ORIGINAL

Development of a Navigation-guided Fence-post Catheter for Brain Tumor Resection

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Abstract : Background : Navigation system devices have been developed to allow precise resection of brain tumor. The fence-post catheter techniques that use a navigation system have been used in many neurosurgery centers. However, an exclusive catheter for the fence-post catheter techniques have not been made, and substituted silicon tube of the cerebral ventricle drainage or a Nelaton catheter is widely used. Objective : In this brief technical note, we describe a new fence-post catheter with steel tip device that was designed for more precise tissue resection and is useful in tumor resection. Methods : The newly designed fence-post catheter helps to visually gauge the accurate depth from the tumor bottom during tumor resection. Furthermore, the catheter tip has moderate weight and is made of a non-magnetic material. Results : Using our fence-post catheter, which has a metal part at the tip of the tube (length, 13 mm), operators can clearly notice that they are getting closer to base of the tumor by checking the metal part during the resection of deep tumors. Conclusion : Our newly developed fence-post tube enables easy confirmation of the distance to deep-tissue regions and improves the degree of safety during tumor removal. J. Med. Invest. 69 : 117-119, February, 2022

Keywords : *fence-post catheter technique, neuro-navigation, glioma*

INTRODUCTION

Many reports have shown that radical resection is required to control brain tumors, and several reports have revealed that total or subtotal resection of the tumors is a significant predictive factor associated with longer survival time. Conversely, radical resection increases the risk of a worse functional outcome (1-3). Navigation system devices have been developed to allow precise resection and avoid postoperative motor and sensory deteriorations. However, a navigation system does not provide real-time information of the image and, thus, does not consider the problem of brain shift due to cerebral fluid withdrawal, gravity, and tissue removal during the surgery (4-6). Therefore, for the resection of gliomas, metastatic brain tumor as intra-axial brain tumor was operated, fence-post catheter techniques that use navigation system have been used in many neurosurgery centers (7, 8). However, an exclusive catheter for fence-post-catheter techniques has not been developed, and the silicon tube of the cerebral ventricle drainage tube or a Nelaton catheter is generally used as a substitute. However, with these devices, a surgeon cannot assess the accurate depth from the tumor bottom when resecting tumor margin along the fence-post catheter.

In this brief technical note, we describe a new fence-post catheter with a steel tip device designed to resect tissues more precisely, and which was useful in tumor resection.

DEVICE DESIGN

The ideal fence-post catheter should have the following characteristics : 1) have the smallest diameter to avoid injury to the normal brain tissue ; 2) a catheter through which the navigation can be introduced as a pestle, and through which navigation registration is possible ; 3) presence of scales in the steel tip of catheter to aid the operator in assessing the accurate depth from the tumor bottom when removing a tumor ; 4) moderate weight in the catheter tip to avoid slippage from surface of resected brain tissue ; and 5) the tip of the catheter should be made of a non-magnetic material to enable its use with a magnetic navigation system too and permit intraoperative magnetic resonance imaging when needed. The fence-post catheter, SP puncture—manufactured by S&Brain corporation (Chiba, Japan), was created to address these five design concepts in a simple instrument that is easy and intuitive to use.

Because the size of passive catheter introducer of the navigation system adopted at many neurosurgery centers was 1.2–1.8 mm, the total length of the catheter is 10 cm (Fig. 1A) ; it is made of silicon, and the catheter has an inner and outer diameter of 2.5 mm and 3.0 mm, respectively. The catheter introducer of the navigation system can be used as a stylet for the catheter. The tip of the catheter has an inner and outer diameter of 2.5 mm and 3.0 mm, respectively. The length of the tip is 13 mm, and there are laser markings at distances of 5 mm and 2.5 mm from the tip. The tip is made of titanium and weighs 2 g (Fig. 1B).

SURGICAL TECHNIQUE

The Stealth-Station ®S7 system (Medtronic, Inc., Louisville, CO, USA) was used. Two-millimeter-thick axial T1-weighted magnetic resonance (MR) images with gadolinium enhancement were used for the registration. The MR images were imported into the workstation ; we assumed a cuboidal area that completely contained the tumor mass. The four corners correspond to the fence posts, and we decide their entry and target points. After craniotomy and before making a dural incision, the new fence-post catheters (S&Brain Co., Ltd., Chiba, Japan) were attached to the passive catheter introducer of the navigation system (Medtronic, Inc., Louisville, CO, USA) and registered

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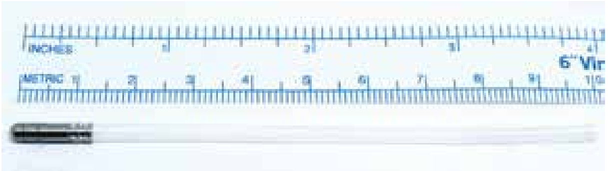
1A



