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REVIEW ARTICLE

Disappearance of degenerative, non-inflammatory, retro-odontoid pseudotumor following posterior C1–C2 fixation: case series and review of the literature

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Abstract
Purpose Retro-odontoid pseudotumor, not related to inflammatory or traumatic conditions, is an uncommon pathology. Atlanto-axial instability has been advocated to explain the pathophysiology of retro-odontoid pseudotumor's formation and growth. Despite pseudotumor direct removal through transoral or lateral approach represented the main surgical strategy for a long time, in the last decade several authors highlighted the possibility to treat retro-odontoid pseudotumor by occipito-cervical or C1–C2 fixation without removal of the intracanalar tissue. The goal of this study is to analyze the data collected in a series of patients suffering from cervical myelopathy due to non-inflammatory, degenerative retro-odontoid pannus and treated by posterior C1–C2 fixation. The relevant literature is also reviewed.
Methods Five patients, not suffering from inflammatory diseases, were treated between 2009 and 2012. Abnormalities of cranio-cervical junction and/or lower cervical spondylotic degeneration were observed in all patients. No evidence of atlanto-axial instability was demonstrated. Clinical and radiological evaluation included pre- and post-operative Nurick score as well as pre- and post-operative X-rays, CT and MRI. In one case, CT scan highlighted an eggshell calcification of the pannus. All patients underwent either a C1–C2 fixation (C1 lateral mass and C2 isthmus-pedicle screws) or occipito-cervical fixation (2 patients) in cases of C0–C1 fusion.
Results Follow-up ranges from 22 to 45 months (mean 32) in four patients. One patient died of surgery-unrelated disease. Nurick score changes suggest a clinical improvement in four cases. Neuro-radiological evaluation shows a progressive but incomplete reduction of thickness of retro-odontoid pseudotumor in one patient, and its disappearance in the other three cases. A second-stage transoral or posterior lateral approach was not required.
Conclusion Although the etiopathogenesis of non-inflammatory, i.e., degenerative, retro-odontoid pseudotumor is still controversial, our series (the second largest on degenerative retro-odontoid pannus in the literature) confirms that a posterior approach may be sufficient and transoral surgery is not required.

Keywords Atlanto-axial fixation · Atlanto-axial joint · Myelopathy · Odontoid process · Retro-odontoid pseudotumor

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Introduction

The retro-odontoid pseudotumor [33], also named pannus or phantom tumor [32], is a non-tumoral, fibro-cartilaginous mass or granulation tissue frequently associated with inflammatory diseases like rheumatoid [5, 11, 21] or psoriatic [23] arthritis. Among non-inflammatory conditions, such as post-traumatic pseudoarthrosis of the odontoid process [42], unstable odontoid fractures [44], os odontoideum [1, 2, 17, 29], kyphotic cervical instability after

laminoplasty [25], long-term hemodialysis [31], and cranio-cervical junction malformations [19], chronic atlanto-axial subluxation is considered a predisposing factor leading to the development of a retro-odontoid pannus [13, 33].

In 1991, Crockard et al. [6] hypothesized that damage to C1–C2 ligamentous structures leads to the onset of chronic atlanto-axial instability, which, in turn, may induce the development of a retro-odontoid pannus. More recently, very few cases of non-inflammatory retro-odontoid pseudotumor [13, 16, 36] or degenerative articular cysts [4, 14] have been reported.

A common feature to the above conditions is the progressive pseudotumor's reduction, or disappearance, following either a posterior occipito-cervical fixation [7, 19, 20, 25, 28, 46] or C1–C2 osteosynthesis [4, 7, 11, 16, 17, 29, 36, 37, 41, 44] or C1 laminoplasty [32] without direct tissue removal, as an alternative surgical strategy to the previously suggested transoral [5, 26] or high cervical anterolateral approaches [30].

However, following a C1–C2 osteosynthesis, the degenerative pseudotumor may not always disappear or significantly reduce in size.

This paper reports a single-institution experience in the treatment of five patients with degenerative retro-odontoid pannus showing different patterns of reduction over time. The relevant pathogenetic mechanisms and radiological features are discussed and the literature on the management of non-inflammatory retro-odontoid pannus is reviewed.

