www.surgicalneurologyint.com

ScientificScholar® Knowledge is power
Publisher of Scientific Journals

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: General Neurosurgery

Editor
Eric Nussbaum, MD
National Brain Aneurysm and Tumor Center, Twin Cities, MN, USA

SNI® Open Access

Technical Notes

Neuronavigation device for stereotaxic external ventricular drainage insertion

Anton Konovalov, Dmitry Okishev, Oleg Shekhtman, Yuri Pilipenko, Shalva Eliava

Burdenko Neurosurgical Center, Moscow, Russia.

E-mail: *Anton Konovalov - ankonovalov@nsi.ru, Dmitry Okishev - dokishev@nsi.ru, Oleg Shekhtman - oshekhtman@nsi.ru, Yuri Pilipenko - 3664656@mail.ru, Shalva Eliava - eliava@nsi.ru

***Corresponding author:**
Anton Konovalov,
Burdenko Neurosurgical Center, Moscow, Russia.

ankonovalov@nsi.ru

Received : 19 February 2021
Accepted : 20 May 2021
Published : 07 June 2021

DOI
10.25259/SNI_180_2021

Quick Response Code:

ABSTRACT

Background: The insertion of an external ventricular drainage (EVD) is one of the most frequently used neurosurgical procedures. It is performed to adjust intracranial hypertension in cases of severe craniocerebral injury, acute posthemorrhagic hydrocephalus, meningitis, and oncological diseases related to impaired circulation of cerebrospinal fluid circulation (CSF).

Methods: In 2020, three patients with subarachnoid aneurysmal hemorrhage underwent insertion of an EVD navigation percutaneous stereotaxic device. Three cases introduced.

Results: In all cases, satisfactory EVD functioning was noted during the surgery and during the early postoperative period. The EVD insertion procedure took an average of 10 min. The EVD insertion route calculations using the software took about 5–15 min. No cases showed any infection, hemorrhagic complications, or EVD dysfunction. According to the control brain computed tomography data, the catheter position was satisfactory and corresponded to the target coordinates in all cases.

Conclusion: The use of the device, with its high accuracy and efficiency, can reduce the incidence of unsatisfactory EVD implantation cases in patients with neurosurgical pathology.

Keywords: Device, External ventricular drainage, External ventricular drainage, Hydrocephalus, Insertion

INTRODUCTION

The insertion of external ventricular drainage (EVD) is one of the most frequently used neurosurgical procedures. It is performed to adjust intracranial hypertension in cases of severe craniocerebral injury, acute posthemorrhagic hydrocephalus, meningitis, and oncological diseases related to impaired circulation of cerebrospinal fluid circulation (CSF). As a rule, the insertion of EVD is performed by freehand technique while determining the insertion route of the catheter according to the so-called craniometric points. However, this inevitably leads to the errors, which can range from 12.5% to 40% in some cases.[3,7] A navigation device is available for performing stereotaxic percutaneous EVD implantation and allows for high accuracy to be achieved with a comparable procedure time. The device is safe and can be easily introduced into the practice of neurosurgical departments.

MATERIALS AND METHODS

In 2020, three patients with subarachnoid aneurysmal hemorrhage underwent insertion of an EVD navigation percutaneous stereotaxic guide device. All patients underwent a computed tomography (CT) scanning of the brain on admission to the Burdenko National Medical Research Center of Neurosurgery and during the device usage period. A control brain CT was performed on the 1st day after the main microsurgical intervention in relation to the aneurysm. The EVD insertion route's accuracy, the absence of complications related to the procedure, and the efficiency of the EVD operation were assessed.

Description of the B-guide device

The guide device contains a retaining ring with three legs, a horizontal scale, a vertical scale, a hinge, and a trocar that fixes the lock [Figure 1]. All elements of the device are made of titanium (Grade 5), which provides the possibility of temporary implantation into the human body and an absence of background artifacts during X-ray examinations (CT and 3D reconstruction). The retaining ring contains a slot. The legs have holes and are located outside the ring to provide the ability to fix the device in any area of the convexity brain surface. There is a mark on the ring that protrudes beyond the surface of the circle opposite to the slot, which is used to determine the device's position in space according to the CT data. The retaining ring has a protrusion for securing the clamp.

