Extended Endoscopic Endonasal Approach to the Anterior Cranio-vertebral Junction: Anatomic Study

Anterior Kranyo-vertebral Bileşiğe Genişletilmiş Endoskopik Endonasal Yaklaşım: Anatomik Çalışma

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Received : 24.04.2009
Accepted : 12.06.2009

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ABSTRACT

OBJECTIVE: Our aim in this study was to identify the endoscopic anatomy of the anterior cranio-vertebral junction to be able to perform minimal invasive endoscopic surgical procedures to this region (such as dens resection) safely with better postoperative performance of the patients.

MATERIAL and METHODS: Five fresh adult cadavers were studied (n=5). We used Karl Storz 0 and 30 degree, 4mm, 18cm and 30cm rod lens rigid endoscope in our dissections. After cadaveric specimen preparation, we approached the anterior cranio-vertebral junction by binostril extended endoscopic endonasal approach.

RESULTS: The cranio-vertebral junction was located by orientating the endoscope between -10 to +10 degrees. The rhinopharynx was widely exposable after resection of the vomer. The safe lateral limit of this approach was the occipital condyles and foramen lacerum. We could perform odontoid process resection with a pure endoscopic endonasal approach.

CONCLUSION: Our anatomic study offered the facility to learn the endoscopic anatomy of the anterior cranio-vertebral junction and understand the appropriate approaches to this region. Our approach is appropriate for treatment of some pathologies of this region, with less invasiveness compared to the traditional transoral approach.

KEY WORDS: Cranio-vertebral junction, Endoscopic endonasal approach, Odontoid process, Surgical anatomy

ÖZ

AMAÇ: Bu çalışmadaki amacımız, anterior kranyo-vertebral bileşkenin endoskopik anatomisini tanımlamaktır. Böylece, bu bölgeye minimal invazif işlemlerin (dens rezeksiyonu gibi) daha güvenli bir şekilde uygulanır, ve hastalarda daha iyi postoperatif performans elde edilir.

GEREÇ ve YÖNTEMLER: Beş adet taze kadavra çalışılmıştır (n=5). Diseksiyonlarımızda Karl storz 0 ve 30 dereceli, 4mm, 18 cm ve 30 cm rod lens rijit endoskop kullanıldı. Kadavraların hazırlanması ardından anterior kranyo-vertebral bileşkeye binostril genişletilmiş endoskopik endonasal yaklaşım ile ulaşıldı.

BULGULAR: Kranyo-vertebral bileşkeye endoskopu -10 ve +10 derece ile yönlendirilerek ulaşıldı. Vomer rezeksiyonundan sonra rinofarinks geniş olarak ekspoze edilebildi. Yaklaşımın lateral güvenli sınırı oksipital kondiller ve foramen lacerum olarak kabul edildi. Pür endoskopik endonasal yaklaşım ile dens rezeksiyonu uygulanabildi.

SONUÇ: Bu anatomik çalışmamızda, anterior kranyo-vertebral bileşkenin anatomisi ve bu bölgeye uygun cerrahi yaklaşım tanımlandı. Bu yaklaşım bu bölgenin bazı patolojilerinin tedavisinde uygundur. Ayrıca, klasik transoral yaklaşımlara göre daha miminal invazif sayılmaktadır.

ANAHTAR SOZCÜKLER: Kranyo-vertebral bileşik, Endoskopik endonasal yaklaşım, Odontoid çıkıntı, Cerrahi anatomi

INTRODUCTION

Approaches to the anterior cranio-vertebral junction and odontoid process are considered one of the most challenging subjects in the practice of the neurosurgery. The transoral transpharyngeal is the most favored route, and has been considered a standard approach (3,6,18,25,27,28,29,33,34,35). Among the microsurgical approaches to the cranio-vertebral junction and odontoid process, this corridor is the shortest route with the least tissue destruction. However, splitting of the soft palate as well as removal of the hard palate may be required, especially in pathologies with rostral clival extension. Many anatomic studies (17,30) and refinements of surgical techniques have significantly reduced the mortality and morbidity rates for the standard approach (8,15,19). However, many difficulties and complications are still encountered, such as, the risk of contamination by bacterial flora, prolonged postoperative intubation and nasogastric tube feeding, and possible effects on phonation as the result of soft palate splitting or hard palate resection in some cases. Since the introduction of the endoscopic endonasal techniques in the neurosurgical practice (21,22), the surgical experience has gradually increased and the endoscopic approaches to the anterior cranio-vertebral junction has progressively been improved (1,2,14,20,23,26,30,36).

