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1   **Title:**

2   Odontoid-sparing transnasal approach for drainage of cranio-cervical epidural abscess; a novel technique and

3   review of the literature

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2 **Manuscript**

3 **Abstract**

4 **Background**

5 Surgical approaches to the cranio-vertebral junction (CVJ) are challenging. Available approaches

6 include posterior, trans-oral, endonasal, and anterior extended retropharyngeal approach. Resection

7 of the odontoid process is necessary to gain access to the pathology posterior to it. The resultant

8 cranio-atlanto-axial instability usually necessitates subsequent posterior stabilization.

9 **Purpose**

10 To describe a new odontoid-sparing approach to the spinal canal at the (CVJ). This dens-sparing

11 approach preserves occipito-atlanto-axial stability and avoids the need for occipito-cervical

12 stabilization that adds to the extent of surgery and its associated morbidity and mortality.

13 **Study Design**

14 Describing a novel technique and reporting two cases

15 **Patient Sample**

16 Two patients that presented with infection at the CVJ with a retro-odontoid epidural abscess were

17 operated upon.

18 **Outcome Measures**

19 • Self-reported measures: Visual Analogue Scale (VAS) for neck pain.

20 • Physiologic measures: plain x-rays (antero-posterior and lateral views), MRI with contrast,

21 CT scan, C Reactive Protein (CRP) and leukocytic count.

22 • Functional measures: dynamic flexion-extension views of the cervical spine.

23 **Methods**

24 Two patients were operated upon using a combined endoscopic transnasal-transoral approach for

25 drainage of a retro-odontoid epidural abscess and debridement without dens resection.   A 4 mm,

26 degrees rigid endoscope was used. Preoperative clinical and neurological status was evaluated. The

2

1   follow up period was 12 months.   The study received no funding from any organization. None of

2   the authors has any relevant financial disclosures or conflict of interest.

3   **Results**

4   Both patients improved clinically after the endonasal transoral abscess drainage. Follow-up contrast

5   MRI showed complete resolution of the abscess after three weeks. Culture-sensitivity tests were

6   positive for Staphylococcus aureus in one patient. Antibiotic therapy with Clindamycin and

7   flucloxacillin was continued for 12 weeks postoperatively. There were no intraoperative or

8   postoperative complications. There was no need for posterior occipito-cervical stabilization in both

9   cases.

10   **Conclusion:**

11   This represents the first clinical report of accessing the spinal canal at the CVJ without resection of

12   the odontoid or the anterior arch of the atlas. The addition of endoscopic-assisted supra-dental

13   approach to the trans-oral one improved visibility, and allowed access to the most cranial part of

14   spinal canal without the need for dens resection, a procedure that significantly compromises C0/1/2

15   stability necessitating stabilization. This novel odontoid-sparing approach showed a favorable

16   outcome in our first 2 cases with retro-odontoid abscess, however, it would likely pose a high risk

17   in other pathologies including tumors.

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1 **Abbreviations**

CVJ	Craniovertebral Junction
ICU	Intensive Care Unit
ER	Emergency Room
CRP	C Reactive Protein
MRI	Magnetic Resonance Imaging
ENT	Ear Nose Throat
NPL	Naso-palatine Line
CSF	Cerebro-spinal Fluid

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1   **Manuscript Text**

2   **Introduction**

3   The craniovertebral junction (CVJ) possesses unique anatomical and biomechanical properties that

4   allow large degrees of motion while maintaining stability. An understanding of the complex

5   anatomy and biomechanics of the CVJ is necessary to evaluate and effectively treat various

6   pathological processes that affect this region [1].

7   The stability of the CVJ is determined by ligaments that constrain movement at the bony

8   articulations involoved. Ligamentous attachments at the CVJ are complex, but they can be

9   simplified into four broad categories: odontoid-specific ligaments, articular ligaments, ligaments of

10   the anterior column, and ligaments of the posterior column [2]. The most critical ligaments that

11   contribute to the stability of the CVJ are the transverse ligament of the cruciform complex, the alar

12   ligaments, and the tectorial membrane [3 -5].

