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Original Investigation

Endoscopic Endonasal Approaches to Craniovertebral Junction Pathologies: A Single-Center Experience

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ABSTRACT

AIM: To review our experience of using the endoscopic endonasal approach for clivus and odontoid pathologies as well as craniovertebral junction anomalies at our institution.

MATERIAL and METHODS: We retrospectively evaluated 41 patients (21 male, 20 female; age range, 2–65 years) who underwent endoscopic endonasal procedures for craniovertebral junction pathologies between 2008 and 2017.

RESULTS: Of the 41 patients, 27 had clivus lesions, 7 had odontoid lesions, 6 had basilar invagination, and 1 had rhinorrhea repair. Six patients underwent an additional posterior decompression/fusion either before or after the endonasal procedure. None of the patients required tracheostomy, and cerebrospinal fluid leakage was postoperatively detected in one patient. The patients' mean modified Rankin scale and visual analog scale scores were 3 and 4, respectively. The follow-up period ranged from 12 to 50 months.

CONCLUSION: Although the microscopic transoral approach has been considered the gold standard for craniovertebral junction surgical management, endoscopic approaches are feasible, safe, and effective for addressing pathologies in this region, with developing technique and surgical experience.

KEYWORDS: Endoscopy, Craniocervical junction, Clivus, Odontoid

■ INTRODUCTION

The craniovertebral junction (CVJ) forms a transition between the brain and cervical spine and comprises the foramen magnum, atlas (C1), axis (C2), and ligaments and musculature associated with the C1-C2 vertebrae. Various congenital, developmental, and acquired pathologies can result in the compression of the bulbomedullary junction. However, the surgical management of CVJ pathologies remains a challenge because of the unique anatomical and biomechanical features of this region (36).

The traditional procedure for decompression of the ventral brainstem related to CVJ pathologies is the microsurgical transoral approach (TOA) with posterior fixation (11). Although CVJ is easily accessible with TOA, this approach has some disadvantages, including increased risks of contamination from oral flora and oral cavity/oropharynx injury, prolonged intubation, and enteral nutrition requirement (47,61). TOA can therefore be associated with remarkable morbidity (35), and safer ways to access CVJ are being sought (3).

Improvements in endoscopic technology have provided safe and effective alternatives for accessing CVJ, enabling a wide exploration for surgeons and rendering TOA unnecessary (22). Many anatomical studies have demonstrated the feasibility of reaching this area via an endoscopic endonasal approach

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(EEA) (3,27,31,59). In 2005, Kassam et al. (28) described an expanded EEA that has been performed world wide and modified it (1,2,21,33,60,63). In the present study, we present our experience of using EEA for CVJ pathologies at our institute, with a review of the associated literature.

MATERIAL and METHODS

Patients

In this retrospective study, we evaluated 41 patients who underwent EEA procedures for basilar invagination, clivus, and odontoid pathologies at our institute between 2008 and 2017. All the patients provided written informed consent. All data about the patients were obtained by file scanning, telephone calls with patients, and face-to-face interviews. In the preoperative period, all patients underwent computed tomography (CT) scans, magnetic resonance imaging (MRI), and dynamic cervical radiograph studies to assist with navigation during the procedure. Medications for rheumatoid arthritis were discontinued for 15 days before and after surgery.

Surgical Procedure

Ear-Nose-Throat (ENT) surgeons accompanied our team during all endoscopic procedures, using a two-surgeon, four-handed technique. All the procedures were performed under general anesthesia with orotracheal intubation. The patients were positioned supine on a radiolucent operating table with the head in slight flexion, tilted slightly toward the surgeon, without using a fixation system. An antibiotic infusion was performed for infection prophylaxis, and the nasal mucosa was infiltrated with lidocaine and epinephrine. For all procedures, 0° and 30° wide-angle endoscopes were used with a neuronavigation system (Karl Storz, Tuttlingen, Germany) for confirming anatomical areas during all stages of the procedure and neurophysiological monitoring of motor and somatosensory evoked potentials. A portion of the upper leg was prepared for possible fat or fascia lata graft.