Materials and methods

Between July 2009 and November 2012, five patients (3 males), aged 55–76 years (mean 64.8), presented to the Neurosurgical Department, Policlinico University Hospital, Catania, Italy, because of severe myelopathy secondary to spinal cord compression at C1–C2 level. Patients with traumatic or neoplastic retro-odontoid pannus are not included in this series. No studied patients suffered from inflammatory diseases; no previous history of neoplastic disease or trauma was reported, with the only exception of one patient who had sustained a cervical trauma, with loss of consciousness, 4 years earlier. Another patient had already undergone two surgeries, nearly 6 and 5 years earlier, respectively, for a C5/C6 and C6/C7 ACDF and a foramen magnum decompression and C1 laminectomy for a Chiari I malformation. Neurological examination revealed a severe spastic tetraparesis, associated with tetrahyperreflexia, upper motor neuron signs, and sphincteric disturbances, in all patients.

Preoperatively, two female patients were grade 5 according to the Nurick score; two males were grade 4 and one grade 3. The following conditions were demonstrated, respectively, in three patients: atlas assimilation (1), platybasia with atlas assimilation and Chiari I malformation (1), diffuse idiopathic skeletal hyperostosis (DISH) (1) (Table 1). Pre-operative imaging included cervical X-rays, with flexion–extension views, magnetic resonance imaging (MRI) and angio-computed tomography (Angio-CT) with multiplanar reconstructions. These examinations ruled out

Table 1 Review of a personal series of degenerative retro-odontoid pannus treated by posterior fixation

Author/year	No. of Patients	Inflammatory disease (Y/N)	AAI or AAS (Y/N)	Associated conditions	Type of surgical procedure	Time to pannus reduction/disappearance
Current Study	5	N	N	Subaxial spondylosis (5); atlas assimilation (1); atlas assimilation, platybasia and Chiari malformation (1); DISH and C5–C6 fusion (1)	C1–C2 fixation with C1 laminectomy in 2 pts (C1 lateral mass and C2 pedicle screws); C0–C3 in 1 pt with C1 assimilation (C2 translaminar screws and C3 lateral mass); occipito-C3 fixation in 1 pt with C1 assimilation (C2 translaminar screws and C3 lateral mass); occipito-C5 fixation in 1 pt with C1 assimilation (C2 translaminar screws and C3 lateral mass, C4 and C5 pedicle screws on one side and lateral mass screw on the other side)	Pt 1: Disappearance at 8 months Pt 2: Significant reabsorption at 5 and 8 months and disappearance at 13 months Pt 3: Disappearance at 6 months Pt 4: Progressive reduction observed at 4, 10 and 14 months, but pannus still present Pt 5: N/A

C1–C2 instability and MRI confirmed a retro-odontoid mass compressing the spinal cord anteriorly. The retro-odontoid pseudotumor appeared hypointense on T1-weighted images and with a mixed intensity on T2-weighted images (Figs. 1, 2, 3). After Gadolinium infusion, no contrast enhancement of the pseudotumor was seen.

Interestingly, on imaging, all patients presented clear signs of cervical subaxial spondylosis: in particular, one patient had already undergone C5–C6 and C6–C7 ACDF and another patient had a C5–C6 vertebral body fusion with DISH (Figs. 1, 2, 3, 4).

Two patients underwent a C1–C2 Harms fixation, one patient with a C0–C1 fusion had a C0–C3 fixation and the other two patients with C0–C1 fusion were treated with occipito-cervical fixation. C2 translaminar screws were inserted in two patients and a combination of C2 translaminar screws and subaxial pedicle and lateral mass screw in another patient, according to the anatomical