13   Surgical approaches to the CVJ are challenging. Available approaches include posterior, anterior

14   trans-oral, anterior trans-nasal, and anterior open cervical or extended retropharyngeal. Recently, a

15   few case reports described an endoscopic trans-nasal approach to the CVJ. Most of these reports

16   entailed odontoid resection [6-10]. The resultant cranio-atlanto-axial instability usually necessitated

17   subsequent posterior stabilization [11]. Resection of the odontoid process was generally performed

18   to gain access to the pathology posterior to it. The approach, extent of surgery, as well as the goals

19   of care depended upon the pathology, anatomy, and surgeon's experience, and needed to be tailored

20   for each patient [12].

21   To the best of our knowledge, this is the first report describing an approach to the spinal canal

22   cranial to the dens through the soft tissue window between the dens and clivus using a combined

23   endoscopic trans-nasal and trans-oral approach. The aim of this article is to describe the evolution

24   of our surgical technique preserving the CVJ stability and to report the outcomes of 2 patients.

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1 **Methods**

2 **Surgical technique:**

3 Both operations were performed under general anaesthesia with the patients in the supine position.

4 After prepping and draping, a self-retaining mouth retractor was applied. A 4 mm endoscope (18

5 cm length with a lens angle of 30 degrees) was carefully placed through one nostril and

6 subsequently the other. The posterior nasopharyngeal target area was evaluated and the nostril that

7 provided better visualization of the midline was chosen as the port for the endoscope. The other

8 nostril was utilized as the working channel. Resection of the nasal septum or turbinates was not

9 necessary. The level of mucosal dissection was determined by insertion of a 1.2 mm guide wire

10 trans-orally in the midline at the anterior atlas arch. Position was further confirmed using

11 fluoroscopy in the lateral plane. Mucosal dissection was performed using micro-scissors just cranial

12 to the guide wire up to the clivus cranially. Haemostasis was maintained using trans-oral bipolar

13 diathermy. A linear vertical incision of the mucosa was performed. After dissection of submucosal

14 soft tissue and ligaments, the upper part of the anterior tubercle and the tip of the dens were

15 exposed. Suction and retraction of the posterior pharyngeal wall mucosal flaps along with the

16 submucosal tissues using blunt 90 degrees retractors were done trans-orally.

17 Subsequently, the middle part of the anterior atlanto-occipital membrane and the apical ligament

18 were resected. The deeper layers including the anterior atlanto-occipital membrane, the apical

19 ligament, and the tectorial membrane were difficult to distinguish due to infection. These layers

20 were severely affected by the inflammatory process in both cases.

21 During the procedure, instruments were alternatively introduced through the nostril or through the

22 mouth, based on convenience. The epidural abscess was then evacuated, and decompression was

23 done until the dura was clearly visible. Repeated irrigation with saline through a small pore cannula

24 was performed. Using a 90-degree ball-tipped blunt hook, extension of the abscess posterior to the

25 dens was evacuated.

6

1 Stability of the CVJ was not assessed intra-operatively, however, neither of the two patients

2 presented with clinical symptoms of CVJ instability such as pain or neurological deterioration post-

3 operatively. Postoperative flexion/extension views did not show any evidence of instability.

4 Adequate biopsies and samples were taken for histopathology, and culture and sensitivity tests.

5 Neuro-navigation was not used in this technique.

6 As the incision was performed in the most cranial part of the nasopharynx, there was no need for

7 closure, as this part of the pharynx is well protected with the soft palate during swallowing. We also

8 recommend leaving the posterior pharyngeal wall open to drain any recollection of inflammatory

9 debris. At the end of the procedure, a nasogastric tube was inserted for feeding. The patient was

10 then extubated and transferred to the ICU.