Using knowledge of the endoscopic anatomy and neurovascular relations, and with good manipulation of the endoscope, defined surgical endoscopic approaches can help us to deal better with wide variety of pathologies, with minimal invasive techniques and less postoperative complications. In our study we report the anatomic basis of the extended endoscopic endonasal approach to the anterior cranio-vertebral junction.

MATERIAL and METHODS

Five fresh adult cadavers consisting of 3 males (60%), and 2 females (40%) were studied (n=5). Endoscopic dissections were performed in the Turkish Republic Ministry of Justice, Forensic Medicine Institution, Morgue Specialization Department autopsy hall. The corpse selection criteria were: 1) 18 years of age or older, 2) no history of head trauma or craniofacial surgery and 3) dissection of corpses already autopsied or during autopsy (no dissection made before the evaluation and permission of forensic medicine doctors). Dissection was performed by using of Karl Storz 0 and 30 degree, 4mm, 18 cm and 30 cm rod lens rigid endoscope (Karl Storz and Co., Tuttlingen, Germany), The endoscope was connected to a light source via a fiberoptic cable and to a camera fitted with 3 charge-coupled device sensors. The video camera was connected to a 21-in monitor. As surgical instrumentation, we used the Karl Storz Kassam-Snydermann surgical set. Cadaveric specimens were placed in a supine position with the head in neutral position. We prefer to adduct the cadaver’s head 10-15 degree toward the left shoulder in endoscopic endonasal approaches to the skull base. This position is more suitable for the surgeon in that it does not disturb the surgical orientation and avoids the lateral bending of the surgeon’s trunk toward the patient, causing less fatigue during the surgical procedures. In contrast, the cadaver’s head is preferred to be in neutral position when performing endoscopic endonasal approach to the anterior cranio-vertebral junction. Positional changes of the joints of this region and distraction of the paraspinal muscles and ligaments are prevented in this way, with more neutral anatomic orientation and easier muscle dissection.

DISSECTION TECHNIQUE

The endoscope is introduced to the right nostril nearly parallel to the nasal cavity floor. Medially the nasal septum and laterally the inferior and middle turbinate are first identified (Figure 1A). The endoscope is advanced following the inferior turbinate toward its tail. The choana is identified, located at the rear end and medially to the inferior turbinate and the most posteroinferior of the nasal cavity and laterally to the vomer (Figure 1B). With closer endoscopic view of the choana, laterally the Eustacius Canal, in the middle the Rosenmoller fossa, and medially and posteriorly, more deeply located, the prominence of the anterior mass of atlas (C1) can be seen. The middle turbinate is lateralized to expose the sphenoethmoidal recess. In this recess, nearly 15mm superior to choana, the sphenoid ostium is exposed, and the anatomic relation identified (Figure 1C). The position of the C1 anterior mass is checked by fluoroscopy (Figure 2A,B,C).

The vomer is totally resected and the rhinopharynx is exposed widely. In this step, the binostril approach was performed. The area superior to the soft palate, inferior to the midclivus, and

