World Journal of Otorhinolaryngology-Head and Neck Surgery (2020) 6, 94–99

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Research Paper

Endoscopic endonasal approaches to the craniovertebral junction: The Otolaryngologist's perspective

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Received 4 June 2019; accepted 19 January 2020
Available online 16 March 2020

KEYWORDS
Odontoidectomy;
Craniovertebral junction;
Endoscopic skull base surgery

Abstract *Objective:* To review indications and techniques for the endoscopic endonasal approach to the craniovertebral junction (CVJ), analyze postoperative outcomes, and discuss important technical considerations.
Methods: A retrospective analysis was performed on all patients undergoing endonasal endoscopic approaches to the CVJ from May 2007 to June 2017. Demographic information, presenting symptoms, imaging results, treatment course, postoperative functional status, and follow-up were recorded.
Results: There was a total of 30 patients in this series, with a mean follow-up of 11.7 months. The average age was 33.6 years (range, 5–75 years), with 18 females and 12 males. The majority of patients ($n = 22$, 73.3%) had Chiari malformation type 1 with basilar invagination and symptomatic cervicomedullary compression as the indication for surgery. Intraoperative cerebrospinal fluid leak (CSF) was noted in 3 cases of odontoid resection and a single case of skull base resection. There were no postoperative CSF leaks. Overall, 81% of patients resumed regular diet by post-operative day 2 (range, 0–8 days). Severe postoperative dysphagia occurred in two cases with one requiring gastrostomy tube placement and another utilizing total

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Peer review under responsibility of Chinese Medical Association.

Production and Hosting by Elsevier on behalf of KeAi

https://doi.org/10.1016/j.wjorl.2020.01.001

parenteral nutrition for support prior to eventual gastrostomy. On average, patients were extubated by postoperative day 0.93 (range 0—3 days), with 85% extubated by postoperative day 1. A tracheotomy was required in one patient.
Conclusion: The endonasal endoscopic approach is a valuable technique for access to the CVJ with minimal disruption of respiratory and alimentary function.

Introduction

The craniovertebral junction (CVJ) is a region with complex anatomy and a critical site for the mechanical stability of the cranium with respect to the spine. Pathologic processes in this region lead to compression of the brain stem and spinal cord, and the goal of odontoidectomy is to provide ventral decompression. Previously, this area was approached transorally, but there was considerable morbidity associated with postoperative dysphagia and airway obstruction. With the advent of endoscopic surgery, endonasal approaches have been developed with better outcomes.[1,2] Endoscopic endonasal approaches to the CVJ provide adequate exposure with low morbidity. Previous literature has demonstrated the efficacy of this approach for ventral decompression and our group as previously described the neurosurgical outcomes, but for the Otolaryngologist who may be assisting in the approach, further studies expanding upon the technique as well as postoperative respiratory compromise and dysphagia is warranted. In this study, we discuss our expanded experience with patients undergoing endoscopic endonasal approaches to the CVJ and discuss the technical and functional considerations that are most pertinent to the Otolaryngologist.

Materials and methods

Study design

A retrospective analysis was performed on all patients who underwent endonasal endoscopic approaches to the CVJ at a large tertiary referral center from May 2007 to June 2017. Patients were selected from a prospective database of all endoscopic surgeries performed by the Departments of Neurosurgery and Otolaryngology at Weill Cornell Medical College. Those patients who underwent a purely endoscopic endonasal approach were included. Demographic information, presenting symptoms, imaging results, treatment course, postoperative functional status, and follow-up were recorded and analyzed. The focus of this study was to specifically investigate outcomes that would be most important to the Otolaryngologist, the integrity of the patient's airway and swallowing function.

Surgical technique — key features

The ventral approach most commonly followed posterior fusion, which was performed to minimize the risk of spinal cord injury that could occur from destabilization at C1 and C2 and to decompress any posterior compression caused in the case of Chiari malformation. The surgical technique has been described previously by this group.[2—5] Fig. 1 demonstrates the trajectory of the endonasal approach.

Briefly, following oral intubation, the patient is positioned supine, the head is secured in pins, and stereotactic image guidance registration is performed. Upon entering the nasal cavity, the inferior turbinates are lateralized, and a posterior septectomy is performed at the posterior 2 cm of septal cartilage by using a microdebrider. Next, a high-speed drill is used to remove some of the posterior vomer to enlarge the choanae and provide wide exposure. The microdebrider is then used to remove the posterior 30% of the inferior turbinate bilaterally — this is done to facilitate the positioning of instruments and to provide the additional degrees of freedom required for dissection and closure through a narrow corridor. The maxillary crest isa drilled flush with the hard palate. This is a key maneuver that enlarges the choanae and greatly improves exposure. For additional inferior exposure, a red rubber catheter can be placed through the nasal cavity into the oral cavity to retract the soft palate.

