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Surgical decisions in the management of cerebrospinal fluid rhinorrhoea*

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SUMMARY *The surgical management of cerebrospinal fluid (CSF) rhinorrhoea has changed significantly after the introduction of functional endoscopic sinus surgery in the management of sinusitis. The clear anatomical exposure of the roof of the nasal and the sinus cavities by the endoscope offers the surgeon an opportunity to identify the area of the CSF leak, which enables one to adequately plan the treatment. The incidence of iatrogenic CSF rhinorrhoea has also increased, especially after the introduction of endoscopic sinus surgery. This study and presentation will analyze the various medical and surgical decisions that can be offered in the management of CSF rhinorrhoea from the authors' combined 10-year experience. The early identification of high-risk patients prior to surgery will be stressed including the various diagnostic options which are currently available in isolating the leak. The technique of endoscopic repair in the surgical management of the various leaks and the timing of the repair will be discussed in detail.*

Key words: cerebrospinal fluid, endoscopic sinus surgery, rhinorrhoea, complication, fibrin glue

INTRODUCTION

Cerebrospinal fluid (CSF) fistula is a potentially life-threatening condition. The most common causes of CSF fistula are traumatic, either due to head injury or as a result of intranasal or intracranial surgery. Non-traumatic fistula result from processes that cause increased intracranial pressure or destruction of the skull. The onset may be immediately following the injury or can occur years later. The incidence of CSF leak following endoscopic sinus surgery is reported as 0.07 (Kainz et al., 1989) to 0.9% (Stankiewcz, 1991).

The intracranial approach through a craniotomy was the first surgical technique used to repair anterior cranial fossa leaks. Extracranial approaches have subsequently become more popular. The introduction of endoscopic sinus surgery has added a new technique for closure of CSF rhinorrhoea. In addition, it has been found to be a safer approach to identify and repair leaks which occur intra-operatively during endoscopic sinus surgery.

Dandy (1926) described the first successful intracranial repair of a CSF leak and this approach became the route preferred by most neurosurgeons. The advantages of craniotomy are: (1) direct visualization of the dural tear, and (2) the exposure to inspect and treat any adjacent brain injury, which makes it an excellent choice for exploring an open wound that may communicate with the brain. Despite the excellent exposure there is still a significant recurrence rate.

Disadvantages of this approach are: (1) a poor view of communicating fistulas from the sphenoidal sinus to the anterior cranial fossa, and (2) bifrontal craniotomy to expose the base of the skull leads to anosmia from trauma to the olfactory bulb and cribiform plate area, along with cerebral oedema and occasional post-operative intracerebral haemorrhage. In a recent series, Ray and Bergland (1967) reported an initial rate of failure of 27%, with 10% having persistent leaks despite multiple craniotomies. Park et al. (1983) reported a success rate of only 60% in treating CSF rhinorrhoea through a craniotomy approach.

Dohlman (1948) described the first extracranial approach for repair of CSF rhinorrhoea. Calcaterra (1980) reported on a series of 19 patients with CSF rhinorrhoea successfully treated extracranially with free fascia grafts and mucoperiosteal flaps, and Hubbard et al. (1985) had an 88% success rate with extracranial repair in 17 patients. Yessenow and McCabe (1989) reported long-term results in 16 patients using an external eth-

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moidal approach with an osteomucoperiosteal flap of 100% closure. McCormack et al. (1990) reported on 37 patients with an 86% success rate of the initial procedure and an overall success rate of 97%. The major disadvantage of extracranial approaches is the inability to visualize post-traumatic brain damage or treat intracranial lesions. The external ethmoidectomy approach offers an excellent success rate and low morbidity for the repair of CSF rhinorrhoea.

Hirsch (1952) initially described the transnasal closure of sphenoid sinus CSF leaks. Vrabec and Hallberg (1964) and Lehrer and Deutsch (1970) subsequently reported successful cases utilizing the transnasal approach and advocated the use of an operating microscope. Wigand (1981) was the first to describe transnasal endoscopic visualization and repair of a CSF leak. Papay et al. (1989) reported on four patients with CSF rhinorrhoea who were treated using endoscopic localization and myofascial patch repair. Stankiewicz (1991) reported four cases of CSF leaks which were identified during endoscopic ethmoidectomy and repaired at surgery. Two other patients had delayed leaks which were identified and repaired endoscopically. Mattox and Kennedy (1990) reported successful repair of five CSF leaks through a transnasal endoscopic approach. The advantages of the endoscopic approach for closure of CSF leaks intra-operatively is in the clear identification of the site of the leak and satisfactory control in closure of the same. This report reviews our application of nasal endoscopy in the diagnosis and surgical repair of CSF rhinorrhoea. An algorithm for decision-making with intra-operative and post-operative CSF leaks is presented with a view to anticipate and avoid complications.

