The endoscopic endonasal approach to the odontoid and its impact on early extubation and feeding

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OBJECT The gold-standard surgical approach to the odontoid is via the transoral route. This approach necessitates opening of the oropharynx and is associated with risks of infection, and swallowing and breathing complications. The endoscopic endonasal approach has the potential to reduce these complications as the oral cavity is avoided. There are fewer than 25 such cases reported to date. The authors present a consecutive, single-institution series of 9 patients who underwent the endonasal endoscopic approach to the odontoid.

METHODS The charts of 9 patients who underwent endonasal endoscopic surgery to the odontoid between January 2005 and August 2013 were reviewed. The clinical presentation, radiographic findings, surgical management, complications, and outcome, particularly with respect to time to extubation and feeding, were analyzed. Radiographic measurements of the distance between the back of the odontoid and the front of the cervicomedullary junction (CMJ) were calculated, as well as the location of any residual bone fragments.

RESULTS There were 7 adult and 2 pediatric patients in this series. The mean age of the adults was 54.8 years; the pediatric patients were 7 and 14 years. There were 5 females and 4 males. The mean follow-up was 42.9 months. Symptoms were resolved or improved in all but 1 patient, who had concurrent polyneuropathy. The distance between the odontoid and CMJ increased by 2.34 ± 0.43 mm (p = 0.03). A small, clinically insignificant fragment remained after surgery, always on the left side, in 57% of patients. Mean times to extubation and oral feeding were on postoperative Days 0.3 and 1, respectively. There was one posterior cervical wound infection; there were 2 cases of epistaxis requiring repacking of the nose and no instances of breathing or swallowing complications or velopharyngeal insufficiency.

CONCLUSIONS This series of 9 cases of endonasal endoscopic odontoidectomy highlights the advantages of the approach in permitting early extubation and early feeding and minimizing complications compared with transoral surgery. Special attention must be given to bone on the left side of the odontoid if the surgeon is standing on the right side.

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KEY WORDS cervicomedullary junction; endonasal; endoscopy; extubation; feeding; odontoid; odontoidectomy; transnasal; transsphenoidal; anatomy

A recent paper by Choi and Crockard compared transoral odontoid surgery to the crocodile; it has persisted from prehistoric times but still has a place today.2 Indeed, the transoral approach is considered the gold-standard approach to surgically address periodontoid pathology.10 However, the evolution of endoscopic endonasal surgery has led to the development of a minimally invasive alternative approach to the odontoid. While both the transoral and endonasal approaches are “natural orifice” surgery, the biggest advantage of the endonasal endoscopic approach arises from the location of the mucosal incision in the nasopharynx and not the oropharynx. In theory, minimizing disruption of the oropharynx allows patients to be extubated and to begin oral feeding sooner, thereby reducing the length of stay and the complications that may arise from prolonged intubated and delayed feeding.20 Likewise, the palate does not need to be split, as is sometimes the case with transoral surgery. However, few cases have been reported in the literature to support this claim.
A recent meta-analysis was performed to assess the role of the endonasal endoscopic approach and compare it to the transoral approach. While the meta-analysis did show advantages of the endonasal approach, it was limited by small numbers. The present study reports on a consecutive series of patients from a single center, operated on by the same surgical team, who underwent endoscopic endonasal approaches to the odontoid. The results add significantly to the number of patients reported on in the literature and document markedly earlier extubation and feeding than previously reported.

Methods

A prospective database of all endoscopic skull base surgeries performed at Weill Cornell Medical College, New York-Presbyterian Hospital, between January 2005 and August 2013, was retrospectively reviewed. Institutional review board approval was obtained for this study. Patients who underwent an endoscopic endonasal approach to the odontoid were included, and their hospital and clinic records were reviewed.

The following data were collected: demographic information (including patient age and sex), presenting complaint, operative diagnosis, operative details, blood loss, operative time, time to extubation, time to resumption of oral feeding, length of stay; complications, adjuvant operations (including posterior fusion and/or decompression), and status at follow-up. To quantify the efficacy of the technique, we measured the amount of T2 signal in front of the cervicomedullary junction (CMJ) at the level of the odontoid before and after surgery on MRI (when available). The measurement was taken at the area of greatest compression or closest proximity between the odontoid and the CMJ. This was done by 2 separate neurosurgeons, and the average of the 2 measurements was used for calculations. The postoperative CT scans were reviewed and the location of residual odontoid, if any, was recorded. Paired nonparametric statistics were used to determine significance.