11

12 **Case 1**

13 An 87-year old female presented to the Emergency Room (ER) with fever and progressive

14 weakness of both upper limbs. She had severe neck pain for about one week with limited ability to

15 move her head. Laboratory investigations revealed a total leukocytic count of 18×10^9/L, and a C-

16 reactive protein (CRP) of 200 mg/dl. MRI of the whole spine confirmed the diagnosis of

17 spondylodiscitis with a large anterior epidural abscess extending from the CVJ down to C7.

18 Considering the progressive neurological deficit, anterior cervical decompression, drainage,

19 debridement and fusion of C4-6 was urgently done. Anterior discectomy C4-6 with interbody

20 fusion using titanium cages was performed. The goal was to decompress the spinal canal to prevent

21 further neurological deterioration and obtain material for microbiological tests. An empirical

22 combination of broad spectrum antibiotics (flucloxacillin and clindamycin) was administered until

23 the sensitivity results were available. The neurological deficits improved rapidly. The patient was

24 transferred to a regular inpatient bed.

25 Two days later, the patient developed fever while still on the antibiotics. The CRP and leukocytic

26 count were progressively increasing. Procalcitonin was positive (2.4 microgram/L) with impairment

7

1   of renal function. She was transferred to the Intensive Care Unit with the diagnosis of sepsis. MRI

2   and CT of the CVJ and cervical spine were urgently done. They revealed a retro-odontoid abscess

3   extending from the clivus to C2 without dens destruction. Oral and maxillofacial surgeons

4   confirmed that the primary focus was an infected tooth that was extracted.

5   In cooperation with ENT colleagues, drainage of the abscess through a combined endonasal and

6   trans-oral approach was done. There were no intraoperative or immediate postoperative

7   complications. The patient was extubated immediately postoperatively and transferred to the ICU

8   for one day. Two days later, she was in a regular inpatient ward. Feeding through a nasogastric tube

9   was done for the first 24 hours, and this progressed to oral feeding with fluids and soft foods over

10   the next two days. Culture and sensitivity confirmed Staphylococcus aureus to be the causative

11   organism. Accordingly, clindamycin was prescribed for 12 weeks. Leukocytic count and CRP

12   values progressively decreased with treatment. Within two weeks, the CRP was 18 mg/dl and

13   leucocyte count was 13 x 10^9/L., after which the patient was discharged. No symptoms of

14   velopharyngeal insufficiency such as speech changes or regurgitation of solid foods and fluids

15   through the nose were reported.

16   MRI of the cervical spine one year postoperatively revealed complete resolution of the infection,

17   with no signs of inflammation or epidural abscess (**Figure 1**).

18

19   **Case 2**

20   A 74-year old male patient presented with severe neck pain, restricted head movement, and

21   meningismus-like symptoms. His medical history included hypertension, diabetes mellitus and a

22   non-operable oesophageal carcinoma treated with chemo- and radiotherapy, the last course of which

23   was administered 6 weeks prior to presentation. Contrast-MRI of the cervical spine revealed a

24   cranio-cervical infection with a retro-odontoid epidural abscess extending from the clivus to the

25   level of the C2/3-disc space. Blood cultures were obtained, and a combination of broad spectrum

26   antibiotics were started. Due to his multiple comorbidities and poor overall condition, the patient

8

1   was admitted to the intermediate care unit. Two days after admission, he developed severe headache

2   and temporary neurological deterioration in the form of incomplete quadriparesis (Frankel C) that

3   lasted for about 20 minutes and then improved spontaneously. Urgent MRI of the head and neck

4   revealed progression of the inflammatory process with enlargement of the abscess posterior to the

5   odontoid process. The decision was made to intervene surgically. Combined endonasal and trans-

6   oral debridement and drainage of the abscess was done **(Figure 2)**. The intra-operatively obtained

7   tissue for culture and sensitivity showed no growth. Antibiotics (flucloxacillin and clindamycin)

8   were continued for 6 weeks. Follow up laboratory investigations revealed improvement of the

9   leukocytic count and CRP. MRI examination was performed two weeks post-operatively to evaluate

10   for adequate drainage and exclude re-collection. There was marked improvement of the

11   inflammatory process and the soft tissue edema anterior and posterior to the odontoid process.

