Although transoral odontoidectomy has been accepted as the treatment of choice in the surgical management of basilar invagination, alternative approaches are emerging, including the reduction of atlantoaxial subluxation from posterior and endoscopic approaches for decompression at the ventral cervicomedullary junction. The feasibility of endoscopic transnasal odontoidectomy (ETO) has been demonstrated in cadaveric studies. In the past several years, there also have been case reports of ETO published by several authors worldwide. However, reports on a series of consecutive patients who underwent ETO and long-term follow-up, including data on radiological and clinical outcomes and complications, are still scarce.

The present study is, to date, the largest series reported on purely endoscopic transnasal resection of the odontoid process. The aim of this article is to describe the evolution of our surgical techniques for ETO and the outcomes in our series of patients.

**Methods**

**Patient Population and Preoperative Management**

From September 2004 to December 2012, 13 consecutive patients who underwent ETO in Taiwan’s Taipei Veterans General Hospital were enrolled. The basilar invagination etiologies were rheumatoid arthritis (n = 5), trauma (n = 4), os odontoideum (n = 2), ankylosing spondylitis (n = 1), and postinfectious deformity (n = 1). The average follow-up duration was 51.2 months (range 0.3–105 months). One patient died 10 days after the operation as a result of meningitis caused by CSF leakage. Among the other 12 patients, the average postoperative Nurick grade (3.2) was significantly improved over that before the operation (4.1, p = 0.004). The mean (± SD) duration of postoperative intubation was 1.5 ± 2.1 days, and there was no need for perioperative tracheostomy or nasogastric tube feeding. There also was no postoperative velopharyngeal insufficiency. There were 6 (46%) intraoperative and 2 (15%) postoperative CSF leaks in the 13 patients in this series.

**Conclusions**

ETO is a viable and effective option for decompression at the ventral cervicomedullary junction. This approach is minimally invasive and causes little velopharyngeal insufficiency. The pitfall of this approach is the difficulty in repairing dural defects and subsequent CSF leakage.

**Key Words**

endoscopic transnasal odontoidectomy • cervical • cervicomedullary junction • velopharyngeal insufficiency

Additional information:

- **Abbreviations used in this paper:** ETO = endoscopic transnasal odontoidectomy; VA = vertebral artery.
- **Drs. Chang and Huang contributed equally to this work.**
- This article contains some figures that are displayed in color online but in black-and-white in the print edition.
Veterans General Hospital were enrolled. Their mean age was 52.7 years (range 24–72 years). There were 6 men and 7 women. Basilar invagination etiologies included rheumatoid arthritis (n = 5), old odontoid fracture with inadequate treatment (n = 4), odontoidoideum (n = 2), ankylosing spondylitis (n = 1), and postinfectious deformity (n = 1) with cervicomedullary compression. The mean follow-up duration was 51.2 months (range 0.3–105 months).

The indication for surgery in these patients was irreducible basilar invagination causing ventral compression at the cervicomedullary junction with subsequent myelopathy and quadripareisis. The basilar invagination was considered irreducible if no change on lateral radiographs was found after applying halo traction with at least 12 lb for more than 3 days. If the basilar invagination was reduced, the patient was considered a candidate for posterior fixation only and thus was excluded from the current study. During the study period, 32% (6 of 19) of the patients did not undergo the surgery (i.e., ETO), because traction/reduction of the atlantoaxial subluxation provided significant improvement and thus spared them the need for odontoidectomy.

Surgical Techniques

The patients were placed supine under general anesthesia with halo traction and a slightly flexed head. All ETOs were performed with intraoperative fluoroscopy and a neuronavigation system (VectorVision Cranial, BrainLab). In the first 3 cases, the operation was performed with a nasal speculum retractor via a single-nasotrill approach. The basic techniques have been described previously by our group.37 From the fourth case onward, patients were operated on via a slightly modified ETO (i.e., a transnasal direct-transpharyngeal approach) without entering the sphenoid sinuses.