Surgical Technique

All operations were performed by a surgical team that included an otolaryngologist (V.K.A.) and a neurosurgeon (T.H.S.) at the Institute for Minimally Invasive Skull Base and Pituitary Surgery, Weill Cornell Medical College, New York-Presbyterian Hospital. In cases in which a posterior fusion was indicated this was performed by a spinal neurosurgeon (R.H.). Pediatric procedures were performed in conjunction with a pediatric neurosurgeon (J.P.G.).

The details of the surgery are described elsewhere (Fig. 1). Most patients underwent posterior fusion prior to endonasal odontoid resection, either on a previous day or the same day in the morning. Since endonasal odontoid resection destabilizes C-1 and C-2, we elected to perform the fusion first to minimize the hypothetical risk of cord injury that might occur after endonasal surgery during patient position for a posterior fusion. Some patients were placed in a halo for subsequent posterior fusion.

In brief, after oropharyngeal intubation, prophylactic antibiotics and dexamethasone were administered. The patient was placed supine on the operating table with the head secured in the Mayfield 3-pin headrest, and registration of the frameless stereotactic system was performed. Preoperative CT scans of the CMJ were used for navigation, sometimes coregistered with MRI. Motor evoked potentials and somatosensory evoked potentials were used throughout most procedures. The inferior turbinate were lateralized bilaterally, and a submucosal resection of the posterior 2 cm of the septal cartilage was performed using a tissue shaver and a high-speed drill to enlarge the choana for a wider exposure. A 30-cm, 4-mm rigid 0° endoscope (Karl Storz) was held in the left nostril with an endoscope holder, and surgery was performed using a bimanual technique either through the right or both nostrils as required. The operative surgeon stands on the right side of the patient (Fig. 1).

A red rubber catheter was placed through the nasal cavity into the oral cavity for downward retraction of the soft palate to facilitate exposure. The fascia of the posterior nasopharynx was opened with an inverted U-shaped or linear incision. The longus colli and capitis muscles were elevated bilaterally using monopolar diathermy. Under stereotactic guidance, the inferior portion of the clivus was removed to expose the basilar tip depending on the degree of invagination. Then the anterior ring of C-1 was removed. Finally, the odontoid was resected by internal decompression with a high-speed drill and removal of the lateral and superior rim with a curette. If significant inflammatory pannus was present behind the odontoid, the ultrasonic aspirator and a Kerrison rongeur were used to remove the pannus and transverse ligament to expose the dura. The nasopharyngeal flap was then reapproximated and held in place with TISSEEL (Baxter). Floseal hemo-static matrix (Baxter) was then placed in the nasopharynx. Intraoperative imaging was only used in one case to determine the extent of resection as it is not routinely available at our institution. Follow-up was performed by the neurosurgeons involved and the otolaryngologist. The otolaryngologist performed office-based endoscopic assessment of nasal and pharyngeal function to monitor for complications.

Results

Demographics

There were 7 adult and 2 pediatric patients in this series. Three of these cases (Cases 1, 2, and 3) were previously published as case reports. The mean age of the adults was 54.8 years ± 8.3 years (range 20–77 years). The pediatric patients were 7 and 14 years old. There were 5 females and 4 males. A summary of patient characteristics is shown in Table 1. The average follow-up was 42.9 months (range 1.3–99.1 months).

Patient Presentation and Diagnosis

Neck pain was the most common presenting complaint, occurring in 56% of patients. This occurred in isolation or in conjunction with other complaints, such as cervical myelopathy and swallowing difficulty, both of which occurred in 44% of patients. The patient in Case 2 presented with neck pain but had significant cervicomedullary com-
pression from a combination of basilar invagination and rheumatoid pannus. Both pediatric patients had cerebellar signs on presentation and had a diagnosis of basilar invagination and Chiari malformation. Basilar invagination was present in 43% of adults, which was associated with rheumatoid arthritis and odontoid pannus in 2 cases. The diagnoses in the remaining patients were mass lesions secondary to gout, a ganglion cyst, os odontoideum and a breast metastasis. Individualized details are shown in Table 1.