MATERIAL AND METHODS

This is a retrospective review of 16 patients who have been treated for isolated CSF rhinorrhoea over a period of eight years. All of the patients included in the series were evaluated both by an otolaryngologist and neurosurgeon prior to surgical intervention. The patients who belonged to the peroperative group of CSF rhinorrhoea were examined by the neurosurgeon in the post-operative period. The patients ages ranged from 18 to 65 years. There were nine males and seven females in the group. The patients who were included in this study underwent the surgical decision process as presented in the paper. The patients were radiologically imaged with 2-mm sections on the CT scan and the technique of lumbar puncture with drain insertion was the same in all patients. The endoscopic procedure for closure of the CSF leak was carried out by the senior author (VKA) following the principles of the Messerklinger's technique. The neurosurgical interventions for closure of CSF leaks were carried out by a bicoronal craniotomy approach. The fibrin glue used in the surgical procedure to augment a perfect seal was prepared by the Blood Bank of Greater New York. The procedure in the preparation of fibrin glue was standard and did not vary between patients who underwent surgery.

RESULTS

Sixteen patients with CSF fistulae were treated (Table 1). Seven patients were classified as spontaneous CSF rhinorrhoea with one pituitary tumour, four patients with head trauma, one patient with an encephalocele (Figure 1), and one patient with a nasocranial tumour. Four patients presented as per-operative leaks discovered at surgery. Five patients presented as delayed CSF fistulas. The cribiform plate was the most common site of the leak. In three of four of the per-operative leaks the predisposing surgery was complicated by an unusual pathology of mucocele or encephalocele while the delayed post-operative leaks followed standard endoscopic sinus surgery. Twelve of the patients were treated by endoscopic repair with a fascia graft placed in the dural defect and secured with fibrin glue or fibrin gel. Two patients were treated through an external ethmoidectomy approach and two patients underwent craniotomy. Follow-up ranged from 1 to 8 years and surgical treatment was successful in closing fifteen of the leaks during the first attempt. The one recurrence was associated with a pituitary tumour which required a second intranasal procedure for closure. More than half of the patients were prepared for the operating room by pre-operative placement of lumbar drains. All patients were placed on per-operative antibiotics (Ancef™ and Flagyl™). Complications included one patient who had a hemiparesis which resolved in 24 hours and one case of orbital cellulitis. There were no cases of post-operative meningitis. However, in one of the patients, CSF rhinorrhoea was associated with a subdural haematoma.

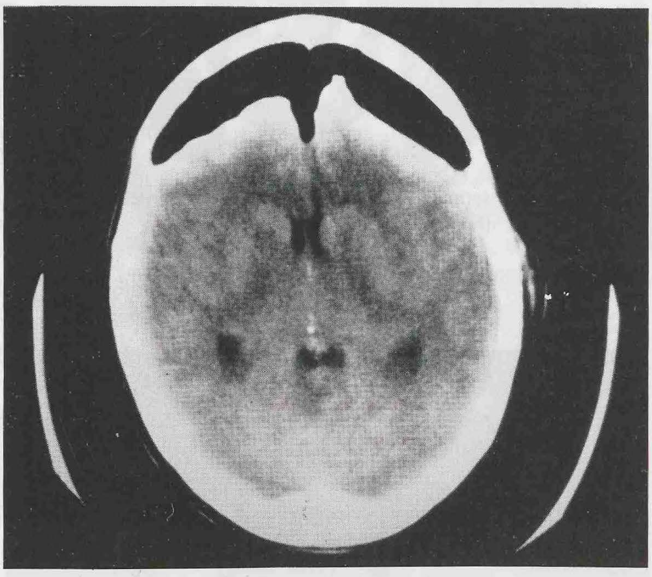

Figure 1. Axial CT-scan revealing air encephalocele in a patient associated with a CSF leak.

