Acta Medica Alanya

Technical Note

Teknik Not

Acta Medica Alanya 2023;7(3): 285-290
Doi: 10.30565/medalanya.1390145

Using navigation in cases requiring upper cervical instrumentation in clinics without intraoperative imaging technology

İntraoperatif görüntüleme teknolojisi olmayan kliniklerde üst servikal enstrümantasyon gereken olgularda navigasyon kullanımı

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ABSTRACT

Upper cervical spine surgery which requires instrumentation is a highly complicated procedure, both due to the presence of critical structures in the region and variable pedicle anatomy. Despite the widespread use of technological advances as intraoperative imaging and navigation technologies aimed at preventing screw malposition and injuries to the critical neural and vascular structures, there are only a few clinics capable of employing those technologies. In clinics lacking intraoperative imaging facilities that assist in the instrumentation of the upper cervical spine, navigation technology can be employed in both posterior and anterior approaches with the assistance of the technique described in this manuscript. This approach will not only decrease complication rates compared with the free-hand method, but also considerably lower radiation exposure for both the patient and surgical team.

Key Words: Upper Cervical; Navigation; Radiation Exposure; Screw Malposition

ÖZ

Enstrümantasyon gerektiren üst servikal omurga cerrahisi, hem bölgedeki kritik yapıların varlığı hem de değişken pedikül anatomisi nedeniyle oldukça karmaşık bir işlemdir. Vida malpozisyonunu ve kritik sinir ve damar yapılarının yaralanmasını önlemeyi amaçlayan intraoperatif görüntüleme ve navigasyon teknolojileri gibi teknolojik gelişmeler yaygın olarak kullanılmasına rağmen, bu teknolojileri kullanabilen sadece birkaç klinik bulunmaktadır. Üst servikal omurganın enstrümantasyonuna yardımcı olan intraoperatif görüntüleme olanaklarının bulunmadığı kliniklerde, bu yazıda açıklanan tekniğin yardımıyla navigasyon teknolojisi hem posterior hem de anterior yaklaşımlarda kullanılabilir. Bu yaklaşım, serbest el yöntemine kıyasla komplikasyon oranlarını azaltmakla kalmayacak, aynı zamanda hem hasta hem de cerrahi ekip için radyasyon maruziyetini önemli ölçüde azaltacaktır.

Anahtar Kelimeler: Üst Servikal; Navigasyon; Radyasyona Maruz Kalma; Yanlış Vida Konumu

Recieved Date: 14.11.2023 / **Accepted Date:** 07.12.2023 / **Published (Online) Date:** 31.12.2023

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To cited: Karaoglu A, Kuytu T. Using Navigation In Upper Cervical Instrumentation In Clinics That Do Not Have Intraoperative Imaging Technology. Acta Med. Alanya 2023;7(3): 285-290 doi: 10.30565/medalanya.1390145

Introduction

Upper cervical spine surgery requiring instrumentation presents challenges arising from variable pedicle anatomy, the close proximity of the vertebral artery to the surgical field along with vertebral artery anomalies, and the potential risk of spinal cord and nerve root injury. Incorrect positioning of the screw could lead to loss of stability or catastrophic neurologic and vascular complications that may be challenging or impossible to reverse.[1] The rate of freehand screw malposition in upper cervical spine instrumentation has been reported to be 14%–23%, whereas vertebral artery injury has been documented in 2.7%–3.3% of these cases.[2-4] Despite the complicated nature of the region and high rates of screw malposition, intraoperative imaging cannot be performed in all clinics, although computer-based navigation procedures are becoming increasingly common these days in accordance with the developing technology. In Turkey, there are only a few clinics which have intraoperative imaging technology. This article describes our technique of utilizing neuronavigation in upper cervical spine surgery requiring instrumentation in clinics that lack intraoperative imaging facilities.

Technical

Upper Cervical Posterior Intervention

Due to the absence of intraoperative imaging at our clinic, the patient initially underwent a cervical computed tomography (CT) scan to input his/her data into the computerized navigation system and align them in the same position. For patients in whom a posterior intervention was intended, a pillow was positioned under the patient's head during CT imaging to facilitate flexion of the head into the surgical prone position, ensuring surgical comfort. Furthermore, the distance between the manubrium sterni and gnathion was measured metrically. Following intratracheal general anesthesia, the patient was transported to the operating room and positioned in the prone posture using a spiked headgear. The metric measurement obtained from the cervical CT scan, which determined the distance between the manubrium sterni and gnathion, was then applied in the operating room to ensure precise positioning. Following surgical site skin preparation and draping, the vertebrae were exposed via a posterior cervical midline vertical skin incision and bilateral dissection, and a total of seven reference points were randomly marked using a sterile navigation probe (Figure-1).

