Direct-Puncture Embolization of Scalp Arteriovenous Fistulae
—Technical Note on the Circular Compression Device—

Sung Won YOUN,1 Nam Joon LEE,2 Sang Il SUH,3 and Sin Hyuk KANG4

1Department of Radiology, Catholic University of Daegu Medical Center, Daegu, Korea; Departments of 2Radiology and 4Neurosurgery, Korea University Anam Hospital, Seoul, Korea; 3Department of Radiology, Korea University Guro Hospital, Seoul, Korea

Abstract
We present our experience of flow control with the aid of a circular compression device (CCD) for embolization of scalp arteriovenous fistulae (sAVFs). A 21-year-old female presented with a pulsating scalp mass with sAVFs fed by the superficial temporal arteries. A CCD with a beveled circular handle and concentric hole was used to treat the condition. After the CCD was compressed over the area of the fistulae, the fistulae were punctured and blood regurgitation was assured. While maintaining flow stasis within the boundary of the CCD and loading heparinized dextrose-saline solution, a 50% mixture of N-butyl-2-cyanoacrylate and Lipiodol was applied during the compression, which was sustained for 1–2 minutes. Finally, the sAVFs were almost completely occluded without complications. Our designed CCD was effective for flow control, and direct-puncture embolization of N-butyl-2-cyanoacrylate during flow control using the CCD was safe and effective for the treatment of sAVFs.

Key words: scalp arteriovenous fistula, circular compression device, flow control, direct-puncture embolization, N-butyl-2-cyanoacrylate

Introduction
Scalp arteriovenous fistulae (sAVFs) are high-flow shunts between multiple feeding arteries and the draining veins of the scalp. Capillary beds are absent and the draining veins are often enlarged and tortuous.6,8,13) Conventional surgery, which has been performed in the past to remove sAVFs or to ligate the feeding arterial pedicle, is associated with the risks of blood loss and recurrence from recruitment of a collateral supply.11,14) Endovascular embolization via a transarterial or transvenous route, or via direct puncture, using N-butyl-2-cyanoacrylate (NBCA; Braun, Melsungen, Germany),2,5,7) coils,2,10,15) or Onyx (ev3, Plymouth, Minnesota, USA)1) has been adopted as either a curative or preoperative option to improve these problems with surgery. However, the main technical problem of endovascular embolization is systemic migration of the embolic agents through the shunts, which is driven by both the venous outflow and arterial inflow.3,9) Manual compression of the draining veins may be helpful,7) but has limited effectiveness for the stasis of embolic material and involves increased exposure to the radiation field. Therefore, a compression device has been introduced to enable safe and effective embolization.4,12)

We present our experience of further modification of the circular compression device (CCD) that allows safe and effective direct-puncture embolization for the occlusion of sAVFs.

Case Report and Technique
A 21-year-old woman presented with a pulsating mass on the left preauricular scalp that grew progressively over 3 months after she had fallen down and banged her head. Computed tomography angiography revealed a vascular mass with hypertrophic bilateral superior temporal arteries and engorged superior temporal veins, but brain computed tomography revealed no cerebral lesion. Digital subtraction angiography (DSA) revealed multifocal sAVFs at the left temple area (Fig. 1). The main feeding arteries arose from the superficial temporal arte-
Fig. 1 A 21-year-old female with scalp arteriovenous fistulae (sAVFs). Left external carotid angiogram, lateral projection, showing sAVFs fed by the superficial temporal arteries. Numbers (1, 2, 3, 4, and 5) denote the serial order of the puncture sites.

Table 1 Serial puncture sites and penetration of N-butyl–2-cyanoacrylate (NBCA)

<table>
<thead>
<tr>
<th>Serial No.*</th>
<th>Feeding artery</th>
<th>Draining vein</th>
<th>Puncture site</th>
<th>Penetration of NBCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>STA</td>
<td>STV</td>
<td>venous side</td>
<td>good penetration, reflux to the arterial side after filling</td>
</tr>
<tr>
<td>2</td>
<td>STA</td>
<td>STV</td>
<td>venous side</td>
<td>poor penetration</td>
</tr>
<tr>
<td>3</td>
<td>STA</td>
<td>STV</td>
<td>arterial side</td>
<td>reflux into the arterial side after partial filling partial penetration</td>
</tr>
<tr>
<td>4</td>
<td>STA</td>
<td>STV</td>
<td>venous side</td>
<td>good penetration, migration of NBCA outside the CCD**</td>
</tr>
<tr>
<td>5</td>
<td>STA</td>
<td>STV</td>
<td>arterial side</td>
<td>good penetration, migration of NBCA outside the CCD**</td>
</tr>
<tr>
<td>6</td>
<td>mMA, aMA</td>
<td>maxillary veins</td>
<td>not treated</td>
<td>minimal residual lesions</td>
</tr>
</tbody>
</table>

*Serial number of the puncture site (same as in Fig. 2). **Compression was not effective due to the uneven surface and overlapping of the tragus. aMA: accessory meningeal artery, CCD: circular compression device, mMA: middle meningeal artery, STA: superficial temporal artery, STV: superficial temporal vein.

For effective compression, we constructed a CCD from a drink bottle: the neck portion of the plastic bottle was cut from the cup body, and 90° of the peripheral margin was removed at the upper aspect after turning upside down (Fig. 2). Under skin preparation, the central hole was firmly attached to the patient’s scalp and the remaining 270° of the peripheral margin with its beveled slope were used as a handle for grasping. The removed 90° of the peripheral margin was opened to provide access for the puncture needle. After placing the CCD centered on the nidal point, external carotid injection DSA revealed stasis of the flow within the boundary of the CCD. The area of the fistulae was punctured with a 23-gauge scalp needle, and regurgitation of blood was ensured. After checking that the contrast agent was contained within the boundary of the CCD and loading of a heparinized dextrose-saline solution, a 50% mixture of NBCA and Lipiodol was applied during compression (Fig. 3), which was maintained for 1–2 minutes to allow polymerization of the NBCA. After releasing the CCD, the NBCA cast neither changed shape nor showed distal migration.