The horizontal scale is a slotted ring connected to the retaining ring. The vertical scale is a hemisphere with a hole at the top and a slot going down. Two scales in the form of parallel arcs with divisions are installed on the hemisphere. The hinge has a slot and is installed inside the hemisphere of the vertical scale. The trocar also has a slot and is installed inside the hinge. The slots in the retaining ring, horizontal scale, vertical scale, hinge, and trocar are aligned. The device provides the required tool rigidity during the surgery and navigational accuracy, which has been repeatedly confirmed during experiments on phantom models.

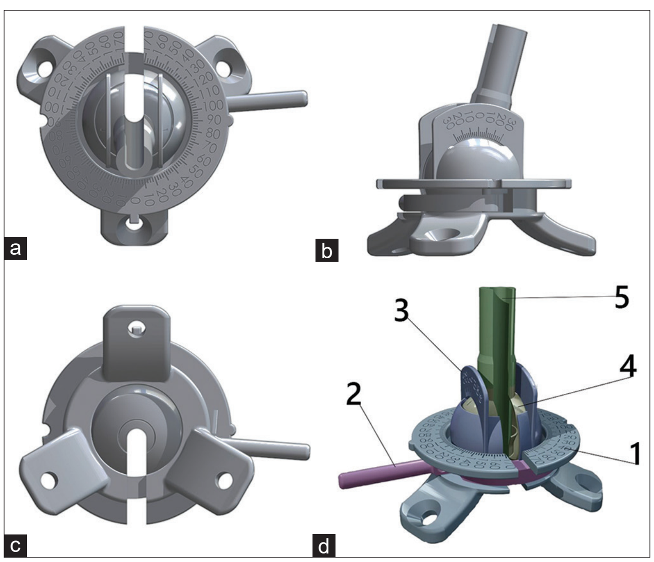

Figure 1: Drawing and 3D view of the navigation device with a list of its components. (1) Base; (2) clamp; (3) bushing; (4) swivel; (5) rod.

It is an experimental device. The model was designed and manufactured by neurosurgical team from Burdenko Neurosurgical Center (Moscow, Russia) and 3D printed from titanium. The national innovative grant was obtained for developing this device.

Use of the B-guide

After selecting the area for the EVD insertion (the right premotor area was used in all cases), the area for the device fixture was prepared by shaving and establishing aseptic conditions. Using three self-tapping titanium Grade 5 bolts, the device's ring base was fixed through the skin to the cortical plate [Figure 1]. The area of the inserted device was covered with a sterile self-adhesive film material to ensure sterility of the device and the patient's skin.

The patient was transported to the CT scanner in the intensive care unit. The brain CT scanning was performed with the device inserted, and then, the patient was transported to the neurosurgical operating room to perform EVD implantation and the main microsurgical intervention, aneurysm clipping. The EVD insertion route was predicted using Inobitec software (https://inobitec.com/2019, INOBITEC LLC, Voronezh), and then, three indicators were calculated: (1) the angle of inclination, (2) the angle of rotation, and (3) the depth of the EVD implantation. The indicator calculation algorithm is shown in [Figure 2].

The film covering is removed, and additional aseptic processing is performed on the area of the retaining ring and the patient's soft tissues in the operating room under sterile conditions. A complete assembly of all device elements was carried out. A 5 mm skin incision was made, the previously calculated parameters were applied on the device, and its final fixation was performed. A trephine opening was made with a strictly specified trajectory through the guiding trocar set according to the calculated parameters using a medical drill. The drill diameter was 4 mm, and the drill length was set by considering the trocar length and thickness of the soft tissues and skull bones [Figure 3].

After feeling a slight dip during the drilling procedure, the drill was removed, and the EVD was inserted to a depth of 60 (±1.3) mm from the surface of the patient's skin. In all cases, the EVD implantation was successful in the first attempt, and xanchromatic CSF was obtained under high pressure. At the