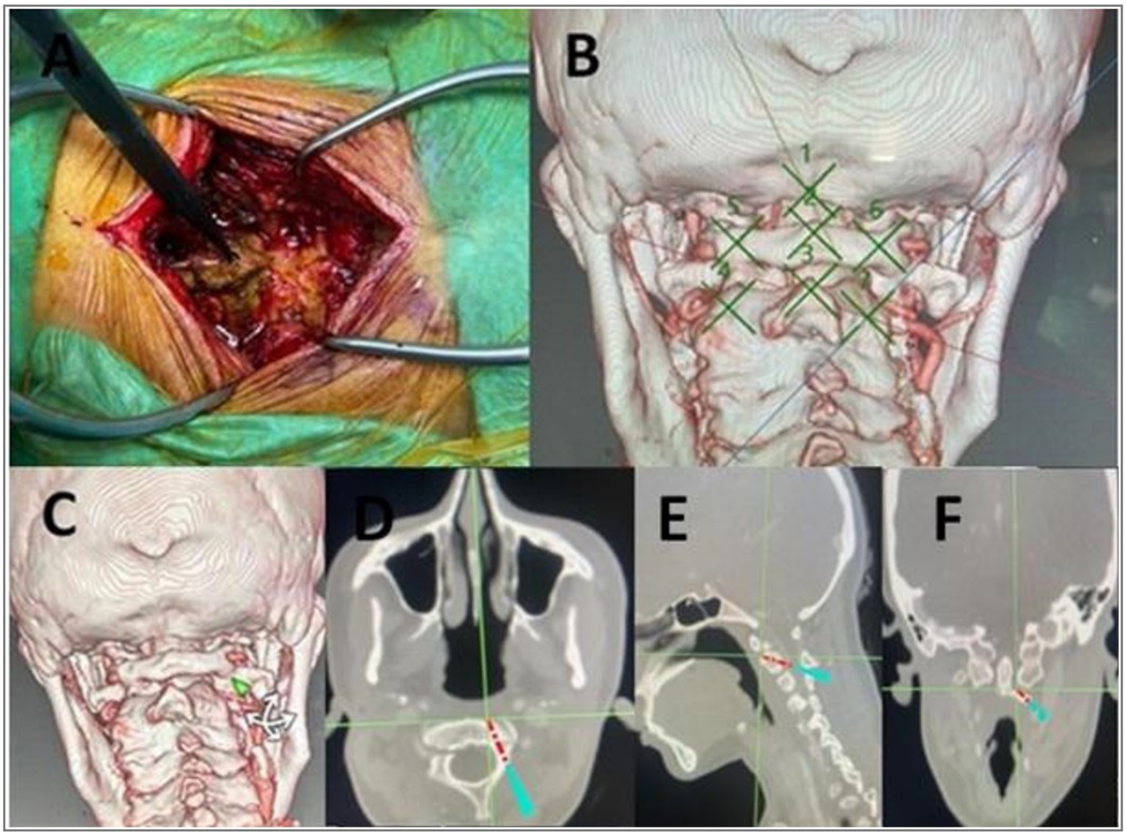

Figure 1. A. After exposing the vertebrae to cervical posterior intervention, the references points were marked using a sterile navigation probe; B.Navigation screenshots after marking the seven reference points; C, D, E, F. Navigation screenshots during positioning before intraoperative vertebral access.

Acta Medica Alanya 2023;7(3): 285-290
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After establishing the reference points, the patient's data were aligned with the CT images loaded onto the computerized navigation device and the surgical procedure was conducted under the guidance of navigation.

In addition, the projections of vascular structures were obtained with the help of navigation in all posterior cervical procedures. This was valuable for us in identifying possible anomalies before intervention (Figure-2).