Fig. 2 A, B: Top (A) and horizontal (B) views of the circular compression device (CCD). A CCD was made by cutting the neck portion of a drink bottle. In the upside-down position, 90° of the upper aspect of the peripheral margin was removed to provide access for the puncture needle. C: Intraoperative photograph. Under skin preparation, the central hole was attached to the patient’s scalp and the remaining 270° of the peripheral margin with its beveled slope were used as a handle for grasping. The removed 90° of the peripheral margin was opened to provide access for the puncture needle. After placing the CCD centered on the nidal point, external carotid injection DSA revealed stasis of the flow within the boundary of the CCD. The area of the fistulae was punctured with a 23-gauge scalp needle, and regurgitation of blood was ensured. After checking that the contrast agent was contained within the boundary of the CCD and loading of a heparinized dextrose-saline solution, a 50% mixture of NBCA and Lipiodol was applied during compression (Fig. 3), which was maintained for 1–2 minutes to allow polymerization of the NBCA. After releasing the CCD, the NBCA cast neither changed shape nor showed distal migration.

Fig. 3 A, B: Top (A) and horizontal (B) views of the circular compression device (CCD). A CCD was made by cutting the neck portion of a drink bottle. In the upside-down position, 90° of the upper aspect of the peripheral margin was removed to provide access for the puncture needle. C: Intraoperative photograph. Under skin preparation, the central hole was attached to the patient’s scalp and the remaining 270° of the peripheral margin with its beveled slope were used as a handle for grasping. The removed 90° of the peripheral margin was opened to provide access for the puncture needle. After placing the CCD centered on the nidal point, external carotid injection DSA revealed stasis of the flow within the boundary of the CCD. The area of the fistulae was punctured with a 23-gauge scalp needle, and regurgitation of blood was ensured. After checking that the contrast agent was contained within the boundary of the CCD and loading of a heparinized dextrose-saline solution, a 50% mixture of NBCA and Lipiodol was applied during compression (Fig. 3), which was maintained for 1–2 minutes to allow polymerization of the NBCA. After releasing the CCD, the NBCA cast neither changed shape nor showed distal migration.

**Neurol Med Chir (Tokyo) 52, July, 2012**
Fig. 3 Left external carotid injection digital subtraction angiograms during the procedure. Under compression with the circular compression device (2 and 3, arrows), direct-puncture embolization of a 50% mixture of N-butyl-2-cyanoacrylate (NBCA) and Lipiodol was performed. NBCA migrated into the superficial temporal vein due to an uneven surface and overlapping of the tragus (5, arrowhead). Numbers (1, 2, 3, 4, and 5) denote the serial order of the puncture sites.

Postembolization DSA demonstrated near-complete occlusion (Fig. 4). The patient suffered severe pain, which was managed with an ice bag and analgesics. The scalp mass became swollen and hard, but throbbing and skin necrosis were absent. No cranial nerve damage was noted. Curative resection of the embolized sAVFs was performed 1 month later.

Discussion

sAVFs are either congenital or traumatic in origin.6,8,13) Traumatic sAVFs develop with some temporal interval after scalp trauma, whereas congenital sAVFs that have existed since birth may become symptomatic at puberty along with activating factors including trauma, pregnancy, or hormonal changes.9) sAVFs comprise multiple feeding arteries, nidal points, and venous drainage, and so treatment is particularly challenging due to these angiarchitectural complexities and the high-flow nature. Various embolic agents and routes have been considered, but transarterial embolization with contour polyvinyl alcohol particles is not recommended because of incomplete obliteration or recurrence.2) Transarterial embolization with NBCA results in permanent occlusion, but multiple sessions with microcatheter navigation for the multiple feeding arteries are necessary, and distal microcatheter access may be difficult in the presence of excessive vascular tortuosity. Furthermore, the risk of adhesion and entrapment of the microcatheter tip within vessels during NBCA polymerization is substantial. Fortunately, sAVFs are superficial lesions, and so direct puncture to the nidus and flow control by compression is possible.7)

The simplicity of the direct puncture protocol reduces the procedure time and eliminates the risk of microcatheter adhesion. Nonetheless, occlusion
of only the venous drainage without nidus obliteration may result in recurrence from the collateral supply, and inadvertent egress of the embolic agent to the venous side of a high-flow shunt, especially into the pulmonary circulation, may be a serious problem. Manual compression of a draining vein into the pulmonary circulation, may be a serious problem in certain cases.

In our patient, the CCD was modified from those described previously. The open window at the upper aspect of the device provided more free handling of the puncture needle and the closed ring at the lower aspect achieved more secure compression of the patient's scalp. The portion of the peripheral handle compared to that of the central hole was enlarged, and the degree of bevel was quasi-horizontal, which was more convenient for grasping and application of an even force onto the curved scalp. By using this CCD, the sAVFs were almost completely occluded without complication.

Our modified CCD was effective for flow control, and direct-puncture embolization with NBCA during flow control using the CCD was effective for the treatment of scalp AVFs.

Acknowledgment

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (grant number 20119123). Otherwise, the authors have no conflicts of interest and/or disclosure.

References


Address reprint requests to: Nam Joon Lee, MD, Department of Radiology, Korea University Anam Hospital, Anam-dong 5–Ga, Seongbuk-Gu, Seoul, 136-705, Korea.

E-mail: njlee@kumc.or.kr

Neurol Med Chir (Tokyo) 52, July, 2012