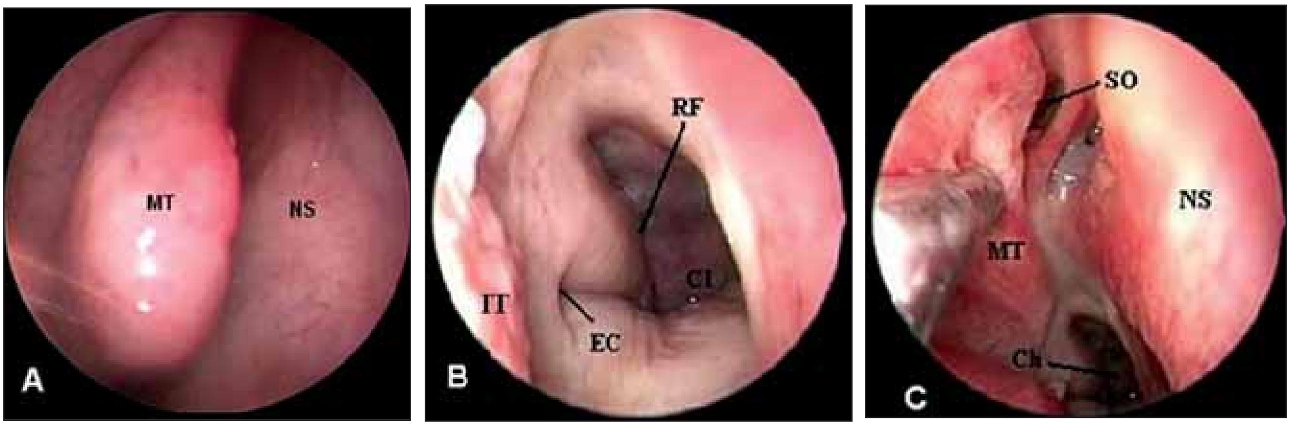

Figure 1: *Endoscopic view of the right nasal cavity. MT: middle turbinate, NS: nasal septum, Ch: choana, IT: inferior turbinate, C1: anterior arch of atlas, EC: Eustacius canal, RF: Rosenmoller fossa, SO: sphenoid ostium.*

Figure 2: A*) Endoscopic view of the choana and the anatomic position of the anterior arch of atlas,* ***B****) Fluoroscopic view of endoscope orientated toward odontoid process.* ***C****) The direction of the endoscopic approach is demonstrated on the sagittal plane on cranial computerized tomography (CT) scan. C1: anterior arch of atlas, EC: Eustacius canal, RF: Rosenmoller fossa.*

between the both Eustacius canals is widely exposed (Figure 3). The mucosal flap is incised in an inverted 'U' shape with the lateral limits being the Eustacius canals and the superior limit being the inferior clivus. This mucosal flap is dissected and retracted behind the soft palate to pass to the oropharynx. In this way the mucosal flap does not fill the dissection (or operation) field. After this step the paraspinal muscles are exposed (longus capitis and longus colli) (Figure 4). The inferior clivus is resected by 2 mm Kerrison or 2 mm diamond burr drill, until the occipital condyles, and the foramen lacerum on both sides is identified because it represents the lateral limit of the approach. A midline incision is made with an endoscopic knife and the muscles are dissected and retracted laterally exposing the anterior tubercle of atlas and the atlantooccipital membrane (Figure 5A). The anterior arch of C1 is widely exposed with a more lateral dissection of the paraspinal muscles (Figure 5B).

The anterior arch of atlas is resected and the odontoid process of axis (C2) is exposed (Figure 6) with 2 mm Kerrison or 2 mm diamond burr drill. The odontoid process of C2 is resected (Figure 7) with 2 mm Kerrison or 2 mm diamond burr drill. The cortex of the anterior face of the odontoid process and its trabecular portions are drilled to prevent injury of the underlying dura, leaving the cortex of the posterior face of the dens. This remaining part is dissected and mobilized from the underlying dura carefully. After completing dens resection, the dura of the brain stem is widely exposed.

RESULTS

Cadaveric specimens were placed in the supine position with the head in the neutral position. We prefer to adduct the cadaver's head 10-15 degrees toward the left shoulder in endoscopic endonasal

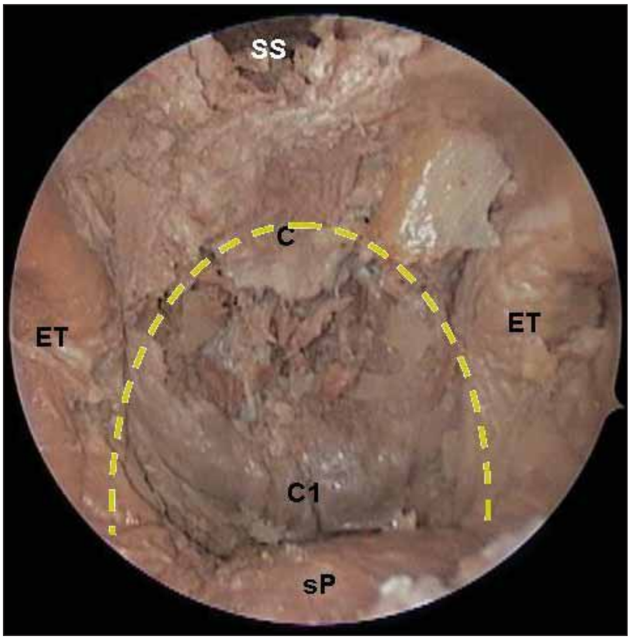

Figure 3: *Endoscopic view of the nasopharynx after removal of the vomer. Dotted line indicates the mucosal flap incision site. C: clivus, C1: anterior arch of atlas, ET: Eustacius tube, sP: soft palate.*