Utilizing a 0-degree rigid endoscope fixed in an endoscope holder allows for bimanual surgical technique. The posterior nasopharynx is opened with a linear incision using monopolar cautery. An inverted U-shaped incision was originally used but this limited inferior exposure and was hard to close. The longus colli and capitis muscle are elevated laterally using monopolar cautery. The clivus is then removed to expose the basilar tip, under stereotactic guidance. The anterior ring of C1 is then removed, and the odontoid is resected using a combination of a high-speed drill and curettes. A rongeur may be used to help remove any further tissue. The nasopharyngeal flap is closed endoscopically with simple interrupted chromic sutures tied with the assistance of a knot pusher (Fig. 2). A small amount of thrombin gel matrix (Floseal, Baxter) is placed in the nasopharynx for hemostasis.

Results

A total of 30 patients underwent endonasal endoscopic approaches to the craniovertebral junction during the study time period and met inclusion criteria. The average age was 33.6 years (range 5—75 years). There were 18 females and 12 males included in the analysis. The majority of patients (73.3%) had Chiari malformation with significant basilar invagination as the indication for surgery. The remaining

Fig. 1 CT Head demonstrates the trajectory of the approach through the nasal cavity. A, C: Axial plane. B, D: sagittal plane.

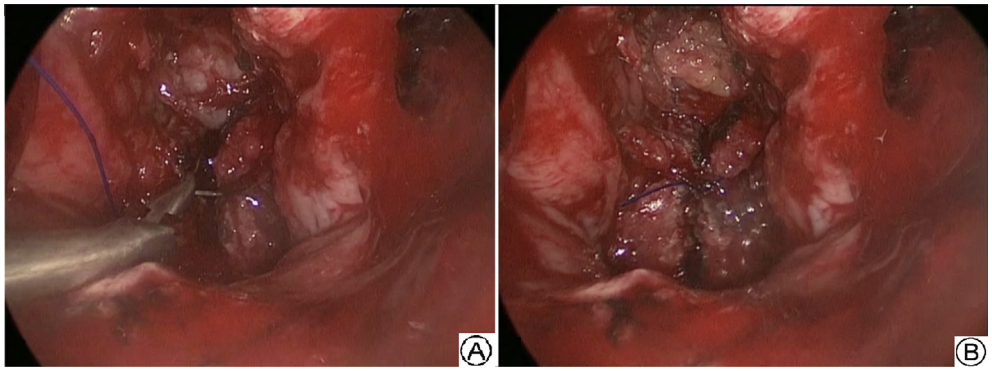

Fig. 2 Endoscopic closure of mucosal incision. A: Simple interrupted suture closing the pharyngeal flaps. B: Knot tied, demonstrating re-approximation of flaps.

patients had cervical instability from rheumatoid arthritis (RA, 10.0%), skull base tumor (6.6%), other unspecified causes of cervical instability (6.6%), and retroodontoid cyst (3.3%), showed in Fig. 3. Headache was the most common preoperative symptom (Table 1).

Intraoperatively, cerebrospinal fluid leaks (CSF) were noted during 3 cases of odontoid resection, and 1 skull base resection where there was planned removal of the dura. Postoperative major complications occurred in 2 patients, both of whom developed severe dysphagia requiring

