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Image-guided neuronavigation assisted endoscopic repair of CSF rhinorrhoea: an institutional experience

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Keywords
CSF rhinorrhoea, Neuronavigation, Endoscopic repair, Skull base defect, Image-guided surgery

ABSTRACT

Background: Cerebrospinal fluid (CSF) rhinorrhea occurs due to communication between the intracranial subarachnoid space and the sinonasal mucosa. It could be due to trauma, raised intracranial pressure (ICP), tumors, erosive diseases, and congenital skull defects. Some leaks could be spontaneous without any specific etiology. The potential leak sites include the cribriform plate, ethmoid, sphenoid, and frontal sinus.

Methods: We retrospectively reviewed the medical records of 26 patients who underwent endoscopic repair of CSF rhinorrhoea with image-guided neuronavigation (IGN) between 2018 and 2021. The IGN system used was the easyNav. All patients underwent preoperative computed tomography (CT) scanning and magnetic resonance imaging (MRI) to identify the site of the CSF leak.

Results: The mean age of the patients was 42 years (range, 22-67 years). The most common cause of CSF rhinorrhoea in our study was spontaneous leak (n=12), followed by post-traumatic leak (n=8) and post-operative CSF rhinorrhoea (iatrogenic) (n=6). The most common site of the leak was the cribriform plate, followed by the ethmoid roof, followed by the frontal sinus. The mean operative time was 128 minutes (range, 60-240 minutes). There were no intraoperative complications. Postoperatively, one patient developed meningitis which recovered with antibiotics. All patients had complete resolution of their CSF rhinorrhoea at follow-up.

Conclusion: IGN is a safe and effective technique for the repair of CSF rhinorrhoea. It allows for accurate localization of the leak site and facilitates a minimally invasive approach to the repair.

INTRODUCTION

Cerebrospinal fluid (CSF) rhinorrhea is defined by a channel between the intracranial subarachnoid space and the sinonasal mucosa. The CSF can escape into the nose due to a weakness in the anterior cranial fossa through the frontal sinus, ethmoid sinuses, sphenoid sinuses, or the cribriform plate. CSF rhinorrhoea is caused by multiple etiologies such as traumatic, iatrogenic, spontaneous, and congenital. The majority

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of cases are seen due to head trauma or iatrogenic injury [1,2]. CSF leaks can be secondarily observed in raised intracranial pressure (ICP), erosive cancerous diseases, and in the event of congenital skull base weakness. Such leaks can be spontaneous too, without any major cause.

Major traumatic CSF leaks usually heal with conservative management, while those with persistent CSF rhinorrhoea may require definitive treatment. The meningitis risk is approximately 10% annually in untreated patients [3].

Persistent CSF rhinorrhoea requires definitive treatment. Several methods have been developed for the treatment of CSF rhinorrhoea, ranging from conservative management to craniotomy to endoscopic approaches. Over the last few years, transnasal endoscopic techniques have been preferred to transcranial approaches in the surgical management of CSF rhinorrhea. Recently, image-guided neuronavigation systems have become popular in neurosurgery.

In our study, we describe the repair of CSF rhinorrhoea using an image-guided neuronavigation transnasal endoscopic approach.

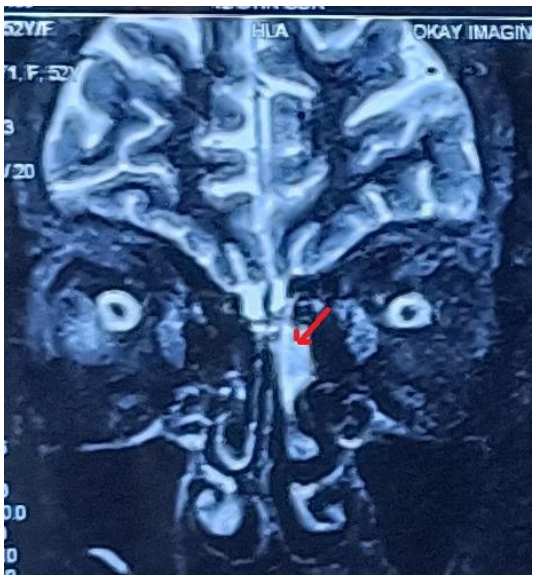
Material and Methods

This is a retrospective study carried out on 26 patients with CSF rhinorrhoea who were admitted to Neuro Care Hospital from 2018 to 2021. All cases were analysed with regard to thorough history, leak duration, mode of onset, aetiology, and history of meningitis. Nasal secretion was collected and sent for glucose concentration analysis. β2-transferrin testing was not available in our department. All patients had a computed tomography (CT) scan and CT cisternogram with magnetic resonance imaging (MRI) cuts for detection of the leak site. The navigation system was used in every case. All operations were performed with proper endoscopic surgical equipment.