**Timing of Fusion**

All patients who underwent odontoidectomy had supplemental posterior instrumented fusion. This varied be-
between C1–2 fusion and occipitocervical fusion, as shown in Table 2. Some patients underwent fusion prior to the endonasal odontoidectomy, while others were immobilized with a halo brace and underwent fusion later. In 2 cases both procedures were performed on the same day. The 2 patients who underwent odontoid biopsy did not undergo fusion, and follow-up dynamic radiography demonstrated no macroinstability.

Immediate Postoperative Outcome

The mean operative time for the endonasal portion was 308 ± 147 minutes (range 117–500 minutes). Two-thirds of patients were extubated at the end of the procedure, with the remainder on the 1st postoperative day (POD). If immediate extubation is considered POD 0, the mean time to extubation occurred on POD 0.3. The mean time to resumption of oral feeding in this series was POD 1. One patient resumed oral feeding on POD 1 but had a poor oral intake that required observation and encouragement. This patient resumed a full diet on POD 4, although the etiology of this delay was unclear since the patient did not have any mechanical limitations on POD 1.

Treatment Complications

There was one delayed posterior cervical wound infection, which occurred 1 month postoperatively. The patient was treated with antibiotics and had clinical and radiological resolution. Two patients had postoperative epistaxis which required additional nasal packing. There were no instances of CSF leak. No patients required reoperation. No patients had velopharyngeal insufficiency.

Symptomatic Outcome

All preoperative symptoms completely resolved in 2

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presenting Symptoms &amp; Signs</th>
<th>Diagnosis</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>71, M</td>
<td>NP</td>
<td>Gout</td>
<td>Resolved</td>
</tr>
<tr>
<td>2*</td>
<td>32, M</td>
<td>NP</td>
<td>Juvenile RA, pannus, basilar invagination, cervicomедullary compression</td>
<td>Improved</td>
</tr>
<tr>
<td>3*</td>
<td>50, F</td>
<td>CM</td>
<td>Os odontoideum</td>
<td>Improved</td>
</tr>
<tr>
<td>4</td>
<td>59, F</td>
<td>SD</td>
<td>Basilar invagination, Chiari malformation</td>
<td>CM, SD resolved; CS improved</td>
</tr>
<tr>
<td>5</td>
<td>14, M</td>
<td>CS, CM, SD</td>
<td>Ganglion cyst</td>
<td>NP improved; CM, gait improved but has numbness in hands &amp; head</td>
</tr>
<tr>
<td>6</td>
<td>77, F</td>
<td>NP, CM</td>
<td>RA, pannus, basilar invagination</td>
<td>Symptoms stable; patient also has chronic inflammatory demyelinating polyneuropathy</td>
</tr>
<tr>
<td>7</td>
<td>75, M</td>
<td>CM</td>
<td>RA, pannus, basilar invagination</td>
<td>NP, SD resolved; CS improved</td>
</tr>
<tr>
<td>8</td>
<td>20, F</td>
<td>NP, SD</td>
<td>Basilar invagination, Chiari malformation, cat’s eye syndrome</td>
<td>SD resolved, NP improved; patient has headaches</td>
</tr>
<tr>
<td>9</td>
<td>7, F</td>
<td>NP, SD, CS</td>
<td>Basilar invagination, Chiari malformation</td>
<td>NP, SD resolved; CS improved</td>
</tr>
</tbody>
</table>

CM = cervical myelopathy; CS = cerebellar signs; NP = neck pain; RA = rheumatoid arthritis; SD = swallowing disturbance.

* These cases were previously published as case reports.

### Table 1. Patient demographics, presentation, diagnosis, and follow-up

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presenting Symptoms &amp; Signs</th>
<th>Diagnosis</th>
<th>Follow-Up</th>
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</thead>
<tbody>
<tr>
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<tr>
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</tr>
</tbody>
</table>

CM = cervical myelopathy; CS = cerebellar signs; NP = neck pain; RA = rheumatoid arthritis; SD = swallowing disturbance.

* These cases were previously published as case reports.