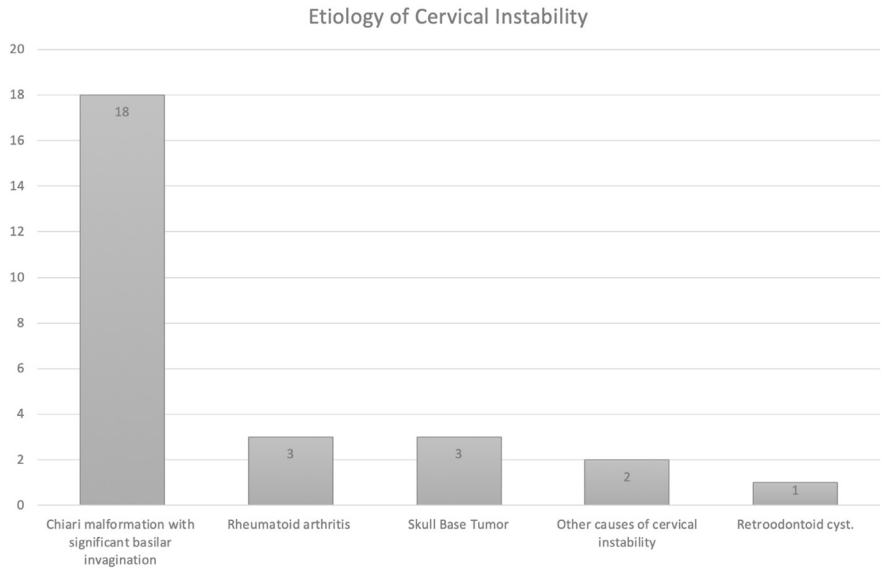

Fig. 3 Etiology of cervical instability and indications for surgery.

Table 1 Patient summary.

Number of subjects	30
Demographics	
Mean age, years (range)	33.6 (5—75)
Gender, Male/Female	12/18
Mean follow-up, months (range)	11.7 (1—66)
Symptoms (%)	
Headache	20 (66.7)
Neck pain	15 (50.0)
Cervical myelopathy	12 (40.0)
Dysphagia	8 (26.7)
Dizziness	6 (20.0)
Lower extremity motor dysfunction	3 (10.0)
Brainstem compression	2 (6.7)
Autonomic instability	2 (6.7)
Bladder dysfunction	1 (3.3)
Timing of fusion (%)	
Simultaneous	13 (46.4)
Separate	15 (53.6)
Average time prior to initiating diet, days (range)	2.04 (0—8)[a]
Average time prior to extubation, days (range)	0.93 (0—3)
Average length of hospitalization, days (range)	7.0 (2—34)
CSF Leaks (%)	4 (13.3)
Major complications (%)	4 (13.3)
TPN/PEG	2 (6.7)
Tracheotomy	1 (3.3)
Wound infection/dehiscence	1 (3.3)

TPN/PEG: total parenteral nutrition/percutaneous endoscopic gastrostomy; CSF: cerebrospinal fluid;

[a] TPN/PEG patients excluded.

percutaneous endoscopic gastrostomy (PEG) tube placement, in addition to one case of wound breakdown and one case of airway obstruction requiring intervention. The first patient had comorbid Ehlers-Danlos Syndrome (EDS) and was a traumatic intubation due to difficult exposure following cervical fusion. She subsequently developed significant postoperative pharyngeal edema and dysphagia with clinical swallow evaluation concerning for aspiration. She received total parenteral nutrition (TPN) followed by PEG placement. Interestingly, this patient also developed a posterior cervical wound dehiscence and collection, which was managed conservatively with local debridement and packing. The other patient had dysphagia and airway obstruction associated with significant posterior pharyngeal edema following posterior cervical fusion prior to ventral decompression. This patient required reintubation, and ultimately tracheotomy, as well as PEG for postoperative dysphagia. Overall, 81% of patients resumed a regular diet by postoperative day 2 (range 0—8 days). On average, patients were extubated by postoperative day 0.93 (range 0—3 days), with 85% extubated by postoperative day 1. The average length of hospitalization was 7.07 days (range 2—34). Table 1 summarizes the results for this cohort.

Discussion

This paper expands on a prior review of 9 patients published by our group.[2] There are several pathologies can affect the CVJ including basilar invagination, RA or gout associated pannus, tumors, traumatic fractures, metastases, and os odontoideum.[6] In this series, basilar invagination caused by Chiari malformation was the most frequent indication for surgery. Presenting symptoms included headache, cervical pain and myelopathy, dizziness, lower extremity dysfunction, cerebrospinal fluid leak, brainstem compression, autonomic instability, and bladder dysfunction. As has been reported previously, there appeared to be an association between EDS and Chiari malformation: 6 out of 30 (20%) patients in this study who underwent endonasal odontoidectomy had known EDS.[7]

The CVJ can be accessed through three corridors, including anterior, posterior, and lateral approaches. Previously, the upper cervical spine was most commonly

approached either transorally or transcervically, with each approach having its limitations. The transoral approach carries a risk of velopharyngeal insufficiency (VPI) from disruption of the soft palate, with resultant hypernasal speech and nasal regurgitation. Moreover, local injury to the tongue and dentition, as well as retropharyngeal edema, can lead to significant dysphagia or airway obstruction.[8,9] The transcervical approach preserves pharyngeal function, but offers limited exposure and working space, with increased risk of neurovascular injury.[10]

