

# Endoscopic Endonasal Repair of Cerebrospinal Fluid Leakage Caused by a Rare Traumatic Clival Fracture

Akihiro HIRAYAMA,<sup>1</sup> Fuminari KOMATSU,<sup>1</sup> Kazuko HOTTA,<sup>1</sup> Masaaki IMAI,<sup>1</sup> Shinri ODA,<sup>1</sup> Masami SHIMODA,<sup>1</sup> and Mitsunori MATSUMAE<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Tokai University Hachioji Hospital, Hachioji, Tokyo

<sup>2</sup>Department of Neurosurgery, Tokai University School of Medicine, Isehara, Kanagawa

## Abstract

An 89-year-old male presented with cerebrospinal fluid (CSF) rhinorrhea associated with head trauma sustained as a pedestrian in a traffic accident. Computed tomography (CT) showed pneumocephalus and multiple cranial bone fractures, including the clivus. Although the CSF rhinorrhea was treated conservatively for a week, clinical symptoms did not improve and surgical repair was performed. Preoperative thin-sliced bone CT and steady-state magnetic resonance images revealed a bone defect at the middle clivus and a collection of CSF fluid from the clival fistula in the sphenoid sinus. Endoscopic endonasal reconstruction was performed, and the 3-mm diameter dural tear and bone defect at the middle clivus were well visualized. The fistula was repaired using a pedicled nasoseptal mucosal flap. The CSF rhinorrhea completely disappeared as a result of the endoscopic endonasal surgery. The present report describes a rare case of CSF rhinorrhea caused by a traumatic clival fracture and surgical management by endoscopic endonasal surgery.

Key words: cerebrospinal fluid rhinorrhea, clival fracture, endoscopy, head trauma

## Introduction

Cerebrospinal fluid (CSF) leakage is a medical condition originating from the breakdown of a physical barrier composed of the skull base bone and dura mater, resulting in abnormal release of CSF from the arachnoid space into an extracranial component.<sup>1)</sup>

Because CSF leakage carries the potential risk of ascending infection, which may cause critical meningitis, appropriate diagnosis and treatment are essential. Surgical intervention is required when CSF leaks do not resolve with conservative treatment.<sup>2–6)</sup>

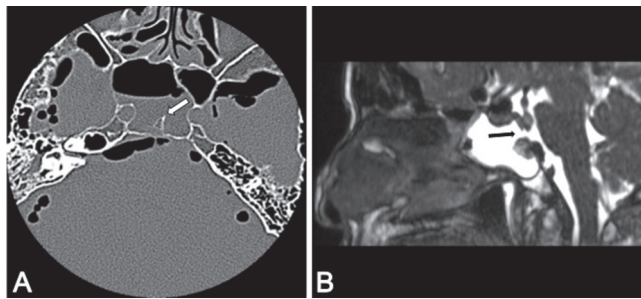
CSF leakage usually occurs following traumatic skull-based fractures, and common locations of such fractures are the anterior skull base, including the cribriform plate; the roof of the sphenoid sinus; and the posterior wall of the frontal sinus.<sup>1,3,7)</sup> In contrast, CSF leakage due to a traumatic clival fracture is very rare and has scarcely been described to date.<sup>8)</sup> Herein, we report a rare case of CSF leakage caused by a traumatic clival fracture and successful surgical management by endoscopic endonasal surgery.

## Case Report

An 89-year-old male pedestrian injured in a traffic accident during a daily jog was admitted to our hospital. On admission, CSF rhinorrhea was observed and physical examination revealed bruises in the frontal and occipital regions of the head. Glasgow Coma Scale (GCS) was 15 and no cranial nerve deficits were seen. Computed tomography (CT) revealed severe pneumocephalus, traumatic subarachnoid hemorrhage, and multiple occipital bone fractures, including the clivus. The CSF rhinorrhea was treated conservatively by intravenous administration of broad-spectrum antibiotics and bed rest for a week; however, CSF rhinorrhea continued without improvement and disturbance of consciousness deteriorated (GCS 11: E3, V3, M5) with the progression of bacterial meningitis. Thus, surgical repair was performed. Preoperatively, thin-sliced bone CT (Fig. 1A) and steady-state magnetic resonance imaging (MRI; Fig. 1B) were performed, which identified the fistula causing the CSF leakage. The axial CT bone image showed a bone defect at the middle clivus, and a free bone fragment in the sphenoid sinus (Fig. 1A). Moreover, the continuity of CSF between the sphenoid sinus and prepontine cistern was clearly demonstrated

on the sagittal MR image (Fig. 1B). MR angiography did not show any vascular damage to the carotid, basilar, or vertebral arteries.