1B

Figure 1. (A) A catheter tube for fence-post catheter techniques.
(B) The length of the tip of the catheter is 13 mm, marked at 5 mm and 2.5 mm from the tip with laser beam ; the tip is made of titanium and weighs 2 g.

to the navigation system (Fig. 2). The dura is pierced with a small knife, following which, the pia mater is coagulated and the catheter inserted into the brain as planned preoperatively. The passive catheter introducer is removed, and the excessive part of the catheter is cut by scissor. After dural incision, the cuboidal tumor mass is resected along the catheters because the fence-post catheters establish resection planes including the tumor depth. Neurosurgeon could recognize the current position of the catheter from the tumor bottom (Fig. 3).

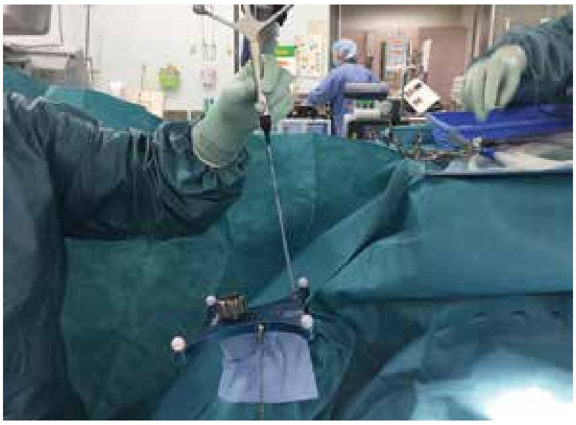


Figure 2. The new fence-post catheters are attached to the passive catheter introducer of the navigation system and registered with the navigation system.

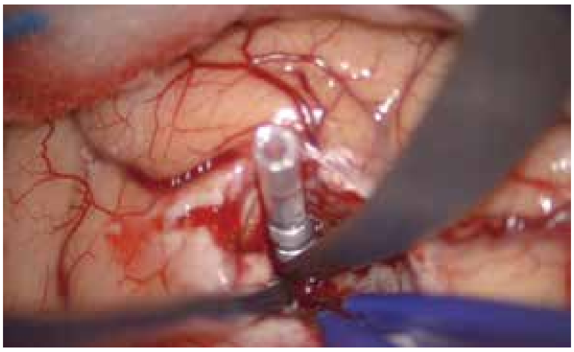


Figure 3. The operator can recognize the current depth because the first and second scale marks is at 5 mm and 2.5 mm from the base, resulting in successful removal of the deep part while preventing excessive removal.

DISCUSSION

In this report, we describe a new catheter for use with fence-post catheter techniques for safely and accurately resecting tumor margins. In case of intramedullary tumor, such as malignant glioma, metastatic brain tumor, and low grade glioma, the approach used for maximal tumor resection/removal without causing complication affects patient prognosis (1-3). Since the boundary between the tumor and normal brain tissue is often obscure, experience and technique is required for operators to improve the degree of tumor removal without causing complication. This factor results in a difference in surgical performance between operators. The fence-post method enables easy tumor removal by recognizing the tumor's boundaries within the normal brain tissue, improving the degree of removal ; the fence-post method could be markedly effective for brain tumor removal (3, 7-9). While the fence-post method has been used for brain tumor removal in many neurosurgical institutions, dedicated fence-post tube has not been developed yet ; therefore, external ventricular drainage tube or a Nelaton catheter is used as substitute. However, with these substitutes, it is hard to recognize scale marks on the tube and also notice when the procedure is getting closer to base of the tumor at the final phase of brain tumor removal. By using our newly designed fence-post catheter, which has a metal part of 13 mm in length at the tip of the tube, operators can notice that they are getting closer to base of the tumor by checking the metal part when proceeding with resection of deep part of the tumor. After slowing down the removal procedure upon recognizing the metal part, operators can recognize the current position is at 5 and 2.5 mm from the base when the first and second scale marks were recognized, respectively, resulting in successful removal of the deep part, while preventing excessive removal. In addition, when performing peeling procedure around the tube at the time of removal, it is possible to minimize movement of the tube caused by the peeling procedure because suitable weight is given to the tip part.

Use of this catheter is limited in some cases. First, the catheter cannot be used for patients who are allergic to titanium because the tip of the catheter is made of this metal. Second, the new fence-post catheter cannot be attached when the passive catheter introducer of the navigation system has a diameter >2.5 mm because the inner diameter of this catheter tube is 2.5 mm.

CONCLUSIONS

By using a fence-post catheter that we developed, it becomes possible to easily confirm the distance to the deep part and improve the degree of safety during tumor removal procedures.

CONFLICT OF INTEREST DISCLOSURE

None. The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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