12   Follow up dynamic plain x-rays (flexion-extension views) showed no evidence of cranio-atlanto-

13   axial instability **(Figure 3)**.

14

9

1 **Discussion**

2 Pathologies of the CVJ can result in anterior bulbomedullary compression, requiring a

3 decompression procedure including odontoidectomy. The trans-oral approach is the historical

4 standard to perform this anterior decompression [13]. The endonasal approach to the CVJ was

5 originally described by Kassam and colleagues [14]. The advantage of the endonasal approach is

6 that it provides direct surgical access to anterior and anterolateral CVJ lesions without the need to

7 mobilize or retract cranial nerves, the lower brainstem, or upper cervical spinal cord. In addition,

8 the endoscope adds the advantages of high illumination and a wide field of view [15, 16].

9 The best understood alterations in kinematics of the CVJ are those resulting from iatrogenic injury

10 (e.g., after odontoidectomy), which could be explained by the disconnection of C1 from its axis of

11 rotation around the dens [17]. The biomechanical effect of odontoidectomy was studied in vitro by

12 Dickman et al. They found statistically significant increase in flexion, extension, and lateral

13 bending. The axes of axial rotation were profoundly deranged by odontoidectomy; the centrode of

14 the axes of rotation for axial rotation was diffuse across almost the entire body of C2, reflecting the

15 disorganized, unconstrained, and hypermobile motion at the joint. Furthermore, significant

16 translational instability occurred in all directions [18]. Disruption of the stabilizing ligaments of the

17 CVJ, with or without bony injury, is sufficient to destabilize the CVJ. Biomechanically, disruption

18 of the transverse-atlantal ligament functions in a manner equivalent to an odontoidectomy.

19 Unilateral alar ligament disruption is associated with a modest increase in axial rotation. However,

20 bilateral alar ligament injury significantly increases axial rotation, lateral bending, and flexion-

21 extension [19]. The atlanto-occipital membrane contributes little to the stability of the CVJ [20].

22 The apical ligament of the dens (or apical odontoid ligament) is proposed to be vestigial; the

23 ligament was absent in 20% of specimens examined by Tubbs et al and does not possess sufficient

24 integrity to impact even the physiological forces of flexion or extension [21]. The anterior atlanto-

25 occipital membrane also contributes minimally to stability of the CVJ [22].

10

1 In both of our cases, only the central part of the soft tissue window and the ligamentous complex

2 were disturbed due to the surgical approach. The superior crus of the cruciform ligament was

3 resected, otherwise all structures were preserved including the alar ligaments, the transverse

4 ligament and the lateral parts of the atlanto-occipital membrane. Thus, our novel approach did not

5 affect craniovertebral stability ,negating the need for subsequent posterior stabilization.

6 Posterior occipito-cervical stabilization may be indicated after odontoid resection based on the

7 subsequent degree of instability. El-Sayed et al [23] reported that the combination of an endonasal

8 and trans-oral route was a pragmatic way to conserve the advantages of endoscopic visualization via

9 different corridors, while minimizing procedure-related morbidity due to splitting of the soft palate.

10 Furthermore, using a trans-oral corridor has the advantage of allowing for an extended reach

11 inferiorly and greater manual dexterity because surgical instruments can be angled laterally within

12 the oral cavity [24].

13 This inferior access was not required in the two cases reported here, but it may be required for

14 pathologies extending below the middle of the body of axis. Moreover, in standard, open trans-oral

15 approaches with microscope visualization, the hard palate sometimes still obstructs visualization of

16 the upper portions of a lesion. The use of the endoscope overcomes this obstacle, as it can be

17 navigated to look around the palate [7].

