The transcondylar approach to extradural nonneoplastic lesions of the craniovertebral junction

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The craniovertebral junction is a common site of neoplastic, vascular, traumatic, congenital, and degenerative lesions. The complex anatomy of this area, along with its deep, central, and vital location, create special problems for operative treatment of these lesions. The anterior approach, currently the mainstay of treatment for extradural lesions located in the ventral aspect of the craniovertebral junction, has significant disadvantages. We have routinely used the transcondylar approach to expose intradural neoplastic and vascular lesions of the foramen magnum. Relying on anatomical studies in cadavers and surgical experience with other lesions in this area, we used the transcondylar approach in eight patients with extradural nonneoplastic compression of the spinomedullary junction by bone or soft-tissue abnormalities.

Clinical Material and Methods

Surgical Technique

The transcondylar approach is taken on the side of the lateral extension of the lesion. When the lesion is midline, the side is chosen according to the anatomy of the vertebral artery, the sigmoid sinus, and the jugular bulbs. The side of the nondominant vertebral artery and nondominant jugular bulb is preferable for the approach. The surgical approach is presented here in three stages: positioning and soft-tissue dissection, bone work, and craniocervical stabilization.

Positioning, Monitoring, and Soft-Tissue Dissection. Before surgery, the patient is placed in a halo brace to maintain the head and neck in a neutral position. The horseshoe-shaped halo ring opens posteriorly to allow access to the surgical field. Awake intubation is performed with the aid of the bronchoscope. The patient is then placed supine with the entire body being rotated 45° to the opposite side.

Intraoperative monitoring includes bilateral somatosensory evoked potentials, bilateral brainstem auditory evoked response, and cranial nerves 10, 11, and 12. The 10th cranial nerve is monitored with a double-balloon endotracheal tube. The 11th and 12th nerves are monitored via electrodes placed directly into the sternocleidomastoid muscle and the tongue, respectively.

The skin incision begins behind the ear at the level of the external auditory canal and extends medially to the midpoint and inferiorly to the level of C-4, where it curves anteriorly to reach the anterior border of the sternocleidomastoid muscle. The skin flap is elevated anteriorly, ex-
posing the greater auricular nerve and the sternocleidomastoid muscle. A plane of dissection is then created along the anterior border of the sternocleidomastoid muscle, which is followed superiorly to its attachment on the mastoid process. The sternocleidomastoid, the splenius capitis, longissimus capitis, and semispinalis muscles are detached from the mastoid in one layer and retracted inferiorly and medially. The 11th cranial nerve must be identified and preserved where it enters the middle third of the sternocleidomastoid muscle. When the 11th nerve has a high entry into the muscle, dissection along its course in the medial aspect of the muscle provides additional length.

At this stage, the posterior belly of the digastric muscle should be kept in place to protect the facial nerve as it exits the stylomastoid foramen. The splenius cervicis muscle, which attaches superiorly on the lateral process of C-1, is kept in place to protect the jugular vein. A clear dissection plane appears between the superficial and deep muscular layers, and a variable amount of fat is found in this area.

The deep muscular layer forms the suboccipital triangle, which is delimited by the major and minor rectus capitis muscles medially, the superior oblique muscle superiorly, and the inferior oblique muscle inferiorly. The apex of the triangle is the transverse process of C-1. Inside the suboccipital triangle, the horizontal segment of the vertebral artery and C-1 root can be seen (Fig. 1 left). The major rectus capitis muscle inserts superiorly on the inferior nuchal line and inferiorly on the spinous process of C-2, and the minor rectus capitis muscle inserts superiorly on the inferior nuchal line and inferiorly on the posterior arch of C-1. The superior oblique muscle inserts superiorly at the temporoparietal suture and inferiorly on the transverse process of C-1; the inferior oblique muscle inserts superiorly on the transverse process of C-1 and inferiorly on the spinous process of C-2.

At this stage of the procedure, control of the vertebral artery is crucial. The C-2 nerve root can be followed laterally to where it crosses over the vertebral artery in its vertical segment between C-1 and C-2, and the root can be preserved. The superior and inferior oblique muscles are detached from their insertion on the transverse process of C-1 and removed. After these maneuvers, the vertebral artery can be identified from the transverse foramen of C-2 to its entry into the dura mater (Fig. 1 right). Bleeding is avoided by keeping alveolar tissue around the artery. The transverse foramen of C-1, which transmits the vertebral artery, is opened with a diamond drill, and the vessel is moved out of the foramen and held inferomedially. At this point, the C-1 nerve root may be sacrificed.

**Bone Work.** To begin the bone work, the mastoid tip is drilled to expose the occipital condyle and the jugular bulb. The occipital condyle and the condylar surface of C-1 are exposed widely and drilled off. At this point, the hypoglossal canal must be identified and the 12th nerve preserved. After the lateral bone structures are resected, the odontoid process and its surrounding ligaments are clearly seen (Fig. 2 left). The odontoid process is drilled until the contralateral condyle is identified, and the connective tissue or rheumatoid pannus is removed (Fig. 2 right). The anterior arch of C-1 usually does not need to be resected. Areas limiting the transcondylar approach are the nasopharynx anteriorly, the spinomandibular junction posteriorly, and the jugular bulb and hypoglossal nerve superiorly. The inferior limit can be tailored to each situation; extending the skin incision allows inferior resection to be as low as necessary.
In patients with severe odontoid invagination, the jugular bulb must be skeletonized to permit a more superior extension. To achieve additional visualization superior to the jugular bulb, the microscope and axis of vision are angled in a caudocranial direction. The intraoperative use of a frameless stereotactic device proved to be helpful in gaining information about the spatial relationship of the structures in this area and the extent of resection in our Case 8.