Surgical Procedures

After obtaining written informed consent for image-guided endoscopic surgery and explaining the pros and cons of the procedure, the patient was shifted to the operation theatre. After anesthetic induction, patients were placed in the supine position with the head tilted toward the surgeon. Registration was performed in the neuronavigation system. Each neuronavigation system follows the same steps for the surgical procedure: (1) obtaining preoperative images (CT, MRI) (Figure 1) and images can be transferred to the navigation system via a computer network; (2) patient registration (Figure 2); (3) intraoperative localization (Figure 3); (4) intraoperative control; (5) obtaining intraoperative images and fusion with preoperative ones; (6) visualization and surgery (Figure 4). After registration, the nasal cavity was packed with xylocaine- and adrenaline-soaked cotton patties. Endoscopic inspection was performed with a 0-degree telescope (Karl Storz). Conventional dissection was done to expose the defect area. The defect area was localized with the image-guided navigation system (easyNav, optical system).

Surgical instruments were traced in accordance with the reference arch fixed on the patient's head with the help of light-emitting diode (LED) arrays. The location of the tip of the instruments and a projected virtual trajectory were visualised on the computer, combined with the endoscopic view, giving a real-time experience during the procedure. After confirmation of the leak site, mucosal tissue was cleaned from the bony borders with the help of a microdebrider in order to allow close contact between the graft and the bone; thereafter, the defect was closed with fat and fascia harvested from the thigh, and fibrin glue. Nasal packing was done with Merocel. All patients stayed in hospital for 1 week postoperatively and were managed with antibiotics, stool softeners, and other required medicines. Nasal packing was removed on the 5th day.



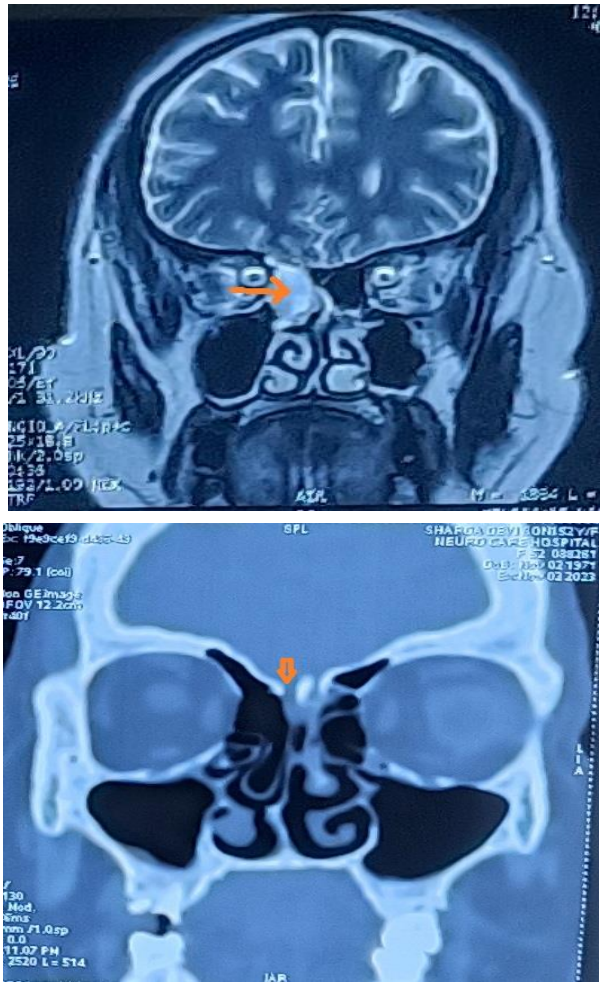


Figure 1. MRI T2-weighted coronal image showing CSF flow through a defect in the left cribriform plate (arrow) (A). MRI T2-weighted coronal image showing CSF leak through the right cribriform plate (B). CT PNS coronal image showing a defect in the right cribriform plate (C).