The modification was developed by the lead neurosurgeon of this series (Y.S.Y.), with the major evolution of turning a single-nasotrill approach into a 2-nasotrill approach and abandoning the use of a nasal speculum. Because the working trajectory of transnasal odontoidectomy is downward, aiming toward the pharynx, even lower than the skull base, there is no need for resection of the middle or inferior nasal turbinates or for entering the sphenoid sinuses, which the expanded endonasal procedure commonly uses in endonasal skull base approaches.13–16,26 By careful placement of the endoscope (18 cm with a lens angle of 0°, mounted to a digital video camera system [Karl Storz GmbH & Co.] and a pneumatic scope holder) into the upper limit of 1 nostril, the deeply seated small operative field in the posterior pharyngeal wall was visualized (Fig. 1A). Subsequently, 2 instruments (usually 1 suction tube and 1 dissector or drill), 1 in each nostril, were placed into the operative field. The most critical step of this endoscopic approach was the placement of 3 instruments (the endoscope, suction tube, and dissector) precisely so that they converged through the 2 nostrils toward the pharyngeal mucosa ventral to the anterior tubercle of the atlas. After adjustment of the endoscope mounted to a pneumatic scope holder, the operating surgeon used 2 instruments, 1 in each hand, to allow for simultaneous suction during dissection or drilling.

After visualization of such a small target zone confronted by the nasopharyngeal mucosa, right in front of the lower end of the clivus and the atlas and measuring approximately 3 × 2 cm, the remaining procedures were basically straightforward. A linear vertical incision of the mucosa was made by electrocautery (Fig. 1B). After dissection of submucosal soft tissue and ligaments, the anterior tubercle was exposed (Fig. 1C). Subsequently, the abnormal bony structures and connective tissues were drilled or resected piecemeal (Fig. 1D–G). As decompression proceeded, the depth of the working level increased, and more ligamentous tissues were removed. Reexpansion of the underlying thecal sac was visualized after decompression (Fig. 1H). Intraoperative fluoroscopy was then used for confirmation of adequate decompression before closure. An autologous fat graft from the abdominal wall was subsequently placed into the linear mucosal defect (Fig. 1I). It should be noted that there was no need for resection of nasal turbinates, mucosal flaps, or paraspinal muscles with this approach.

Evaluations and Occipitocervical Fusion

Standard anterior-posterior and lateral flexion/extension radiography, CT, and MRI were routinely performed preoperatively. Detailed information was collected about craniovertebral stability, the extent of neural tissue compression, bone quality, and deformity.

After ETO, CT scans were routinely used for confirmation of sufficient decompression and evaluation of the anatomical structures of the atlas, axis, and the occiput after reduction. After 3–7 days, occipitocervical fixation was performed for patients who had craniovertebral junction instability, including those with basilar invagination or severe deformity between the condyles and the atlas. For those who needed no occipitocervical fusion because instability was caused only by atlantoaxial subluxation, C1–2 arthrodesis was performed. Patients were then put in a Miami soft neck collar for immobilization and followed up regularly. Rehabilitation programs were suggested and arranged for the patients.

Results

Thirteen consecutive patients (6 men and 7 women) with a mean age of 52.7 years (range 24–72 years) were enrolled (Table 1). The mean follow-up period was 51.2 months (range 0.3–105 months). All 13 patients underwent ETO, and in 10 patients occipitocervical fusion was performed after ETO. None of these patients received tracheostomy for the ETO. There was no new onset of velopharyngeal insufficiency (i.e., hypernasal speech, nasal emission, and nasal regurgitation of fluids). There was 1 death that resulted from sepsis.

Adequate decompression was achieved in all cases, as confirmed by postoperative CT. Most of the patients in the series had significantly improved neurological function (Table 2). For all 12 surviving patients, the average postoperative Nurick grade (3.2) was significantly improved over the average preoperative grade (4.1; p = 0.004, paired t-test). One month after the operation, 12 patients (92%) (all patients except the patient who died on postoperative
Day 10) were recovering very well and showed continuous improvement in their sensory and motor functions (Figs. 2 and 3).