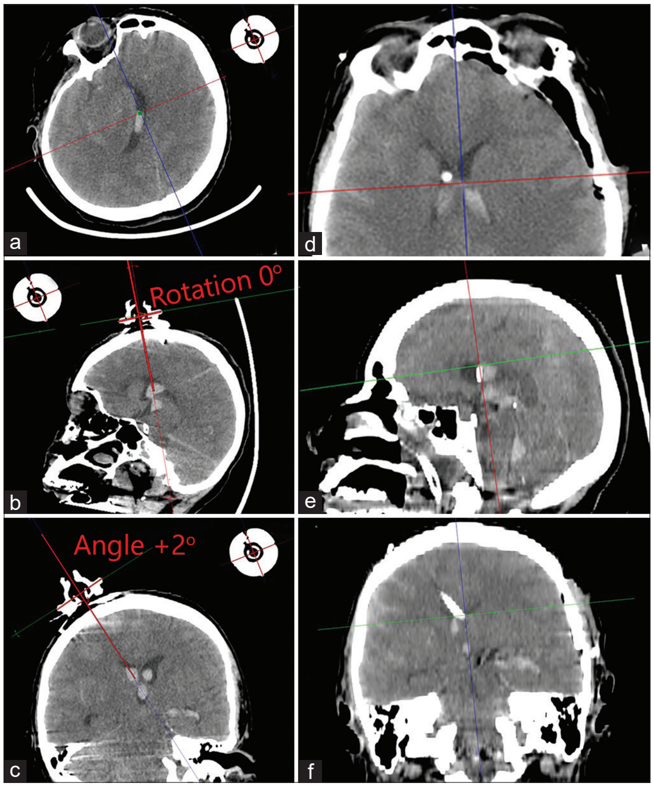

Figure 2: Clinical example of using a navigation device. Insertion of an external ventricular drainage in the area of the patient's right lateral ventricle on the 1st day after subarachnoid hemorrhage from an aneurysm of the left internal carotid artery. (a-c) Calculation of parameters for planning a navigation insertion of the external ventricular drainage using the DICOM viewer: the plain of the ring has chosen, the rotation angle and inclination angle calculated with Cobb's angle tool. Angle of inclination: 2? Angle of rotation: 0?. (d-f) Brain computed tomography after surgery.

stage of tunneling, fixation, and suturing of soft tissues, the drainage was blocked. The device was removed from the skin surface by unscrewing the screws, and the drain tube was taken out of the device through the slots in all the elements of the device. Using a stylet, a contraincision was made through the incision, the EVD was fixed to the skin with a single interrupted suture, and the incision area was covered with a single suture. The EVD was connected to a closed system for passive drainage.

RESULTS

In all cases, satisfactory EVD functioning was noted during the surgery and during the early postoperative period. The EVD insertion procedure took an average of 10 min. The EVD insertion route calculations using the software took about 5–15 min. No cases showed any infection, hemorrhagic complications, or EVD dysfunction. According to the control brain CT data, the catheter position was satisfactory and

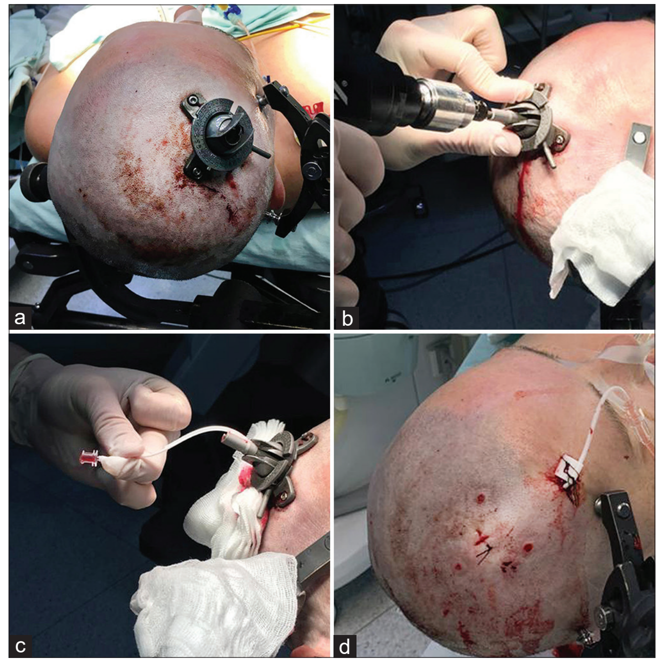

Figure 3: Clinical example of using a navigation device. Insertion of an external ventricular drainage in the area of the patient's right lateral ventricle on the 1st day after subarachnoid hemorrhage from an aneurysm of the left internal carotid artery. (a) View of the device after fixation. (b) Device insertion, performing of the stereotaxically specified trephination. (c) Insertion of an external ventricular drainage. (d) Drainage through the contraincision, view of wound after the procedure.

corresponded to the target coordinates in all cases. Detailed results are given in [Table 1].

