Microsurgical Anatomy in Transoral Odontoidectomy

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Abstract

Objective The transoral approach allows direct view of the ventral craniovertebral junction and provides useful management of the various lesions of this area. We present a step by step guide to the performance of the transoral excision of the odontoid process in the cadaveric model.

Methods Ten cadaver heads were used in fixed or unfixed state. We describe the relevant surgical anatomy in the cadaveric dissection and surgical technique of transoral transpharyngeal odontoidectomy.

Results The surgical procedure of transoral odontoidectomy was categorized by six steps: soft palate, posterior pharyngeal wall, muscular structures, osseous structures, odontoid process and ligaments, cruciate ligament and dura.

Conclusion With anatomical knowledge of these regions neurosurgeons can deal with wide variety of lesions in the ventral craniovertebral junction.

KEY WORDS Transoral odontoidectomy · Cadaveric dissection · Microsurgical anatomy · Craniovertebral junction.

Introduction

The transoral transpharyngeal approaches to the ventral craniovertebral junction (CVJ) are regarded as direct and efficient procedures but these are not used widely because of limitation of exposure, complications like cerebrospinal fluid leakage, meningitis, and lack of anatomical knowledge. With the increasing experiences and widening of indications, the transoral transpharyngeal approach must be now regarded as a valuable asset to the neurosurgical armamentarium.

In 1951 Scoville and Sherman suggested that transoral excision of the odontoid process was the optimum procedure to alleviate brainstem compression in patients with platybasia. Six years later, Southwick and Robinson removed an osteoma arising from the second cervical vertebra via a transoral approach. The first series of cases of transoral surgery of the odontoid process is credited to Fang and Ong in 1962. Mullan and colleagues reported excision of two tumors via the transoral route in 1965. But this approach did not become popular due to suboptimal imaging techniques and lack of suitable illumination and instrumentation. The introduction of the surgical microscope together with improvements in instrumentation and imaging modalities has revolutionized the investigation and treatment of ventrally placed lesions at the craniovertebral junction. In recent years several authors have reported their experiences with transoral surgery for congenital, traumatic, inflammatory, neoplastic, and vascular conditions in the regions of the CVJ.

Even if the surgical fields in these approaches are familiar to neurosurgeons, the anatomy of these regions is not difficult to understand. With anatomical knowledge of
these regions neurosurgeons can deal with wide variety of lesions in the ventral CVJ. We therefore present a step by step guide to the performance of the transoral excision of the odontoid process in the cadaveric model, and also stress the technical points to make the operative fields wide and complications low.

**Materials and Methods**

Ten cadaver heads were used in fixed or unfixed state. The heads are fixed using head clamps and the transoral transpharyngeal odontoidectomies were performed microsurgically using high speed drill (Midas Rex, Ft. Worth, TX) and operating microscope (Zeiss OPMI 6C contraves microscope, Carl Zeiss Company, thorwood, NY). Photographs were taken step by step.

**Results**

The surgical procedure of transoral odontoidectomy was categorized by six steps, soft palate, posterior pharyngeal wall, muscular structures, osseous structures, odontoid process and ligaments, cruciate ligament and dura.

1. **Soft palate**

The soft palate is suspended from the posterior border of the hard palate and extends downward separating the nasal from the oral cavity. The uvula hangs from the middle of its lower border. It is continuous from the hard palate and composed of aponeurosis in the center and covered by mucosa. The midline of these structure is made of connective tissue without functioning muscles. Damage to the function of the soft palate is minimal if the incision is made in the midline avoiding uvula. Division of the soft palate should be performed in the midline which is essentially devoid of muscle.

The endotracheal tube is retracted to the left whilst the uvula is retracted to the right with the special retractors (Fig. 1-1). If required (usually for lower clival lesions) the soft palate is divided in the midline as far as the hard palate. The incision is deviated to one side of the uvula inferiorly (Fig. 1-2).

![Fig. 1-1. Photograph showing the uvula(arrow) and posterior pharyngeal wall after application of special retractor.](image1)

![Fig. 1-2. Photograph showing the soft palate(arrow) incision sparing the uvula.](image2)
2. Posterior pharyngeal wall

The posterior pharyngeal wall consists of three layers: the mucous membrane, the muscular layer which forms a raphe in the midline, and a fibrous layer. A loose connective tissue layer separates the pharyngeal muscular layer from the prevertebral fascia.

By palpating the anterior tubercle of the atlas the midline and C1 are identified and mental picture noted. If in doubt the position may be confirmed radiographically or using frameless stereotactic guide. A vertical mucosal incision is made centered on the anterior tubercle of the atlas. The edges are retracted exposing the pharyngeal constrictor muscles (Fig. 2).