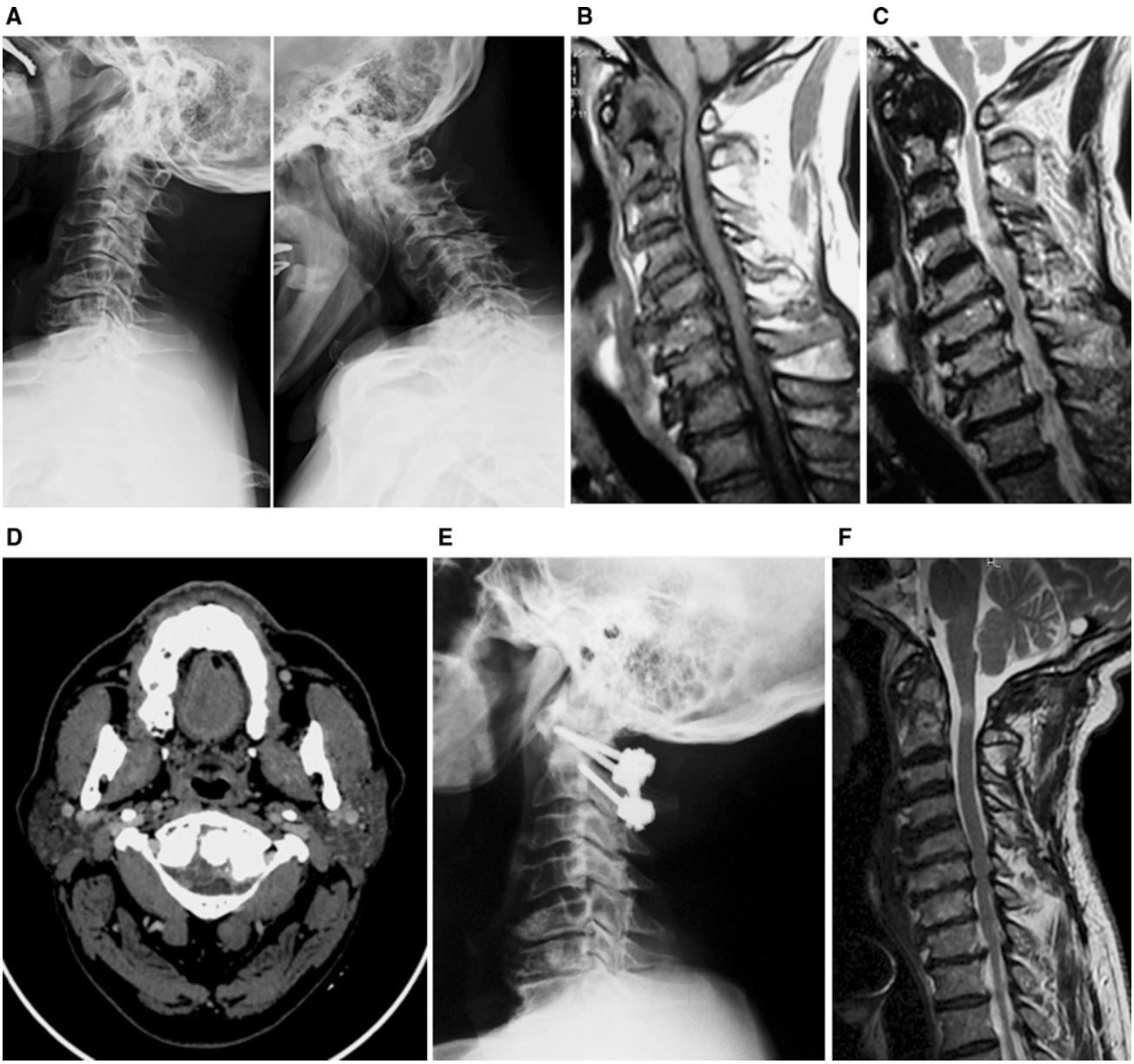

Fig. 1 Patient 1: lateral radiograph showing extensive degenerative changes involving the cervical spine, with no overt C1–C2 instability (**a**). Pre-operative sagittal, T1- (**b**) and T2-weighted (**c**) MRI scan demonstrating a retro-odontoid pannus severely compressing the spinal cord as well as subaxial degenerative changes. On CT-angiography (**d**), a non-uniformly enhancing retro-odontoid soft tissue, mostly located on right side, is compressing the spinal cord. Post-operative X-ray showing a C1–C2 fixation (**e**). At the 8-month follow-up, MRI scan confirms the pannus reabsorption (**f**)