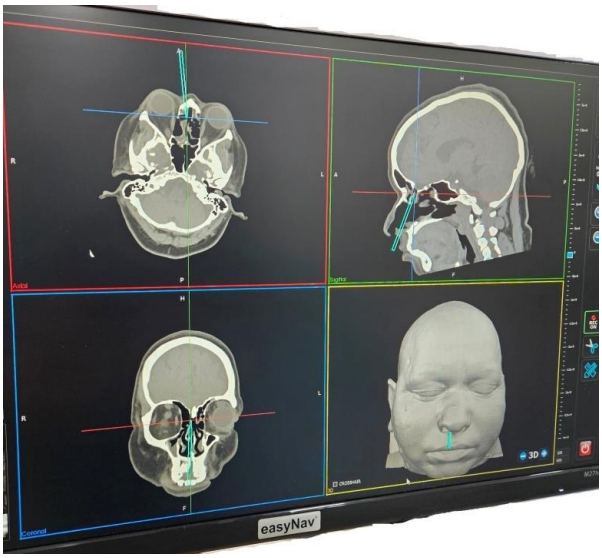
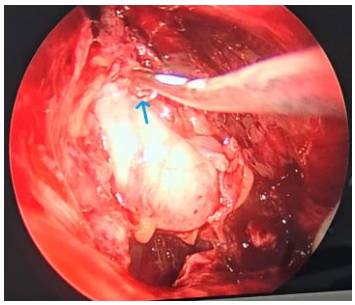
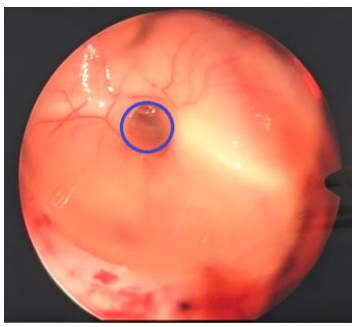


Figure 2. Preoperative patient registration and identification of the leak site during surgery. The screen provides real-time localisation of the instrument in 3D reconstructions of previously acquired CT images of the patient.

Figure 3. Intraoperative view. Surgeons using both the endoscope and the neuronavigation system.





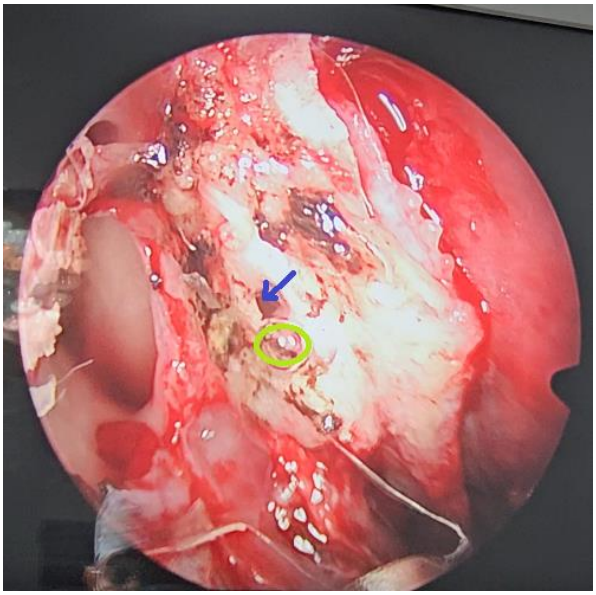


Figure 4. Endoscopic view of the dural defect (A and B). In (A), the blue arrow indicates the leak site and the green mark shows a CSF drop; in (B), the mark indicates the leak site. Closure of the defect with fat and fascia with fibrin glue (blue arrow indicates fibrin glue) (C).

Results

Demographics

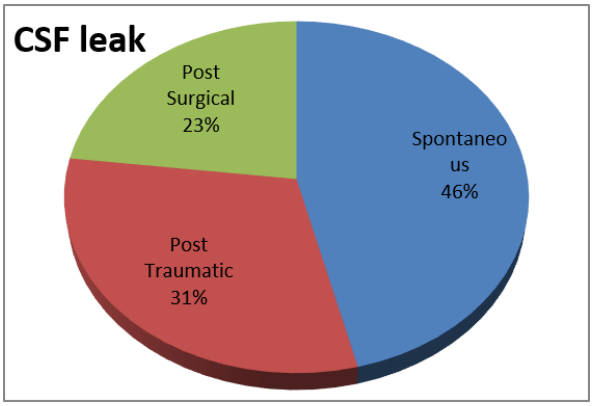
A total of 26 patients were enrolled in our study, of whom 16 were male and 10 were female. The majority of patients were between 40 and 50 years of age. The mean age was 42 years, with the youngest patient being 24 years old and the oldest being 64 years (Table 1).