The mean (± SD) postoperative intubation duration was 1.5 ± 2.1 days (Table 2). Eleven of the 13 patients were extubated in the recovery room or on postoperative Day 1 (within 1 day). There were 2 patients who required prolonged intubation. Patient 8 was the oldest (72 years) in this series. She presented with severe quadriparesis and was kept intubated because of a high risk of respiratory failure until the posterior fixation operation the next week. Patient 12 had a tracheostomy 8 months earlier in another hospital. She suffered from a severe falling accident and was transferred to our hospital after 8 months for surgical management of the basilar invagination. She had been quadriplegic and ventilator dependent since then and was using the tracheostomy postoperatively. All patients except for Patient 12 were successfully extubated. Also, no patients required prolonged intubation or feeding with a nasogastric tube except for Patient 12, who remained intubated and did require such feeding. One week after the ETO, this patient started to wiggle her fingers and toes even though her neurological status remained at Nurick Grade 5 postoperatively. Overall, 85% (11 of 13) of the patients were extubated within 1 day after the operation, and 92% (12 of 13) of the patients required no nasogastric tube feeding.
Imaging studies confirmed adequate decompression and realignment of the craniovertebral complex (Figs. 2–5). However, there was 1 patient (Case 9) who, having shown significant improvement in lower-limb muscle strength since postoperative Day 2, died as a result of meningitis complicated by sepsis and multiple organ failure on postoperative Day 10. The disseminated infection was likely caused by leakage of the CSF from the mucosal wound in his nasopharynx. There was inadvertent durotomy intraoperatively, and we could not place a suture for closure. Attempts were made to repair the dural defect by packing it with an autologous fat graft, together with

Table 1: Demographic and clinical data

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yrs), Sex</th>
<th>Diagnosis</th>
<th>Clinical Condition</th>
<th>Previous Op</th>
<th>Follow-Up (mos)</th>
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<tbody>
<tr>
<td>1</td>
<td>41, M</td>
<td>RA w/ BI</td>
<td>myelopathy, neck pain</td>
<td>ACDF</td>
<td>105</td>
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<tr>
<td>2</td>
<td>59, M</td>
<td>RA w/ BI</td>
<td>myelopathy, neck pain</td>
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<td>92</td>
</tr>
<tr>
<td>3</td>
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<td>71</td>
</tr>
<tr>
<td>4</td>
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<td>myelopathy</td>
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<td>63</td>
</tr>
<tr>
<td>5</td>
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<td>myelopathy</td>
<td>none</td>
<td>59</td>
</tr>
<tr>
<td>6</td>
<td>55, F</td>
<td>RA pannus formation</td>
<td>myelopathy</td>
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<td>53.5</td>
</tr>
<tr>
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<td>myelopathy</td>
<td>ACDF</td>
<td>57</td>
</tr>
<tr>
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<td>72, F</td>
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<td>myelopathy</td>
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</tr>
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<tr>
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<td>49</td>
</tr>
<tr>
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<td>myelopathy</td>
<td>none</td>
<td>37</td>
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<tr>
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<td>18</td>
</tr>
<tr>
<td>13</td>
<td>64, M</td>
<td>postinfectious deformity w/ BI</td>
<td>myelopathy</td>
<td>C1–2 laminectomy</td>
<td>4</td>
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</tbody>
</table>

* ACDF = anterior cervical discectomy and fusion; BI = basilar invagination; RA = rheumatoid arthritis.
Endoscopic transnasal odontoidectomy