Fig. 2 Patient 2: **a** sagittal, T2-weighted MRI showing the severe cord compression due to a large retro-odontoid pseudotumor along with a osteophytosic cord compression at C5–C6 in a patient with DISH; **b** lateral X-ray showing the C1–C2 fixation and axial CT scan demonstrating the correct device position (**c**, **d**). Post-operative, sagittal, T2-weighted MRIs confirming the progressive pannus reabsorption at 5 (**e**), 8 (**f**) and 13 (**g**) months follow-up. The "key-hole" approach to remove the focal compression at C5–C6 is seen on coronal (**h**) and axial (**i**) CT scan

peculiarities. Decompressive C1 laminectomy was performed in two patients, a C1–C3 laminectomy and foramen magnum decompression in other two cases demonstrating, respectively, atlas assimilation and spinal cord circumferential compression also involving the C2–C3 level (Table 1). All patients were operated by the first author (GMVB).

Results

Post-operative check X-rays and CT scans showed the spinal cord decompression and correct positioning of the screws.

Follow-up ranges from 22 to 45 months (mean 32) in four patients. One patient (a 76-year-old lady) died 10 days

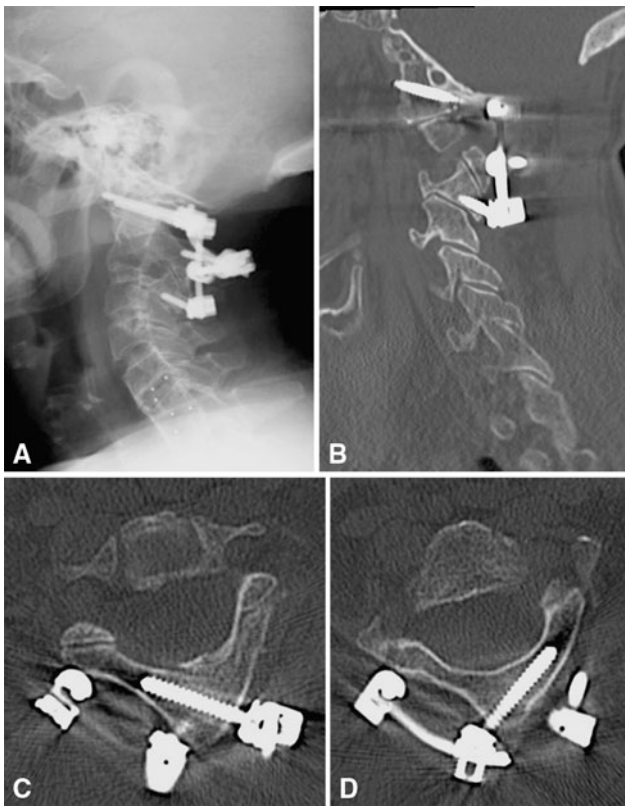

Fig. 3 Patient 3: **a** lateral radiograph and **b** sagittal, CT scan showing a C0–C2–C3 fixation in a patient with C0–C1 assimilation. Translaminar screws have been used at C2 level (**c**, **d**) and lateral mass screws at C3

after surgery because of acute renal failure and associated cardiopulmonary complications.

Over the following months four patients (80 %) showed a progressive neurological improvement as well as of their Nurick score, which improved from grade 5 to 3 in one woman, from grade 4 to 2 in one male and from 3 to 1 in another man; only one male patient (the one with the eggshell calcification of the pannus) suffered a worse motor deficit in the right upper limb, which gradually recovered over the following 6 months. Post-operative CT images showed the correct positioning of C1 and C2 screws. Serial follow-up MRI scans showed a progressive reabsorption of the retro-odontoid pannus, and improvement or resolution of spinal cord compression. The time to pannus reduction or disappearance ranges from 4 to 14 months (Table 1). In the patient with C0–C1 assimilation, platybasia and Chiari I malformation, in view of radiological appearance we evaluated the need for a transoral approach to resect the tip of the odontoid process. However, this second-step surgery was not performed because of progressive clinical improvement.

