Anterior Odontoid Resection

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Goals of Surgical Treatment
1. Decompression of the neuraxis at the craniovertebral junction.
2. Correction of an anterior irreducible pathologic entity causing significant distortion of the cervicomedullary junction.
3. Ventral access to the craniovertebral space-occupying lesions (extradural and rarely intradural tumors).

Diagnosis
The factors that influence specific anterior odontoid resection are whether the bony abnormality can be removed or reduced to its normal position according to the etiology of the lesion and the direction and the biomechanics of the compression. It is axiomatic that the spinal cord or neuraxis be decompressed in the direction from which it is compromised; therefore, anterior compression at the cervicomedullary area should be accessed ventrally. Decompression must be considered in every case where there is significant compression, prior to craniovertebral fixation or stabilization. The apparently stable lesion in this area may not be stable under special circumstances (anesthesia, skull traction, decompression, and removal of some of the compressive material). Thus, it is essential to repeat studies postoperatively to ascertain if a fixation in addition to decompression is required.

The patients’ presentation varies widely. The symptoms can be nonspecific and difficult to localize. In spite of these variations, however, there is usually the following:
1. Neck pain, particularly suboccipital pain with reflection behind the ear (irritation of C2 root), especially when spinal instability superimposes on the compressive signs and symptoms.
2. Deforrmity (limitation of neck movements, shorter and/or twisted neck, torticollis).
3. Progressive spastic quadriaparesis (stiff legs) with wasting of the small muscles of the hands. The latter sign should alert the examiner as to the possibility of craniovertebral junction pathology.
4. Lower brainstem signs (slight change in voice, occasional difficulty in swallowing, or recurrent episodes of aspiration pneumonitis). These patients with bulbar signs, when asleep, display abnormal respiratory patterns.

Preoperative Neuroradiologic Investigations

Plain Radiographs of the Craniovertebral Area (Flexion and Extension)
These radiographs are important in assessing every patient with a craniovertebral junction abnormality, abnormal mobility of any joint from the occiput down to lower subaxial levels, particularly in cases of rheumatoid atlantoaxial subluxation. In addition, calcification, expansion, erosion, or destruction of bony anatomy will be seen.

Computed Tomography (CT; Thin Slice 1.2 mm) and Three-Dimensional Reconstruction of Images to Visualize the Bone
The value of this diagnostic modality, especially in sagittal reconstruction, to outline bony abnormalities is very useful. Measurement of atlantoaxial subluxation and of the canal diameter of the atlas can be easily obtained. While McGregor’s line was important in the past, we do not use these measurements now.

Magnetic Resonance Imaging (MRI)
This mode of imaging provides the most exquisite soft tissue detail, including the quality of the cervicomedullary junction (the presence of spinal cord atrophy preoperatively is a bad prognostic sign). MRI with gadolinium enhancement and MR angiography are only occasionally used to outline the vertebral arteries and to ensure that there is a competent circle of Willis.

Neural Navigation (Fig. 2–1)
Navigational systems use dynamic referencing technology to establish a computer map between all locations on the preoperative images and the corresponding anatomic locations in the surgical field. Using the registration probe, the surgeon selects diverse points over the surgical anatomy to approximate the surgical space surface. These modern navigational systems enable the surgical team to operate with more confidence, speed, and accuracy, resulting in better surgical efficacy.

Indications: Surgical decompression via transoral odontoidectomy of the cervicomedullary junction is required in patients with irreducible ventral pathology.

Rheumatoid Arthritis
1. Irreducible atlantoaxial subluxation causing significant neuraxial distortion.
2. Significant soft tissue mass (the pannus).
3. Translocation of the odontoid peg with extensive lateral mass erosion.

Anterior Bony Decompression
1. Basilar invagination (congenital or acquired due to bone softening conditions).
2. Atlantoaxial subluxation and pseudotumor (Down syndrome, spondyloepiphyseal dysplasia, Ehlers-Danlos syndrome, Morquio-Brailsford disease).
3. Basilar impression, in-folded skull base (Klippel-Feil anomaly, osteogenesis imperfecta).
4. Posttraumatic deformities (undetected or untreated odontoid peg fracture).

Ventral Access to Extradural Lesions in the Foramen Magnum
1. Chordomas and chondrosarcomas of the clivus and C1–C2 complex.
3. Osteoblastomas.
4. Abscesses.
5. Pseudotumors of the transverse ligaments and foreign bodies removal. Contraindications: Ventral access for pure intradural lesions (e.g., foramen magnum meningiomas). A far lateral approach allows the access and better visualization of the entire pathology with surrounding anatomical structures.
6. Extralumbar tumors that do not arise from the midline, but may invade the clivus and C1–C2 complex, require some dissection from the front (far lateral approach is more suitable for these cases).
7. Surgery may not be of benefit in long-term bed-bound rheumatoid patients (Ranawat III B).