### Table 2. Operative details, outcomes, and complications

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>ENB No</td>
<td></td>
<td>123</td>
<td>1</td>
<td>1</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ENR OCF*</td>
<td></td>
<td>496</td>
<td>20</td>
<td>0</td>
<td>Reduced oral intake–resolved Day 4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ENR OCF†</td>
<td></td>
<td>242</td>
<td>100</td>
<td>1</td>
<td>2</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>ENB No</td>
<td></td>
<td>117</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>ENR Decompression &amp; OCF*</td>
<td></td>
<td>376</td>
<td>40</td>
<td>0</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>ENR C1–2 fusion†</td>
<td></td>
<td>646‡</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>Posterior wound infection; treated w/ antibiotics, did not require reop</td>
</tr>
<tr>
<td>7</td>
<td>ENR C1–2 fusion*</td>
<td></td>
<td>300</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>Epistaxis</td>
</tr>
<tr>
<td>8</td>
<td>ENR Decompression &amp; OCF*</td>
<td></td>
<td>500</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>Epistaxis</td>
</tr>
<tr>
<td>9</td>
<td>ENR Decompression &amp; OCF*</td>
<td></td>
<td>311</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>None</td>
</tr>
</tbody>
</table>

ENB = endonasal odontoid biopsy; ENR = endonasal odontoid resection; OCF = occipitocervical fusion.

* Performed prior to endonasal surgery.

† These procedures were performed during the same session of anesthesia.

‡ Operative time includes fusion performed during the same procedure.
patients, and a subset of symptoms completely resolved in another 3 patients (Table 1). All other patients showed improvement in all symptoms with the exception of the patient in Case 7, who had concurrent chronic inflammatory demyelinating polyneuropathy. Despite adequate radiographic decompression (Fig. 2), the patient had residual symptoms of gait disturbance and upper- and lower-extremity paresthesia. Those patients who underwent diagnostic biopsy reported resolution of their symptoms following institution of appropriate medical or adjuvant therapies.

**Radiographic Outcome**

Odontoidectomy resulted in a significant (p = 0.03) spinal cord decompression as determined by a mean increase in T2 signal (CSF space) on postoperative MRI of 2.34 ± 0.43 mm (range 1.72–3.03 mm) (Table 3 and Fig. 3). One patient did not have an MR image available for comparison. For those patients in whom the goal of surgery was complete odontoidectomy, on postoperative CT there was complete resection in 57%. The remaining patients had small, clinically insignificant fragments of bone always on the left side (Table 4 and Fig. 4).

**Discussion**

The traditional method for anterior decompression of CMJ abnormalities is the transoral approach. The transoral approach provides a direct midline route to the ventral CMJ. Because of the deep surgical corridor, the approach occasionally needs to be widened with transmandibular or transmaxillary extensions to improve the rostral and caudal limits of the exposure. Splitting of the soft palate and resection of the hard palate are often incorporated into the transoral approach to increase the exposure, particularly in patients with a small mouth. A recent review of the transoral approaches showed that a soft palate incision is used in 33.6% of cases. Postoperative complications secondary to the approach and its modifications include tongue edema and even necrosis, tracheal edema, hypernasal speech, and nasal regurgitation. As a result of such maneuvers and complications, the patient may need additional tracheostomy and gastrostomy that may lead to prolonged recovery and hospitalization. In fact, gastrostomy tubes were placed in roughly 14.8% of transoral cases in a recent review with a tracheostomy rate of 3.8%, a 4% rate of velopharyngeal insufficiency, and a perioperative mortality rate of 2.3%.

In contrast, the minimally invasive nature of the endonasal endoscopic approach aims to reduce these complications and comorbidities. To date there have been roughly 25 cases of endonasal endoscopic odontoid resection, most of which have been published as case reports. A recent review comparing transoral with endonasal odontoidectomy has shown that the average time to extubation and time to feeding in the currently published literature following transoral surgery is 3.5 and 5.2 days, respectively, compared with 0.43 and 3.86 days following endonasal endoscopic surgery. In our current paper, we report a series of 9 cases in which extubation and feeding occurred a mean of 0.3 and 1 day after surgery, respectively. These cases add significantly to the existing literature, not only in number of cases but also in demonstrating the rapidity with which patients can be extubated and fed after endonasal endoscopic odontoidectomy.

