Anterior transoral odontoid resection is a useful surgical treatment for ventral, midline irreducible pathology at the craniovertebral junction. With modern imaging and surgical advances, transoral odontoid resection can be safely performed. Evaluation and care of the patient undergoing transoral surgery are reviewed, as are relevant anterior craniovertebral anatomy, surgical indications, operative technique and complication avoidance. Operative Techniques in Orthopaedics 17:156-162 © 2007 Elsevier Inc. All rights reserved.

**KEYWORDS** odontoid resection, basilar invagination, transoral, craniovertebral junction, rheumatoid arthritis

Anterior odontoid resection was first described by Fang and Ong in 1962, when they published their series of patients who underwent the transoral approach for decompression of the spinal cord and brainstem for irreducible compressive atlantoaxial pathology. Nevertheless, given the high complication rate observed in the early experience associated with this procedure, many have avoided surgery via this route. As technology improved, however, and better imaging techniques became available, including improved surgical technique, the use of the operating microscope, frameless stereotaxy, and improved antibiotics, there has been a resurgence in the use of the transoral approach. Through meticulous planning and a detailed understanding of anatomy of the craniovertebral junction, it is possible to perform the procedure in a safe, effective manner to address irreducible pathology at the craniovertebral junction.

**Indications**

The transoral approach is indicated for ventral midline irreducible extradural pathology at the levels of atlas and the axis (Fig. 1). Most commonly, the procedure is used to decompress the craniovertebral junction when craniovertebral settling is present and for resection of a compressive pannus associated with rheumatoid arthritis. Compression at this junction also can be seen secondary to neoplasms, basilar invagination, other causes of craniovertebral settling, congenital deformities, fibrocartilaginous masses (nonrheumatoid pannus formation) secondary to chronic nonunion, and other soft tissue masses in the region. Some authors have even used the approach for intradural pathology, including menigiomas and schwannomas, and even vascular lesions.

**Physical Examination**

Patients considered for the transoral approach undergo examination of the oral cavity. Ideally, a patient should be able to open his or her mouth greater than 25 mm. This would permit improved visualization of the pathology as well as provide the needed room to access the region surgical instrumentation. Nevertheless, the procedure can be performed in patients with minimal mouth opening with the assistance of various mandibular splitting/osteotomy techniques to increase exposure.

The mouth should be inspected for any evidence of infection, including dental caries, periodontal abscesses, and dental root abscesses. Irregularities in the dentition may make retractor placement difficult; thus, authors have advocated gum guards to be fashioned before surgery that accommodate both irregular dentition and standard retractors. Additionally, the temporomandibular joint should be inspected in mouth opening because pathology here could limit mouth opening and subsequently the use of this approach. A detailed neurologic and musculoskeletal examination must be performed.

**Surgical Anatomy**

A detailed understanding of the cervical anatomy of the craniovertebral junction and detailed imaging is mandatory be...
Figure 1 T2-weighted sagittal MRI (A) and CT (B) sagittal reconstruction demonstrating an os odontoideum with associated irreducible midline ventral cyst compressing the spinal cord. The cyst has high signal on T2-weighted imaging and may have resulted from chronic instability.

fore undertaking the transoral approach. Below the level of foramen magnum, the oropharynx is well delineated from the prevertebral fascia by an areolar tissue plane. It should be noted that the oropharyngeal mucosa heals very well after surgical incision and repair. In terms of bony landmarks, the most important anatomic structure is the anterior arch and tubercle of C1. Additionally, on each side of the dens is flanked by the longus coli muscle and more laterally the dens if flanked by the longus capitis muscle. The anterior longitudinal ligament then continues caudally at the midline.11

It is imperative to know the location of the vertebral arteries when performing this approach. Typically, the vertebral arteries are located 14 mm laterally from the midline at the arch of C1 and approximately 11 mm laterally at the C2-3 junction and at the foramen magnum (Fig. 2). Nevertheless, this can be considerably distorted by pathology such as rotary subluxation. Typically, however, the anatomic midline can accurately be defined via the position of the anterior longitudinal ligament and longus coli muscle.12 If anatomic variations are significant (as seen in Down’s syndrome) or are anticipated, imaging with fluoroscopy or use of intraoperative frameless stereotaxy are extremely helpful.

Preoperative Work-Up

The preoperative workup for this procedure should include detailed imaging of the cervical spine. This includes both plain films with flexion/extension views and computed tomography (CT) scans with sagittal and coronal reformatting for a detailed understanding of bony anatomy. Magnetic resonance imaging (MRI) is very useful for further imaging any soft-tissue pathology. Because some odontoid lesions consist entirely of soft tissue and others entirely bone, and many with both, both studies should be performed whenever possible. Additionally, detailed bony imaging obtained from CT scan may be useful in planning posterior stabilization procedures.13,14 Finally, fluoroscopic CT imaging (Iso-C) may also be useful intraoperatively.