3. Muscular structures

The superior oblique part of the longus coli arises from the anterior tubercle of the transverse processes of the third through fifth cervical vertebrae and passes upwards and medially to attach to the anterolateral aspect of the anterior tubercle of the atlas (Fig. 3). The vertical part of the longus coli arises from the front of the bodies of the upper three thoracic and lower three cervical vertebrae and attaches to the front of the bodies of the second, third, and fourth cervical vertebrae. The rectus capitis anterior is not exposed during the procedure.

The pharyngeal constrictor muscles, the insertion of the longus coli and the anterior longitudinal ligament are divided exposing anterior tubercle and arch of atlas for a distance of approximately 10mm. The retractors are repositioned to a deeper plane.

4. Osseous structures

The odontoid process is situated behind the anterior arch of the atlas and articulating with it through a synovial joint. The convexity of the anterior arch is accentuated by the midline anterior tubercle, which serves as an important surgical landmark. Anterior tubercle and arch of atlas are removed using high speed drill exposing the odontoid process (Fig. 4). The exposure does not exceed 10mm from midline not to violate atlantoaxial joint.

5. Odontoid process and ligaments

The odontoid process is approximately 14mm in height.
and 10mm in thickness. The anterior longitudinal ligament is attached to the basilar part of the occipital bone superiorly from which it extends to the anterior tubercle of the atlas, the front of the body of the axis and is then continued inferiorly. The atlanto-occipital membrane is composed of densely woven fibers, which pass from the anterior margin of the foramen magnum to the upper border of the anterior arch of the atlas. It blends with the anterior longitudinal ligament.

Two ligaments connect the odontoid process and to the cranium. The apical ligament extends from the tip of the odontoid process to the anterior margin of the foramen magnum and the alar ligaments starts on each side of the upper part of the odontoid process and pass obliquely to impressions on the medial side of the occipital condyles and the lateral mass of the atlas (Fig. 4).

The odontoid process is hollowed out using a cutting burr (Fig. 5). A diamond burr is employed when the posterior wall is resected. The base is then divided and the odontoid process is displaced antero-inferiorly thus exposing the apical and alar ligaments. These are divided close to the bone and the odontoid process is removed with forceps. In some circumstances the odontoid process must be removed in a piecemeal manner. In patients with cranial settling the dura may be draped over the odontoid process and care must be exercised superiorly to avoid dural penetration.

6. Cruciate ligament and dura

The cruciate ligament of the atlas is located posterior to the odontoid process and maintains it in close apposition to the posterior surface of the anterior arch of the atlas (Fig. 6). It consists of two limbs; the transverse ligament is a thick strong band which arches across the ring of the atlas attached to a tubercle on the medial surface of the lateral mass, the lesser vertical limb attached to the basilar part of the occipital bone superiorly and to the posterior aspect of the body of the axis inferiorly. The tectorial membrane, a continuation of the posterior longitudinal ligament, blends with the cruciate ligament on its posterior aspect (Fig. 7).

The transverse ligament is removed by sharp dissection thus exposing dura. In cases of rheumatoid arthritis there

![Fig. 4. Photograph showing the apical and alar ligaments (arrows) after removal of anterior arch of atlas.](image)

![Fig. 5. Photograph showing the internal hollowing of odontoid process (arrow).](image)
may be extensive tenacious pannus posterior to the odontoid process and this is removed by a combination of sharp and blunt techniques. In the case of intradural lesion dura is incised and vertebral artery and ventral brainstem can be seen directly (Fig. 8).

Discussion

The cranio-vertebral junction area can be approached by various routes. When the predominant compression is posterior or instability is main problem a posterior approach is recommended. If the main compression is anterior and instability is problem anterior decompression by transoral route and posterior fusion is recommended. The transoral transpharyngeal approach exposes the middle compartment of anterior skull base limited by the inferior petrosal sinuses and hypoglossal canals from the lower one third of the clivus to the foramen magnum and the upper cervical spine as far as the C2-3 intervertebral disc. If needed a labiomentabolossootomy or its variants allows more inferior exposure to C4. The transoral approach is indicated for the various pathology including primary basilar invagination, rheumatoid cranial settling, secondary basilar invagination due to migration of odontoid fracture fragments, dystopic os odontoideum, tumor etc.

The transoral approach, which has been widely used for the management of extradural lesions in this area, is also useful for the treatment of intradural lesions. It provides direct view of ventral aspects of CVJ without need for brain retraction. Even though the complications are diminished by use of fibrin adhesive and prolonged diversion of cerebrospinal fluid, the risks of cerebrospinal fluid leakage and infection are still significant. In the case of intradural pathology a lumbar drain is inserted prior to the commencement of surgery and left open for 5 days at which time it may be converted to a lumboperitoneal shunt.