## Table 3. Pre- and postoperative mean measurements (in mm) of T2 signal (CSF space) ventral to the spinal cord at the level of the odontoid

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Preop</th>
<th>Postop</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biopsy</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>0.875</td>
<td>3.90</td>
<td>3.025</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>Biopsy</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>0.25</td>
<td>2.075</td>
<td>1.825</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>1.72</td>
<td>1.72</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>2.40</td>
<td>2.40</td>
</tr>
<tr>
<td>8</td>
<td>0.454</td>
<td>3.07</td>
<td>2.616</td>
</tr>
<tr>
<td>9</td>
<td>0.015</td>
<td>2.65</td>
<td>2.635</td>
</tr>
</tbody>
</table>

NA = not applicable; — = not available.

**FIG. 3.** Graph showing the measurement of the distance between the back of odontoid and front of CMJ before and after decompression based on MRI findings. Each line represents 1 patient. Images were not available in 1 patient.
The largest single series of endonasal odontoidectomies published to date was by Nayak et al., who reported their experience in a series of 9 patients. Four of 9 patients required tracheostomy in the perioperative period, 3 required postoperative gastrostomy, and 2 developed transient velopharyngeal incompetence. Although the rate of these complications and comorbidities is higher than expected for the endonasal endoscopic approach, it should be noted that 4 of the 9 patients presented with dysphagia or respiratory failure preoperatively. In another prior series the authors inserted nasogastric tubes endoscopically at the time of surgery for postoperative feeding, reportedly to prevent infection. The results in our series demonstrate that even better results can be achieved, particularly in patients without preoperative dysphagia or respiratory failure, and that nasogastric tubes are not required to prevent infections.

With respect to extent of resection of the odontoid, a prior review demonstrated rates of 100% and 97% for the transoral and endonasal approaches, respectively. In the current paper, we did not specifically look at gross-total resection of the odontoid since the odontoid is not a tumor and since the inferior extent of the resection is not clearly defined. For this reason, we developed a novel and more useful metric, namely the distance between the back of the odontoid and the front of the CMJ, consisting of high T2 signal on sagittal MRI, or the CSF space, to demonstrate the adequacy of achieving the anatomical goal of surgery. This metric correlated well with improvement in symptoms, which occurred in all patients except one whose symptoms were likely caused by chronic inflammatory demyelinating polyneuropathy. These results compare favorably with those reported in the literature for both transoral (73.3% improvement) and endonasal (100% improvement) surgery.

Although we performed fusion in all patients in this series who underwent an odontoidectomy, rather than just a biopsy, prior reports have claimed that fusion may not be necessary after endonasal odontoidectomy. This was attributed to a reduction in instability due to the minimally invasive endonasal approach and preserving the C-1 arch. In our series, we have not been able to remove the odontoid adequately without removing the anterior ring of C-1. However, there are likely patients whose spines may have already autofused who may not require an instrumented fusion. Indeed, in the transoral series by Choi and Crockard, fusion was also not always performed and its indication was dictated on a case-by-case basis.

Although the transoral approach is still considered the gold standard, in light of the above findings, we believe that the endoscopic endonasal approach offers several dis-

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### TABLE 4. Postoperative CT assessment of extent of odontoid resection

<table>
<thead>
<tr>
<th>Case No.</th>
<th>CT Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biopsy</td>
</tr>
<tr>
<td>2</td>
<td>Complete resection</td>
</tr>
<tr>
<td>3</td>
<td>Complete resection</td>
</tr>
<tr>
<td>4</td>
<td>Biopsy</td>
</tr>
<tr>
<td>5</td>
<td>Small fragment of bone on left</td>
</tr>
<tr>
<td>6</td>
<td>Complete resection of cyst, rim of bone on left</td>
</tr>
<tr>
<td>7</td>
<td>Small fragment of bone on left</td>
</tr>
<tr>
<td>8</td>
<td>Complete resection</td>
</tr>
<tr>
<td>9</td>
<td>Small fragment of bone on left</td>
</tr>
</tbody>
</table>