Occipital–Cervical Fusion and Stabilization. After the odontoidectomy is completed and the pannus is removed, the pedicle of C-2 is carefully cleared of soft tissue and the medial and lateral borders of this pedicle are identified. The lamina of C-2 is prepared for possible insertion of a sublaminar titanium cable. The vertebral artery is released to its original course and observed. A small and flexible measurement plate is then placed between the occiput and the articular mass of the cervical spine. Great care is taken to shape this plate to fit the contours of the patient’s suboccipital anatomy. A reconstructive titanium plate must be bent slowly and carefully to avoid its fracture, then modeled after the measurement plate. The cranial pole of the plate should be fashioned with a beak at the end to prevent erosion of soft tissue or an irritating protruding mass.

Screw fixation begins at a site located at the midpoint of the exposed pedicle on the dorsal surface of the lamina of C-2. Preoperative computerized tomography (CT) with thin slices can show the size, configuration, and angle of the pedicle. Intraoperative frameless stereotaxy, which we used in Case 8, will assure the trajectory. An awl or small straight curette is used to create a starting point for the drill and to keep it from slipping on the bone surface. Drilling takes place in the sagittal plane, and the drill is advanced through the pedicle of C-2. At this level, screws 14 to 16 mm long are adequate. The drill hole is probed to ensure that a wall of bone is present on all sides. In individuals with poor bone density, additional security can be attained with a sublaminar cable. Drill holes are made in the occipital squama and appropriate short screws are inserted. When the squama is too thin or poor to support screw fixation, a wire cable is passed through the drill holes in the occiput and screwed to the plate (Fig. 3 left).

A corticocancellous graft and cancellous chips of sufficient quantity are then removed from the anterior iliac crest, and the occipital squama and the remaining arch of C-1 and lamina of C-2 are decorticated. The solid corticocancellous graft is placed along the medial side of the plate and secured with a cable passed around the plate and graft (Fig. 3 right). The cancellous chips are placed from the occiput to the decorticated surface of C-2. After the procedure, the patient wears a Philadelphia collar or a customized orthosis for 3 to 4 months.

Case Material

Over the past 7 years, we have treated eight patients for extradural nonneoplastic lesions of the craniovertebral junction using the transcondylar approach (Table 1). Six of the patients were women, two were men, and the mean age was 55.8 years (range 17–72 years). Two patients had rheumatoid arthritis, two had congenital abnormalities of the atlantoaxial complex, one had a synovial cyst, one os odontoideum, one Down’s syndrome, and one had nonspecific inflammatory changes surrounding the odontoid. A stereotactic device was used in this last case (Fig. 4). In all patients, magnetic resonance (MR) imaging depicted anterior or anterolateral compression of the spinomedullary junction by a mass (Figs. 5 and 6). Four patients had radiological signs of atlantoaxial subluxation. A stereotaxic device was used in this last case (Fig. 4). In all patients, magnetic resonance (MR) imaging depicted anterior or anterolateral compression of the spinomedullary junction by a mass (Figs. 5 and 6). Four patients had radiological signs of atlantoaxial subluxation. Magnetic resonance angiography, both arterial and venous, was used in four patients to delineate the anatomy of the vertebral artery and the dural sinus (Fig. 7). Normal patency of the arterial and venous structures was documented in all patients, but one had an asymmetrical caliper of the vertebral arteries.

Seven patients underwent one-stage procedures. One patient (Case 2), who was treated at another institution for a possible chordoma, was referred to us with progressive hemiparesis secondary to invagination and instability,
which was the cause of the patient’s symptoms. A cranio-
cervical fusion was done, but the patient’s symptoms did
not improve. The transcondylar approach was then used to
decompress the mass. Pathological analysis was negative
for chordoma, and nonspecific inflammatory tissue was
found.

All patients had an improved neurological status after
the procedure, except in Case 8 that is too early in the
postoperative period for the outcome to be assessed. ... 10
days later, the patient was readmitted to the hospital with
a severe pulmonary infection and subsequently died.