18 Previous reports mentioned C1 rim to be the most caudal limit of the trans-nasal route [15]. De

19 Almeida et al [26] defined the nasopalatine line (NPL) to describe the limit for endonasal surgery of

20 the spine. They concluded that the NPL accurately predicts the most inferior limit of surgical

21 exposure of the extended endoscopic endonasal approach in patients requiring resection of the

22 odontoid and of a trans-odontoid approach. Further inferior dissection may require the use of angled

23 instruments or a trans-oral approach. By combining the endonasal approach with a trans-oral

24 approach, the caudal access to C2 and below is easily achieved [7].

25 Presuming favorable anatomy of the NPL, both cases described in this report could have been

26 relatively easily and safely drained using the endonasal option in experienced hands. Using a

11

1 combination of transoral endonasal routes allowed us to combine the advantages of the transoral

2 route (which we have ample experience utilizing) with direct visualization provided by the

3 endonasal one (which we are less familiar with).

4 The potential complications related to the extended endonasal approach include surgical bleeding

5 from vascular structures. Postoperative cerebrospinal fluid (CSF) leakage is the most common

6 complication of the endonasal approach. These complications occur mainly with extended

7 endonasal approach and not the limited endonasal approach we employed.

8 When possible, preserving the C1 anterior arch and odontoid helps preventing cranio-cervical

9 instability. Pathologies that cause anterior spinal cord compression at the CVJ without odontoid

10 destruction are uncommon. Such pathologies include: rheumatoid pannus, which rarely necessitates

11 anterior decompression, retro-odontoid abscess, or a cranially migrated sequestrated disc [27].

12 One of the advantages of the endoscopic endonasal technique lies in the trajectory of approaching

13 the odontoid **(Figure 4)**. With the trans-oral method, the odontoid process is approached in a caudo-

14 cranial direction, and resection of the anterior arch of C1 to expose the odontoid is often mandatory.

15 Endonasal endoscopic approaches, however, allow the surgeon to reach the odontoid process in a

16 cranio-caudal direction, permitting resection of the odontoid and preserving the arch of the atlas

17 [28, 29]. Even in these two cases, it allowed access to the spinal canal superior to the dens, and thus

18 spared the patients the morbidity and instability associated with resection of the dens or the anterior

19 arch of the atlas. The degree of instability resulting from such restricted soft tissue dissection cranial

20 to the dens is insignificant. This was demonstrated in the postoperative dynamic flexion-extension

21 views. In these two cases, the need for better access to the spinal canal was the primary reason the

22 trans-oral and endonasal approaches were combined, as the abscess was located behind the intact

23 odontoid process.

24 Raper et al [30] reviewed a total of 40 studies that reported on odontoid resection, with 764 patients

25 included. There were 32 studies of trans-oral odontoid resection and 8 studies of endonasal

26 endonasal endoscopic resection. Their results indicated that the endonasal approach may cause less trauma to

12

1   the retropharyngeal tissue. Mucosal incisions are in the nasopharynx rather than the oropharynx

2   which greatly improves normal oropharyngeal function after surgery. Rapid extubation and feeding,

3   in turn, contribute to an overall shorter recovery time, faster mobilization, and discharge from the

4   hospital.

5   Nonetheless, endonasal and trans-oral approaches, remain challenging procedures due to the depth

6   and narrowness of the corridor, and the risk of potentially dramatic neurologic sequelae related to

7   the close relationship with the brainstem and spinal cord [17].

8

13

1 **Conclusion**

2 To the best of our knowledge, this report represents the first clinical description of a novel

3 supradental approach to access the spinal canal at the CVJ with resection of neither the odontoid nor

4 the anterior arch of the atlas. The anterior gap between the clivus and the tip of the dens represents a

5 possible anatomical soft tissue window to access the spinal canal without any bony resection, thus

6 preserving CVJ stability. Whenever possible, sparing the anterior arch of the atlas and dens

7 contributes significantly to occipito-atlanto-axial stability. This approach showed a favorable

8 outcome in cases with retro-odontoid abscess, however, it would likely pose a high risk in patients

9 with other pathologies including tumors. We recommend this combined trans-oral endonasal

10 approach in cases with unfavorable anatomy or insufficient experience with the endonasal

11 approach.

