Original Article

Odontoidectomy through posterior midline approach followed by same sitting occipitocervical fixation: A cadaveric study

ABSTRACT

Object: Atlantoaxial instability with irreducible odontoid process is one of the challenges in spine surgery. These lesions are commonly treated through anterior transoral approach which is followed by posterior atlantoaxial fusion. However, there are still many limitations, especially cerebrospinal fluid fistula with subsequent life-threatening infection, difficulty in cases with limited opening of mouth due to temporomandibular arthritis or anomalies of naso-oropharynx. Türe *et al.* used the extreme lateral transatlas approach for the removal of odontoid. In this study, we applied the transatlas approach but through posterior midline incision aiming to evaluate its safety and feasibility.

Methods: In four silicon injected, formalin-fixed cadaver heads, posterior removal of the odontoid was done through the familiar midline incision and subperiosteal muscle separation and elevation of muscles as on unit followed by microscopic exposure and mobilization of the vertebral artery after opening of the foramen transversarium of atlas followed by drilling of lateral mass and odontoidectomy. Occipitocervical stabilization was done between the occiput and C2, C3 (C1 lateral mass screw can be added in the contralateral side for better stabilization).

Results: Unilateral excision of the lateral mass of atlas after mobilization of the vertebral artery provided safe and excellent exposure of the odontoid process in the four cadaver heads without injury to vertebral artery or retraction of the dura.

Conclusion: Posterior removal of the odontoid can be done safely through wide and sterile operative field, and occipitocervical fixation performed at the same sitting without need for another operation and hence avoids the risk of cord injury from repositioning.

Key words: Craniocervical junction; extreme lateral-transatlas approach; removal of the odontoid.

Introduction

Atlantoaxial instability with irreducible odontoid process is one of the challenges in spine surgery.[1-5] These lesions are commonly treated through anterior transoral approach.[1,2,4,6-10] However, there are still many limitations, especially cerebrospinal fluid (CSF) fistula with subsequent life-threatening infection and the need for craniocervical stabilization in another sitting.[5,10-12] Türe and Pamir, 2002,[5] used the extreme lateral transatlas approach for posterolateral removal of the odontoid that followed by unilateral occipitocervical fixation.

Since that time, the application and reports about this approach are limited, and we owe this for the difficulty and the risks of exposure of the vertebral artery through posterolateral approach, and most of spine surgeons are not accustomed for this approach to the atlantoaxial region.

In this study, we applied the transatlas approach but through the more familial posterior midline incision that followed by bilateral occipitocervical fixation. The surgical technique is

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detailed, and the results are analyzed and discussed aiming to evaluate its safety and feasibility.

Methods

This is a cadaveric study that performed in anatomical laboratory of the university. In four silicon injected, formalin-fixed cadaver heads, posterior removal of the odontoid was done in prone position.

Surgical technique

Head position, skin incision, and exposure of the vertebral artery

The head is fixed in prone position with head tilt 15° opposite to side, in which C1 lateral mass will be removed. The familiar midline skin incision is performed and extended laterally (as inverted L) to help in lateral dissection and exposure of the vertebral artery.

Subperiosteal separation and elevation of muscles as on unit was done extending from the external occipital protuberance to C3 with proper exposure of C2/C3 facets bilaterally. This was followed by microscopic exposure of C1/C2 joint bilaterally.

Ipsilateral dissection is continued aiming for proper exposure of the vertebral artery. C2 neurectomy and exposure of C2 pars interarticularis and the inferior articular surface of C1 lateral mass are performed. The inferior articular facet of the atlas is used as a guide that followed to expose atlanto-occipital joints because its vertical projection leads to superior articular facet. These bony landmarks are used for identification and exposure of the vertebral artery. Dissection lateral to C1/C2 joint will expose vertical segment of the vertebral artery before entry into C1 foramen transversarium. Continued dissection lateral to the inferior facet of C1 on the lateral aspect of its posterior arch will expose foramen transversarium with vertebral artery passing through it. The superior facet of C1 lies directly in close relation of the horizontal segment of the vertebral artery and its venous plexus resting over the posterior arch of C1 till dural entry [Figure 1].