Advantages and Disadvantages
1. Midline ventral access to odontoid peg has the advantage that there are no important vessels or nerves sagittally.
2. Midline clival lesions with extension to the odontoid process or C1–C2 complex distort neurovascular structures around their lateral boundaries.
3. The spinal cord or the medulla is decompressed in the direction from which it is compromised.

The main disadvantages are visibility, complex retraction of oropharyngeal structures, and the depth at which the surgeon is working (10 to 15 cm) from the dental margin. Surgical pathology in the mouth itself has a profound effect on the execution of transoral procedures.

Procedure
Preoperative assessment of the oral cavity and its contents is crucial to success in any transoral procedure: If the maximal interdental opening is less than 25 mm, then a conventional transoral approach is unlikely to be successful. In these rare cases the division of the soft palate alone may be enough for the transoral odontoidectomy to allow exposure of the odontoid peg and foramen magnum, as well as in mild cases of basilar invagination. Division of both the hard and soft palate will be required as a minimum to expose the lower half of the clivus.

Anesthesia
1. A nasotracheal airway is the method most commonly employed in comparison with orotracheal intubation. Tracheostomy is used now in <15% of cases (patients in whom long-term ventilation problems are anticipated and in cases of extended maxillotomy). In cases with instability of the craniovertebral junction, fiberoptic nasotracheal intubation is performed on the awake patient.
2. A nasogastric tube is inserted, first to empty the stomach before and after surgery, as well as to prevent gastric contents from soiling the pharyngeal wound, and second (after the first 24 hours) to introduce fluids and alimentation for 5 days, allowing the best chance for healing.
Figure 2–1
(A) Schematic representation of the philosophy of navigational systems, in the approach of the C1–C2 complex. (B) Computed tomography (CT) scan preoperative image, during the intraoperative establishment of navigational lines, in anterior odontoid resection.
Figure 2–2  
(A) Insertion of the transoral retractor in the final position. (B) Elevation of the handle of the retractor with caudal rotation of the tongue blade for wider exposure of the C1–C2 complex. (C) The soft palate has been retracted by the attachment to the transoral retractor. The pharyngeal incision is held apart by the pharyngeal retractor. Lower exposure is obtained by tilting up the transoral tongue retractor handle using a folded sheet.
Figure 2-3
(A) Retraction of the soft palate and inspection of the posterior pharynx. (B) Creation of the midline incision with center the tubercle of C1, revealing the target of the operation. (C) Wound closure with two layers of interrupted sutures.

Figure 2-4
Appropriate exposure of craniocervical junction, via open-door maxillotomy, in patients with congenital anomalies.
in the area [longer alimentation by percutaneous endoscopic gastrostomy (PEG)].

3. A wide-bore lumbar drain is inserted before surgery in a potential situation of cerebrospinal fluid (CSF) leakage, although it is unlikely to occur in simple odontoidectomy (after the CSF escapes, the catheter may be very difficult to insert).

**Patient Position**

The patient is placed in the three-quarter supine position on the operating table with the head slightly elevated compared to the feet, and held in the Mayfield head holder. The lateral tilt facility of the operating table will almost provide this supine position. This position allows blood and washings to drain away from the operative field and lets the surgeon be seated comfortably for a prolonged period. Placing the head in slight extension makes the craniovertebral junction more accessible in patients with complex congenital malformations.

**Prior to Surgery**

1. Bacteriologic swabs should be taken and the sensitivity of any organisms known.

2. The mouth is cleaned with an aqueous cetavlon solution.

3. Antibiotics (cephalosporin and metronidazole) are given and continued for 2 days postoperatively.

4. A 1% hydrocortisone ointment is applied to the mouth, tongue, and lips for prevention of intraoperative swelling (more effective than systemic steroids), and more is used during the postoperative period.

**Operative Steps**

**Step 1:** The transoral retractor is inserted with the tongue blade (suitable length) pulling the tongue down between the lower teeth and the countertraction applied on the upper alveolar margin (Fig. 2–2A). To obtain exposure lower than the arch of C1, elevating the handle of the retractor of the chest will rotate the tongue blade caudally and provide this exposure (Fig. 2–2B).

The senior author uses a completely integrated system (Codman and Shurtleff, Randolph, MA) with instruments of an appropriate length and sufficient strength for retraction, protection of tissue, and visualization.

