satile tinnitus was decreased by manual compression of right carotid artery. Neurological examination was normal, but bruit was audible by auscultation on the right temporal area.

Image findings
Brain MRI did not show any brain parenchymal lesions, but TOF MRA images demonstrated tangled vessels on right temporo-parietal area. Bone window of brain CT showed prominent intraosseous diploic space on the basal portion of right parietal bone with small defect on inner table of the skull (Fig. 1A, B). Digital subtraction angiography revealed DA VF within the basal portion of right parietal bone along the middle meningeal artery (MMA). Dilated fistulous venous pouch within diploic space of the right parietal bone was measured 29×9 mm on 3D rotational angiogram. The DA VF was fed by frontal branch of right MMA and drained into right transverse sigmoid sinus junction through dilated middle meningeal vein. The intraosseous DA VF involving diploic vein was successfully obliterated with Onyx embolization via transarterial route.

Key Words: Dural arteriovenous fistulas · Tinnitus · Onyx · Diploic vein · Transarterial embolization.

INTRODUCTION
Intracranial dural arteriovenous fistulas (DAVFs) are abnormal arteriovenous connections that lie within the dura. Intraosseous DAVFs involving diploic venous system are extremely rare. A 46-year-old woman presented with headache and right pulsatile tinnitus for three weeks. The tinnitus started after yelling. Digital subtraction angiography revealed DAVF within the basal portion of right parietal bone along the middle meningeal artery (MMA) groove. The fistula was fed by frontal branch of right MMA and drained into right transverse sigmoid sinus junction through dilated middle meningeal vein. The intraosseous DAVF involving diploic vein was successfully obliterated with Onyx embolization via transarterial route.

CASE REPORT
History and examination
This 46-year-old woman without medical history presented with headache and right pulsatile tinnitus for three weeks. This pulsatile tinnitus started after yelling. There was no history of head trauma or other precipitating event. The intensity of pulsatile tinnitus was decreased by manual compression of right carotid artery. Neurological examination was normal, but bruit was audible by auscultation on the right temporal area.

Image findings
Brain MRI did not show any brain parenchymal lesions, but TOF MRA images demonstrated tangled vessels on right temporoparietal area. Bone window of brain CT showed prominent intraosseous diploic space on the basal portion of right parietal bone with small defect on inner table of the skull (Fig. 1A, B). Digital subtraction angiography revealed DAVF within the basal portion of right parietal bone along the middle meningeal artery (MMA). Dilated fistulous venous pouch within diploic space of the right parietal bone was measured 29×9 mm on 3D rotational angiogram. The DAVF was fed by frontal branch of right MMA. It was drained into right transverse sigmoid sinus junction through the middle meningeal vein (MMV) without retrograde cortical venous reflux (Fig. 1C, D, E). Internal carotid arterial system did not contribute to the fistulous flow.

Treatment
Under general endotracheal anesthesia, a 5 French Envoy guiding catheter (Cordis, Miami, FL, USA) was placed proximal to the origin of right internal maxillary artery via a transfemoral arterial route. After intravenous bolus injection of 3,000 unit of heparin, a microcatheter of Echelon-10 (ev3 Neurovascular, Irvine, CA, USA) was introduced and placed to the
Intraosseous Dural AVF

| JH Shim, et al. |

Intraosseous dural arteriovenous fistula (DAVF) is a rare vascular malformation involving the cranial dura mater and the dural sinus or emissary veins. Common extraosseal locations are the skull base, tentorium, and intraorbital area via emissary veins. However, DAVFs involving the dural sinuses are extremely rare and only a few cases have been reported.

The known causes of DAVFs are related to the head injury. Frontal branch of MMA at the just proximal portion of DAVF under roadmap guidance. Microcatheter angiograms clearly demonstrated multiple fine arterial channels of MMA connecting to dilated venous pouch, drained into right transverse sigmoid sinus junction through enlarged MMV (Fig. 2A, B).