Another patient, showing an eggshell calcification surrounding the retro-odontoid pannus, who underwent occipito-cervical fixation and C1 laminectomy, presents an incomplete reduction of the pannus at the 21-month follow-up. Nevertheless, he has clinically improved, his Nurick score reduced from 4 to 3 and he did not consent further surgery (either transoral or by far lateral approach) to directly address the retro-odontoid pannus.

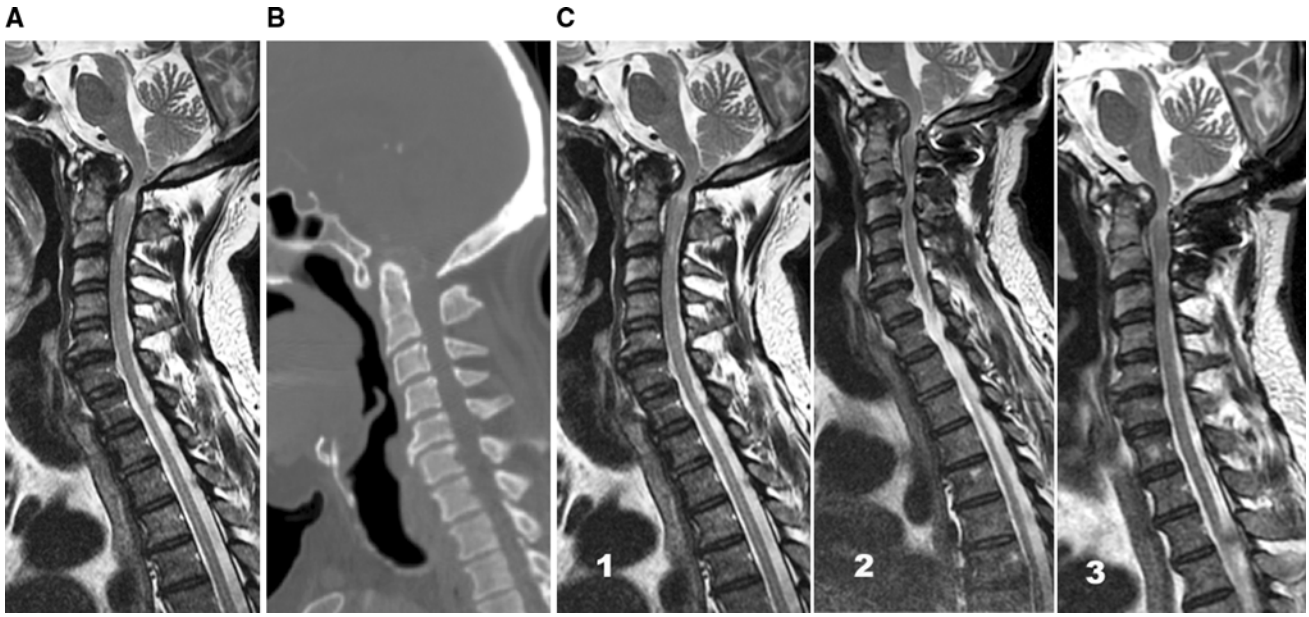

Fig. 4 Patient 4: **a** sagittal, T2-weighted MRI demonstrating a retro-odontoid pseudotumor, with patchy signal alteration, compressing the spinal cord. Such appearance is also seen on sagittal CT scan (**b**), which also shows an eggshell calcification of the pseudotumor. Postoperatively, serial, sagittal follow-up MRIs confirm the progressive pannus reduction in volume (**c**), respectively, at 4, 10 and 14 months

Table 2 Review of studies reporting cases of retro-odontoid pannus treated by posterior approach