TABLE 2: Perioperative events and postoperative improvement*

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Posterior Fixation</th>
<th>Intraop CSF Leak</th>
<th>Postop CSF Leak</th>
<th>Periop Tracheostomy</th>
<th>Intubation Days</th>
<th>Feeding Route</th>
<th>VPI</th>
<th>Neurological Function</th>
<th>Nurick Grade</th>
<th>Preop</th>
<th>Postop</th>
<th>Improvement†</th>
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<tr>
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<td>OC</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>2</td>
<td>OC</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>OC</td>
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<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>4</td>
<td>OC</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>+2</td>
</tr>
<tr>
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<td>C1–2</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
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<td>2</td>
<td>1</td>
<td>+1</td>
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<td>oral</td>
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<td>2</td>
<td>3</td>
<td>+3</td>
</tr>
<tr>
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<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
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<td>no</td>
<td>no</td>
<td>8</td>
<td>tube/oral§</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>9</td>
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<td>yes¶</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
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<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>11</td>
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<td>no</td>
<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
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<td>2</td>
<td>1</td>
<td>+1</td>
</tr>
<tr>
<td>12</td>
<td>OC</td>
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<td>no</td>
<td><strong>††† tube</strong></td>
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<td>oral</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>OC</td>
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<td>no</td>
<td>no</td>
<td>≤1</td>
<td>oral</td>
<td>no</td>
<td>improved</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>+2</td>
</tr>
</tbody>
</table>

mean ± SD 1.5 ± 2.1 4.1 ± 1.3 3.2 ± 1.2

* OC = occipitocervical; VPI = velopharyngeal insufficiency.
† p = 0.004, preoperative compared with postoperative Nurick grade.
‡ CSF leak noted before the second operation (OC fusion) but stopped with impaction of Cottonoids and absolute bed rest for 2 weeks.
§ Received feeding tube between 2 surgeries and resumed oral intake after the second operation.
¶ Improved neurologically but complicated with sepsis and death.
** Longstanding tracheostomy and feeding tube before this surgery.
†† Longstanding ventilator dependence before this surgery.

Dural sealants. It likely held for 3 more days until he was placed prone for posterior surgery. Continuous drips of CSF came out just before the start of posterior surgery, and it was packed temporarily. He started to be febrile
on the 2nd day after posterior fixation, and he soon deteriorated with septic shock. On postoperative Day 3, we placed a lumbar drainage catheter, and turbid CSF came out (Streptococcus pneumonia was found in culture). The sepsis was complicated with multiple organ failure, and the patient died on postoperative Day 10.

**CSF Leakage and Strategies for Repair**

Incidental intraoperative durotomy and CSF leakage were encountered in 6 patients (46.2%; Patients 3, 6, 7, 9, 10, and 13) (Table 2). Every effort was made to repair each inadvertent durotomy under the endoscopic view, but it was never easy. In Patient 6, whose case was earlier in the series, an autologous fat graft harvested from the abdominal wall was placed onto the durotomy and sealed with fibrin glue. Postoperatively, no CSF leakage was detected for 5 days until she was positioned prone to undergo posterior fixation surgery. To control the dripping of CSF from her nostrils, they were packed with large Cottonoids immersed in antibiotic ointment. After the secondary occipitocervical fusion, she was put on complete bed rest for 2 weeks. There was no more CSF rhinorrhea, and the nasopharyngeal mucosal defect healed afterward without the need for lumbar drainage.

Suture closure of the vertically incised mucosa provides the best repair for CSF leakage. Although previous reports have supported the use of an autologous fat graft and fibrin glue for repair, the persistent CSF leak in Patient 9 set us on the goal of suturing the mucosal incision. However, the extraordinarily deep and small working corridor plus the lack of specialized instruments made it extremely difficult to put in even 1 suture. After adjustment of the endoscope, 2 simple stitches of catgut were placed in Patients 10 and 13 using microendoscopic forceps (Fig. 6). The inadvertent durotomy was closed intraoperatively. These sutures truly facilitated mucosal healing, and there was no CSF leakage after the operation, even once the patients were ambulatory. Overall, there were 6 (46%) intraoperative and 2 (15%) postoperative CSF leaks in the 13 patients in this series.

