Technical Note

Use of Frameless Stereotactic Neuronavigation and O-arm for Transoral Transpalatal Odontoidectomy to Treat a Very High Basilar Invagination

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ABSTRACT

Frameless stereotactic neuronavigation system has been in wide use since many years for precise localization of cranial tumors and navigation for spinal instrumentation. We present its usage in the localization of odontoid process in a very high basilar invagination for a transoral transpalatal resection of the same. We discuss the technical aspects of assembly of neuronavigation system, O-arm and Mayfield head frame on Allen spine system to achieve precise and accurate localization of high riding odontoid process through an extremely narrow operative corridor.

KEYWORDS: *Neuronavigation, transoral transpalatal odontoidectomy, basilar invagination*

INTRODUCTION

With the evolution of technology there has been a paradigm shift from frame to frameless stereotactic neuronavigation to avoid limitations that are encountered with the stereotactic frame,^[1,2] such as increased anesthesia and operation time,^[3] dependency on patient's head and neck size and space occupancy.^[4] Frameless stereotactic neuronavigation has played a pivotal role in modern neurosurgery for safe approach to lesions located in eloquent cortex and deep locations of the brain. More recently, it has been used for posterior spinal instrumentation to optimize screw trajectory. However, existing literature on its use for anterior spinal approach, particularly transoral odontoidectomy (TOO) in craniocervical junction (CVJ) anomaly is sparse. We present a technical note on the usage of frameless stereotactic neuronavigation along with O-arm system in the localization and resection of the odontoid process through transoral transpalatal approach in a patient with very high basilar invagination (BI) along with hypoplastic clivus and platybasia. Standard spinal procedures on an Allen spine system (which facilitates intraoperative C-arm or O-arm access) does not provide attachment system for a Mayfield three-pin skull clamp required for a frameless stereotactic neuronavigation coupling. We at our institution used Mayfield three-pin skull clamp as an alternative for a traction device and attached the articulating arm of Medtronic StealthStation S7 surgical navigation system (Frameless stereotaxy) for surface contour registration using recognizable facial bony prominences in preoperative computed tomography (CT) done under the image-guided protocol.

Clinical presentation

The index case was a 35 years male who presented with a history of gradually progressive ascending weakness of all

four limbs for 1 year and dysarthria for 6 months. Examination confirmed the presence of spastic quadriparesis (Medical Research Council grading 4/5), lower cranial nerve paresis and cerebellar involvement. Dynamic X-ray revealed irreducible BI. CT CVJ [Figure 1] confirmed the presence of very high BI, hypoplasticclivus and associated platybasia. Magnetic resonance imaging revealed evidence of cord compression, small posterior fossa, and Chiari malformation (Type I). Considering the presence of high BI along with myelopathy, plan to proceed with transoralodontoidectomy followed by posterior occipitocervical fixation and foramen magnum decompression was made. Owing to the anticipated technical difficulties in the form of suboptimal trajectory and accurate identification of odontoid process, which might be faced in TOO, intraoperative neuronavigation was used.

Figure 2 shows the patient positioning and neuronavigation assembly.

He was placed in supine position on an Allen spine system attached as an extension to the standard operating table. Orotracheal intubation was done using fiberoptic bronchoscope. Mayfield 3 pin Infinity skull clamp system is then fixed to skull and locked with traction of 4.5 kg weight attached to it and passed through the pulley on the Allen table. Articulating arm of the Medtronic StealthStation S7 surgical navigation system is now attached to the Mayfield arm, and passive cranial reference frame is attached to the Articulating arm. Surface contour registration was then done

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by cloud of paired points using navigation probe and infrared optical tracking system. Since three-dimensional (3D) spatial coordinates for the skull, mayfield frame, and an articulating arm with passive reference frame were all constant to each other, accuracy of neuronavigation setup in real time was quite high (1.4 mm) despite the assembly not attached to operating table. This accuracy was also verified after application of transoral retractors intraoperatively.