Author/year	No. of Patients	Inflammatory disease (Y/N)	AAI or AAS (Y/N)	Associated conditions	Type of surgical procedure	Time to pannus reduction/ disappearance
Zygmunt et al. [46]	9	Y	Y	–	Occipito-cervical fixation	NA
Grob et al. [11]	22	Y	Y	–	C1–C2 transarticular screw fixation	40 months (average, range 12–75)—reduction in 19 pts, stability of the pannus in 3 pts
Jun [17]	1	N	Y	Os odontoideum	C1–C2 transarticular screw fixation	2 years (disappearance)
Chang et al. [1]	1	N	Y	Os odontoideum	C1–C2 fusion with Roger's wiring	3 months (reduction)
Ito et al. [14]	1	N	Y	Multiple epiphyseal dysplasia, hypoplasia of the dens	C1–C2 transarticular screw fixation	6 weeks (disappearance)
Isono et al. [13]	1	N	Y	Cervical spondylosis	Occipito-cervical fixation using Hartshill–Ransford loop	2 months (reduction)
Young et al. [44]	3	N	Y	Previous odontoid fracture	C1–C2 transarticular screw fixation	6 months (reduction)
Joly-Torta et al. [16]	2	N	Y	History of cervical trauma (case 1) previous multilevel ACDF (case 2)	Occipito-cervical fusion combined with C1–C2 transarticular screw fixation	3 months (reduction—case 1) 6 months (reduction—case 2)
Lagares et al. [19]	1	N	Y	Assimilation of the atlas	Occipito-cervical fixation	12 months (disappearance)
Matsumoto et al. [25]	1	N	Y	Previous C3–C7 laminoplasty	Occipito-cervical fixation	12 months (reduction)
Suetsuna et al. [32]	3	N	Y (in 1 of 3 cases)	–	C1 laminoplasty	10 months (disappearance—case 1) 16 months (disappearance—case 2) 3 months (reduction—case 3)
Yamaguchi et al. [41]	3	N	Y (in 2 of 3 cases)	Occipital injury (case 1)	Occipito-cervical fixation	3 years (disappearance—case 1) 4 months (disappearance—case 2) 6 months (reduction—case 3)
Takami et al. [35]	3	NA	Y	–	C1–C2 fixation (C1 lateral mass and C2 pedicle screws)	6 months (reduction)
Cihanek et al. [4]	1	N	Y	–	C1–C2 transarticular screw fixation	NA
Chikuda et al. [3]	10 (9 underwent posterior fixation)	N	Y (in 2 of 10 cases)	Occipito-C1 ankylosis (in 4 cases), cervical spondylosis (in 4 cases)	Occipito-cervical fixation (9 cases)	NA
Ogata et al. [29]	1	N	Y	Os odontoidum, C2–C3 fusion	C1–C3 fixation with hooks and rods	3 months (disappearance)
Tanaka et al. [36]	1	N	N	–	C1–C2 transarticular screw fixation	6 months (reduction)
Yamazaki et al. [43]	1	N	Y	Cervical spondylosis	C1–C2 fixation (C1 lateral mass and C2 pedicle screws)	12 months (reduction)

Table 2 continued

Author/year	No. of Patients	Inflammatory disease (Y/N)	AAI or AAS (Y/N)	Associated conditions	Type of surgical procedure	Time to pannus reduction/ disappearance
Kakutani et al. [18]	7	N	N	–	C1 laminectomy (4 pts) C1 laminectomy + C3–C6 laminoplasty (3 pts)	12 months (significant reduction in 4 pts)
Tachibana et al. [34]	1	N	NA	–	C1 laminectomy	12 months (mild reduction)

AAI atlanto-axial instability, *AAS* atlanto-axial subluxation, *NA* not available

Discussion

The presence of a retro-odontoid pseudotumor causing spinal cord compression has been classically associated with inflammatory diseases involving the spine, like rheumatoid or psoriatic arthritis [5, 11, 21, 23]. However, retro-odontoid pseudotumors have also been reported in non-inflammatory conditions [1, 2, 17, 19, 25, 29, 31, 42, 44], and a differential diagnosis between retro-odontoid pseudotumor and other masses such as meningioma, chordoma, osteochondroma, metastatic tumors, or disc hernia is fundamental [6, 27, 33]. Usually, MRI findings and clinical features of the lesion after gadolinium infusion, combined with CT-scan data, allow a differential diagnosis among inflammatory, degenerative and tumor disease. Nonetheless, biopsy and histological examination are mandatory in controversial cases.