Upper Cervical Anterior Intervention

For anterior interventions, the patient's head was placed in the supine position with the head extended by placing a towel in the neck cavity to ensure surgical comfort, and the distance between the manubrium sterni and gnathion was measured metrically before the preoperative cervical CT scan. The patient was then transported to the operating room. Following intratracheal general anesthesia, the patient was placed in the supine position with the patient's head aligned in midline neutral position and extended. The metric measurement obtained from the cervical CT scan, which determined the distance between the manubrium sterni and gnathion, was employed to guide the patient's positioning in the operating room. Following surgical site skin preparation and draping, the anterior aspects of the vertebrae were exposed via a right anterior cervical vertical skin incision near the midline and classic dissection, and a total of seven reference points were randomly marked using a sterile navigation probe (Figure-3).

After establishing the reference points, the patient's data were aligned with the CT images loaded onto the computerized navigation device and the surgical procedure was conducted under the guidance of navigation.

Discussion

Surgery for upper cervical pathologies requiring instrumentation is still regarded as a complex procedure.[2-5]

The atlantoaxial joint acts as a highly mobile hinge present at the craniocervical junction. Deformity in this region creates cervical instability and causes severe bulbomedullary compression, which is usually defined as cord dysfunction.[6] Internal fixation is the main treatment for atlantoaxial instability. Currently, the most commonly used methods are atlantoaxial transarticular facet screws (Magerl technique) and axial pedicle screws with atlantal lateral mass screws (Harms technique).[7-9] Both methods

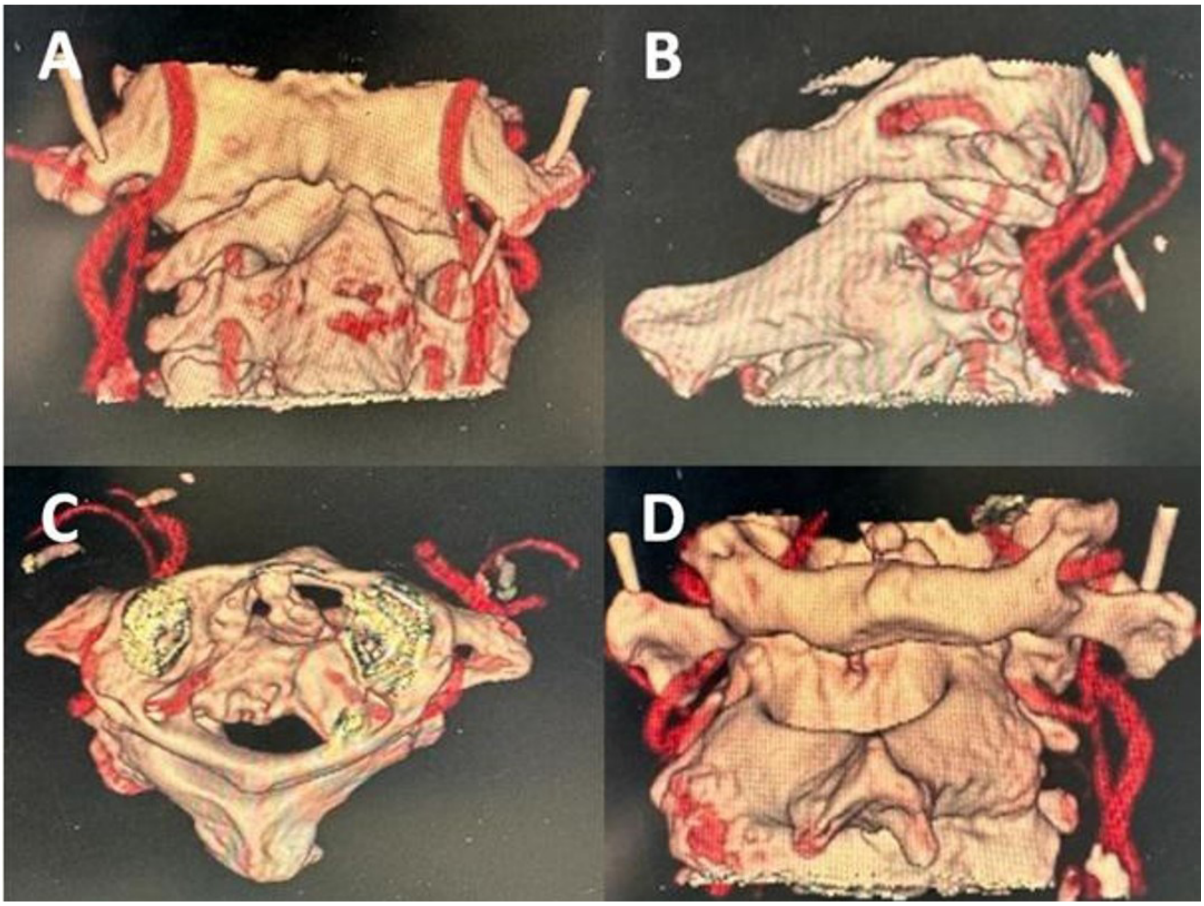

Figure 2. Three-dimensional projections of vertebral arteries with preinterventional navigation