The nasoseptal flap was elevated, and following the bilateral out fracture of the inferior turbinates, endonasal access to the nasopharynx was ensured via both nares. The inferior nasal meatus was used as a guide to directly access the nasopharynx overlying CVJ. The eustachian tubes lie approximately at the level of the occiput–C1 junction, acting as an important landmark for the lateral limit of exposure. We palpated the anterior tubercle of C1 and confirmed this with neuronavigation. A midline vertical linear incision was made using monopolar cautery. We dissected myomucosal layer subperiosteally and exposed the C1 anterior arch, dens, and lower clivus. A high-speed drill was used to remove C1 and odontoid, leaving the posterior cortical shell and ligamentous attachments in place. A Kerrison rongeur or micro dissector was then used to remove the cortical shell and ligaments. The dura was visualized to confirm sufficient decompression. Intraoperative CT was used for all odontoidectomy and posterior fusion procedures. In addition, intraoperative X-ray was used for all posterior fusion procedures. In case of a cerebrospinal fluid (CSF) leak, the protocol was to repair the dural injury with the placement of a fat or fascia lata graft and fibrin glue or a Foley balloon and lumbar drain.

Postoperative Care

Following the procedure, all patients were extubated in the operating room. No imaging study was performed if the patient was neurologically intact. Prophylactic antibiotics were routinely used for 5 days, but if a CSF leak occurred, this was extended to 7 days and the drainage was retained for 7 days; patients who had a Foley balloon placed were provided close respiratory follow-up. After an evaluation of swallowing, a liquid diet was started. Nasal merocel packs were usually removed on postoperative day 5, but they were removed on day 7 in case of a CSF leak. After discharge, the operation field was controlled endoscopically on postoperative day 15. Modified Rankin scale was used to measure the degree of disability or dependence in the daily activities with 0–6 points (decreasing disability), wherein zero point indicated no symptom and 6 points indicated death. Visual analog scale (VAS) was used to measure the pain intensity: the scale was anchored by no pain (score = 0) and worst imaginable pain (score = 10).

RESULTS

This case series review included 21 male patients (51%) and 20 female patients (49%), with ages ranging from 2 to 65 years (mean, 38 ± 12 years). Table I presents the common symptoms in patients. The mean duration of symptoms was 20 ± 13 months. The most common medical condition was rheumatoid arthritis (five patients, 12%); the mean age of patients with rheumatoid arthritis was 44 ± 12 years. The indications for surgery are presented in Table II.

The most common causes of CVJ compression were clivus chordoma [n=17 (41%), Figure 1A, B], basilar invagination [n=6, (14.5%)], and rheumatoid arthritis [n=5, (12%)]. Odontoidectomy (Figure 2A, B) was the second common procedure and was performed in 13 patients (31%). Only one patient (2.5%) needed further surgery after clivus chordoma resection because of rhinorrhea. Pneumocephalus without CSF leakage occurred in one pediatric patient after endoscopic odontoidectomy; this disappeared in a week with follow-up, and we published this complication as a lesson learned (26). The second rhinorrhoea case was of a patient who suffered from trauma and had clivus fracture. Rhinorrhoea repair and lumbar drainage were performed, and the patient's condition improved postoperatively.

Six patients (14.6%) underwent additional posterior fusion involving the occiput and/or cervical spine (Figure 2C). All

Table I: Presenting Symptoms of the Patients

Symptom	Number of Patients (%)
Myelopathy	25 (60)
Dysphagia	12 (29)
Neck stiffness	6 (14)

