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Technical Note

A Novel Technique of Microcatheter Shaping using Real Image Display for Endovascular Aneurysmal Coil Embolization

Abstract

In coil embolization of intracranial aneurysms, guiding the microcatheter to an appropriate site in the aneurysm and stabilizing it there are important. In paraclinoid internal carotid aneurysms, complicated three-dimensional (3-D) shaping of the microcatheter tip is occasionally required. We devised a novel shaping method for microcatheters by using a real image display (RID). The usefulness of this technique was validated. We used a RID consisting of a couple of concave mirrors. A piece of patient-specific vascular model, which was made using a 3-D printer before the operation, was set inside the RID. We obtained a real 3-D image just above the RID. As a microcatheter and its shaping inner mandrel could be entered in the hologram of the vasculature, we could create the actual shape of the microcatheter. The shaped microcatheter could be navigated at the desired position in the aneurysm. Complete obliteration of the aneurysm was achieved without any trouble among 30 consecutive cases. We evaluated the effectiveness of the RID for making and navigating a microcatheter in cases with challenging anatomies. It was useful for favorable microcatheter shaping, as the RID could be entered inside the aneurysm models, unlike when tracing the outer surface of rigid 3-D models.

Keywords: *Coil embolization, intracranial aneurysm, microcatheter, shaping*

Tomotaka Ohshima, Yoshitaka Nagano[1], Shigeru Miyachi[2]

Neuroendovascular Therapy Center, Aichi Medical University, [2]Department of Neurosurgery, Aichi Medical University, Nagakute, [1]Department of Electronic Control and Robot Engineering, Aichi University of Technology, Gamagori, Aichi, Japan

Introduction

Navigating a microcatheter into an aneurysm is necessary for successful coil embolization; however, it is often difficult because of the underlying anatomical condition, especially in paraclinoid internal carotid artery aneurysms.[1-5] Recently, we created patient-specific three-dimensional (3-D) vascular models, using a 3-D printer before performing endovascular operations. However, creating a suitable catheter shape by tracing the outer surface of the rigid 3-D models is still challenging.[6]

Some authors reported that a spatial augmented reality by a special electrical device was used for clinical training and simulation.[7,8] It allowed insertion of the microcatheter inside the vascular model during its shaping. We wondered if a classical real image display (RID), which consists of a couple of concave mirrors, could be used for catheter shaping. Here, we report a novel microcatheter shaping method using a RID.

Technique

The RID is a classical toy that is available commercially (Opti-Gone International, Ojai, CA, USA). It consists of two concave mirrors. When a small object is set at the bottom of the RID, a 3-D spatial augmented image appears beyond the display [Figure 1]. The image cannot be touched but can enter inside the object. The theory is shown in Figure 2. A parabolic mirror is a special type of curved mirror that looks like a bowl. It takes incoming light from all directions and reflects it toward a signal focus point. Parabolic mirrors also reflect light coming out from the focus point outward in a parallel beam. The RID utilizes these two properties to create the hologram. The object is at the focus point of the top mirror, and its light is reflected down onto the bottom mirror. This reflected light is then reflected again upward where it converges at the focus point recreating the object as a 3-D image. Before endovascular intervention, a patient-specific 3-D vascular model is made using a 3-D printer. Its materials and methods are reported in the literature.[5]

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Address for correspondence:
Dr. Tomotaka Ohshima, 1-1 Yazakokarimata, Nagakute, Aichi 480-1195, Japan.
E-mail: tmtkoh@gmail.com

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In the endovascular intervention, the 3-D vascular model was set in the RID. A translucent sterilized drape was used to cover the RID [Figure 3]. The tip of the Headway 17 straight microcatheter (Terumo, Tokyo, Japan) was placed inside the hologram of the vascular model along with an attached shaping mandrel. After designing and manually shaping the microcatheter according to the length of the tip and the sites against the vascular wall, the tip of the microcatheter was set 3 cm from the nozzle of the hot air gun (BOSCH, Gerlingen, Germany) at 130°C for 30 s. The microcatheter had the ideal shape we were expecting. The shaped microcatheter could be navigated at the desired position in the aneurysm. Complete obliteration of the aneurysm was achieved without any trouble among 30 consecutive cases.

Discussion

In coil embolization of cerebral aneurysm, safely guiding the microcatheter to an appropriate site in the aneurysm and stabilizing it there are extremely important. Reports have described the characteristics of various microcatheters, differences in responses to steam shaping, and techniques to guide a microcatheter into the aneurysm.[1-4] In paraclinoid internal carotid aneurysms, complicated shaping of the microcatheter tip is occasionally required, and various methods, including shaping under 3-D angiographic guidance and using a 3-D printer, have been reported.[5] We agree that the 3-D printer is useful for shaping microcatheters; however, rigid vascular models prepared with a 3-D printer are not hollow and cannot reproduce the actual curves of the catheter in the body.[6] Therefore, catheters shaped by tracing the outer surface of the rigid vascular models are considered to not faithfully trail the long axis of the parent artery.