Endoscopic endonasal surgery was carried out to repair the clival fistula. During the operation, fluid collection was observed in the sphenoid sinus after anterior sphenoidotomy, and a fistula and small bone fragment were confirmed around the center of the clivus (Fig. 2A). The dural tear and bone defect were clearly visualized under endoscopic view after removal of the small bone fragment and the mucosa on the posterior sphenoid wall (Fig. 2B). The basilar artery came into view through the dural defect behind the clivus (Fig. 2B). The dural and bone defects at the clivus were repaired using a pedicled nasoseptal mucosal flap, and then abdominal fat and fibrin glue were applied (Fig. 2C). Finally, a nasal balloon was placed in the sphenoid sinus. Postoperatively, the nasal balloon and external lumbar drainage were maintained for 7 days. After the



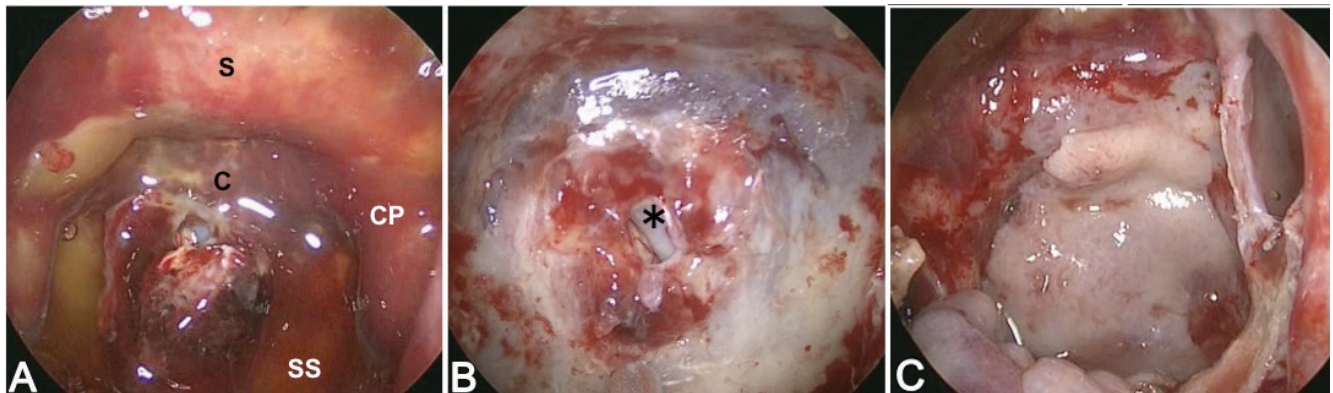
**Fig. 1** Preoperative neuroradiological images. A: Axial thin-sliced computed tomography (CT) showing the clival defect and bone fragment (white arrow) at the middle clivus and fluid collection in the sphenoid sinus. B: Sagittal steady-state magnetic resonance image revealing the continuity of cerebrospinal fluid between the sphenoid sinus and prepontine cistern (black arrow).

endoscopic procedure, CSF rhinorrhea completely disappeared, and the clival defect and fluid collection in the sphenoid sinus had improved on MR imaging (Fig. 3A, B). The patient was allowed out of bed and recovered enough to be able to ambulate independently. He was transferred to a rehabilitation hospital for further recovery.

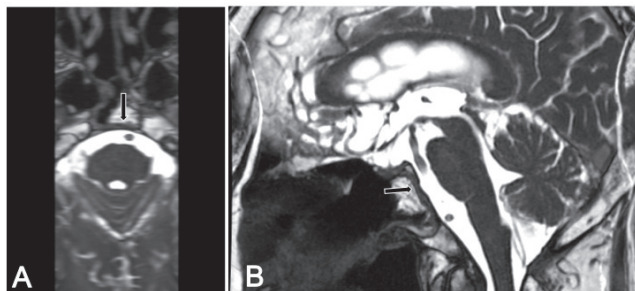
## Discussion

Traumatic clival fractures are rare because of their deep anatomic location in the skull base, and typically result from a severe mechanism of injury; the incidence is reported to be between 0.21% and 0.56% of all traumatic head injuries.<sup>9)</sup> The majority of clival fractures are demonstrated as linear fractures on CT and can be classified into three types: longitudinal, transverse, and oblique.<sup>10)</sup> Additionally, clival fracture cases are associated with a high mortality rate (38.5%) due to primary brainstem damage, brain herniation from associated injuries, or vascular complications of the carotid, basilar, and vertebral arteries.<sup>9,11)</sup> On the other hand, reports of traumatic clival CSF leakage are extremely rare.<sup>8,12)</sup> Non-traumatic clival CSF rhinorrhea has also been reported.<sup>13–16)</sup> The most frequent cause of non-traumatic clival CSF rhinorrhea is considered to be meningoencephalocele, which is a congenital malformation of the skull base.<sup>15)</sup> Moreover, there have been reports of spontaneous CSF rhinorrhea due to a vulnerable clival bone in relation to either obesity, benign intracranial hypertension, continuous basilar artery pulsation, or advanced aging.<sup>13,14)</sup>