Table II: Pathologies of the Patients

Pathology	Number of Patients (n=41)
Clivus lesions	**n (%)**
Chordoma	17 (41)
Cholesterol granuloma	2 (5)
Chondrosarcoma	1 (2.5)
Chondroblastoma	1 (2.5)
Squamous cell carcinoma metastasis	1 (2.5)
Undifferentiated round cell and spindle cell sarcoma	1 (2.5)
Meningioma	1 (2.5)
Plasmacytoma	1 (2.5)
Fibrous dysplasia	1 (2.5)
Angiomyoma	1 (2.5)
Rhinorrhea repair (Clivus fracture)	1 (2.5)
Odontoid lesions	**n (%)**
Rheumatoid arthritis pannus	5 (12)
Hydatid cyst (6)	1 (2.5)
Enchondroma	1 (2.5)
Basilar invagination (Occipitocervical malformation with anterior compression)	6 (14.5)

posterior approaches were performed in the same session. The remaining 36 patients (85.4%) did not require additional posterior decompression or fusion.

None of the patients required tracheostomy, but one patient (2.5%) needed reintubation for a day following surgery. No oral nutrition was given during the first 5 postoperative days; after oral nutrition was initiated in three patients (7%) who postoperatively required nasogastric tube feeding for a duration of 5–10 days. No patient required enteral nutrition support. No patient experienced velopharyngeal insufficiency. No CSF leakage was detected intraoperatively, but CSF leakage was detected in one patient postoperatively (2.5%); lumbar drainage was performed, but the patient required reoperation for repair. None of the patients died.

The patients' mean modified Rankin scale and VAS scores were 3 and 4, respectively. The mean follow-up time was 40 ± 10 months (range, 12–50 months). Neurological improvement was observed in 36 patients (85.4%); the other six patients (14.6%) were neurologically stable.

DISCUSSION

The physiological criteria and guidelines for the management of CVJ pathologies were well defined by Menezes et al. in the

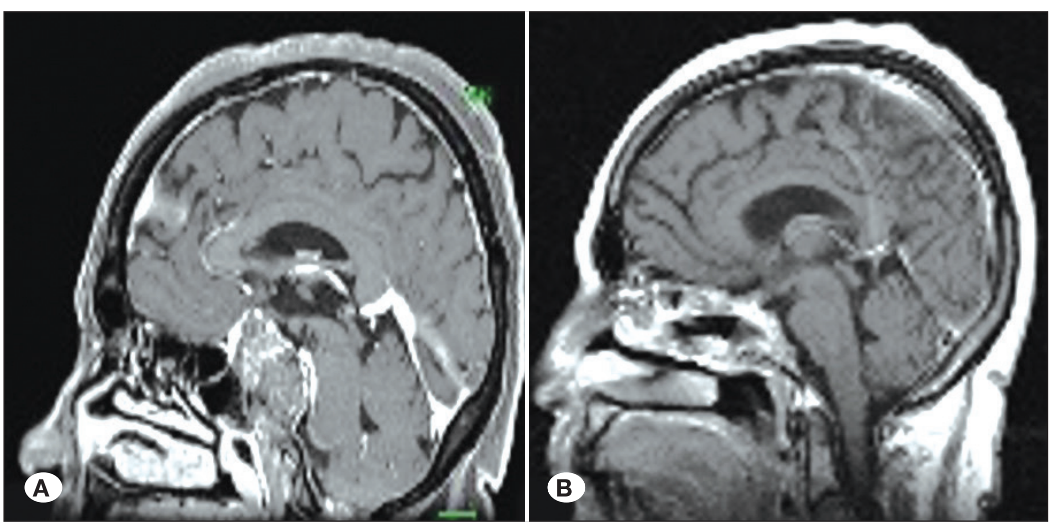

Figure 1: (A) A 57-year-old woman diagnosed with clivus chordoma on sagittal T1-weighted contrast-enhanced magnetic resonance imaging (MRI). **(B)** After performing the procedure via an endoscopic endonasal approach, postoperative MRI demonstrated that the lesion had been totally resected.