In these non-inflammatory pathologies, it has been hypothesized that a "chronic" atlanto-axial instability is the predisposing factor leading to the development of a retro-odontoid pannus [13, 33].

In patients with symptomatic spinal cord compression, the transoral approach was considered to be the treatment of choice to remove the retro-odontoid mass and decompress the neural structures [5, 26]. Nonetheless, in the last decade, several authors have reported a significant pannus reduction, even as to a complete regression, following only a posterior C1–C2 fixation procedure with restoration of the atlanto-axial stability [7, 11, 17, 46].

Magerl and Seeman [24] introduced the C1–C2 transarticular fixation technique; this is considered biomechanically the best technique due to its stability and also high fusion rate, approaching 100 %; however, it is associated with risk of injury to the vertebral artery (VA) [40]. To reduce such risk while still achieving similar stability, Goel and Laheri [8, 9, 10, 15] and Harms and Melcher [12] introduced a technique using four screws, which are inserted respectively in the C1 lateral mass and C2 pedicle or isthmus. This new surgical technique has proven its efficacy in the treatment of atlanto-axial instability, with or without associated inflammatory disease; decompression of the spinal cord and improvement of myelopathy, along with better radiological outcomes than transarticular fixation, have also been reported following the latter C1–C2 fixation technique [22].

In patients with a narrow C2 pedicle or a high-riding VA, determining a large VA groove and a small C2 pedicle/isthmus, to reduce the potential risks of damaging the VA, Wright [45] proposed a novel technique based on the insertion of bilateral crossing C2 laminar screws. He described this surgical nuance by applying it also in degenerative disease and obtaining satisfactory biomechanical and clinical results.

The retro-odontoid pannus is frequently related to rheumatoid arthritis and the consequent chronic C1–C2 subluxation; however, it has been found even in cases of instability in the absence of rheumatoid arthritis.

In 2008, Cihanek et al. [4] described the application of C1–C2 transarticular fixation in a case of C1–C2 subluxation. Recently, Tojo et al. [39] analyzed the MR features of retro-odontoid pannus in a retrospective consecutive series of 503 patients, focusing on the relationship between retro-odontoid thickness and patients' related factors such as age, sex, and degenerative changes of cervical spine. Although there is a direct correlation between the occurrence of a retro-odontoid pannus and known factors such as age, sex and dialysis, the author concluded that the association between the occurrence of pseudotumor and degeneration of the cervical spine is relevant.

In patients without atlanto-axial subluxation, it has been hypothesized that the pathogenesis of pseudotumor could be independent of the presence of atlanto-axial instability. In these cases, the treatment is controversial. Some authors [3, 18, 32, 34] suggested that a simple posterior laminectomy, without removal of the pseudotumor, may be considered the best therapeutic strategy. Conversely, Tanaka et al. [36] reported their experience in a case of histologically confirmed retro-odontoid pseudotumor without atlanto-axial subluxation treated by posterior C1–C2 fixation: at the 6-month follow-up, a significant reduction of the pseudotumor was observed. Such reasoning and surgical strategy is similar to that used in our cases. Indeed, in three

of our patients, a posterior fixation, either a C1–C2 or C0–C2 in patients with C0–C1 fusion, fixation proved to be enough for a pannus reabsorption and anterior neural structures decompression. The review of the literature highlighted that the reported studies on the treatment of retro-odontoid pannus without atlanto-axial instability [18, 32, 36, 41] focused on single case reports. Chikuda et al. [3] reported on ten patients without inflammatory disease: eight of them did not show C1–C2 instability and four also presented subaxial spondylosis. Our series, albeit based on a small number of cases, suggests that there is a constant correlation between the onset of retro-odontoid pannus and subaxial cervical spondylotic degeneration. Indeed, a reduced subaxial mobility seems to be always associated with the development of the so-called degenerative retro-odontoid pannus.

Pseudotumor's reabsorption in a non-rheumatoid atlanto-axial instability treated by occipito-cervical fixation or C1–C2 fixation has already been reported; nonetheless, reviewing the literature we noticed that a condition of atlanto-axial instability is present almost in all published cases, as shown in Table 2.