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1   **Figure Legend:**

2   **Figure 1:** Preoperative MRI sagittal T2 showing a large anterior epidural abscess extending from

3   the caudal tip of clivus to the lower border of C5 vertebral body with its largest diameter behind the

4   body of C4. CT sagittal reconstruction postoperatively showing the intact odontoid process after

5   drainage of the abscess and the cages inserted after anterior debridement, decompression and fusion

6   of C4-6. The fourth image shows the sagittal T2 MRI at 3 months follow up with complete

7   resolution of the epidural abscess and intact odontoid process.

8   **Figure 2:** a. intraoperative endo-nasal image (from the right nostril) showing the midline and the

9   edematous pharyngeal wall. b. incising the posterior pharyngeal wall of the naso-pharynx in the

10   midline. c. the inflamed retropharyngeal structures here mainly the longus colli muscles at their

11   insertion after lateral dissection of the posterior pharyngeal wall. d. Debridement and removal of the

12   phlegmonous retropharngeal tissues. e. note the cranio-caudal direction of the Kerrison rongeur

13   introduced through the nose. f. and g. draining pus from the retro-odontoid space. h. at the end of

14   the procedure notice the anterior arch of atlas, tip of odontoid process and clivus marked from

15   caudal to cranial direction.

16   **Figure 3:** Dynamic flexion-extension views of case 2 on 12th postoperative day showing no

17   evidence of cranio-atlanto-axial instability.

18   **Figure 4:** The trajectories that can be targeted through the endonasal and transoral approaches.