DISCUSSION

Clinical diagnosis

The usual form of presentation of CSF rhinorrhoea is a complaint of clear, watery nasal discharge with a history of head trauma or predisposing surgery. The symptoms may be exaggerated on flexing the body, straining, or lying down.

Biochemical analysis of the fluid will demonstrate high glucose and low protein levels which are typical of CSF. An analysis for ß-2 transferrin is the most reliable method for making the diagnosis as this protein is present in CSF and not in blood or nasal

Table 1. Clinical data of 16 patients with CSF fistulae.

case no.	age/sex	duration of leak	pathology	location of leak	diagnostic tests	type of closure	complications	lumbar drain	follow-up
1	31/F	per-operative	FESS/encephalocele	L: ant. cribriform plate	CT scan, MRI	endoscopic temporalis fascia+ fibrin glue	transient hemiparesis (24 hrs)	yes	2 years
2	26/M	per-operative	mucocele of left orbit	L: lamina dura	CT scan, MRI	external temporalis fascia	orbital cellulitis	yes	8 years
3	62/M	per-operative	left frontal sinus mucocele	L: lamina dura	CT scan	external temporalis fascia	none	yes	8 years
4	65/M	per-operative	FESS	L: post. cribriform plate	CT scan, MRI	endoscopic temporalis fascia + fibrin glue	none	no	3 years
5	64/M	1 year	FESS	L: ant. cribriform plate	CT scan, CT cisternogram, MRI	endoscopic temporalis fascia + fibrin glue	none	yes	2 years
6	29/F	1 year	FESS	R: lamina dura	CT scan, CT cisternogram	endoscopic fascia lata + fibrin glue	none	no	2 years
7	32?F	3 months	FESS	L: post. cribriform plate	CT scan, CT cisternogram, MRI	endoscopic temporalis fascia + fibrin glue	none	no	4 years
8	22/F	2 weeks	FESS	R: cribriform plate	CT scan, MRI, RISA	endoscopic temporalis fascia + fibrin glue	none	yes	1 year
9	38/F	4 weeks	FESS	R: lamina dura	CT scan, MRI	endoscopic temporalis fascia + fibrin glue	none	yes	2 years
10	48/M	spontaneous (3 months)	head trauma	L: ant. lamina dura	CT scan, MRI	endoscopic temporalis fascia + fibrin glue	none	no	1 year
11	18/M	spontaneous (2 months)	head trauma	L: ant. cribriform plate	CT scan, CT cisternogram, MRI	endoscopic temporalis fascia + fibrin glue	none	no	2 years
12	46/M	spontaneous (6 weeks)	pituitary tumor	sphenoid sinus	CT scan, CT cisternogram, MRI	endoscopic muscle/fat + fibrin glue	recurrence in 6 months	yes	3 years
13	38/M	spontaneous (24 hours)	head trauma	cribriform & R lamina dura	CT scan	craniotomy	subdural hematoma	yes	2 years
14	46/M	spontaneous (2 weeks)	osteoma of R ethmoid	R: cribriform plate	CT scan, MRI	craniotomy/ external ethmoid	none	yes	1 year
15	18/M	spontaneous (8 months)	encephalocele	R: cribriform plate & R lamina dura	CT scan, MRI	endoscopic temporalis fascia + fibrin glue	none	yes	3 years
16	23/F	spontaneous (2 weeks)	head trauma	R & L cribriform plate	CT scan, MRI	endoscopic temporalis fascia + fibrin glue	none	yes	1 year

secretions (Oberascher et al., 1986). Once the presence of a CSF fistula is established, it is necessary to localize the site of the leak through a radiological work-up prior to proceeding with surgical closure.

Radiological diagnosis

Radiological imaging is an integral part in the successful management of the identification of the site of CSF rhinorrhoea. The precise localization of dural defects in the anterior skull base and ethmoidal sinuses were identified by tomographic studies in the past in patients with head trauma. Intrathecal injection of contrast materials and radioactive tracers have been used to localize the site of leaks. Indium-111 and RISA are the most frequently used isotopes in the localization of CSF rhinorrhoea. The introduction of high-resolution CT scanning has revolutionized the state of the art in identifying the site of leaks (Figure 2). The application of metrizamide (Amipaque™) cisternography coupled with CT scan has been shown to identify up to 85% of the sites of CSF leaks (Nabawi et al., 1982). Digital subtraction fluoroscopic cisternography is recommended in patients where the above-mentioned techniques have been unsuccessful (Byrne et al., 1990).