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**FIG. 4.** Illustrative example of pre- and postoperative axial, coronal, and sagittal CT images demonstrating small residual fragment of bone on the left.
tinct advantages. Endoscopic surgery brings vision and light directly to the surgical target. This allows for ade-
quate visualization through a more limited corridor and exposure. In particular, the corridor being above the or-
opharynx reduces exposure to saliva, potentially decreasing wound infection and dehiscence. In addition, this permits
reduced tracheal and glossal edema, offering the potential for faster extubation and tracheostomy avoidance, as well as more rapid reintroduction of oral feeding. Significant-
ly, a proportion of patients with odontoid pathology may present with bulbar symptoms. In such cases, it is espe-
cially beneficial that the endonasal approach circumvents the oropharynx, avoiding further perturbation to swallow-
ing mechanisms.

Despite these advantages, the endonasal approach is not always feasible. The endonasal corridor is limited later-
ally by the eustachian tubes, cranially by the nasal bones and nasal soft tissues, and caudally by the soft and hard palates.8 Crucially, the odontoid pathology or surgical target must be within these borders. When this is not the case, another approach is required either as an alternative or an adjunct to the endonasal approach. It has been sug-
gested that the endonasal approach may be more useful for pathology located in the clival to upper odontoid re-
region, whereas the transoral approach may be best suited for pathology located between the lower clivus to the body of C-2 and the transcervical approach for pathology not involving the clivus.20 However, the transcervical route is not always feasible due to precluding factors such as obe-
sity, barrel chests, or kyphotic deformities.7 The key deter-
minant of approach viability will be the relative location of the odontoid to the back of the hard palate. The palate line and nasopalatine angle have been shown to be impor-
tant determinants in selecting the most appropriate candi-
dates for the endonasal approach.8,9 When the endonasal approach is precluded, it may be combined with the trans-
oral approach or the transoral approach can be used in iso-
lation, or a transcervical approach can be entertained.1,7 The best approach therefore needs to be individualized for each case.

There are some important differences in the surgical technique used in this series from those previously report-
ed. Others have advocated a wide opening of the sphenoid sinus.19 We have found that a minimal or even no spheno-
dotomy is all that is required, mainly to provide famil-
 iar surgical landmarks. Others have concurred, with the exception of cases of severe basilar invagination, when a more rostral exposure is required.11 While all series use a binostril, 4-hand technique, we have found the endoscope holder to be a helpful adjunct in endonasal endoscopic cases in general.28 In the current series, this is no exception and it was introduced at the point at which the odontoid was reached. This is helpful to maintain a steady view and allow for an extra hand to assist if required. For these rea-
sons we disagree that the endoscope holder limits the pro-
cedure;19 in fact, we believe it enhances the procedure. We used both a U-shaped flap in the nasopharyngeal mucosa as well as a linear incision and did not have any healing complications. A linear incision in the mucosa has been suggested as preferable and both are viable in our hands.12 Finally, we found that in spite of achieving an adequate anatomical decompression of the CMJ as well as symp-
tomatic relief, it was not uncommon to find a small shell of residual odontoid on the left side, seen in 43% of patients. This finding is puzzling since a right-sided approach should direct the surgeon more to the left. However, since we generally place the scope in the left nostril, the field of view may favor the right side. These results indicate the importance of using intraoperative imaging, such as intra-
operative CT scanning or the O-arm, to ensure adequate bone decompression. Likewise, placing the scope in the right nostril at some point in the operation to reach the left side of the odontoid may reduce the incidence of residual bone fragments on the left.

Limitations
The study is limited by its small numbers and the fact that patients were reviewed retrospectively. While ideally a meaningful comparison with other approaches would be conducted by a randomized trial, due to small numbers and anatomical and pathological differences as well as inher-
ent issues in surgical trial design,2 it is unlikely that such a trial will be conducted. We also wish to point out that 3 of these patients were previously published as case reports (Cases 1–3).10,21,22

Conclusions
This series of 9 cases of endonasal endoscopic odon-
toidectomy adds significantly to the existing literature not only in the number of cases compared to the small number already published, but in the results, which are markedly better than those of previous reports. Although this is a small case series, these cases suggest that there are advan-
tages of the endonasal endoscopic approach in permitting early extubation, early feeding and minimizing complica-
tions compared with transoral surgery. We hope that ad-
tional cases from other centers will further substantiate our claims.

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