Microscopic mobilization of the vertebral artery [Figures 2 and 3]

The foramen transversarium of C1 is opened after putting small dissector between its posterior limits and the vertebral artery to achieve safe drilling.

Subperiosteal dissection of the vertebral artery is then performed with cutting of muscular branches if needed to achieve maximum mobilization, but care should be taken to avoid extradural origin of posterior inferior cerebellar artery which is uncommon variety that happens near the vertebral dural entry at foramen magnum. After mobilization [Figure 4], the artery can be covered by silastic material or part of surgical gloves to achieve complete protection of it during drilling of the lateral mass.

Drilling of atlas with subsequent odontoidectomy [Figures 5-7]

The lateral mass is completely exposed as it has the following surfaces: The superior condylar surface that articulates with occipital condyle, inferior surface with the axis, posterior surface related to the vertebral groove of the posterior arch and hence drilling of this groove separates the lateral mass from posterior arch, anterior surface related to the internal jugular vein, lateral surface related foramen transversarium of the atlas which already opened in the previous stage, and finally the medial surface which is the only one that is invisible at the beginning of drilling, and it seen at the end of this step as it directly related to the odontoid with the ligaments covering it. The drilling is started from the lateral surface at the point of opening of foramen transversarium as with the head position mentioned before this surface is the one that come mostly into the surgical view. The aim of the drilling started from this point is to remove the cortical bone of this surface to proceed into the cancellous bone of lateral mass which removed completely until the cortical bone of the other surfaces appears which further thinned to great degree and removed by curette except anterior surface as it related to the jugular vein. The odontoid process with the covering ligaments is exposed, and confirmation by fluoroscopy can be done. These ligaments are removed, and the odontoid is drilled.

Occipitocervical stabilization [Figure 8]

It was done after returning head to the neutral position between the occiput and C2, C3 on both sides with the same known screw entry points and directions. C1 lateral mass screw of the contralateral side can be added for stronger stabilization.