**Discussion**

To date, this is the largest reported series of patients who underwent ETO with a mean follow-up period of more than 4 years (maximum follow-up duration 105 months). We analyzed data in 13 patients who had basilar invagination causing severe compression at the cervicomedullary junction and quadriplegia and who underwent ETO. The average postoperative Nurick grade was significantly improved over that before surgery (3.2 vs 4.1, respectively, p = 0.004). The majority (92%) of these patients had neurological improvement 1 month after the operation. However, there was 1 death caused by meningitis 10 days after the operation. Failure to intraoperatively repair an inadvertent durotomy that causes CSF leakage can be lethal. Additional investigation is warranted to confirm the efficacy of ETO and its risks and complications.

The ETO technique described in this report requires only 1 operating neurosurgeon. Unlike ETO methods described in other series, our technique does not require another surgeon to control the endoscope, because we mounted the endoscope to a pneumatic scope holder. By alternately placing the endoscope, suction tips, angled drills, and dissectors into both nostrils, this approach also spared the need for entry into the sphenoid sinus or deviation of the nasal septum. Thus, without disturbing the nasal turbinates and sinuses, ETO can be performed by 1 surgeon controlling the endoscope and operating independently.

A number of case reports have been published about the use of ETO to decompress the ventral cervicomedullary junction to treat patients with rheumatoid arthritis, Down syndrome, osteogenesis imperfecta, Chiari malformation, and radiation fibrosis.11,12,17,18,26,30,31 There also have been reports about using ETO in pediatric and elderly patients.12,19,28 Unlike the technique used in these other published cases, which uniformly involved a U-shaped mucosal flap, we used a linear vertical mucosal incision in the nasopharynx. By following the midline, this vertical linear incision theoretically reduced the risks of compromising the opening of the eustachian tubes or vidian nerves. Furthermore, this incision was made directly on the pharyngeal mucosa ventral to the anterior tubercle of the atlas, sparing the need to disturb the sphenoid sinus or the nasal septum, as required by the expanded endonasal approach described by Kassam et al. It is reasonable to infer that, by using this smaller linear incision rather than creating a flap, our approach provides a more minimally invasive route for odontoectomy. However, this inference can be corroborated only by a larger series of studies and more evaluations. Moreover, there is another transcervical endoscopic odontoectomy technique that is performed via the route commonly used for standard anterior cervical discectomy.4,19,30 Therefore, the optimal surgical approach for odontoectomy remains uncertain.

In the current series, only 3 of 13 patients avoided occipitocervical fusion. All 3 had deformities limited to C1–2. Two had os odontoideum, whereas the third had an old odontoid fracture (Tables 1 and 2). In cases in which basilar invagination or an anomaly around the foramen magnum did not exist, we tried to avoid occipitocervical fusion. However, because of the preexisting C1–2 deformities, we instrumented C1–2 after each odontoectomy. Only in cases in which the relationship between the condyle and
the atlas is normal might occipitocervical fusion be spared. There are scarce biomechanical data focusing on stability after odontoidectomy, although instability is intuitively assumed. Furthermore, Menezes and Foltz\textsuperscript{20} concluded that 97\% of 693 patients in their series treated with the transoral approach required craniocervical stabilization. The competence of the transverse ligament, the jointing odontoid process, and the atlas was obviously compromised after odontoidectomy.\textsuperscript{38} In addition to a preexisting C1–2 deformity in many of our cases, C1–2 fixation was considered mandatory. Whether there was instability of the occipitocervical junction was determined by the alignment and relationship between the condyle and the atlas, which were evaluated by preoperative CT. However, preoperative determination of the instability after odontoidectomy was not always achievable. Whenever there was ambiguity, we had planned to apply occipitocervical fusion. Therefore, in the current series, there were patients who received occipitocervical fusion despite there being no preoperative basilar invagination (Table 2).

