ORIGINAL ARTICLE

# Combined HRCT and MRI in the Detection of CSF Rhinorrhea

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## ABSTRACT

Cerebrospinal fluid (CSF) rhinorrhea is a potentially dangerous problem. Accurate preoperative localization of the site of leakage is mandatory. The standard diagnostic technique is computed tomography (CT) cisternography. Because of its related risks, however, various alternatives have been suggested. High-resolution CT (HRCT) provides good bony details, but fluid is poorly detected. In contrast, T2-weighted magnetic resonance imaging (MRI) shows CSF as a bright signal, but spatial resolution is poor as is the depiction of bony details. To overcome the shortcomings of both techniques, we superimposed the images obtained from each modality and used the result to plan surgical explorations. The sensitivity of HRCT was 88.25%. Fat-suppressed T2-weighted MRI detected a CSF-like density in 18 cases (90%) with a sensitivity of 88.88%. Superimposing the CTs and MRIs accurately localized the site of CSF leakage in 17 of 19 cases with a sensitivity of 89.74%. This finding compares favorably with the results of other techniques. We thus recommend this technique as the primary diagnostic method of choice for the investigation of patients with CSF rhinorrhea.

**KEYWORDS:** CSF rhinorrhea, high-resolution CT, MRI cisternography

Successful surgical repair of cerebrospinal fluid (CSF) leaks depends on accurate preoperative localization of the site of the defect.[1,2] Several diagnostic techniques advocated for such localization can be notoriously difficult to perform. High-resolution computed tomography (HRCT) provides thin overlapping cuts in both the axial and coronal planes and enables good definition of bony structures. On plain CT scans, a CSF leak may appear as an opacification of a sinus, but this may be CSF, a mucosal reaction, a meningocele, or percolated CSF from a distal breach.[1,3–7]

CT metrizamide cisternography is considered to be the gold standard for detecting CSF leaks. Its detection rate ranges between 40 and 92%, and the leak must be active.[5,6,8] The modality is therefore unsuitable for patients with intermittent leaks. Furthermore, it is contraindicated in patients with

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high intracranial pressure and in those with spinal disorders. Its acceptability is low and accurate results are highly operator dependent.

Magnetic resonance imaging (MRI) cisternography depends on heavily T2-weighted sequences with fat suppression. CSF appears as a bright signal without the need to inject contrast media intrathecally. Furthermore, MRI details the intracranial anatomy and pathology in multiple planes within a relatively short time. The main disadvantage of MRI is its poor spatial resolution and lack of bony details.[3,9–11] Thus, CT and MRI seem to be complementary in the diagnosis of CSF leaks.[2,4,6,7]

This study was therefore conducted to determine the reliability of combining routine CT scans and MRIs to identify the site of CSF leakage to avoid the need for CT cisternography.

## MATERIALS AND METHODS

### Patients

This study included 20 patients (12 females, 8 males) with CSF rhinorrhea. Fifteen leaks were spontaneous, three were traumatic, and two were iatrogenic (age range, 1 month to 63 years).

### Methods

All patients underwent a full otorhinolaryngological history and examination to determine the presence of CSF leakage. All suspected fluid was collected and tested for glucose and β2-transferrin.

All patients underwent HRCT in axial and coronal planes. A 3-mm axial and coronal bone window study and a noncontrast MRI with T1-, T2-, and fat-suppression heavily T2-weighted sequences were obtained. A CT metrizamide cisternography study was available in 12 patients. Selected relevant CT and MRI cuts were scanned and stored on a personal computer and processed with commercial graphics software (Micrografix Picture Publisher v.8). CT cuts were reviewed for areas of defective bone. If a defect was found in two contiguous coronal cuts, it was suspected as being the site of leak. The presence of a fluid-like density in a sinus on both axial and coronal scans was considered to be corroborative evidence that the site was most likely the site of leakage.

CT cisternography depicted the site of leakage in 10 of the 12 patients (83.3%). Coronal T2-weighted MRIs that showed a CSF-like density in the nose, sinuses, or both were selected. Such sequences showed a marked difference in density between CSF and the surrounding bony and soft tissue structures.

The graphics software was used to apply a narrow-range detection tool to delineate areas of similar densities. A false color fill was applied for clarity. Selected relevant CT cuts and MRIs were resized and referenced. The main references were the optic nerve, crista galli, and basal attachment of the middle turbinate. The CT scan was used as the base picture and the MRI cut was superimposed on it. These composite pictures were reviewed and correlated with intraoperative findings.

## RESULTS

A bony defect was detected on the HRCTs of 15 of 20 patients. In all cases fluid-density opacification of the multiple sinuses could be seen even if the bony defect was not depicted.

On T2-weighted MRIs, the continuity of a CSF-like density could be traced intracranially in 18 of the 20 cases.

In all cases the suspected site of the leak was explored endoscopically. In 19 cases a leak was detected and sealed. The combined CTs and MRIs correctly depicted the site of the leak in 17 of 19 cases.

