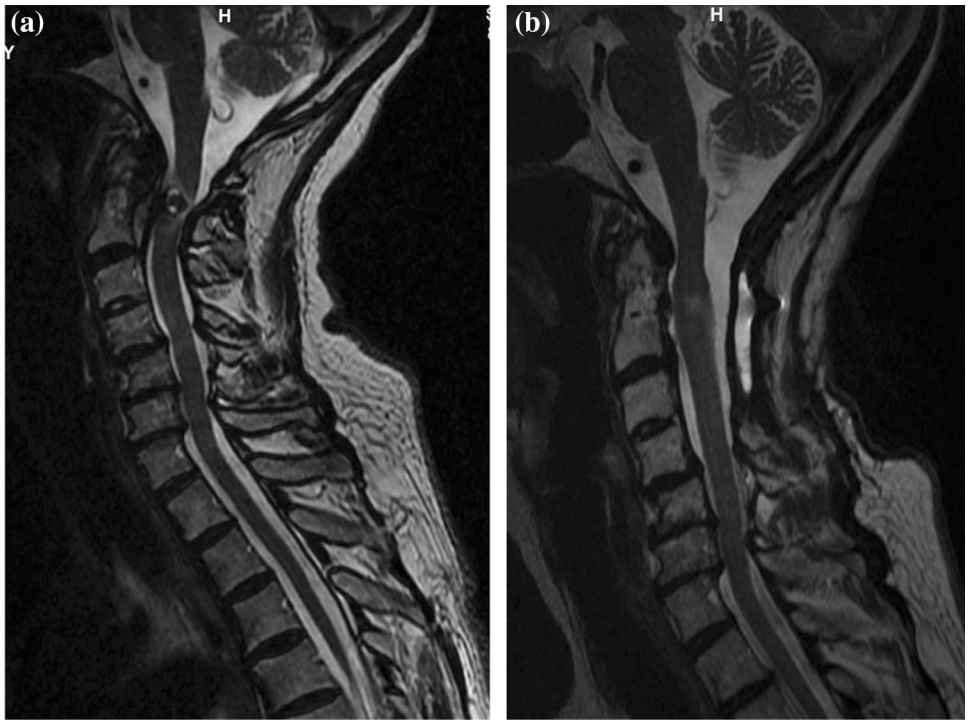

Fig. 6 Case 2: **a** Preoperative MRI T2-weighted sequence in the sagittal planes demonstrating a large extradural retro-odontoid calcified pseudotumor mass with severe distortion and displacement of the spinal cord. **b** Repeated MRI-scans performed 6 months after surgery showing excellent decompression of the spinal canal on representative sagittal images without any signs of recurrence