Surgical procedure

Intraoperatively, we observed that despite uvula retraction and maximal mouth opening, we could reach only till base of C2 vertebral body. We decided to partially split the soft palate with sparing of uvula attachment to achieve desired trajectory and space for doing transoral transpalatal odontoidectomy along with anterior C1-arch removal under neuronavigation guidance [Figure 3] coupled with intraoperative O-arm imaging. Combining frameless stereotaxy and real-time imaging generated by O-arm, guided us to perform safe and predictable decompression of thecal sac through a very complex surgical anatomy. Layered closure of posterior pharyngeal wall and soft palate concluded the anterior procedure. Subsequently, posterior occipitocervical (O-C3/C4)

fixation along with foramen magnum decompression and posterior C1 arch removal was performed using O-arm guided neuronavigation in prone position. The patient had an uneventful postoperative recovery with evidence of a decrease in the spasticity of limbs. Postoperative CT CVJ revealed adequate bony decompression both anteriorly and posteriorly with the implant *in situ* [Figure 4].

DISCUSSION

Neuronavigation system provides 3D spatial orientation of the part of the body being operated on.^[5] Its application has been mainly in the excision of intracranial tumors and is now slowly expanding in the spinal procedures for C1 C2 transarticular,^[1] thoracic, and lumbar screw fixation.^[6] There are few articles with endoscopic transcervical^[7] or endoscopic transnasal^[8] approaches to the CVJ using image guidance. In the index case, transcervical approach was not feasible as there was a very high BI and transnasal approach gives a very narrow corridor for the procedure with restricted manipulation of the instruments.^[9] We have obtained similar results using transoral route. The working of current frameless Neuronavigation system involves registration which is either using fiducials or surface contour registration. It makes use of infrared rays for identification of navigation probe and cranial passive probe by the camera.^[10] The infrared camera and the reference arc as well as former and the operating field should be in a straight line with no objects in between blocking them. Incorrect placement results in failure in navigation with resultant requirement for peroperative adjustment of instruments. Direct light on the reference arc should be avoided as this affects its

Figure 1: Computed tomography of craniovertebral junction showing presence of high basilar invagination, hypoplastic clivus, and associated platybasia

Figure 3: Display on the neuronavigation system

Figure 2: Patient positioning and neuronavigation assembly

Figure 4: Postoperative computed tomography of the craniovertebral junction showing adequate bony decompression both anteriorly and posteriorly with implant *in situ*

ability to reflect infrared rays back to the camera with resultant failure of navigation.^[11]

CVJ anomalies can be either congenital or acquired. The common denominator in such conditions is instability at CVJ with resultant compression on the cord and consequent myelopathy. The occipital bone is composed of basioccipital, exoccipital, and supraoccipital portions enclosing the foramen magnum.^[7] The basiocciput embryologically derived from the fusion of four occipital sclerotomes forms the lower portion of the clivus.^[12] The upper portion of the clivus is formed by the basisphenoid, separated from the basiocciput by the sphenooccipital synchondrosis. Hence, embryological defects can cause hypoplastic clivus with a resultant upward displacement of the cervical vertebrae leading to high BI.

The standard direct approach to this area for anterior decompression is through the transoral transpharyngeal approach.^[13,14] However, this approach can be challenging in the presence of a very BI as adequate trajectory and confirmation of the vertebrae cannot be obtained without image guidance.

CONCLUSION

Neuronavigation system can be used for localizing the cervical vertebrae and odontoid process in the setting of very high BI. Assembling the parts on an unfavorable Allen spine system can be done using the method as described above so that both neuronavigation and O-arm can be used intraoperatively for higher precision and better accuracy. Using neuronavigation system also decreases the need for intraoperative fluoroscopy hence decreasing the amount of radiation exposure to the patient as well as to the operating team.

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Conflicts of interest

There are no conflicts of interest.

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