Table 1. Age and sex distribution of patients.

Variable	Number (percentage)
Male	16 (61.53%)
Female	10 (38.46%)
Mean age (years)	42

Etiology

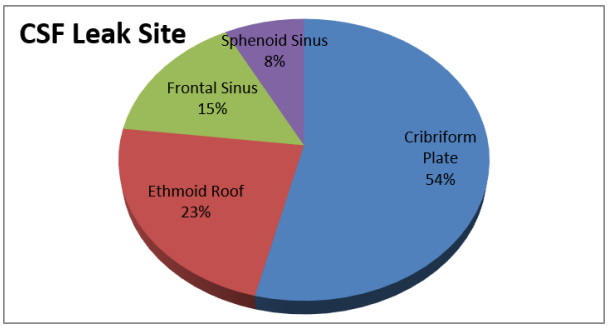
Twelve patients had a spontaneous CSF leak, while eight patients developed a post-traumatic leak and six patients had post-operative CSF rhinorrhoea (iatrogenic). Fourteen patients had right-sided CSF rhinorrhoea and 12 patients had left-sided CSF rhinorrhoea (Graph 1).



Graph 1. Etiology and laterality of CSF rhinorrhoea (n=26). Chart drawn by the editor from the figures reported in the text; author to verify or supply original chart.

Location

The defects were found most frequently at the cribriform plate in fourteen cases (53.84%), followed by the ethmoid roof in 6 cases (23.07%), the frontal sinus in 4 cases (15.38%), and the sphenoid sinus in 2 cases (7.69%) (Graph 2).



Graph 2. Site of the skull base defect (n=26). Chart drawn by the editor from the figures reported in the text; author to verify or supply original chart.

Complications

Nasal packing was removed on the 5th day. After this, patients were monitored for 3-4 days for any leakage. Postoperatively, one patient developed meningitis, which resolved with antibiotics. No recurrence of CSF leak occurred. A lumbar drain was not used in a single case postoperatively.

Pros and Cons of Neuronavigation

The use of this system requires extra surgical time, as additional time is needed to enter the patients' data into the workstation, upload CT/MRI images, match the patient with the acquired images, and calibrate the instruments. Approximately 30-40

minutes were needed for this. The mean operative time was 128 minutes (range, 60-240 minutes). The advantages of the system are that it localises the defect precisely and reduces peri- and postoperative complications, thereby increasing the success rate of surgery.

Follow-Up

In our study, the follow-up period was between 6 and 12 months, and no recurrence of CSF leak or other related complications was observed.

Discussion

There are multiple options for the treatment of CSF rhinorrhoea, including intracranial, extracranial, and endoscopic trans-nasal approaches. In the present era, the intracranial approach with a bifrontal or unifrontal craniotomy has limited value due to its higher complication rates, and thus this approach may be used only for larger bony defects or in cases of a damaged posterior frontal sinus wall. Postoperative intracerebral haemorrhage, anosmia, cerebral oedema, epilepsy, infection, and meningitis are the main complications. Hence, endoscopic trans-nasal management of CSF rhinorrhoea has become a popular method in recent years. The success rates of endoscopic management are high (90%) on the first attempt and up to 96% after a second surgical attempt [4,5]. This success rate was independent of the cause of the leak, defect size, material choice, and method employed [6,7].

Meningitis, chronic headache, pneumoencephalus, failure in fistula repair, or recurrence with signs of meningeal irritation have been reported as sequelae of endoscopic repair [5].

The surgical quality and prognosis of CSF leak repair have greatly improved through the combined use of neuroendoscopy and neuronavigation.

Image-guided neuronavigation is a valuable technology for the more accurate repair of CSF leaks. It helps in the precise localisation of the defect and reduces peri- and postoperative complications, thereby increasing the success rate of surgery. In our study, only one patient developed meningitis; apart from this, no other complications occurred, including leak recurrence or failure to identify the leak site. Although this is an excellent technique, it has some drawbacks, such as the cost of surgery, the extra time required for the procedure, and the fact that it is not a real-time technology. It is also noted that it does not reflect intraoperative anatomical changes.

Conclusion

Endoscopic CSF repair combined with image-guided neuronavigation is a safe and definitive method for the repair of CSF rhinorrhoea. It allows for accurate localisation of the leak site and facilitates a minimally invasive approach to the repair, despite its inherent limitations.

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