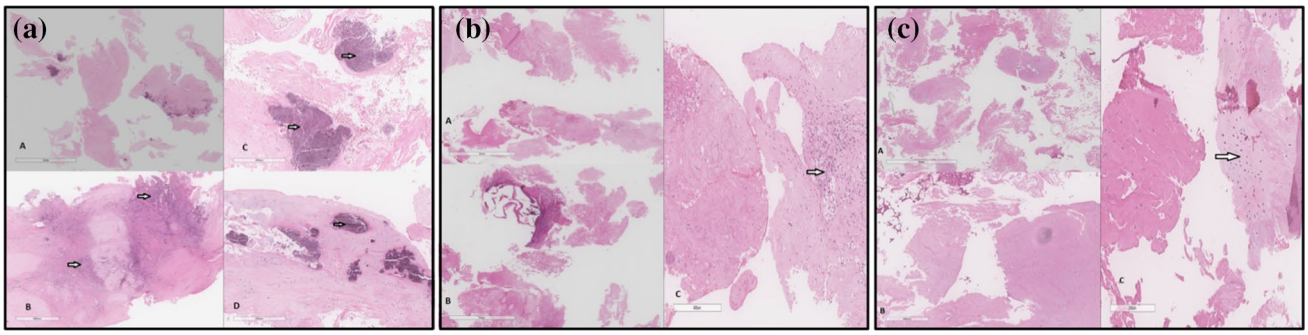

Fig. 7 **a** Case 1: (A, B) Fragments of disk material including fibro-connective tissue and cartilage with degenerative and reactive changes (arrows). No inflammatory infiltrate or malignancy. (C, D) Calcium pyrophosphate crystals (arrows). **b** Case 2: (A, B) Fragments of fibrous tissue and disk material displaying degenerative changes and calcifications. (C) Focal lymphohistiocytic infiltrate (arrow). **c** Case 3: (A, B) Fragments of fibrocartilaginous tissue with reactive changes and hyalinization. (C) Focal increase in cartilage cellularity (arrow) which represents exuberant reactive process

performed a posterior fusion procedure, while the other was a laminectomy without fusion [25].

Limitations of the transdural surgical technique are the risks of potential injury to neural tissue and CSF leakage, especially in cases with calcified and adherent lesions to the dura and surrounding tissue (Table 1). However, the majority of pseudotumor lesions are soft or fibrous and easily dealt with through a posterolateral transdural approach. The presence of significant calcification on CT would represent a contraindication to the posterior transdural technique of resection, and we would favor a transoral approach in such cases. A preoperative CT scan can give useful information about tissue specific qualities of the lesion.

In summary, the transdural resection of retro-odontoid pseudotumors has advantages of reduced bleeding, fewer adhesions and more straightforward access to the mass, which is usually located in the central part of the ventral spinal cord. Also, the use of a posterior midline incision provides flexibility to extend fusion and instrumentation when required. This flexibility can reduce the need for a front and back or staged procedure, which is usually required in situations where additional fusion is needed when approaching the retro-odontoid mass anteriorly or laterally.

Table 1 Literature review with summary of seven previously reported uses of a transdural approach for the cervical spine and own cases

References	No of cases	Approach and procedure	Outcome	Complications	Post. fusion
Fox and Onofrio [21]	7	Decompressive laminectomy, transdural excision	Full recovery ×2, Improvement ×5	None	No
Fujimoto et al. [22]	30	Transdural discectomy, laminoplasty	Improvement	Transient C5 palsy (×2)	No
Koizumi et al. [26]	1	Transdural approach	Improvement	None	No
Sameshima et al. [27]	1	Transcondylectomy, C1 hemilaminectomy, transdural removal	Improvement	None	No
Fujiwara et al. [24]	1	C1 laminectomy, transdural resection	Improvement	None	No
Tominaga et al. [8]	1	C1 laminectomy, transdural resection	Improvement	None	No
Madhavan et al. [25]	3	Suboccipital craniectomy, C1 + partial C2 laminectomy, transdural resection, posterior fusion (×2)	Improvement	×1 CSF leak	Yes (×2)
Current manuscript cases	3	Suboccipital craniectomy, C1 + C2 + C3 laminectomy, transdural resection, posterior fusion (×3)	Improvement	None	Yes (×3)

In our opinion, a transdural resection performed through a posterior cervical approach is an appropriate option to remove mucoid and fibrous soft or semi-soft retro-odontoid pseudotumors without relevant spinal cord traction. We do, however, acknowledge the technical difficulty of this surgery, which requires the support of intraoperative ultrasound and neurophysiological monitoring. Further, we highly recommend that this procedure be carried out by a microsurgical trained spine surgeon with experience in intradural pathology resection.

Conclusion

The posterior cervical transdural approach, when supported with intraoperative ultrasound and neurophysiological monitoring, appears to be a safe alternative procedure for retro-odontoid non-calcified pseudotumor mass excision. A preoperative CT scan can evaluate tissue characteristics and distinguish between a soft or ossified mass in front of the spinal cord. Regional anatomical conditions facilitate less bleeding and adhesions in the intradural space. Additionally, a cranio-cervical and suboccipital stabilization can be easily and safely performed through this exposure without any limitations.