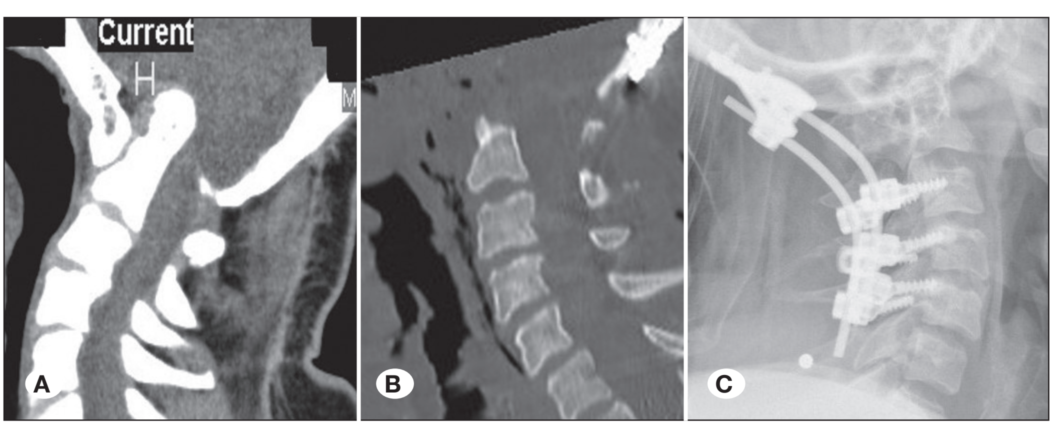

Figure 2: A 32-year-old man with dysphagia. **(A)** Computed tomography of the craniocervical junction showed basilar invagination. **(B)** The patient underwent endoscopic odontoidectomy and the compressive bone segment was totally resected. **(C)** Posterior fusion was performed during the same session.

1980s (40,41,51); this resulted in TOA gaining popularity. TOA alone or with extended modification by addition of mandibulotomy, mandibuloglossotomy, palatotomy, or transmaxillary approaches (62), has traditionally been considered the gold standard for ventral CVJ pathologies (12,13,23,34,39), because it provides the most direct access (32).

The standard TOA is optimal for midline extradural lesions that are located behind the inferior clivus down to the C2 vertebral body. For lesions that involve the sphenoid sinus and upper/middle clivus, the recommended approaches are transpalatal, transmaxillary (Le Fort I maxillotomy), or transmaxillary with a midpalatal split (extended "open-door" maxillotomy) (4,25,50). A median labiomandibular glossotomy or a mandibular swing–transcervical approach may be required for lesions that extend more inferiorly from C2 to C4 (15,43). Palatal division carries the risk of phonation dysfunction and velopharyngeal insufficiency.

Deconstruction of the facial skeleton (transmaxillary/transmandibular) can result in cosmetic deformity. Tracheostomy can be required following TOA if there is prolonged intubation or tongue swelling, or gastrostomy if the patient has difficulty swallowing (60). There is also a risk of oral flora contamination owing to the pharyngeal incision. With EEA, the incision along the posterior wall of the nasopharynx is smaller. However, with TOA, the transoral dissection is located more caudally, so the risk of oral flora contamination is greater (9,12,24,47,60).

The aperture of the mouth and the presence of micrognathia and/or macroglossia can be restrictive factors during TOA (33,37,38). Choi and Crockard reviewed 500 operations that were performed using TOA/extended approaches and reported the following complication rates: CSF leakage, 1.2% (6/500); respiratory problems (detailed information not given), 3% (15/500); velopharyngeal incompetency, 6.6% (33/500); and death, 6.4% (32/500) (8). In a review of transoral odontoidectomies, Komotar et al. reported that 14 of 351 cases (4.0%) resulted in velopharyngeal incompetency (29). The complication rates in both studies were considerably higher than those found in a literature review of the endonasal approach.

In recent years, EEA to the craniovertebral junction has been proposed as an alternative procedure to the standard TOAs (2,3,5,17,19,20,22,24,28,33,37,38,42,44-47,49,55,56).The applicability of endoscopic endonasal odontoidectomy was first described in 2002 by Alfieri et al. in cadaveric studies (3). Following anatomical studies, Kassam et al. (28) reported the first successful EEA to CVJ.

