

# Translucent Three-Dimensional CT is Useful in Considering the Treatment Strategy for the Penetrating Skull Base Injury With a Metal Rod: Case Report

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## Abstract

An 18-year-old male suffered a penetrating skull base injury caused by a metal rod. We made translucent three-dimensional (3D) computed tomography (CT) for clearing the injury site. This method has revealed that right carotid artery was compressed directly by the foreign body, and internal carotid artery trapping was carried out based on hemodynamics as revealed by angiography. This patient achieved modified Rankin scale score of 1 at discharge. Cases of trauma involve a variety of circumstances and therefore require a case-by-case evaluation that depends on the patient's condition. Translucent 3D CT was useful in considering the treatment strategy of the penetrating skull base injury.

Key words: arterial occlusion, internal carotid artery, penetrating head trauma, translucent three-dimensional (3D) computed tomography (CT)

## Introduction

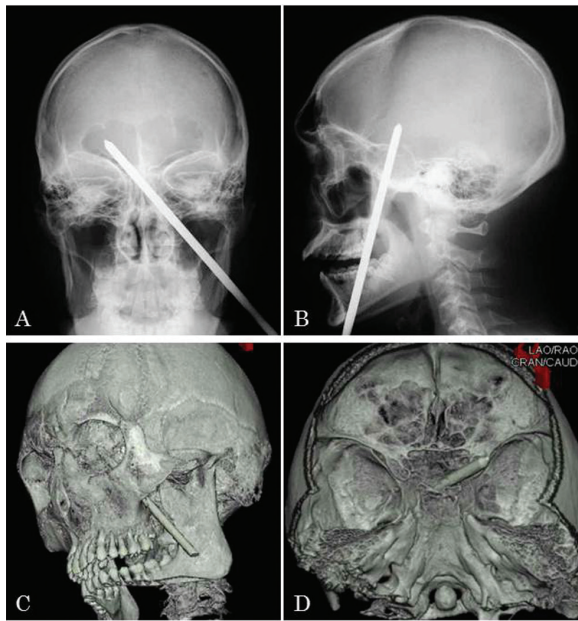
Penetrating head injuries (PHIs) account for about 0.4% of all head injuries, usually causing serious damage to the brain or neurovascular structures. A PHI at a middle and anterior location is especially dangerous, and carries a poor prognosis.<sup>1,6)</sup> Traumatic internal carotid artery (ICA) occlusion is rare but often results in a lethal condition. Early diagnosis and treatment are thus essential.<sup>10,11)</sup> We report here a case of direct carotid artery injury by penetration of the skull base with a metal rod. Translucent three-dimensional (3D) computed tomography (CT) image was useful in considering the treatment strategy.

## Case Presentation

An 18-year-old male suffered a penetrating skull base injury caused by a metal rod that he was holding when he accidentally slipped. He was taken to the local emergency hospital, having not lost consciousness at that time. He could not open his mouth due to a locked jaw, and he vomited. A tracheotomy was performed to prevent choking. On arrival at our hospital he was sedated and showed stable vital signs.

The length of the rod was about 50 cm, with a 5-mm diameter, and about 12 cm penetrated the patient's head (Fig. 1). The entry point was the left subzygomatic bone, maxilla, and finally the right frontal lobe. The proximal end of the rod impeded movement of the patient's head as well as the examination, and we therefore shortened it. A CT scan taken 8 h after the trauma showed pneumocephalos with a suspicion of compression of the right ICA, but with no ischemic lesion at the right hemisphere. Partially translucent 3D CT revealed fine anatomical bone structure and the metal rod (Fig. 1). Digital subtraction angiography showed complete occlusion of the right ICA, and well-developed collateral circulation via the circle of Willis (Fig. 2). There was no left external carotid artery injury.

Emergency surgery was performed to remove the rod. The tip of the rod lodged under the right ICA of segment C2 and the right optic nerve, compressing them (Fig. 3). The tip was detected in the right frontal lobe and was carefully detached from the artery and the optic nerve. The wall of the right ICA was reddened and partially dissected. We interrupted the right ICA with a titanium clip at the proximal point of the posterior communicating artery after ligation of the right cervical ICA. Another clip was then applied to the proximal point of the right ophthalmic artery. The metal rod was gently removed by pulling it along the original trajectory of the stick. Dural



**Fig. 1** Preoperative neuroradiological findings. A and B: The preoperative skull X-ray (A: antero-posterior view, B: lateral view). The metal rod penetrating the skull base. C and D: Translucent 3D computed tomography (CT) of the head. This examination showed that the tip of the metal rod was located in the right frontal lobe, compressing the right internal carotid artery (ICA) and right side of the chiasma.

repair was performed using galea and fibrin glue. The operative field was irrigated with saline.

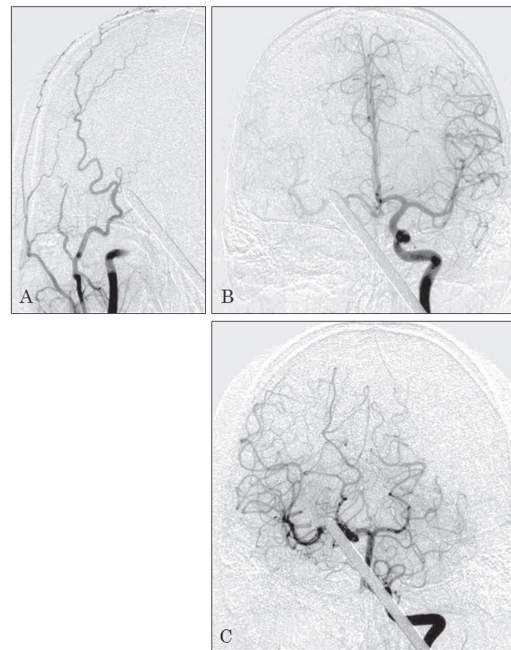
The postoperative course was uneventful. The cerebral blood flow (CBF) measured by single-photon emission CT at 17 days postop revealed no insufficient CBF of his right hemisphere.