The most common site of CSF leakage was the junction of the cribriform plate, fovea ethmoidalis, and perpendicular lamella of the middle

**Table 1 Sites of CSF Leakage**

| Site | No. of Leaks |
|---|---|
| Fovea ethmoidalis | 11 |
| Cribriform plate | 5 |
| Sphenoid sinus | 3 |
| Frontal sinus | 1 |

turbinate (Table 1). The leak was continuous in 15 cases and intermittent in 5 cases.

The sensitivity of HRCT was thus 88.25%. Fat-suppressed T2-weighted MRIs showed a CSF-like density in 18 cases (90%). In one case, however, the site proved to be a false-positive. No true leak was identified intraoperatively. In another case the leak was remote from the site suggested by the MRI. The sensitivity of MRI was therefore 88.88%. Superimposing the CTs and MRIs accurately localized the site of leakage in 17 of 19 cases with a sensitivity of 89.74%. In one case there was no leak. In the other case, the leak was more posterior than suspected from the combined study. In all 10 cases with positive CT cisternography, the combined CT and MRI pinpointed the site of leak.

## ILLUSTRATIVE CASES

### Case 1

A 55-year-old man had a long history of recurrent left-sided clear nasal discharge. One year earlier the patient had an attack of meningitis that was treated without considering the possibility of CSF rhinorrhea as the cause. A second attack of meningitis prompted the treating physician to investigate the cause. A CT of the sinuses showed a fluid-like density of the left ethmoids with a suspected defect at one level (Fig. 1). A T2-weighted MRI showed CSF percolating through the junction of the cribriform plate, fovea ethmoidalis, and middle turbinate (Fig. 2). Superimposition of both images accurately pinpointed the site of the leakage (Fig. 3), and the site correlated with the patient's intraoperative findings.

**Figure 1** CT scan showing thinning of the fovea and a fluid-like density in ethmoids.

### Case 2

A 59-year-old woman had a persistent bilateral watery discharge. A CSF leak was suspected. CT cisternography showed two suspicious areas of thinning of the cribriform region and contrast leaking on both sides (Fig. 4), especially on the right. T2-weighted MRI showed a CSF-like density at the right cribriform area (Figs. 5, 6). The right side was explored and the leak was repaired. At surgery no leak was found on the left. The patient has been free of CSF rhinorrhea for 3 years.

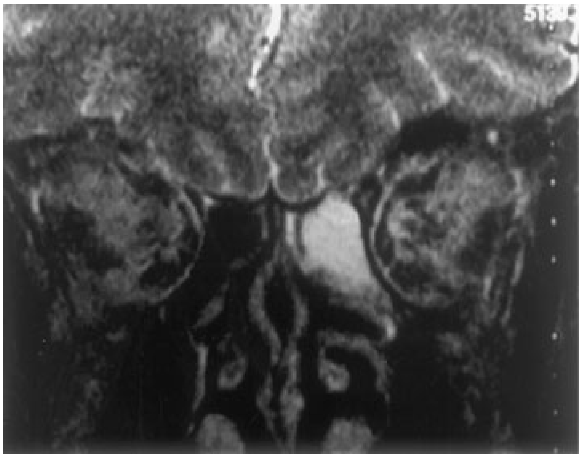

**Figure 2** Fat-suppressed T2-weighted MRI shows a CSF leak in the ethmoids.

**Figure 3** Composite picture showing the site of CSF leakage.

### Case 3

A 44-year-old woman had a 1-year history of right-sided CSF leakage. HRCT showed a defect of the right fovea at the junction of the perpendicular plate of the middle turbinate with a fluid-like density in the anterior ethmoid cells. T2-weighted MRIs showed a CSF-like density in the ethmoids and the presence of an empty sella but no fluid in the sphenoid sinus (Figs. 7, 8). Endoscopic exploration confirmed the presence of a meningocele in the anterior ethmoid cells with CSF leakage. There were no defects or leaks in the sphenoid-sellar region. The defect was repaired and the patient has been free of leakage for 6 months.

**Figure 4** CT cisternogram shows bilateral CSF leaks.

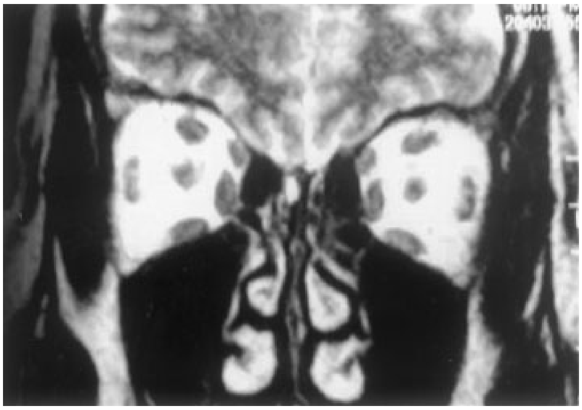

**Figure 5** MRI shows a CSF leak only in the cribriform plate.

## DISCUSSION

CSF leakage from the subarachnoid space to the frontal, sphenoidal, or ethmoidal sinuses can occur spontaneously.[12] Different techniques have been associated with various rates of success in locating CSF fistulas. Precise localization of a CSF fistula helps in surgical planning and enhances the chances of a successful dural repair. Coronal HRCTs of 1- to 2-mm thickness (with a bone algorithm used for better definition of the bony details) through the region of interest can accurately outline the bony details.[1,3–7] However, partial volume averaging can