An advantage of the endonasal route is the anatomical corridor that allows a deep located area to be reached with a wide and panoramic view (1,47,64,65). However, the EEA procedure has some limitations. The operation field is really narrow, limited to the area from the lower clivus to the atlas rim in a rostral–caudal direction, approximately 1 cm from the midline mediolaterally. El Sayed et al. and de Almeida et al. have identified anatomical landmarks for EEA (14,18). The back of the hard palate limits the rostral exposure to the CVJ lesion and ventral brainstem or upper cervical spinal cord (14). Odontoidectomy is possible via this surgical corridor, but it is insufficient for a total C2 corpectomy. EEA cannot be fully successful for lesions that extend laterally to the lower cranial nerves (30). In addition, EEA limits the feasibility of dural repair (61). The vertebral artery is at risk during EEA procedures for CVJ pathologies; to minimize this risk, Yen et al. suggested that deviation from the midline should be avoided and neuromonitoring should be performed (61).

The technological evolution of EEA provides neuronavigation, neurophysiological monitoring, and intraoperative imaging to neurosurgeons. The standard approach in our institution is to use neuronavigation and monitoring during EEA. In addition, intraoperative CT is standard for odontoidectomy and posterior fusion. Choudhri et al. reported that the use of navigation and imaging is useful in understanding skull base anatomy as well as limiting the morbidity (10).

Fuji et al. prepared a systematic review and reported the most common pathology as basilar invagination (60.6%); however, the most common pathology in our study was clivus chordoma (41%) (20). Posterior fusion rate was 81% in the review (20) but only 14.6% in our study. Tracheostomy requirement and reintubation rates were 8.8% and 3.5%, respectively, in the review (20), whereas these rates were 0% and 2.5%, respectively, in our study. The nasogastric feeding rate was reported to be the same (7%) in the systematic review and our study (20). The review (20) reported the rate of intraoperative CSF leak as 11.3%, whereas we reported only one case of intraoperative leak (2.5%).

Yen et al. performed 13 odontoidectomy, and the frequency of pathologies was as follows: rheumatoid arthritis (38.5%), trauma (31%), os odontoideum (15.3%), ankylosing spondylitis (7.6%), and postinfectious deformity (7.6%) (61). Occipitocervical malformation with anterior compression (5/12 cases, 41.6%) was reported as the most common cause for odontoidectomy by Zenga et al. (64). In our study, the most common cause of odontoidectomy was occipitocervical malformation with anterior compression (6/13 cases, 46%) followed by rheumatoid arthritis pannus (5/13 cases, 38.5%). Thus, the results in the literature are incompatible with each other because of the presentations of odontoidectmies are usually case series with a small number of patients.

Several authors have compared TOA and EEA (2,47,54,57,64). In a study of head cadavers, Baird et al. reported that the distance to CVJ was shorter than that to EEA (5). Seker et al. reported that EEA offers the shorter route to CVJ, although TOA provided a wider opening (52). Shidoh et al. reported that EEA was a less invasive and more useful surgical procedure for clival chordomas; however, if the tumor was situated around CVJ, EEA was of limited use and thus TOA should be considered (53). Ponce-Gómez et al. have suggested EEA for odontoidectomy because of its effectiveness, feasibility, and the reduction in complication rates (47). Deopujari et al. used combined nasal and oral endoscopic approaches, reporting low rates of postoperative complications following endoscopic procedures (16). Visocchi et al. declared that EEA alone is superior if a CVJ lesion reaches the upper limit of the inferior third of the clivus (58). Shriver et al. reported that there was no significant difference in complication rates without postoperative tracheostomy requirement (54). The requirement for tracheostomy was statistically higher in the transoral group (54). In addition, an endoscopic TOA has been described for decompression of CVJ lesions (7,18,46,48).

■ CONCLUSION

The surgical management of CVJ pathologies remains a challenge for surgeons. Although TOA has been considered the gold standard in CVJ surgery, anatomical and clinical studies over the last decade have shown EEA methods to be superior.

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