Discussion

Transoral Versus Transcondylar Approach

Extradural nonneoplastic lesions of the anterior fora-
men magnum are not rare, and the primary lesion usually
involves the osseous and ligamentous structures of the
anterior craniovertebral junction. These lesions are most
commonly treated via the transoral approach or its varia-
tions. These approaches allow a direct surgical route with-
out having to work around the brainstem and cranial
nerves. The advantages of the transoral approach are its familiar anatomy, simple surgical technique, direct
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Transcondylar approach to craniovertebral junction lesions

1) a deep and narrow working space; 2) a lateral exposure limited by the atlantooccipital joint; 3) difficulty in closing tears of the dura mater; 4) direct communication with the nasopharynx, creating a risk of serious infection; 5) the necessity of a mandibular split to gain surgical access when there is an interdental distance of less than 25 mm (as encountered in our Case 8); and 6) the need for a second surgical procedure to stabilize the cervical spine. Crockard and colleagues have described a one-stage transoral decompression and posterior fixation in patients with rheumatoid atlantoaxial subluxation. The procedure is done with the patient in the lateral position, allowing simultaneous anterior and posterior exposure. The disadvantages of this approach, however, are similar to those of the standard transoral approach. Although a second surgical procedure for cervical fixation is performed in the same setting, these remain two different operations, and the lateral position may be awkward.

The lateral approach to the craniovertebral junction has been used to treat lesions of the vertebral artery,12 dumbbell spinal neurinomas,16 meningiomas of the foramen magnum,3,4,11,23,24 and tumors of the jugular foramen.15 Many variations of the transcondylar approach have been described.

The greatest advantages of the lateral transcondylar approach are safe exposure of the space anterior to the neuraxis and the ability to manipulate the lesion in a parallel plane. In addition, the surgical corridor is short, wide, and sterile. Furthermore, stabilization is performed via the same exposure.

Indications and Limitations

The transcondylar approach to extradural nontumorous lesions of the craniovertebral junction has clear indications and limitations. Preoperative assessment must be thorough because many of these patients have systemic disease. Plain x-ray films of the craniovertebral area have been replaced by the use of MR imaging with dynamic flexion and extension.22 Bone structures can be evaluated using CT; sagittal and coronal slices are essential to the treatment plan. The height of the jugular bulb and its relation to the odontoid tip are important. When the odontoid tip projects above the line between the jugular bulbs, the transcondylar approach may not be feasible. In these situations, the anterior approach to the craniovertebral junction should be used.1 Knowledge of the anatomy of this area is crucial to avoid catastrophic complications.

The surgical position we use differs from those previously reported.4,11,16,17,23 The patient is kept in the supine position and, after craniovertebral fixation with the halo vest, is rotated 45° to the opposite side. This technique allows the surgeon to view the odontoid process from a lateral perspective. Despite satisfactory cervical stabilization in patients, we believe the titanium plate should be adjusted to provide the dimensions necessary for fixation without the bending that may preclude optimum long-term stabilization. Thus, we strongly advocate the use of an autologous bone graft.

![Fig. 6. Imaging studies of Case 7. Upper and Lower Left: Sagittal T1-weighted magnetic resonance images showing compression of the spinomedullary junction secondary to severe abnormalities at the level of the body of C-2 and odontoid process. The flexion and extension studies demonstrate signs of severe instability and atlantoaxial subluxation. Upper Right: Coronal computerized tomography (CT) scan showing the bone anatomy of the atlantooccipital area after removal of odontoid process through the transcondylar approach. Lower Right: A three-dimensional CT scan depicting the posterior bone construction of the occipitocervical junction.](image1)

![Fig. 7. Left: Magnetic resonance angiogram of Case 4 showing the course of the vertebral arteries and their junction with the basilar artery. Right: Magnetic resonance venogram showing the anatomy of the transverse and sigmoid sinuses, the lack of connection at the torcular herophili, and the position and size of the jugular bulb.](image2)

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Congenital Abnormalities. Patients with congenital abnormalities may have an occipitalization of the atlas and a severe degree of odontoid invagination. Despite the severe degree of abnormalities seen, the rate of instability after the ventral deformities are resected by the transoral approach is not always associated with initial instability; therefore, posterior occipitocervical fusion may not be necessary.14 The use of the transcondylar approach in these lesions requires the removal of the condyles and necessitates occipitocervical stabilization and fusion.

Rheumatoid Arthritis. The cranio cervical junction is a common site of rheumatoid arthritis, and the resultant instability and neural compression are recognized complications. The prevalence of subluxation has been reported to be 43% to 86%, and the magnitude has been related to the severity of the systemic disease process. Atlantoaxial subluxation is the most common type of instability (seen in 50%–70% of patients) and is usually anterior, but posterior and lateral subluxation may also occur.21 The rheumatoid pannus has a predilection for the periodontoid region and may insinuate itself between the anterior arch of C-1 and the dens, and then expand laterally in continuity with the atlantooccipital joint, occasionally preventing full reduction of anterior subluxation. Menezes and colleagues10 reviewed the records of 45 patients with rheumatoid arthritis and "cranial settling." Among these, 36 patients had an acceptable reduction of the basilar invagination and underwent posterior occipitocervical fusion. Nine patients had irreducible ventral compression of the cervicomедullary junction by the invaginated odontoid process and granulation tissue. In these patients, transoral resection of the odontoid process and granulation tissue was followed by posterior occipital–C-2 fusion. In eight of the patients in that series, a significant amount of rheumatoid granulation tissue was found behind the odontoid process in continuity with granulation tissue from the lateral occipitoatlantaoaxial joints. In patients like those the transcondylar approach is particularly advantageous.

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References


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