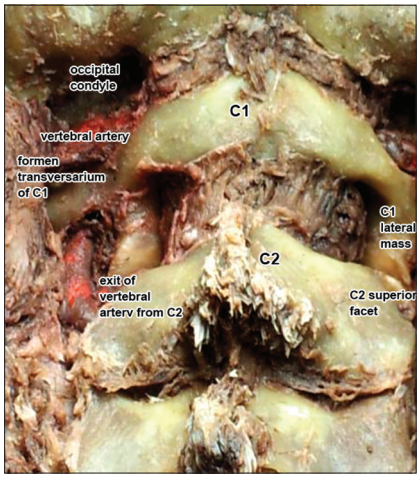

Figure 1: The view provided after muscle separation

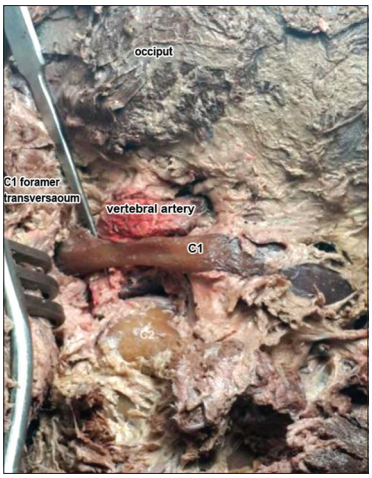

Figure 2: The dissector introduced in C1 foramen transversarium

Figure 3: Opening of C1 foramen transversarium

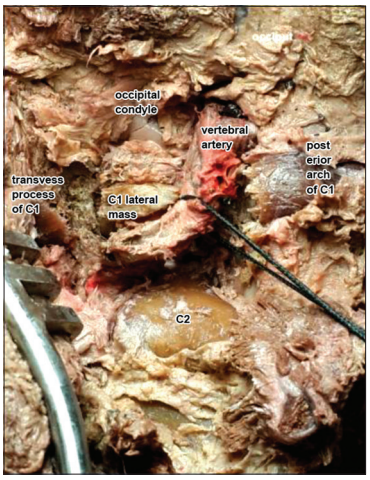

Figure 4: Mobilization of the vertebral artery

Figure 5: Drilling of C1 lateral mass

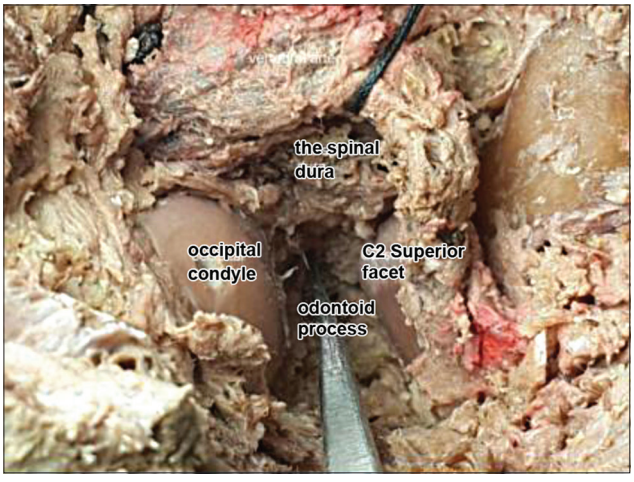

Figure 6: Lateral view shows the exposure of the odontoid process

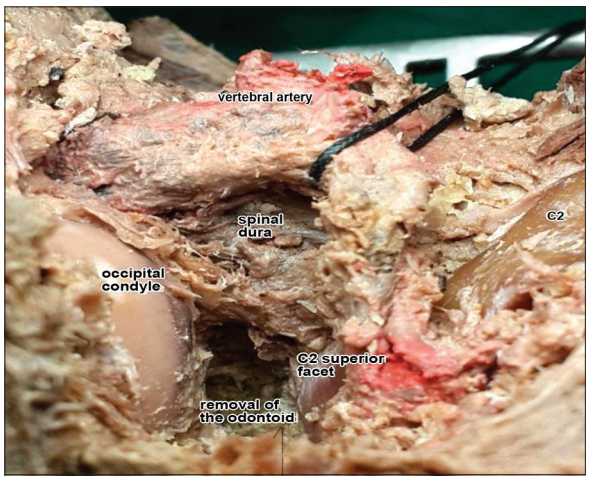

Figure 7: Complete removal of the odontoid process and decompression of spinal dura

Results

The posterior midline skin incision in the inverted L-shaped manner allows proper and simple dissection and exposure of the atlanto-occipital joint, atlantoaxial joint, and vertebral artery.

Unilateral excision of the lateral mass of atlas after mobilization of the vertebral artery provided safe and excellent exposure and removal of the odontoid process in the four cadaver heads without injury to vertebral artery or retraction of the dura.

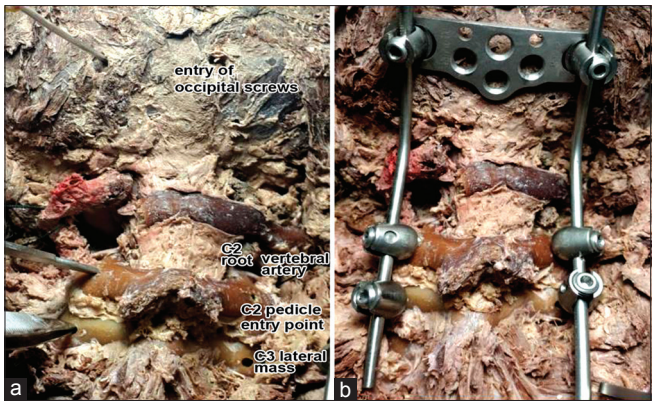

Figure 8: (a and b) The entry points for screws placement in occiput and C2 pedicle and C3 lateral mass and occipitocervical stabilization

Occiput and C2, C3 fixation was done on both sides in all heads in a simple manner.