Recently, some authors reported that a spatial augmented reality by a special electrical device was used for clinical training and simulation.[7,8] As it allows the placement of the tip of the microcatheter inside the virtual vascular model during its shaping, the precise long axis from the parent artery to the inside of the aneurysm can be traced. However, the virtual reality system for medical use is expensive. Moreover, virtual sickness cannot be ignored during extremely delicate neurointerventions.

We discovered that the RID could be used for microcatheter shaping. It is available commercially as a toy for kids, who enjoy the discrepancy of their feelings between real and virtual images. However, its cost depends on the diameter, a small RID costs approximately 10 USD. We have introduced this technique in 30 cases of unruptured paraclinoid internal carotid artery aneurysms. Using the RID for catheter shaping, we obtained a more favorable microcatheter shape in our initial attempt than when tracing the outer surface of rigid 3-D models.

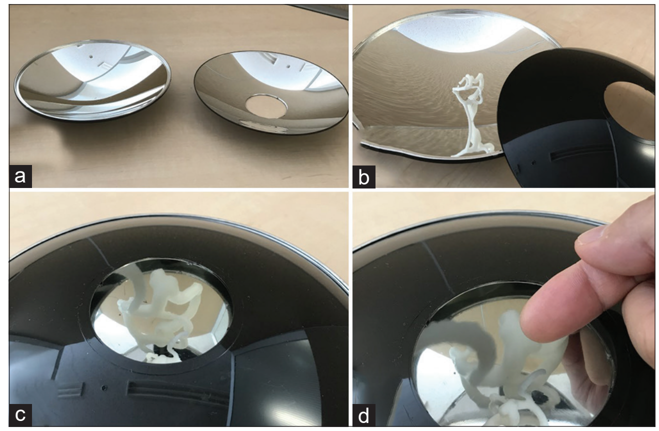

Figure 1: Photographs of the real image display. (a) It consists of two concave mirrors. (b) The vascular model is set at the bottom of the bowl. (c) The three-dimensional hologram appears at the top of the display. (d) Although we can enter in the three-dimensional vascular model, we cannot touch it

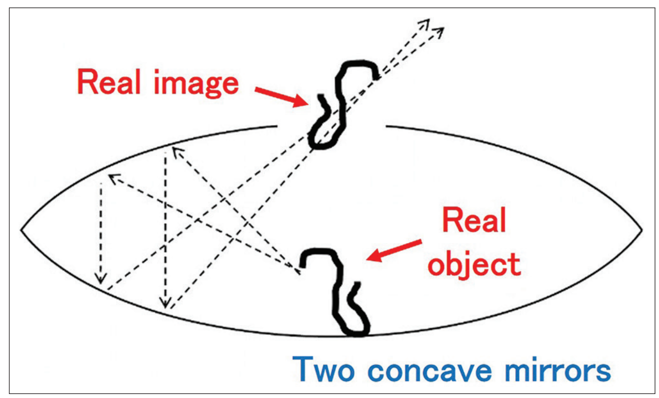

Figure 2: Schematic illustration of the principal of the real image display. The reflected parallel lights from the real object then reflected again upward where it converges at the focus point recreating the object as a real image. We can see the real image as a hologram

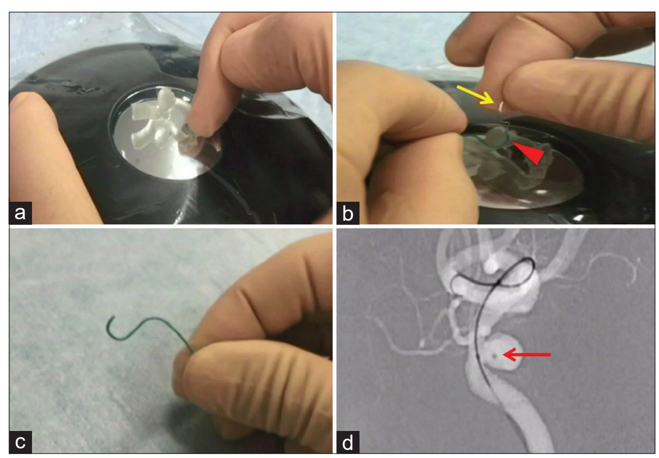

Figure 3: A representative case. (a) A translucent sterilized drape covers the real image display. (b) The tip of the microcatheter (arrowhead) is bent inside the three-dimensional hologram. The arrow indicates a shaping mandrel. (c) After heating by a hot air gun, the tip of the microcatheter shows an ideal shape. (d) An intraoperative road-map image is shown. The tip of the microcatheter is navigated at the desired position in the aneurysm (arrow)

This study has some limitations. First, this was a retrospective analysis conducted at a single center with only

30 cases. Second, some gap in size was present between the real object and the hologram. The object is farther away from the bottom of the RID, and the distortion of the size is >120%. Finally, because this technique requires a patient-specific vascular model by a 3-D printer, we cannot introduce it in emergency cases.

We demonstrated the usefulness of the RID for making and navigating a microcatheter in cases with challenging anatomies. As this method allows placement of the tip of the microcatheter inside the virtual vascular model during its shaping, the precise long axis from the parent artery to the inside of the aneurysm can be traced.

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Conflicts of interest

There are no conflicts of interest.

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