Other considerations are the relationship of the hard palate with the pathology. Although not usually an issue with pannus formation, this is a major issue if using the transoral approach for craniovertebral settling. The ideal candidate for the transoral approach can open his/her mouth widely and extend the neck well to facilitate procedure. Nevertheless, many of these patients have spinal instability limited neck extension and exposure.
Surgical Technique

Before intubation, baseline neurophysiologic tracings should be obtained, including somatosensory-evoked potentials and transcranial motor evoked potentials. The patient then is intubated using fiberoptic technique. We typically use an oral endotracheal tube if extubation is planned. Alternatively, a nasotracheal tube is used if prolonged intubation is planned. Tracheostomy is not routinely performed.

Typically, a patient is placed with the neck in very slight extension with the head resting on a donut. Alternatively, a Mayfield pinion with slight cranial extension (always will use if frameless stereotaxy is to be used), or a circular headrest with Garner-Wells tongs or a horseshoe, may be used. Nevertheless, extreme caution should be used in positioning patients who have kyphosis or flexion deformities. Rather than using extension, a slight Trendelenburg position may be useful for these patients (Fig. 3).¹²

Crockard advocated the lateral position in a Mayfield clamp.¹³ Advantages of this position include secretions, blood, and irrigation draining out of the field with the use of gravity. Additionally, with tilting of the table a posterior stabilization procedure could be performed in the same setting. The advantages and disadvantages are discussed in this report. An image intensifier is then brought into the field before prepping and draping the patient. At this point, registration of the patient using frameless stereotaxy can be performed.

Some have advocated obtaining culture swabs before prepping the mouth with a diluted Betadine solution.¹⁰ Additionally, a gauze sponge can be used to pack the upper esophagus to protect against debris running into the airway and gastrointestinal tract. The oral and pharyngeal mucosa are then infiltrated with Lidocaine with epinephrine in the midline, and retractors are used to obtain adequate exposure of the posterior cavity after the front of the spine is exposed.¹² These retractors, including a tongue blade and paddle retractors, are used to protect the surrounding soft tissues. This can be done with a commercially available Crockard retractor (Cod-
man, Raynham, MA), but other retractors available, including the McGiver 3-ring retractor system, which is used along with endotracheal intubation in a similar manner (Fig. 4). Additionally, other commercial ear, nose, and throat systems are available. In fact, it may be useful to consult with otolaryngologic colleagues for this portion of the case. The soft palate can be retracted further with sutures passed through the soft palate and brought out the nares retracted gently through vessel loops (Fig. 5). Subsequently, the tubercle of the atlas is palpated. The location should be confirmed with lateral fluoroscopy.

At this point, the operating microscope is brought into the field. An incision, roughly 1 to 2 cm superiorly and then 1 to 2 cm inferiorly is performed at the midline depending on the location of the pathology. This should be taken through the pharyngeal mucosa, the musculature of the pharynx, and the anterior longitudinal ligament (Fig. 6). On rare occasions, the soft and hard pallets can be divided, especially if exposure of the anterior rim of the foramen magnum is necessary or exposure of a displaced craniovertebral junction is necessary (in case of basilar invagination). Subsequently, a combination of the bipolar and gentle use of a periosteal elevator is used to perform a subperiosteal dissection all the way laterally to the atlantoaxial joints. It should be noted in the event of instability there might be a large amount of granulation tissue or at the level of the inferior margin of C1 and junction of C2. Retractor blades are then used to retract laterally.

A high-speed burr is then used to remove the arch of the atlas resecting approximately 1 cm of bone on each side of the midline (Fig. 7). This is followed by resection of the odontoid mass and any pannus present where the odontoid mass is taken down starting at the top of the odontoid processes and a combination of burr and curette. Another option is to drill the odontoid at its base. A 3-mm cutting burr may be used to
should be placed under direct visualization and also suctioned.

**Postoperative Care**

After performing anterior odontoid resection, extubation is performed if the procedure was done expeditiously. Extubation should only occur if there is no evidence of significant airway or facial swelling. Typically, posterior stabilization is performed with the same procedure. Patients are then kept in a hard cervical collar. Postoperatively, patients should be encouraged to ambulate and to remain erect to minimize the saliva pooling in the oropharynx. Feeding should be via nasogastric tube for 5 days, and then oral feeds are gradually introduced.

Given the intimacy of the craniovertebral junction to this approach and also the contaminated oropharynx in comparison to the sterile cerebrospinal fluid spaces, complication avoidance necessitates careful planning. It should be remembered that a transoral approach is indicated for irreducible ventral pathology. If the pathology can be treated with reduction with traction, then posterior stabilization is indicated and a transoral approach is not indicated. Additionally, the procedure is indicated for midline pathology; any pathology extending beyond 11 mm of midline should not be approached via the transoral approach. Thus the likelihood of injury to the eustachian tubes, vertebral arteries or hypoglossal nerves is minimized.

Given the fact that few surgeons actually perform this approach frequently, there may be doubt as to one's anatomic orientation. If there is any question of one's location fluoroscopy is very useful to accurately establish the surgeon's location. Additionally, resection of the odontoid starting from the rostral on downwards may be less anatomically disorienting.