In the present case, the fracture was not able to be categorized into one of the three types of clival fractures, localized around the sphenoid-occipital synchondrosis, and showed a round-shaped defect rather than a linear fracture. Moreover, this patient presented with CSF



**Fig. 2** A: Intraoperative endoscopic images demonstrating the clival defect, small bone fragment with hematoma, and submucosal hemorrhage in the sphenoid sinus. B: Enlarged view after removal of the bone fragment and sphenoidal mucosa visualizing the basilar artery (asterisk) through the fistula. C: Pedicled nasoseptal mucosal flap being used for reconstruction. C: clivus, CP: carotid prominence, S: sellar floor, SS: sphenoid sinus.



**Fig. 3** Postoperative axial (A) and sagittal (B) steady-state MR images showing successful reconstruction of the clivus (black arrows).

rhinorrhea only, without major brain injury or vascular complications. We hypothesized that this CSF leakage was related to vulnerable clival bone conditions, which included a well-pneumatized sphenoid sinus, advanced age, and the neighboring spheno-occipital synchondrosis. The skull base probably sustained a relatively minor injury. Nevertheless, as the clival bone is fragile, this may have resulted in an uncommon clival fracture and subsequent CSF leakage. We found no reported cases of CSF rhinorrhea alone caused by a traumatic clival fracture.

Regarding surgical treatment, endoscopic endonasal repair of the CSF leak was performed using a vascularized nasoseptal mucosal flap. As endoscopic endonasal surgery has developed,<sup>17–19)</sup> this method of endoscopic repair has been popularized as a reliable technique for closure of a leaking fistula from the anterior midline skull base.<sup>20–22)</sup> In the present case, the fistula was clearly identified under superb endoscopic view, even in the deepest area of the skull base, and effective repair was accomplished with a minimally invasive technique.

Hydrocephalus is the most influential factor leading to recurrence of CSF leak after endoscopic endonasal repair.<sup>23)</sup> The patient in the present case was at high risk for hydrocephalus due to traumatic subarachnoid hemorrhage, bacterial meningitis, and advanced age. Therefore, external lumbar drainage was placed, and post-operative CSF dynamics were carefully observed. Fortunately, hydrocephalus did not develop, and further CSF management such as ventriculoperitoneal shunting was not needed. In addition to excellent surgical technique, post-operative CSF management is important for patients who are at risk for hydrocephalus to ensure successful endoscopic endonasal repair of traumatic CSF leakage.

### Conclusion

In conclusion, CSF rhinorrhea associated with traumatic clival fracture is very rare, and preoperative evaluation by bone CT and steady-state MRI sufficiently demonstrated this rare condition. Endoscopic endonasal surgery provides

a minimally invasive technique for successful repair of CSF leakage due to traumatic clival fracture.

### Conflicts of Interest Disclosure

The authors have no conflicts of interest to disclose. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online using the self-reported COI Disclosure Statement Forms through the website for JNS members.