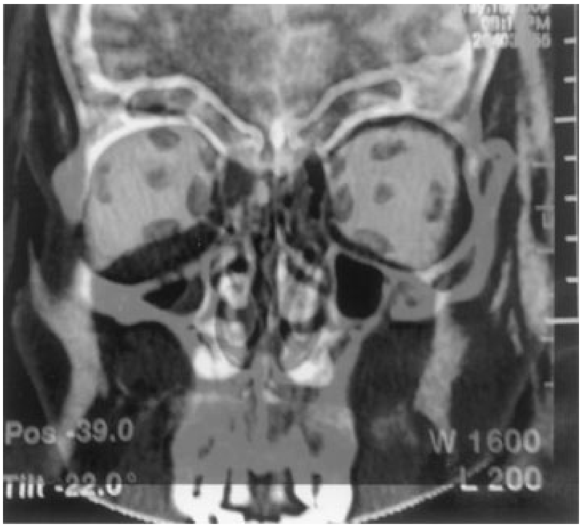


**Figure 6** Composite picture shows the exact site of leakage from the right cribriform area.

**Figure 7** (Top) Coronal T2-weighted MRI with false color rendering showing leakage from the fovea. (Bottom) Coronal CT shows thinning and a fluid-like density in the ethmoids.

cause both false-negative and false-positive findings. Inaccuracies can be minimized by using the thinnest sections possible but at the expense of a significantly higher radiation dose to the eye.[7,13]

CT cisternography is considered to be the standard of reference for the diagnosis of CSF fistula.[6] However, the technique is invasive, its acceptance by patients is low, and it has its own morbidity rates. The specificity and sensitivity of CT cisternography vary between 40 and 91%. However, MR cisternography can noninvasively demonstrate a CSF-like presence in multiple planes without the disadvantage of ionizing radiation. Its accuracy in patients with active CSF rhinorrhea is 86%.[6]

The primary disadvantages of MRI are its poor spatial resolution compared with HRCTs and the absence of bony details.

In this study we combined both techniques of HRCT scans and T2-weighted fat-suppression MRI techniques. Both are standardized, noninvasive, and readily available. The HRCT detected a bone defect in 75% of the cases. In two cases, however, the suspected bony defect did not correlate with the site of leakage. Fat-suppressed T2-weighted MRI detected a CSF-like density in 90% of the cases. One case proved to be a false-positive, and the leak was remote from the site suggested by the MRI in another case. Superimposing the CTs and MRIs accurately localized the site of leakage in 17 of 19 cases with a sensitivity of 89.74%. The correspondence between the results of the combined images and CT cisternography was 100%. The rate of detecting CSF leaks from the anterior skull base was acceptable with this technique, and invasive techniques were not needed. In this phase of the study the radiologist interpreting the images was unaware of the aim of the study. Sometimes the CT and MRI were even performed at different locations. Obtaining both CT and MRI sequences during the same session with fixed cross-referencing would facilitate selection of the relevant cuts to be evaluated.

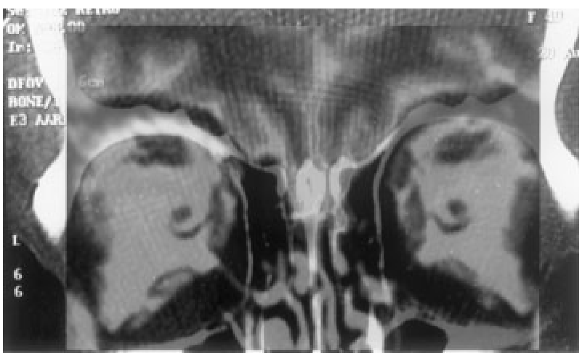

**Figure 8** Composite picture shows the exact site of leakage into the ethmoids.

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# Commentary

Drs. Mostafa and Khafagi have reviewed their experience with the detection of cerebrospinal fluid (CSF) rhinorrhea and have suggested that fusing high-resolution coronal computed tomography (CT) images of the base of the skull with highly fat-suppressed T2-weighted magnetic resonance imaging (MRI) sequences might offer the best of both worlds, marrying high spatial resolution with the ability to visualize the continuity of CSF. Their success in 17 of 19 patients is impressive. One has to remember that the gold standard of CT Omnipaque studies is not particularly comfortable for patients, and the false-negative rate is appreciable. However, one must be cautious about performing CT and MRI in close temporal proximity. Furthermore, the angulation of the cuts must be similar to maximize accuracy of the fusion. I suspect, however, that in a larger series a certain degree of inaccuracy and misleading changes in the paranasal sinuses would still be encountered. In such cases, one could always refer to an intrathecal CT study.

In summary, this article is a valuable addition to the literature. I intend to try this technique at my institution to see if we can replicate these encouraging results.

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