Discussion

The surgical exposure of anterior craniocervical junction is needed in the treatment of different neoplastic, traumatic, vascular, congenital, and degenerative lesions that affect this region. The anatomical complexity of this region with many important and vital structures makes it one of the challenges in the neurosurgery.[10,11,13,14]

These lesions are commonly treated through transoral approach. Transoral approaches (transpharyngeal, transpalatal, transmaxillary, and transmandibular) are not new surgical procedures. In 1917, Kanavel[8] reported removing a bullet fragment from the anterior arch of C1 through this route. Since Kanavel's early report, the approach has been employed in the treatment of both extradural and intradural pathologies affecting this region.[1,2,4,7,9,10,12] This approach was associated initially with high mortality rate.[5,7,10-12] The recent refinements in microsurgical skills and advances in retraction techniques, operative magnification, and illumination, intraoperative radiology, dural closure techniques, and neuroelectrophysiological monitoring have improved patient outcome with this procedure;[1,10] however, even with such measures, there are still many unavoidable problems related to this approach. It includes: 1 - narrow, deep surgical field;[9,11] 2 - CSF fistula and infection;[9,11] 3 - the procedure cannot be done in cases with limited opening of mouth due to temporomandibular arthritis or anomalies of nasopharynx, oropharynx, mandible, and skull base[5] and in patients in whom the interdental space is shorter than 25 mm, as in those with macroglossia or micrognathia require more extensive approaches as transmaxillary, translabiomandibular approach;[5-7] 4 - this type of operation with removal of odontoid should be followed with stabilization[2-4] in the same or in another sitting which carries high risk to the spinal cord during repositioning. Tuite *et al*.[9] have reported four cases of postoperative acute neurological deterioration, and it is possible that injury occurred when the patients were repositioned after transoral decompression for posterior fusion procedure. Many authors perform preoperative tracheostomy to prevent postoperative respiratory complications, avoid obstruction of the operative field, and make it easier to ensure oral antisepsis,[14] but these modifications aid more to the risks of this approach. More recently, the endoscopic surgery is used to access this region anteriorly, but it needs special experience, and the risk of CSF leak with this minimally invasive technique is not far away with more difficulty in dural repair.[10]

The complex anatomy of this region[15] makes the posterolateral approach associated with high risk to the vertebral artery, especially with drilling bones in this region and hence mobilization of this artery which started by George and Laurian[16] provided a great progress to this approach.

Far lateral and extreme lateral are the variants of this approach. The far lateral approach directed from posterolateral aspect behind the sternocleidomastoid muscle as first reported by Heros;[17] then, it was modified by making it horseshoe scalp flap for easier reflection of the muscle layers as one bulk inferiorly or inferolaterally, thus allowing a wider exposure of the lateral aspect of the upper cervical region.[15,18-20] The extreme lateral approach was first described by Sen and Sekhar;[18,19] this approach differs from far lateral variant in the skin incision, muscular reflection, and the direction of the approach. In extreme lateral approach, the sternocleidomastoid muscle is reflected inferolaterally and then the muscle of this region is divided in anatomical manner to get lateral access to the anterior aspect of craniocervical junction.[21] Both far lateral and extreme lateral can be associated with more bone resection according to the exposure needed and hence there are many variants as condylar with removal of the part of occipital condyle, supracondylar with the removal of jugular tubercle to access the clivus, and paracondylar to remove the jugular process to expose sigmoid-jugular junction.[11,13,18,19,22-25]