In 2007, Takami et al. described their personal experience with C1–C2 posterior fixation in the treatment of three elderly patients affected by retro-odontoid pseudotumor associated with chronic atlanto-axial subluxation. They focused on surgical technique for C1–C2 screw placement but overlooked the pathogenesis of the pannus. Yet, it is not clear if patients included in Takami's [35] series suffered from inflammatory pathologies.

In the present study, we describe five patients with severe signs of myelopathy but without evidence of rheumatoid arthritis or other inflammatory disease, in whom the presence of a retro-odontoid pannus may be related to an increased motion at the C1–C2 level as a consequence of a reduced motion of the subaxial spine secondary to spondylotic changes. Moreover, in some of our patients, we also observed C0–C1 fusion and pre-operative imaging never showed C1–C2 instability. It is then possible that the retro-odontoid degenerative pannus can be interpreted as an evolving process of a wider degenerative phenomenon likely involving the subaxial cervical spine at an earlier stage, rather than only a localized (C1–C2) instability-related disease. Indeed, one of our patients had already undergone a C5–C6–C7 ACDF and another received a key-hole osteophytectomy at C5–C6 for spinal cord decompression (Figs. 2, 3). After surgery, three patients presented a complete pannus reduction and in one case only a partial reabsorption of the pannus was observed (Figs. 1, 2, 3, 4). Indeed, this was the patient whose pre-operative CT scan demonstrated a hyperdense "capsule" around the pannus, suggesting the presence of a calcified shell around the pannus itself (Fig. 4). Such hypothesis suggests that the retro-odontoid pannus may be a reactive fibrotic tissue secondary to a chronic stress mechanism rather than an infection-related granulation tissue resulting from the synovial tissue between the dens and the posterior articular facet of the C1 posterior arch or between the dens and the transversal ligament.

A further confirmation to such hypothesis comes from other reports of spontaneous regression of the retro-odontoid pannus in patients suffering from rheumatoid arthritis and treated with C1–C2 fixation [11, 38, 46].

Tanaka et al. proposed an interesting classification of retro-odontoid pseudotumor: in Type 1, it is associated with atlanto-axial instability (like in rheumatoid arthritis); in Type 2, the pannus is associated with spondylosis or ankylosis or ossification of the anterior longitudinal ligament (like in the cases we describe) and in Type 3, the "pannus" is sustained by a C2–C3 disc hernia which has migrated upwards behind the odontoid. They further proposed that a C1–C2 fixation and laminectomy should be the surgical treatment in Types 1 and 2 [36]. According to the above classification, all cases we described would be classified as Type 2 pseudotumor and our surgical management was indeed limited to a posterior fixation. Out of the four patients still followed-up (one died of systemic complications), two received a C1–C2 fixation and in the other two patients a C0–C3 or occipito-C3 fixation was performed (Figs. 1, 2, 3, 4). In the latter patients, the bone quality (patients with extensive degenerative changes) suggested to include one more caudal level. C1 laminectomy was performed to achieve a direct spinal cord decompression, which we believe is a safer option for the patient while waiting for the pannus to reduce in volume. We submit that extensive occipito-cervical fixation is not necessary and inclusion of the occiput in the fixation may only be required in cases of C0–C1 fusion or poor bone quality.

Interestingly, the time required to pannus reduction or disappearance varies significantly. A literature review shows that it can range between 4 and 40 months (Table 2). In our experience, it ranged between 4 and 14 months. However, significant limitations affecting all studies, including ours, consisting of a small number of patients and non-prospective data collection cannot be overlooked.

Conclusion

We have demonstrated that C1–C2 or C0–C3 fixation techniques are able to guarantee the same results in reduction or regression of retro-odontoid pseudotumor and spinal cord decompression both in inflammatory and degenerative conditions. C1 laminectomy is a useful

adjunct as it allows an early decompression of the spinal cord and a safer condition during the following months needed for the pannus reabsorption. The literature review and our data suggest that a transoral approach may not be necessary in the majority of patients suffering from retro-odontoid pannus associated with subaxial cervical degenerative disease.

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Conflict of interest None.

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