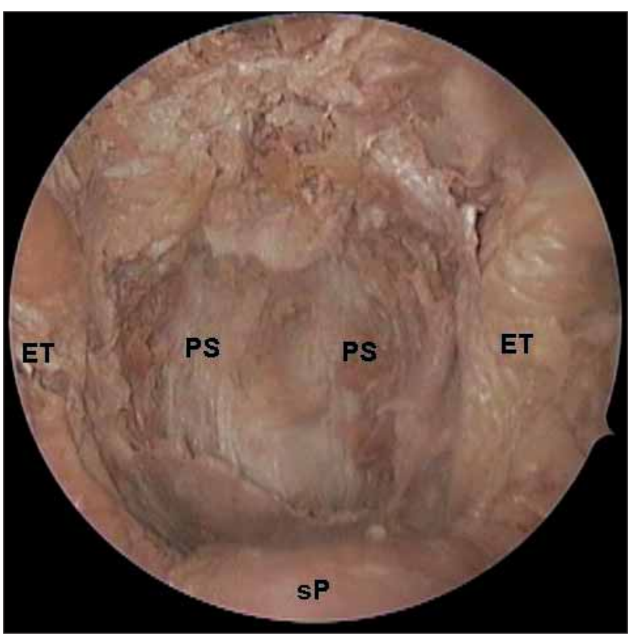

Figure 4: *The mucosal flap is incised and retracted, and the underlying paraspinal muscles (longus capitis and longus colli) are exposed. ET: Eustacius tube, PS: paraspinal muscles, sP: soft palate.*

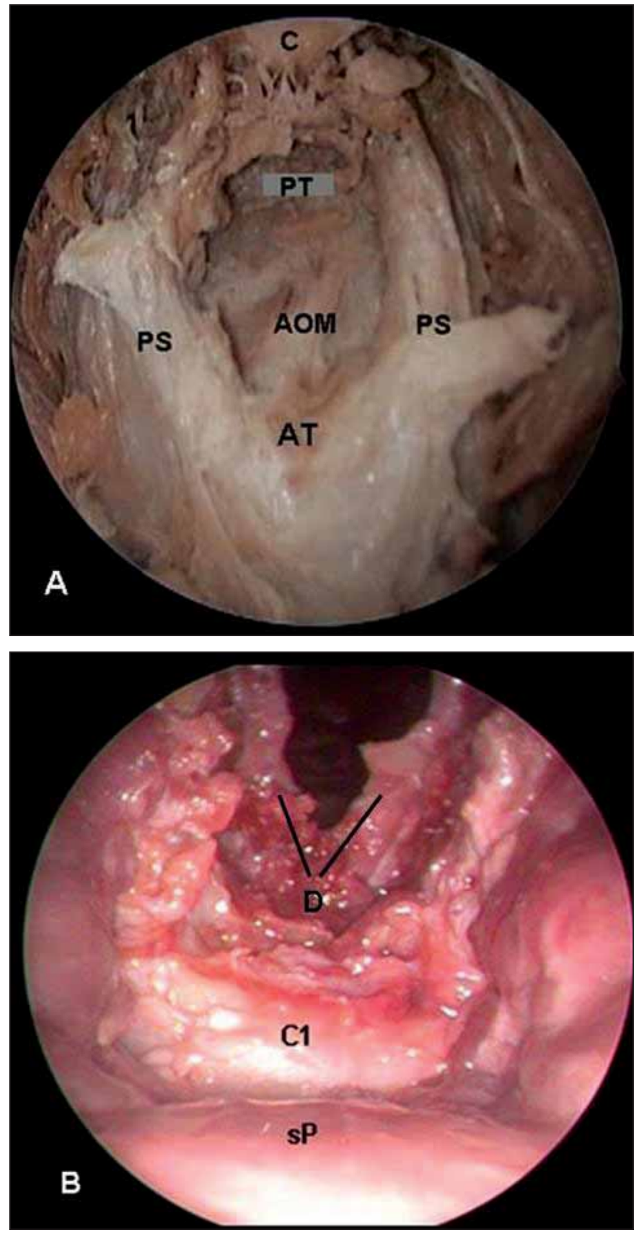

Figure 5: ***A)*** *The paraspinal muscles are dissected and retracted laterally, and the atlanto-occipital membrane is exposed.* ***B)*** *Endoscopic view of another cadaver dissection. The inferior clivus is resected and clival dura was opened. The paraspinal muscles are retracted laterally to expose the anterior arch of atlas. AOM: atlanto-occipital membrane, AT: anterior tubercle of atlas, PS: paraspinal muscles, PT: pharyngeal tubercle, C: clivus, C1: atlas, sP: soft palate.*

approaches to the skull base. This position is more suitable for the surgeon in that it does not disturb surgical orientation and avoids the lateral bending of the surgeon's trunk toward the patient causing less fatigue during the surgical procedures. On the other hand, the cadaver's head is preferred to be in neutral position when performing endoscopic endonasal approach to the anterior cranio-vertebral junction. In this way, positional changes of the joints of this region and distraction of the paraspinal