Acknowledgements MGF would like to acknowledge support from the Halbert Chair in Neural Repair and Regeneration and the DeZwirek Family Foundation.

Funding None.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest

References

1. Penning L, Wilmink JT (1987) Rotation of the cervical spine. A CT study in normal subjects. Spine (Phila Pa 1976) 12(8):732–738
2. Tokuda K, Miyasaka K, Abe H, Abe S, Takei H, Sugimoto S, Tsuru M (1985) Anomalous atlantoaxial portions of vertebral and posterior inferior cerebellar arteries. Neuroradiology 27(5):410–413
3. Chen TY, Lui TN (1997) Retrodental fibrocartilaginous mass. Report of a case. Spine (Phila Pa 1976) 22(8):920–923
4. Crockard HA, Sett P, Geddes JF, Stevens JM, Kendall BE, Pringle JA (1991) Damaged ligaments at the craniocervical junction presenting as an extradural tumour: a differential diagnosis in the elderly. J Neurol Neurosurg Psychiatry 54(9):817–821. https://doi.org/10.1136/jnnp.54.9.817
5. Miller JD, al-Mefty O, Middleton TH III (1989) Synovial cyst at the craniovertebral junction. Surg Neurol 31(3):239–242
6. Tabaddor K, Sachs D, Llena JF, Testaiuti MA (1996) Ganglion cyst of the odontoid process. Case report and review of the literature. Spine (Phila Pa 1976) 21(17):2019–2022
7. Griesdale DE Jr, Boyd M, Sahjpaul RL (2004) Pseudogout of the transverse atlantal ligament: an unusual cause of cervical myelopathy. Can J Neurol Sci 31(2):273–275
8. Tominaga H, Setoguchi T, Nagano S, Kawamura I, Abematsu M, Yamamoto T, Ishidou Y, Matsuyama K, Ijiri K, Tanabe F, Komiya S (2016) Retro-odontoid mass without atlantoaxial instability causing cervical myelopathy: a case report of transdural surgical resection. Spinal Cord Ser Cases 2:16025. https://doi.org/10.1038/scsandc.2016.25
9. Kerschbaumer F, Kandziora F, Klein C, Mittlmeier T, Starker M (2000) Transoral decompression, anterior plate fixation, and