DISCUSSION

The problem of EVD insertion accuracy and methods for achieving the set goals have been studied for a long time.[1] Young neurosurgeons with limited experience often perform insertions of an EVD while a successful implantation preferably at first attempt is imperative to reduce patient's morbidity.[2] Ventriculostomy is usually performed using the classic free hand technique described by Kocher *et al.* methodology.[4] In the literature, the coordinates of the Kocher point differ,[5] which are confirmed by the spread of the overlap of milling holes and trephinations in our study [Figure 2]. The scatter of points for ventriculostomy in the premotor zone did not statistically affect the quality of EVD implantation. In the literature, there are many modifications of the classical Kocher point, which, in some cases, can even improve the trajectory and accuracy of EVD implantation.[5] The number of unsatisfactory installation of EVD can reach 39% when using free hand technology.[6] In 1973, the experience of using the Gajar guide was published to improve the accuracy of the EVD installation.[7] Since

Table 1: Analysis of the EVD insertion results using the B-guide device.

Patient	Angle of inclination	Angle of rotation	Depth of insertion	Point of the EVD insertion (CT scanning results)	Complications	Duration of the insertion procedure and coordinate calculation (min)
No.1	2°	0°	65 mm	Lateral ventricle body	-	15
No.2	5°	2°	62 mm	Anterior horn of lateral ventricle	-	12
No.3	5°	0°	59 m	Lateral ventricle body	-	10

EVD: External ventricular drainage, CT: Computed tomography

then, the literature has described a variety of mechanical and electronic devices capable of improving the accuracy of the direction of the EVD.[3-5,7]

The advantages of the device proposed in this study are the provision of stereotaxic accuracy of the EVD insertion, which makes it possible to reduce the risk of an unsatisfactory catheter position, as well as the traumatization of the adjacent anatomical structures during the repeated EVD insertions "by hand." Notably, the use of the device does not increase the risk of postoperative hemorrhagic or infectious complications. Further study is required for the use of such a navigation device for other neurosurgical diseases, such as a tumor cyst puncture, intracerebral hematomas to perform fibrinolysis, and placement of electrodes for deep brain stimulation or EEG.

CONCLUSION

The proposed device for stereotaxic percutaneous EVD insertion is safe, easy to use, and can be introduced into everyday neurosurgical practice. The use of the B-guide device, with its high accuracy and efficiency, can reduce the incidence of unsatisfactory EVD implantation cases in patients with neurosurgical pathology.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Aschoff A, Kremer P, Hashemi B, Kunze S. The scientific history of hydrocephalus and its treatment. Neurosurg Rev 1999;22:67-93; discussion 94-5.
2. Brenke C, Fürst J, Katsigiannis S, Carolus AE. High accuracy of external ventricular drainage placement using anatomical landmarks. Neurochirurgie 2020;66:435-41.
3. Eisenring CV, Burn F, Baumann M, Stieglitz LH, Kockro RA, Beck J, *et al*. sEVD-smartphone-navigated placement of external ventricular drains. Acta Neurochir (Wien) 2020;162:513-21.
4. Ghajar JB. A guide for ventricular catheter placement. Technical note. J Neurosurg 1985;63:985-6.
5. Ozerov SS, Samarin AE, Mel'nikov AV, Kumirova EV. Placement of a ventricular catheter into narrow lateral ventricles. Popular navigation. Zh Vopr Neirokhir Im N N Burdenko 2017;81:72-6.
6. Roach J, Gaastra B, Bulters D, Shtay A. Safety, accuracy, and cost effectiveness of bedside bolt external ventricular drains (EVDs) in comparison with tunneled EVDs inserted in theaters. World Neurosurg 2019;125:e473-8.
7. Thomale UW, Schaumann A, Stockhammer F, Giese H, Schuster D, Kästner S, *et al*. GAVCA study: Randomized, multicenter trial to evaluate the quality of ventricular catheter placement with a mobile health assisted guidance technique. Neurosurgery 2018;83:252-62.

How to cite this article: Konovalov A, Okishev D, Shekhtman O, Pilipenko Y, Eliava S. Neuronavigation device for stereotaxic external ventricular drainage insertion. Surg Neurol Int 2021;12:266.