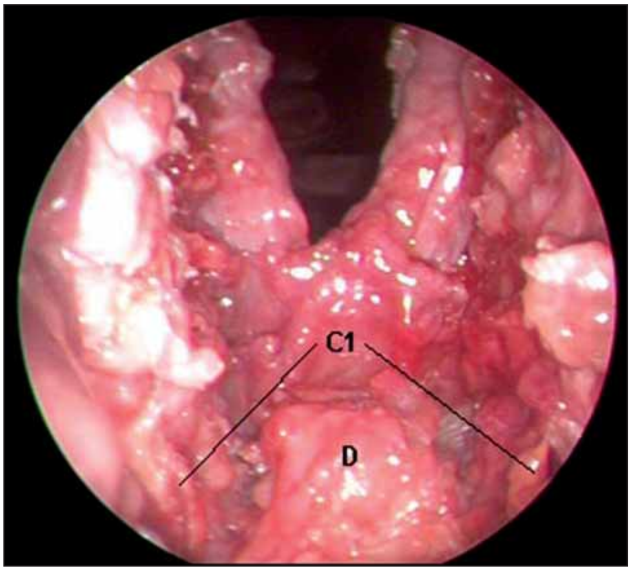

Figure 6: Endoscopic view demonstrating the odontoid process after resecting the anterior arch of the atlas. C1: atlas, D: odontoid process.

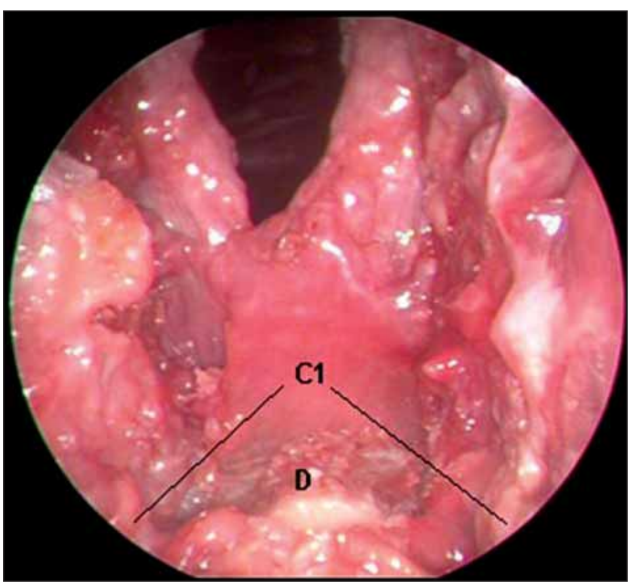

Figure 7: Endoscopic view of resected anterior arch of the atlas and odontoid process. C1: atlas, D: odontoid process.

muscles and ligaments are prevented, with more neutral anatomic orientation and easier muscle dissection.

The anterior skull base was studied in 5 cadaveric specimens. The endoscope was introduced from the right nostril first, and the binostril approach was then performed. The anterior cranio-vertebral junction and dens could be reached by orientation of the endoscope +10 to -10 degrees.

After resecting the vomer we could widely expose the rhinopharynx, including the area superior to the soft palate, inferior to the midclivus, and between both Eustacius canals. After mucosal resection, passing the retracted mucosa behind the soft palate into the oropharynx provided us a wide exposure of the paraspinal muscles (longus capitis and longus colli). The inferior clivus resection lateral limits were the occipital condyles and foramen lacerum. After dissecting the atlantooccipital membrane, longus capitis and longus colli muscles, we could clearly expose the anterior arch of atlas. The odontoid process of C2 is exposed after resection of the anterior arch of C1. Dens resection is performed safely by drilling the cortex of the anterior face and trabecular portion first, followed by careful dissection and mobilization of the cortex of the posterior face. After dens resection, the dural of the brain stem is exposed.