The endoscopic endonasal approach is superior to the transoral and transcervical approaches because it improves visualization, decreases the risk of dysphagia and airway edema, and preserves palate integrity — leading overall to improved respiratory and swallow function.[6] The benefit of this approach is largely afforded by the superior placement of the incision in the nasopharynx, which spares the soft palate and the pharyngeal musculature, thereby reducing risk of VPI and postoperative dysphagia.[11] In addition, a high incision decreases exposure of the wound to saliva and thus mitigates the risk of wound infection and dehiscence. Previous literature has shown the following rates of complications in a group of 9 patients undergoing endoscopic endonasal odontoidectomy: tracheotomy in 44%, PEG in 33%, and transient VPI in 22%, albeit among a significant proportion of patients (44%) with known dysphagia and respiratory insufficiency preoperatively.[6] In our analysis, severe dysphagia requiring TPN and/or PEG occurred in 2 patients (6.7%), a tracheotomy was required in 1 (3.3%), and hardware-associated complications requiring further intervention occurred in 1 (3.3%). Interestingly, these issues appeared to stem more directly from the prior posterior fusion surgery than the endonasal surgery. One patient developed significant posterior pharyngeal edema after posterior fusion and required emergent fiberoptic nasotracheal intubation. A tracheotomy was performed subsequently at the time of ventral decompression due to the need for nasal access and the difficulty of oral intubation in the setting of pharyngeal edema. The same patient later developed significant dysphagia requiring PEG. Notably, the other two major complications (TPN/PEG and wound dehiscence) occurred in a single patient with comorbid EDS, suggesting an increased risk of complications in patients with connective tissue disease. The majority of patients were started on a diet between postoperative day 1—2 and extubated between postoperative day 0—1. The average length of hospitalization after surgery was 7.07 days (range 2—34). The majority (90%) of patients were discharged fewer than 10 days after ventral decompression.

These results compare quite favorably to those in the literature for odontoidectomy. A recent meta-analysis concluded that there was a statistically significant difference in respiratory outcomes between patients undergoing the endonasal versus transoral approach, with a lower incidence of tracheotomy in the endonasal cohort.[12] Other outcomes such as wound dehiscence/infection, meningitis, CSF leak, VPI, and prolonged intubation did not reach significance. It is worth noting, however, that the two groups were heterogeneous in size, with 1238 in the transoral cohort compared to 92 in the endonasal.

There are important considerations regarding the surgical technique for the endonasal approach. The use of image guidance is crucial, as it allows for safe access to the CVJ and ensures adequate bony decompression. Interestingly, an intraoperative CT scan has also been used successfully to ensure complete decompression.[13] Multiple cadaveric and radiologic anatomical studies have demonstrated the limits of endonasal access to the cervical spine. De Almeida et al[14] showed that the nasopalatine line (NPL) accurately predicts the most inferior extent of surgical dissection, suggesting transoral routes should be considered for pathology inferior to the NPL. This study was updated with the use of the rhinopalatine line by La Corte et al[15] and Singh et al[11] showed that the hard palate length was inversely proportional to the lowest part of the cervical spine that could be visualized. These findings are the basis for drilling down the posterior aspect of the hard palate intraoperatively to facilitate further inferior exposure. Inferior septectomy allows better access for instruments in the surgical corridor.

All patients that underwent endonasal odontoidectomy underwent posterior spinal fusion in conjunction with ventral decompression to provide cervical spine stabilization, with variation in the relative timing of posterior fusion. Approximately 46% of patients underwent posterior fusion concurrently with endonasal surgery, while 54% underwent fusion prior to ventral decompression. There are several reports in the literature demonstrating that posterior fusion may not be necessary in all patients, but rather may be considered on a case by case basis.[16]

The limitations of our study are typical of any retrospective review lacking prospective outcome data. Moreover, as a case series of patients solely undergoing endoscopic endonasal approaches to the CVJ, this study was not designed to make direct comparisons between the endonasal versus transoral or transcervical approaches. The majority of patients underwent decompression for basilar invagination associated with Chiari malformation, making our data perhaps less generalizable to all patients with indications for ventral decompression. Interestingly, a sizeable proportion (20%) of patients with ventral compression from Chiari malformation had comorbid EDS, and one of these patients had 2 out of the 4 major postoperative complications. This suggests that patients with connective tissue disorders may require special surgical consideration.

Conclusion

The endonasal endoscopic approach is a valuable technique for accessing the CVJ because it facilitates odontoidectomy and ventral decompression with minimal disruption of respiratory and alimentary function.

Disclosure of funding

None.

Declaration of Competing Interest

None.

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Edited by Zhenxiao Huang, Yi Fang