Postoperatively, hematoma may be problem given the fact...
that there are large venous channels in the region and that vascular tissue may be present. Meticulous hemostasis should be obtained. Additionally, topical hemostatic agents such as Surgicel, Floseal, Avitene (C.R. Bard, Inc., Murray Hill, NJ) and fibrin glue may all be useful to control any venous ooze. Additionally the bipolar diathermy-cautery is useful to control small bleeders in relation to especially from a rheumatoid pannus. If an intradural procedure is performed then dural veins may be ligated with titanium clips.

Cerebrospinal fluid leakage is a serious complication of the transoral approach especially considering that the opening is immediately adjacent to the nasopharyngeal flora. Any violation of the dura should be repaired meticulously using autologous tissue such as fat, muscle, or fascia lata. This can be followed by application of fibrin glue or hydrogel polymer. Additionally, any procedure involving a planned intradural approach should have a preoperative lumbar drain. Typically, lumbar drainage is continued 5 to 10 days afterward in the face of spinal fluid leakage. Some authors recommend triple antibiotic therapy directed at a full spectrum of oral flora including coverage of aerobes and anaerobes. Menezes has advocated spinal fluid cultures for five days, at which point if the cultures remain negative, antibiotics may be stopped.17 Our practice is to use triple antibiotic therapy for all cases for 5 days.

Severe airway complications also may occur. Preoperative otorhinolaryngology assessment may be useful to rule out any lower cranial nerve dysfunction. If there is any evidence of vocal cord motion impairment or pharyngeal dysfunction, or lower cranial nerve dysfunction, tracheostomy placement should be considered. Otherwise, a fiberoptic endotracheal tube placement can be performed. Intermittent retractor release may reduce the amount of oropharyngeal swelling.

Delayed complications also may occur after the transoral approach. Complications described include meningitis, palatal pharyngeal dehiscence, tongue swelling, neurologic deterioration, the development of retropharyngeal abscess, late pharyngeal bleeding, and velophalato incompetence. If pharyngeal dehiscence occurs in the first days to 7 days after surgery, it is typically caused by a technical issue with the closure or oral feedings undertaken too early. The likelihood of this complication occurring could be minimized by having the patient sit up early, by having the patient ambulate frequently to minimize saliva pooling, and by delaying feeding. If early dehiscence of the wound does occur, ENT consultation should be obtained and closure should be attempted. This is followed by total parenteral oral nutrition and intravenous antibiotics. Late dehiscence, however, suggests infection. Osteomyelitis and retropharyngeal abscess must be ruled out. Additionally, poor nutrition may be a contributing factor. The presence of a retropharyngeal abscess warrants an ENT consultation and is usually treated via lateral drainage followed by intravenous antibiotics, nutritional supplementation via nasogastric feeding, and neck immobilization. Our practice has been to have our ENT associates perform exposure and closure of all these procedures to minimize risk of wound problems.

The most likely cause of neurologic deterioration after transoral odontoid resection is craniovascular instability. Virtually all patient undergoing a transoral odontoidectomy require posterior stabilization. Although the timing of stabilization is controversial, advantages of early stabilization earlier immobilization and the patient undergoing a single procedure. In the event, however, of postoperative fever the infectious workup may be confusing if two procedures are performed simultaneously. Should the patient undergo stabilization in a delayed manner, they should be kept immobilized until their second procedure. Should a patient after transoral odontoid resection present with altered mental status, meningitis must be considered on the differential; this is especially true the elderly in whom a change in mental status may be passed off as simply intensive care unit related delirium.11

Any retropharyngeal bleeding occurring in a delayed suggests infection, osteomyelitis, and pseudoaneurysm of the vertebral artery, which need to be rule out with MRI/MRA. Should a vascular pathology be encountered, angiography and potentially neuroendovascular treatment may be warranted.

Velopalatine incompetence is a rare complication typically found in children. Usually, it starts 4 to 6 months after the procedure and may occur secondary to contracture of the soft palate and nasopharynx. Should this be encountered, otorhinolaryngologic evaluation is warranted. This is typically treated with pharyngeal retraining but also possibly a palatal prosthesis and even a pharyngeal flap.17

Key Points

The transoral approach for odontoid resection works best for irreducible midline extradural pathology. Location should be corroborated by either fluoroscopy or frameless stereotaxy. An intimate knowledge of the relationships of the osseous soft tissue and vascular anatomy of the craniovertebral junction should be noted.

The operating microscope may be useful. Recently, the procedure has been performed using endoscopy.2 Strict hemostasis should be obtained with a surgicel, Floseal, and bipolar diathermy. Suturing of the mucosa may be facilitated by bending the needle into a “J” shape. ENT consultation for exposure and closure may be useful.

Any dental pathology may be relative contraindication of the procedure. The procedure best for midline pathology and lateral pathology should be avoided. Any changes such as torticollis and rotary subluxation may distort the anatomy present. Spinal fluid leakage, should it be encountered, must be meticulously repaired. Lumbar drainage also should be used.

Feeding patients orally too early in recovery may result in breakdown of the suture line. We recommend nasogastric tube feeding for 5 days. Mouth thrush should occur for several days followed by the gradual introduction of liquid, then small particles, and finally solids. Patients should be immobilized adequately postoperatively to encourage drainage of saliva and minimize pooling of secretions in the oropharynx.
References