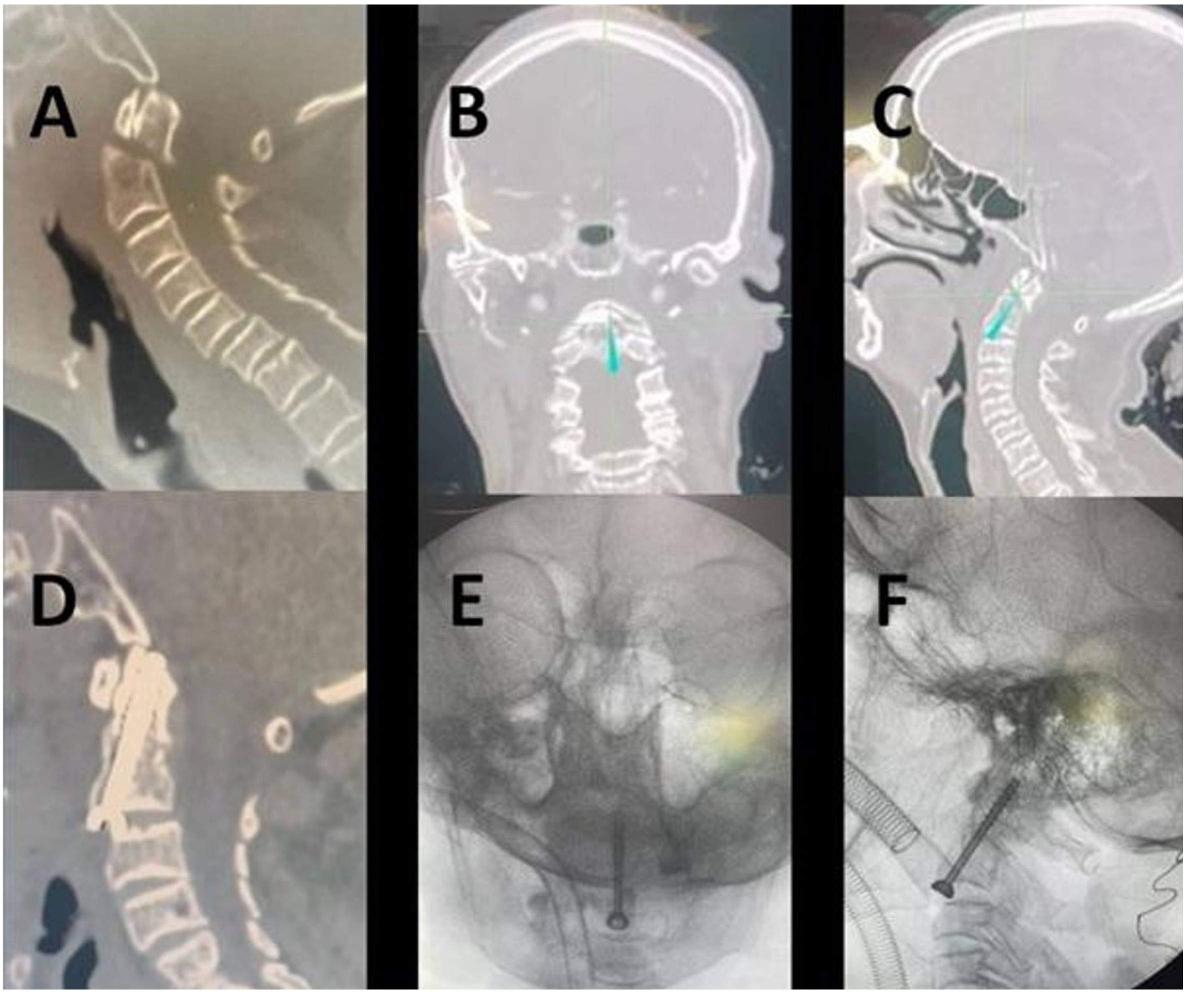

Figure 3. A. Preoperative sagittal view of cervical CT; B.Intraoperative simulation of odontoid screw insertion in coronal plane by navigation; C. Intraoperative simulation of odontoid screw insertion in sagittal plane by navigation; D. Postoperative sagittal view of cervical CT; E. Preoperative scope view after the insertion of the odontoid screw in coronal plane. F. Preoperative scope view after the insertion of the odontoid screw in sagittal plane.