The location of CVJ can be monitored by palpation of anterior tubercle of the atlas or intraoperative radiography and fluoroscopy. But the video-interactive frameless stereotactic guidance system has several advantages over standard radiographic intraoperative localization techniques during transoral approaches to the ventral CVJ. This system
has provides speed, accuracy, localization in the multiple planes simultaneously, and lack of radiation exposure. Several vital structures are located off the midline and the distance must be kept in mind in this approach. The distance from the foramen magnum to the pharyngeal tubercle is 11.2mm. The intercondylar distance is 23.6mm and the distance between the hypoglossal canals is 27.9mm. The thickness of the clivus ranges from 1.5 to 5.8mm at this level. The convexity of the anterior arch is accentuated by the midline anterior tubercle, which serves as an important surgical landmark. The anterior arch is 13.6mm in height and 4mm in thickness. The atlanto-axial joint is approximately 10mm from the midline and the vertebral artery is approximately 25mm from the midline at this level. The odontoid process is approximately 14mm in height and 10mm in thickness. The anterior arch of atlas is resected about 10mm in width to expose the whole odontoid process but care must be taken not to violate the atlanto-axial joint.

The craniovertebral complex must not only secure the heavy cranium to the spinal column in a stable manner, it must also allow for a wide ranges of motion of the cranium.

This is accomplished by the osseous-ligamentous arrangement. Studies on the occipito-atlanto-axial complex demonstrate that the transverse ligament of the atlas is responsible for stability in an antero-posterior plane with the apical and alar ligaments playing minor role. In contrast the alar ligaments are responsible for stability in axial rotation and lateral bending. Although the biomechanical characteristics have been measured, it is difficult to relate this to clinical instability.

A stabilizing procedure must be included in the management of patients exhibiting preoperative instability. But there is considerable debate as to the necessity and timing of a stabilizing procedure in patients with a stable preoperative spine. Crockard and colleagues have described their technique for a one-stage transoral decompression and fusion in patients with rheumatoid arthritis. Transoral surgery may be combined with anterior fixation or may be followed by an occipito-cervical fusion.

Menezes and colleagues reported their experience in 65 adults and seven children who underwent transoral decompression. Postoperative stability was assessed in three planes by radiography. Fifty adults and two children required posterior fusion, Cranial settling in patients with rheumatoid arthritis was also considered unstable. Pasztor and Di Lorenzo regard transoral odontoidectomy as an unstable situation and advocate posterior fusion in these patients. Dickman and colleagues addressed the issue directly in an important contribution. They analyzed 27 cases according to the presence of preoperative instability and the associated pathology. Ten of 11 patients with rheumatoid arthritis and five of 11 patients with congenital osseous malformations required a stabilizing procedure. In contrast Hadley and colleagues reported their experience of 53 patients with rheumatoid arthritis and congenital anomaly being the most frequent indications for operation. Stability was assessed by lateral cervical radiographs in flexion and extension. Only eight patients were considered unstable. The patients who underwent transoral odontoidectomy even without preoperative instability should be assessed postoperatively and closed follow-up is required.

**Conclusion**

The transoral approach provides direct view of the ventral craniovertebral junction and useful management of the various lesions of this area. We present a step by step...
guide to the performance of the transoral excision of the odontoid process in the cadaveric model. Ten cadavers heads were used in fixed or unfixed state. We describe the relevant surgical anatomy in the cadaveric dissection and surgical technique of transoral transpharyngeal odontoidecotomy.

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경구강 치상돌기제거술의 수술해부학

박관·이상구·조태구·남도현·이정일·김종수·홍승철·신형진·이환·김종현

= 국문초록 =

목적

경구강 치상돌기제거술은 경골과의 간접충돌로 인한 손상의 원인을 설명하는 방법 중 하나로, 이에 따라 치료 방법의 결정에 관여한다. 본 연구는 경구강 치상돌기제거술의 수술해부학을 분석한 결과이다.

방 법

10기의 치상돌기제거술을 대상으로 하여 수술 전후의 해부학적 변화를 분석하였다. 수술 전후 해부학적 변화를 분석하여 치상돌기제거술의 효과를 평가하였다.

결 과

6개의 치상돌기제거술을 대상으로 하여 수술 전후의 해부학적 변화를 분석하였다. 수술 전후 해부학적 변화를 분석하여 치상돌기제거술의 효과를 평가하였다.

결 문

본 연구는 경구강 치상돌기제거술의 수술해부학을 분석한 결과로, 치상돌기제거술의 효과를 평가하였다.

중심 단어: 치상돌기제거술, 경구강, 수술해부학, 경골, 형질학.