On discharge, he showed upward anopsia of the right eye, which was only a result of the neurological deficit, due to compression by the rod. The patient was discharged 30 days after the operation.

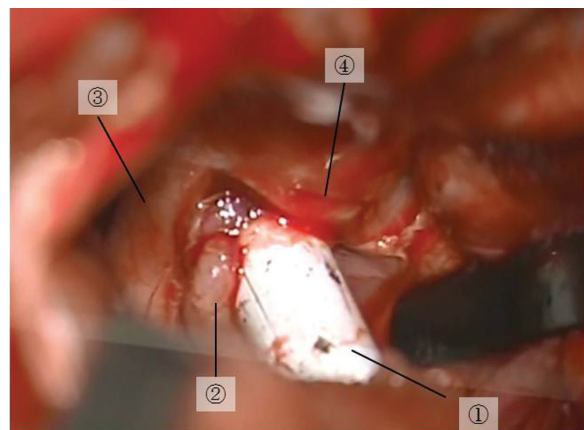
## Discussion

PHI accounts for about 0.4% of all head injuries.<sup>4,6)</sup> There are many causes of PHI, including chopsticks, nail-guns, arrows, pencils, knives, screwdriver, and twigs.<sup>2,5,7,9)</sup> In our case, the foreign body was a metal rod used for engineering measurements. Cases of traumatic ICA occlusion are often reported and they feature various causes, but our case where the tip of a rod compressed the ICA and produced occlusion is very rare. The prognosis of traumatic ICA occlusion is poor and mortality is 30–40%, whereas another 52% have serious neurological deficits.<sup>10,11)</sup> Thus, early diagnosis and treatment are essential in cases of traumatic ICA occlusion.

CT scanning of the head is the most useful and important examination in patients with PHI, because it is quick and



**Fig. 2** Digital subtraction angiography. A: Right carotid angiogram. Right internal carotid artery (ICA) is occluded at level C5. B: Left carotid angiogram. Blood flow of right anterior cerebral artery and middle cerebral artery are fed via the anterior communicating artery. C: Left vertebral angiogram. Blood flow of right middle cerebral artery is supplied via the posterior communicating artery.



**Fig. 3** Intraoperative view. ① Metal rod. ② Partially dissected right ICA. ③ Compressed right optic nerve. ④ Anterior clinoid.

provides information on the extent of the brain injury and the trajectory of the projectile, detection of hematomas, and mass effect.<sup>1,6)</sup> Sometimes, in cases of PHI due to foreign metal bodies, acquiring intracranial information is difficult due to artifacts. Sakagami et al.<sup>9)</sup> recommended changing the window level and/or section of the CT in such cases. In our case, we examined translucent 3D CT, which was very useful in identifying intracranial information. Translucent 3D CT assists in considering

the treatment strategy for this case.

An angiogram is also an important examination. Incidences of vascular complication from PHI range from 5% to 40%. These include traumatic intracranial aneurysms (20%), arteriovenous fistulas, subarachnoid hemorrhage (SAH) (31–78%), and vasospasm.<sup>6)</sup> Nakao et al.<sup>7)</sup> reported a case of PHI caused by a chopstick. In their case, carotid angiography (CAG) before the operation revealed a luminal irregularity of the left ICA, and Day 7 after the operation revealed aneurysm formation at the same site. Kazim et al.<sup>6)</sup> strongly recommended angiography in penetrating brain injury cases with SAH and/or intracranial hemorrhage (ICH). du Trevou and van Dellen<sup>3)</sup> reported that 10% of PHI patients who required removal of the ICH suffered trauma-induced aneurysms, and they also recommended an angiogram or CT angiogram as soon as possible when patients arrive at the hospital. In our case, there was no ICH and SAH, but injury of the right ICA was a concern, due to the location of the tip of the rod. Vascular injuries sometimes exhibit delayed onset, appearing even weeks or months after the trauma. Repeating the test 2 or 3 weeks after the trauma or initial examination is thus recommended.<sup>1,6,7)</sup>

The primary problem in this case was how to process the right ICA. This case featured well-developed collateral circulation and the ICA had not ruptured, hence we could safely interrupt the right ICA at the cervical bifurcation and the proximal point of the ophthalmic artery and the posterior communicating artery. In patients with poor collateral circulation, external decompression is consequently considered due to diffuse brain edema. Most traumatic ICA occlusions that have been reported are due to thrombus formation and dissociation.<sup>4,8,10,11)</sup> In cases of well-developed collateral circulation, conservative treatment or endovascular surgery is certainly one of the choices. However, if the ICA has been compressed directly by a foreign object, such as in our case, surgical treatment is mandatory. In the preoperative imaging examinations, whether the right ICA was compressed or penetrated was not clear. Therefore, we had to consider a situation in which the right carotid artery might have a block. In a rare case such as this, the required approach has to be tailored to the patient's condition.

### Conclusion

We treated a case of PHI and traumatic occlusion of the right ICA caused by a metal rod. Translucent 3D CT is useful in considering the treatment strategy of the penetrating skull base injury with a metal rod. Cases of trauma involve a variety of circumstances and, therefore, require a case-by-case evaluation that depends on the patient's condition.

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### Conflicts of Interest Disclosure

None declared. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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