Al-Mefty *et al*.[11] introduced the transcondylar variant with the removal of condylar surface of atlas for resection of the dens as alternative to anterior approach. The advantages of this technique are 1 - the wide and sterile operative field and 2 - following resection of the dens, stabilization, and fusion of the craniocervical junction can performed at the same sitting without need for another operation and hence avoids the risk of cord injury from repositioning.[5,11] Türe

et al.[5] describe another elegant posterolateral variant to this region by transatlas access for removal of the odontoid without need of occipital condyle resection, and hence it avoids the risk of damage to the hypoglossal nerve because the hypoglossal canal is situated in the anteromedial, one third of the occipital condyle. The condyle when removed completely carries high risk to hypoglossal nerve and also the jugular bulb.

The described technique for the transatlas approach published 2002, use posterolateral skin incision and muscle dissection for exposure and mobilization of the vertebral artery. This access is not familiar for most of the neurosurgeons, and in addition, it allows only for unilateral fixation. Hence, the application and reports about this technique are limited since that time. In our cadaveric study, we used more simple technique through midline posterior skin incision that curved to the side, in which atlas will be removed. This approach is familial for the neurosurgeons performing C1-C2 fixation but needs special effort for exposure and mobilization of the vertebral artery. In addition, this technique allows simple bilateral occipitocervical fixation with the same known entry points and directions.

Al-Mefty *et al*.[11] and Türe *et al*.[5] perform unilateral stabilization and fusion after resection of the odontoid. The unilateral method for stabilization was studied by Song *et al*.[26] who perform C1–C2 unilateral transarticular screw in conjunction with interspinous bone graft wiring, and postoperatively, all patients were placed in Philadelphia collar for 6–12 weeks, with excellent fusion results. The use of unilateral construct for stabilization in craniocervical instability has been investigated using finite element techniques. These studies indicated that unilateral instrumentation provided stability that borders on the minimum threshold for requisite motion reduction although the degree of motion reduction required *in vivo* to promote fusion has not been established.[27,28] Hence, we consider that bilateral fixation (in which contralateral C1 lateral mass screw can be added) performed in our study, and most of studies dealing with occipitocervical fixation provide a more biomechanical stabilization.

We report the same successful results obtained by Türe transatlas approach as regard to adequate exposure and resection of the odontoid without dural injury.

One of the pitfalls and limitations of this study is that there is still a difficulty in exposure and mobilization of the vertebral artery for many neurosurgeons even with this familial midline posterior approach. Hence, we recommend another study in future for the removal of odontoid with same approach but without mobilization of the vertebral artery through bilateral partial atlas resection which allows the removal of odontoid bilaterally (each exposed half of odontoid will be removed from the corresponding side of partially resected atlas).

Special intraoperative consideration

This is a cadaveric study for demonstration of normal anatomical pathway for removal of the odontoid posterolaterally. Application of this technique in real patients needs special considerations starting from the indication for removal of the odontoid which is limited nowadays even in advanced cases of basilar invagination. In elegant studies provided by Goel and Shah, basilar invagination can be treated only by intraoperative traction after anesthesia and atlantoaxial fixation. The weight for traction in extension was progressively increased up to 5–6 kg. The traction together with opening and distraction of C1–C2 joint can be sufficient to solve the problem. In relation to our study, we feel that odontoidectomy can be used in complicated irreducible case and in tumors affecting the axis, and in these cases, intraoperative traction should be applied after the removal of odontoid and starting from 1 to 2 kg and increase gradually until proper alignment.[29-35]

Additional point that should be taken into consideration before choosing this technique is the intraoperative variation of the anatomy in the craniovertebral junction and vertebral artery as in cases of occipitalization of the atlas.[36,37]

Conclusion

Posterior removal of the odontoid can be done safely through wide and sterile operative field and occipitocervical fixation performed at the same sitting without need for another operation and hence avoids the risk of cord injury from repositioning.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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