can provide rigid fixation with high fusion rate.[9] However, surgery in this region is exceptionally challenging due to complicated anatomical structures such as the atlantoaxial joint, adjacent ligaments, vertebral arteries, and the spinal cord.[10] Furthermore, the complexity of surgery increases when upper cervical region deformities are combined with these critical structures.[11] Consequently, unusual complications, including bony structure perforation, severe vertebral artery injuries, and spinal cord damage, can arise during the placement of screws within these structures. In addition, conventional methods require repeated exposure of the surgical team to the radiation emitted by the C-arm X-ray device to confirm the positioning of screws during the procedure.[12]

Odontoid fractures may cause serious morbidity and mortality, especially in old-aged patients.[13] Symptoms in these patients range from severe neurological deficits secondary to spinal cord compression to chronic neck pain. According to the Anderson–D'Alonzo classification, high nonunion rates have been reported in type II odontoid fractures, ranging from 15% to 85%, which have poor prognosis.[13-15] The treatment options for unstable type II odontoid fractures vary, but surgical intervention is often required to reduce the rate of nonunion.

Different techniques such as posterior cervical instrumentation and anterior odontoid screw fixation have been described to stabilize these fractures. In these cases, anterior intervention offers several advantages, including high union rates, rapid stabilization, retention of cervical spine mobility, reduced soft tissue damage, and diminished bleeding, as reported in the literature.[16,17] However, serious complications such as injury to the pharynx, esophagus, trachea, vascular, and neural structures have also been reported in anterior interventions, whether performed through open or percutaneous approaches.[16-18]

In addition, upper cervical anterior interventions, just like posterior interventions, require repeated exposure of the

Acta Medica Alanya 2023;7(3): 285-290
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surgical team to the radiation emitted by the C-arm X-ray device to confirm the positioning of screws during the procedure.[18]

The use of computer-based intraoperative navigation provides substantial advantages in terms of understanding the complex spinal anatomy, minimizing screw malposition, reducing radiation exposure, and shortening the operation time in interventions requiring fixation of the upper cervical region, and its use is becoming increasingly common.[19,20] In clinics equipped with intraoperative navigation capabilities, three-dimensional images can be obtained by performing real-time CT scans; this technology considerably reduces the risk of complications compared with conventional fluoroscopic methods.[21] Even though it reduces the radiation dose to the surgeon compared with conventional fluoroscopy, it increases the radiation exposure of the patient.[22]

In addition, intraoperative imaging is not available in all units. In our country, there are only a very few clinics having intraoperative imaging technology. This article describes our technique of utilizing neuronavigation in upper cervical spine surgery requiring instrumentation in clinics that lack intraoperative imaging facilities. In our clinic (Yüksek Ihtisas Education and Research Hospital, Department of Neurosurgery), four atlantoaxial posterior fixations and two anterior odontoid screw fixations were performed using this technique in the last 1 year. In these cases, no perioperative complications occurred, operation times were shorter than in freehand cases, and blood loss was cnsiderably reduced, especially in posterior interventions.

Conclusions: We believe that the use of navigation in clinics that do not have intraoperative imaging facilities will establish a notable advantage over the freehand approach and will also minimize the radiation exposure of the patient and surgical team. Given the rapid pace of technological advancement, we anticipate that navigation will be employed in spinal cases in a remarkably more practical manner, potentially leading to reduced or negligible radiation exposure. This article is expected to provide insight into the progression of these technologies.

Conflict of Interest: The authors declare no conflict of interest related to this article.

Funding sources: The authors declare that this study has received no financial support.

Ethics Committee Approval: Ethical approval was not required due to technical note article. In this study, national and international ethical rules are observed.

ORCID and Author contribution: A.K. (0000-0002-0505-3027): Study conception and design, Data collection, Draft manuscript preparation, Critical revision, Approved the final version of the manuscript. T.K. (0000-0002-2992-7980): Analysis and interpretation of results, Draft manuscript preparation,

Peer-review: Externally peer reviewed.

Acknowledgement: Authors, thanks to Parents for their contribution. Also, The authors thank Enago – https://www.enago.com.tr/ceviri/ for their assistance in manuscript translation and editing.

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