posterior wire fusion for irreducible atlantoaxial kyphosis in rheumatoid arthritis. Spine (Phila Pa 1976) 25(20):2708–2715
10. Matsuno A, Nakashima M, Murakami M, Nagashima T (2004) Microsurgical excision of a retro-odontoid disc hernia via a far-lateral approach: successful treatment of a rare cause of myelopathy: case report. Neurosurgery 54(4):1015–1018. https://doi.org/10.1227/01.neu.0000114869.89056.be **(discussion 1018)**
11. Ito K, Sakai K, Yako T, Tanaka Y, Hongo K (2007) Atlantoaxial dislocation associated with a mass in the extradural craniovertebral junction unrelated to rheumatoid arthritis. Case report. Neurol Med Chir (Tokyo) 47(4):182–185
12. Chieng LO, Madhavan K, Vanni S (2015) Pooled data analysis on anterior versus posterior approach for rheumatoid arthritis at the craniovertebral junction. Neurosurg Focus 38(4):E18. https://doi.org/10.3171/2015.1.FOCUS14838
13. Sze G, Brant-Zawadzki MN, Wilson CR, Norman D, Newton TH (1986) Pseudotumor of the craniovertebral junction associated with chronic subluxation: MR imaging studies. Radiology 161(2):391–394. https://doi.org/10.1148/radiology.161.2.3763907
14. Fenoy AJ, Menezes AH, Donovan KA, Kralik SF (2008) Calcium pyrophosphate dihydrate crystal deposition in the craniovertebral junction. J Neurosurg Spine 8(1):22–29. https://doi.org/10.3171/SPI-08/01/022
15. Barbagallo GM, Certo F, Visocchi M, Palmucci S, Sciacca G, Albanese V (2013) Disappearance of degenerative, non-inflammatory, retro-odontoid pseudotumor following posterior C1–C2 fixation: case series and review of the literature. Eur Spine J 22(Suppl 6):S879–S888. https://doi.org/10.1007/s00586-013-3004-1
16. Kakutani K, Doita M, Yoshikawa M, Okamoto K, Maeno K, Yurube T, Sha N, Kurosaka M, Nishida K (2013) C1 laminectomy for retro-odontoid pseudotumor without atlantoaxial subluxation: review of seven consecutive cases. Eur Spine J 22(5):1119–1126. https://doi.org/10.1007/s00586-013-2681-0
17. Takemoto M, Neo M, Fujibayashi S, Sakamoto T, Ota M, Otsuki B, Kaneko H, Umebayashi T (2016) Clinical and radiographic outcomes of C1 laminectomy without fusion in patients with cervical myelopathy that is associated with a retro-odontoid pseudotumor. Clin Spine Surg 29(10):E514–E521. https://doi.org/10.1097/BSD.0b013e31829eb7e6
18. Chikuda H, Seichi A, Takeshita K, Shoda N, Ono T, Matsudaira K, Kawaguchi H, Nakamura K (2009) Radiographic analysis of the cervical spine in patients with retro-odontoid pseudotumors. Spine (Phila Pa 1976) 34(3):E110–E114. https://doi.org/10.1097/BRS.0b013e31818acd27
19. Taylor AS (1910) X. Unilateral laminectomy. Ann Surg 51(4):529–533. https://doi.org/10.1097/00000658-191004000-00010
20. Stookey B (1928) Compression of the spinal cord due to ventral extradural cervical chondromas: diagnosis and surgical treatment. Arch NeurPsychol 20(2):275–291. https://doi.org/10.1001/archneurpsyc.1928.02210140043003
21. Fox MW, Onofrio BM (1994) Transdural approach to the anterior spinal canal in patients with cervical spondylotic myelopathy and superimposed central soft disc herniation. Neurosurgery 34(4):634–641. https://doi.org/10.1227/00006123-199404000-00010 **(discussion 641–632)**
22. Fujimoto Y, Baba I, Sumida T, Tanaka N, Oka S, Kawagoe H (2002) Microsurgical transdural discectomy with laminoplasty: new treatment for paracentral and paracentroforaminal cervical disc herniation associated with spinal canal stenosis. Spine (Phila Pa 1976) 27(7):715–721
23. Tanaka N, Fujimoto Y, Sumida T, Manabe H, Nakanishi K, Fujiwara Y, Kamei N, Nakamae T, Izumi B, Ochi M (2013) Long-term clinical results of microsurgical transdural discectomy with laminoplasty: follow-up results over 10 years. J Neurosurg Spine 18(6):653–660. https://doi.org/10.3171/2013.3.SPINE12673
24. Fujiwara Y, Manabe H, Sumida T, Tanaka N, Hamasaki T (2015) Microscopic posterior transdural resection of cervical retro-odontoid pseudotumors. J Spinal Disord Technol 28(10):363–369. https://doi.org/10.1097/BSD.0000000000000335
25. Madhavan K, Chieng LO, Gaynor BG, Levi AD (2018) Transdural approach to resection of retro-odontoid cysts in elderly patients: report of 3 cases. J Neurosurg Spine 28(3):236–243. https://doi.org/10.3171/2017.6.SPINE17429
26. Koizumi H, Shimizu S, Oka H, Sagiuchi T, Utsuki S, Fujii K (2008) Retro-odontoid disc herniation extracted using the posterior-lateral transdural approach: case report. No Shinkei Geka 36(1):59–63
27. Sameshima T, Shibahashi K, Nozaki T, Akabane A, Kihara A, Horiuchi H et al (2013) Atlantoaxial intraspinal juxtafacet cyst. Neurol Med Chir (Tokyo) 53(2):125–128