DISCUSSION

Approaches to the anterior cranio-vertebral junction and odontoid process are considered one of the most challenging subjects in the practice of the neurosurgery. This is due to the deep location with surrounding critical neurovascular structures. Many surgical approaches were described for surgical treatment of retroclival and cranio-vertebral junction pathologies, including anterior, lateral and posterolateral approaches (4,6,9,10,12,13,16,25). The transoral transpharyngeal approach represents a direct midline path to the anterior cranio-vertebral junction, thus, being theoretically the least invasive surgical route for approaching lesions of this region. However, due to the disadvantages of the transoral approach such as the difficulties of dural closure and subsequent increased risk of cerebrospinal fluid (CSF) leak and meningitis and the limited lateral exposure and the depth of the surgical field, this technique is advisable only for the treatment of extradural lesions (6,12,18,27). However, some surgeons have used it for intradural lesions as well.

In general, splitting of the soft palate is often necessary when additional rostral exposure is required. The hard palate is then to be removed (transoral transpharyngeal transpalatine approach) when additional exposure of the clivus is required. A tracheostomy is often opened to maintain safe undisturbed airway and unobstructed access to the operative field, and to facilitate postoperative management. Airway swelling, upper airway obstruction, velopharyngeal insufficiency, damage to the teeth from the retractors, dysphonia (for palate split and bony removal), and / or ischemic necrosis of the tongue due to prolonged compression can occur as complications (11).

Many endoscopic anatomical cadaveric and clinical studies have been performed since the introduction of the endoscopic endonasal techniques in the neurosurgical practice (21, 22). These studies have shown the possibility of extending the standard endoscopic endonasal approach to the removal of craniocervical junction pathologies (2,5,14,24,26,30,36). The endoscopic endonasal route offers a direct access to the anterior cranio-vertebral junction, passing through a corridor not disturbed by important neurovascular structures, and without requiring any cerebral retraction, with wider exposure as compared to that provided by the conventional microscopic anterior approaches. Furthermore, the foramen magnum and clivus can be exposed without the split of the soft palate or the hard palate with the endonasal approach thus causing less insult to phonation. This approach also avoids retraction of the tongue and subsequent swelling. Theoretically, wound contamination of enteric bacteria is less in the endoscopic endonasal approach, as the mucosal incision is done in the nasopharynx, in contrast to the oropharynx incision in transoral approaches. However, the endoscopic endonasal approach can be adapted to a transoral approach itself.

Despite the advantages of the endoscopic technique, there are still some important limitations and difficulties encountering this approach. One limitation of the endoscopic endonasal approach is its relatively small operative field, with limited caudal and lateral extension. The hard palate is the most important factor in the caudal direction limitation of endonasal endoscopic approach. Thus, endoscopic exposure is limited caudally to the anterior arch of C1. Although, structures below this level can be visualized by angled endoscopes, surgical intervention is very difficult. Annoying bleeding from circular sinuses or from the venous plexuses on the dura covering the clivus can occur during surgery, which is difficult to control with coagulation, and need the use of proper hemostatic materials. Another difficulty is the limited working space, thus making the bone grafting and dural suturing impossible, with the risk of postoperative CSF leakage. This is not the case in odontoid process resection, which is a totally extradural procedure. However, care must be taken to avoid dural tears during resection. Surgical treatment of intradural lesions located anteriorly to the brainstem and the foramen magnum is still considered a surgical challenge, as in the case of a transoral approach (6,7,17,31,32,35,37).

Although the endoscopic anatomy of the cranio-vertebral junction had been discussed in previous reports (2,5,30), this is the first study performed in Turkey. This anatomic study, as the previous studies, is helpful to understand the anatomic orientation and the neurovascular relations, and offers better accommodation to the endoscopic instrument manipulation, which neurosurgeons are less familiar with. We believe that this step is essential before starting performing live surgery and that this study will therefore provide an important contribution for starting endoscopic endonasal surgery of the craniovertebral junction in our country. With more experience achieved during this study, and the knowledge gained from the previous anatomical (2,5,30) and clinical (14,24,26,36) reports, we could also construct a more simplified and more direct scheme for approaching the craniovertebral junction endoscopically thus making this approach more easy to understand, especially for neurosurgeons who are in the learning phase of the basic concepts of the endoscopic skull base surgery.

CONCLUSIONS

Our anatomic study offered the facility to learn the endoscopic anatomy of the anterior craniovertebral junction and understand the appropriate approaches to pathologies of this region. It is possible to approach the anterior craniocervical junction and perform dissection safely by the binostril extended endoscopic endonasal approach. The approach is appropriate for some pathologies of this region, with less invasiveness compared to the traditional transoral approach.

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