Onyx 18 (ev3 Neurovascular, Irvine, CA, USA) injection was uneventful. Two milliliters of Onyx injection resulted in complete obliteration of the DAVF including multiple fine arterial channels from the MMA (Fig. 2C, D, E).

**Postoperative course**

Her preoperative symptoms resolved completely after embolization. Postoperative CT showed Onyx cast within the right parietal bone and middle fossa dura along the MMA, which confirmed the intraosseous location of DAVF (Fig. 3). Her postoperative course was uneventful. She was discharged 3 days postoperatively.

**DISCUSSION**

DVs are located between two cortical bones and are lined by a single endothelial layer without vascular valves. In normal conditions, the DVs can be seen as slightly delayed more than the rest of cerebral veins on cerebral angiography. DVs communicate with the dural sinus, emissary veins, pericranial veins, meninges, and skull base. This anatomical relationship plays a role in pathological situations, such as subgaleal hematoma, sinus thrombosis and DAVFs. Under such pathologic circumstances, the normal venous draining pathway can be compromised, and the DVs may show increased flow on cerebral angiography.

Classic DAVFs are situated within the dura adjacent to the venous sinus. However, DAVFs can occur wherever the veins follow adjacent the dura if there is a fistulous connection between the artery and vein. Malik et al. reported 2 cases of DAVFs with vascular nidus that was situated within the bone, and they used the term “intraosseous DAVF.” In intraosseous DAVFs, these extrasinusoidal fistulous connections can be developed between meningeal arteries and the DVs or emissary veins. Common extrasinusal locations are the skull base, tentorium and intraorbital area via emissary veins. However, the DAVFs involving DV are extremely rare and only few cases have been reported.

The known causes of DAVFs are related to the head injury,
cranial surgery, or venous sinus thrombosis\(^9\). But, in this case she had no history of head trauma, or venous sinus thrombosis. Her tinnitus symptom was developed immediately after yelling. It is unclear how the intraosseous DAVF involving DV was formed spontaneously after yelling. One possible explanation is that any fistulous connection between MMA and DV might have been developed after yelling because there was no tinnitus symptom until that event. Her brain CT showed a small defect on inner table of the right parietal bone along the MMA groove as well as neighboring prominent diploic space. Therefore, it is probable that the MMA and DV were being in contact with each other. The longstanding contact of the lateral wall of the MMA with sharp bony spicule on the MMA groove defect could have made some erosion of the MMA wall before the occurrence of fistula. At the moment of yelling, an abrupt increase in blood pressure and intracranial pressure might have resulted in simultaneous ruptures of erosive portion of the MMA and neighboring thin walled DV. Fistulous communication between artery and vein can occur, which further recruits fine meningeal branches to grow intraosseous DAVF.

Intraosseous DAVFs can be treated by surgical resection or endovascular treatment. Surgical resection of DAVFs achieved curative results in several reports, but it still remained the risk of surgery\(^{11,12}\). Historically, transvenous approach has been considered more ideal to occlude the fistula completely than transarterial embolization, which requires multiple feeder catheterization. However, the transvenous approach requires retrograde catheterization, which carries a high risk of sacrifice of the involved venous structures. This approach can be associated with severe complications, such as vessel perforation, venous infarction and hemorrhage\(^9\). Recently, some authors reported high rates of complete obliteration of DAVFs via transarterial approach using Onyx\(^{11,15,19}\). Introduction of Onyx embolic material make it possible to infiltrate the fistulas and their multiple feeders as a retrograde fashion due to good penetration capability of Onyx. Penetration of Onyx through the fistula can be controlled effectively by plug and push technique. In this case, complete obliteration of intraosseous DAVF involving DV was achieved with single arterial injection of Onyx without any complications.

CONCLUSION

Intraosseous DAVF is a rare disease entity. The authors report a case of intraosseous DAVF involving DV which was treated with transarterial injection of Onyx embolic material without any complications. Transarterial Onyx embolization seems to be a safe and effective treatment modality for DAVF involving DV.

References

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