### References

- 1) Komatsu M, Komatsu F, Cavallo LM, Solari D, Stagno V, Inoue T, Cappabianca P: Purely endoscopic repair of traumatic cerebrospinal fluid rhinorrhea from the anterior skull base: case report. *Neurol Med Chir (Tokyo)* 51: 222–225, 2011
- 2) Abuabara A: Cerebrospinal fluid rhinorrhoea: diagnosis and management. *Med Oral Patol Oral Cir Bucal* 12: E397–E400, 2007
- 3) Friedman JA, Ebersold MJ, Quast LM: Post-traumatic cerebrospinal fluid leakage. *World J Surg* 25: 1062–1066, 2001
- 4) Sherif C, Di Ieva A, Gibson D, Pakrah-Bodingbauer B, Widhalm G, Krusche-Mandl I, Erdoes J, Gilloon B, Matula C: A management algorithm for cerebrospinal fluid leak associated with anterior skull base fractures: detailed clinical and radiological follow-up. *Neurosurg Rev* 35: 227–237; discussion 237–228, 2012
- 5) Giovannetti F, Ruggeri A, Buonaccorsi S, Pichierri A, Valentini V: Endoscopic endonasal approaches for cerebrospinal fluid leaks repair. *J Craniofac Surg* 24: 548–553, 2013
- 6) Scholsem M, Scholtes F, Collignon F, Robe P, Dubuisson A, Kaschten B, Lenelle J, Martin D: Surgical management of anterior cranial base fractures with cerebrospinal fluid fistulae: a single-institution experience. *Neurosurgery* 62: 463–469; discussion 469–471, 2008
- 7) Aletsee C, Konopik V, Dazert S, Dieler R: [Surgery of anterior skull base fractures]. *Laryngorhinootologie* 82: 626–631, 2003
- 8) Nakamura F, Naoki T, Yoshihiro K, Tadashi K, Shiro W: Traumatic cerebrospinal fluid rhinorrhea caused by a longitudinal feature of the clivus: a case report. *Jpn J Neurosurg (Tokyo)* 7: 699–702, 1998
- 9) Winkler-Schwartz A, Correa JA, Marcoux J: Clival fractures in a level I trauma center. *J Neurosurg* 122: 227–235, 2015
- 10) Meguro K, Rowed DW: Traumatic aneurysm of the posterior inferior cerebellar artery caused by fracture of the clivus. *Neurosurgery* 16: 666–668, 1985
- 11) Sato S, Iida H, Hirayama H, Endo M, Ohwada T, Fujii K: Traumatic basilar artery occlusion caused by a fracture of the clivus—case report. *Neurol Med Chir (Tokyo)* 41: 541–544, 2001
- 12) Portier F, Salvan D, Duruisseau O, Herman P, Tran Ba Huy P: A rare clival and sellar fracture with pneumatocephalus. *Auris Nasus Larynx* 29: 195–198, 2002
- 13) Maranhã LA, Corredato Rde A, Araújo JC: Nontraumatic clival cerebrospinal fluid rhinorrhea. *Arq Neuropsiquiatr* 70: 550–551, 2012
- 14) Elrahman HA, Malinvaud D, Bonfils NA, Daoud R, Mimoun M, Bonfils P: Endoscopic management of idiopathic spontaneous

- skull base fistula through the clivus. *Arch Otolaryngol Head Neck Surg* 135: 311–315, 2009
- 15) Komatsu F, Komatsu M, Ohmura T, Tsugu H, Oshiro S, Fukushima T, Inoue T: Endoscopic management of a traumatic meningo-encephalocele through a planum sphenoidale defect: case report. *Neurol Med Chir (Tokyo)* 50: 949–952, 2010
  - 16) Van Zele T, Kitice A, Vellutini E, Balsalobre L, Stamm A: Primary spontaneous cerebrospinal fluid leaks located at the clivus. *Allergy Rhinol (Providence)* 4: e100–e104, 2013
  - 17) Ishii Y, Tahara S, Teramoto A, Morita A: Endoscopic endonasal skull base surgery: advantages, limitations, and our techniques to overcome cerebrospinal fluid leakage: technical note. *Neurol Med Chir (Tokyo)* 54: 983–990, 2014
  - 18) Shidoh S, Toda M, Kawase T, Nakajima H, Tomita T, Ogawa K, Yoshida K: Transoral vs. endoscopic endonasal approach for clival/upper cervical chordoma. *Neurol Med Chir (Tokyo)* 54: 991–998, 2014
  - 19) Komatsu F, Oda S, Shimoda M, Imai M, Shigematsu H, Komatsu M, Tschabitscher M, Matsumae M: Endoscopic endonasal approach to the middle cranial fossa through the cavernous sinus triangles: anatomical considerations. *Neurol Med Chir (Tokyo)* 54: 1004–1008, 2014
  - 20) Snyderman CH, Kassam AB, Carrau R, Mintz A: Endoscopic Reconstruction of Cranial Base Defects following Endonasal Skull Base Surgery. *Skull Base* 17: 73–78, 2007
  - 21) Kassam AB, Thomas A, Carrau RL, Snyderman CH, Vescan A, Prevedello D, Mintz A, Gardner P: Endoscopic reconstruction of the cranial base using a pedicled nasoseptal flap. *Neurosurgery* 63(1 Suppl 1): ONS44–ONS52; discussion ONS52–ONS43, 2008
  - 22) Wheless SA, McKinney KA, Carrau RL, Snyderman CH, Kassam AB, Germanwala AV, Zanation AM: Nasoseptal flap closure of traumatic cerebrospinal fluid leaks. *Skull Base* 21: 93–98, 2011
  - 23) Zweig JL, Carrau RL, Celin SE, Snyderman CH, Kassam A, Hegazy H: Endoscopic repair of acquired encephaloceles, meningoceles, and meningo-encephaloceles: predictors of success. *Skull Base* 12: 133–139, 2002
- 
- Address reprint requests to:* Akihiro Hirayama, MD, Department of Neurosurgery, Tokai University Hachioji Hospital, 1838 Ishikawa-machi, Hachioji, Tokyo 192-0032, Japan.  
*e-mail:* a-hira@is.icc.u-tokai.ac.jp