19   Notice the endonasal approach allows cranial entry to the spinal canal between the clivus and the
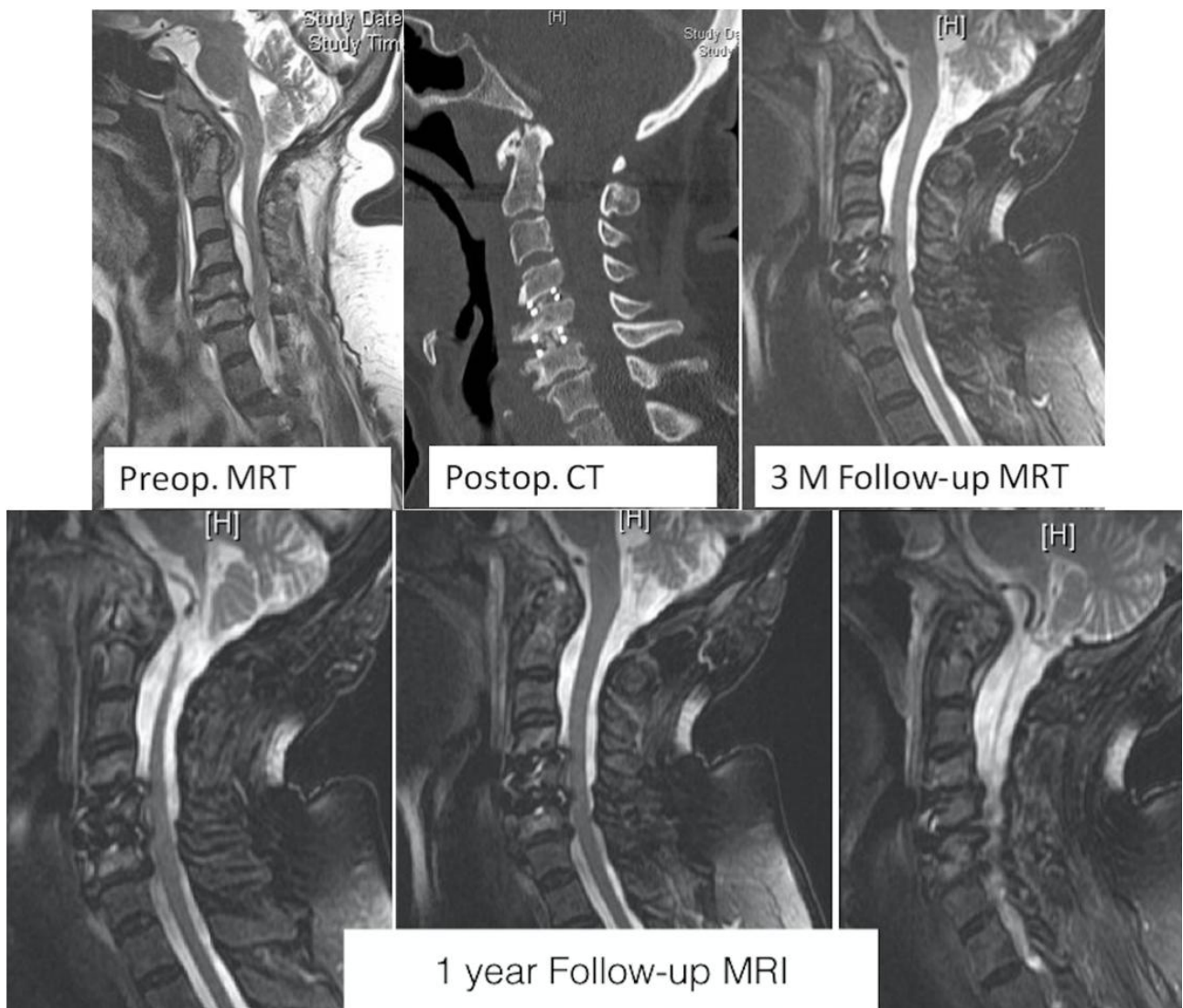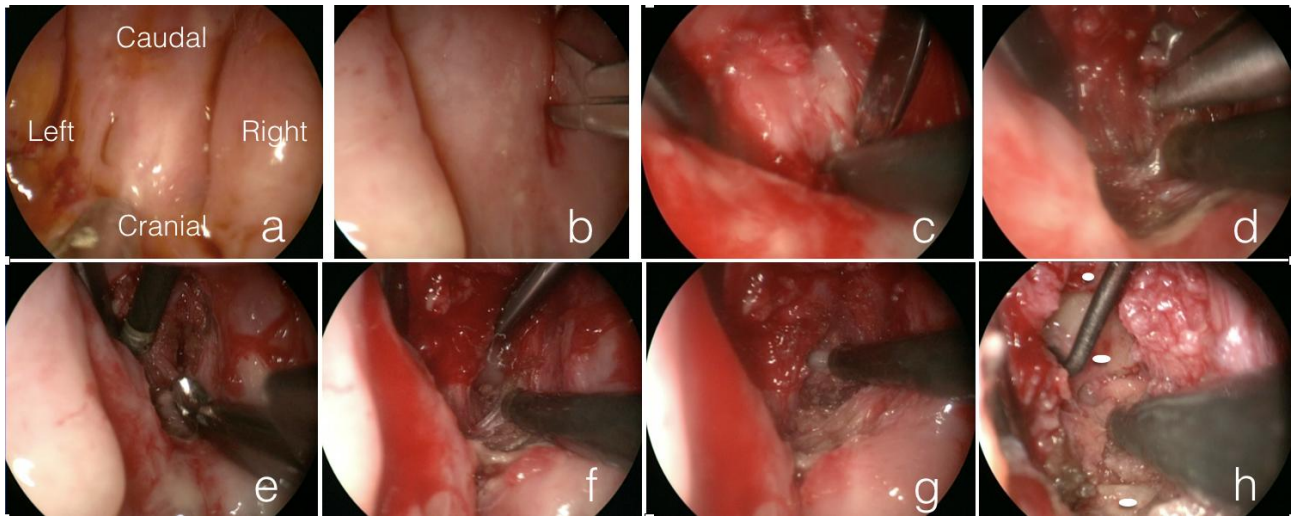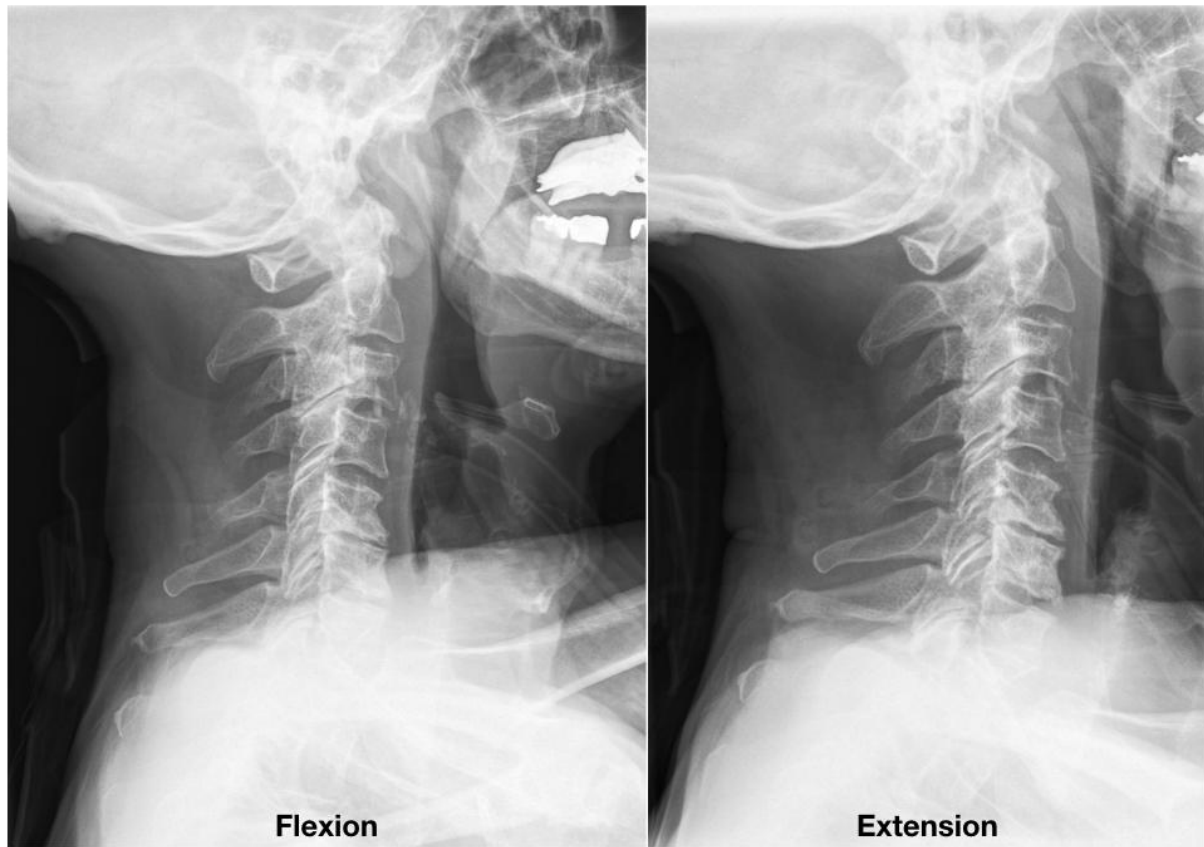
20   apex of the dens.

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18

Preop. MRT   Postop. CT   3 M Follow-up MRT

1 year Follow-up MRI

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2   Figure 1

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19

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4   Figure 2

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2   Figure 3

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2   Figure 4

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