The potential risk of vertebral artery (VA) injury during odontoidectomy has been described,\textsuperscript{25} but, to our knowledge, as of this writing there has been no case report in the literature of such a complication. In the current series, there were no VA injuries. However, after reviewing the preoperative images, we noticed that in some cases, the VA was located very close to the odontoid process to be removed (Fig. 7). In normal anatomy, bilateral VAs course medially into the dural sac at the level of the foramen magnum, which is further lateral to and above the tip of the odontoid process. However, in basilar invagination or severe atlantoaxial subluxation, the odontoid process projects upward toward the brainstem, and thus is located close to the junction of the bilateral VAs. Therefore, the VA is at risk when odontoidectomy is being performed in a patient with such an aberrant anatomy at the craniocervical junction. The best strategy for minimizing this risk is to avoid deviation from the midline. Thus, we advocate frequent use of a navigation system during ETO.

There are limitations of ETO. The effective surgical field of ETO is actually tiny (i.e., limiting from the lower clivus to the atlas rim in a rostral-caudal direction, approximately 1 cm off midline in medial-lateral aspects). Previous reports have also described anatomical landmarks for these limitations.\textsuperscript{5,6} This working space is almost just enough for an odontoidectomy but definitely not enough for a complete C-2 corpectomy. Furthermore, this endoscopic approach remarkably limits the possibility of dural repair. It takes tremendous work to repair an inadvertent durotomy with sutures when using the endoscope, and to our disappointment, it was not always achievable. In our experience, of a total of 6 inadvertent durotomies, 3 repairs by suture were attempted, but only 2 of them were successful, whereas in the other 3 durotomies we just used a graft and glue. Those 2 patients with interrupted sutured mucosa healed perfectly, and their courses were uneventful after the operation. However, 1 (25\%) of the 4 patients whose durotomy was unsutured had a catastrophic infection that spread to the entire CNS, which eventually led to death.

In this series, we disclosed in detailed that 46\% of the patients had intraoperative CSF leakage, and 15\% had postoperative CSF leakage. Most of the published papers reported a postoperative CSF leak rate but not an intraoperative rate. The actual rate of intraoperative CSF leaks in conventional transoral surgery is seldom reported in the literature. Tuite and colleagues\textsuperscript{34} reported in 1996 that 7.4\% (2 of 27) of patients in their study had a postoperative CSF leak, and 1 patient was treated with a lumboperitoneal shunt. In 2013, Choi and Crockard\textsuperscript{2} reported on the largest transoral series, and the rates of pharyngeal infection (0.6\%) and CSF leak (0.3\%) for standard transoral surgery were extremely low. It is reasonable that the rate of CSF leaks went down as the surgeons gained more experience in the transoral approach. They also commented that the number of complications was significantly associated with the preoperative neurological status of the patients, and more complications were seen in patients with myelopathic rheumatoid arthritis and congenital basilar invagination. Furthermore, endoscope-assisted transoral odontoidectomy has been reported in recent years.\textsuperscript{29,35}
these small series (12 patients in the 2 studies), no postoperative CSF leaks were reported. For the present series, we have described in detail the technique developed to suture the dural rent through the long working channel, and we believe that the rate of CSF leaks can be reduced in the future. The overall mortality rate of 7.7% (1/13) in the present series is similar to that in the series of patients who underwent transoral surgery reported in 1989 by Hadley et al. They had 3 (5.7%) deaths in a series of 53 patients. Although not perfect, this series demonstrated that the endoscopic approach may allow earlier extubation, earlier oral food intake, fewer tracheostomies, and more infrequent velopharyngeal insufficiency. Also, the extent of decompression can be confirmed by significant improvement in neurological function after the endoscopic surgery. Therefore, we believe that our overall results, which were obtained with a mean follow-up duration of 51 months, support the use of this endoscopic approach as an alternative treatment for basilar invagination.

Conclusions
Endoscopic transoral odontoidectomy is a viable and effective option for decompression at the ventral cervico-medullary junction. This approach is minimally invasive and does not frequently cause velopharyngeal insufficiency. However, its pitfall is the difficulty in repairing dural defects and subsequent CSF leakage.

Disclosure
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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