In cases of edentulous patients with mandibular resorption, placing some form of packing under the handle of the tongue blade may help to prevent slipping of the transoral retractor (Fig. 2–2C).

**Step 2:** The palate is retracted using the palatal retractors, and the posterior pharynx can be inspected. The soft palate is anchored on its nondependent aspect with the curved soft palate retractor itself firmly attached to the transoral retractor. The other soft palate retractor is used to retract the nasotracheal and nasogastric tubes out of the operative field into the dependent tonsillar fossae (Fig. 2–3A).

The soft palate anatomical landmark is the tubercle of C1: to it is attached the anterior longitudinal ligament and the longus colli muscles (infiltrate with lignocaine and 1:200,000 adrenaline at the tubercle on C1 to dissect off the pharyngeal tissues from the deeper structures and to provide some hemostasis).

**Step 3:** A midline incision (3 cm long) with the center at the tubercle of C1 is made, and the pharyngeal retractor is inserted, converting the vertical incision into a hexagonal exposure. The two blades of pharyngeal retractor act as a “ring of steel” around the area in which the surgery is being carried out, preventing damage from instrument slippage during dissection. The longus colli muscles and the anterior longitudinal ligament are separated with the “cutting” monopolar diathermy, revealing the arch of C1 and the odontoid peg (Fig. 2–3B).

**Step 4:** An angled, high-speed air drill is used to remove cancellous bone (3 to 4 mm cutting bur) and a diamond bur is substituted for the cortical bone. In edentulous patients with mandibular resorption, placing one layer of interrupted Vicryl sutures, one for the muscle layer (superior constrictor and the pharyngobasilar fascia) and the other for the mucosa (Fig. 2–3C).

**Pitfalls**

1. Rotatory subluxation at the atlantoaxial joint will distort significantly the regional anatomy, and the anterior tubercle on the ventrally rotated lateral mass may be mistaken for the midline anterior tubercle in the arch of C1, with disastrous consequences to the underlying vertebral artery. In these cases the disposition of the longus colli muscles and the anterior longitudinal ligament, however, is constant, and despite rotation or distortion, this will define the anatomic midline.

2. The routine transoral procedure cannot be done on basal invagination patients with a stiff neck. They will need a transpalatal open-door maxillotomy, as will patients with osteogenesis imperfecta (Fig. 2–4).

3. Swelling of the tongue and lip can be avoided by careful placement of the retractor. If the tongue is caught between the teeth and the retractor, it will swell.

4. Postoperative instability must be carefully considered, as well as persisting anterior compression. Usually it is failure to decompress the lateral rather than the midline bone that is the problem.

**Complications**

1. Dural opening and CSF leakage (particularly in the severely translocated odontoid peg). Dural closure may not be possible, but a multi-layer closure with thrombin fibrin glue, dermal fat, fascia, and living mucosa covers the risk of permanent leakage and meningitis (reinforcement of the healing process with spinal drainage of CSF for 4 to 5 days postoperatively).

2. Infection (diffuse cellulitis, abscess formation, meningitis). Avoid these problems with careful protection of the mucosal edges during the operation; obliterate the dead space by two-layer closure of the posterior pharynx and avoidance of the patient’s alimentation until the wound has healed. Reexploration indicates when there is a large loculus of pus. The situation usually subsides with the appropriate antibiotics.

3. Bleeding from the vertebral artery (very uncommon) may be controlled initially by Surgicel and bone wax impacted into the vertebral canal (possible definitive ligation of the artery). Venous bleeding (large epidural complex and venous channel communicating with the marginal sinus cephalad) may be controlled by Surgicel and gentle pressure with a neuro-patty. Delayed hemorrhage may occur from the pharyngeal wall (7 to 10 days postoperatively) and is considered to be a consequence of infection.

4. Nasopharyngeal incompetence (multifactorial problem). If there is palatal incision, it is more likely to break down and it must be very carefully sutured initially with a single layer over the hard palate and a double layer in the soft palate (recovery usually in 2 months). In many patients with bulbar palsy there may be permanent swallowing problems because the nerves may not recover (postoperative tracheostomy and gastrostomy for a few months).

**Postoperative Care**

1. The patient remains in the intensive therapy unit for 48 hours.

2. Great care should be taken with the mouth and the nose; 1% hydrocortisone ointment is applied to the mouth, tongue, and lips for prevention of intraoperative swelling (more effective than systemic steroids), and more is used during the postoperative period.

3. Antibiotics are administered for 2 days in the absence of bacterial infection.

4. Postoperative instability must be carefully considered, as well as persisting anterior compression. Usually it is failure to decompress the lateral rather than the midline bone that is the problem.
Suggested Readings