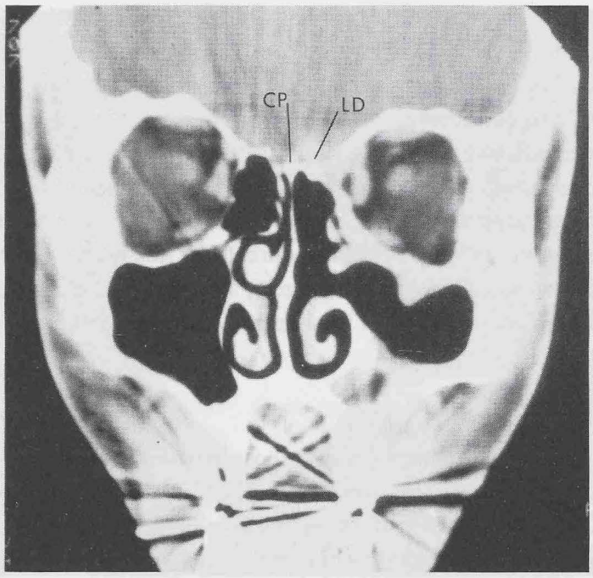

Figure 2. Coronal CT-scan following endoscopic sinus surgery revealing the site of a CSF leak, the cribiform plate (CP), and the lamina dura (LD).

Fluorescein diluted with a CSF solution to a 5% concentration has been found to be useful in localizing the site of leak endoscopically following an intrathecal injection (Mattox and Kennedy, 1990). There have been reported instances of neurological complications following intrathecal injection of fluorescein (Moseley et al., 1978) and metrizamide cisternography (Vincent and Zimmerman, 1980); these include numbness of the limbs, seizures, and opisthotonos in small number of patients.

Surgical technique

The surgical management of CSF rhinorrhoea is dependent on the location of the leak, the type of leak, and the timing of the diagnosis of the leak (Figure 3). Accordingly, the surgical management is reviewed based on our classification of leaks.

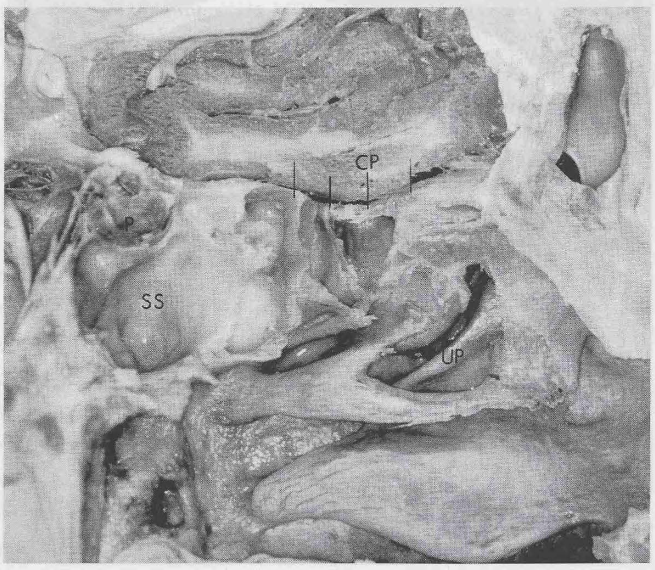

Figure 3. Sagittally sectioned cadaver demonstrating the anatomy of the cribiform plate (CP), the sphenoid sinus (SS) and the pituitary gland (P).

1) Spontaneous CSF rhinorrhoea:

This category of patient will include those with CSF leaks due to tumours, trauma, and idiopathic causes. The diagnosis of spontaneous CSF leak is usually confirmed by clinical examination of the patient and the radiological imaging. The aetiology of spontaneous leaks should be identified and appropriate treatment instituted for its repair. The most common site of spontaneous CSF rhinorrhoea is the cribiform plate of the ethmoid followed by the sella in the sphenoid sinus and the posterior ethmoidal sinuses (Figures 4–6). The localization of the leak will determine the surgical approach. The most commonly performed and reliable approach in our experience is the endoscopic approach and the external ethmoidectomy approach is a reliable alternative. The use of temporalis fascia with autologous fibrin glue is our treatment of choice. The bifrontal

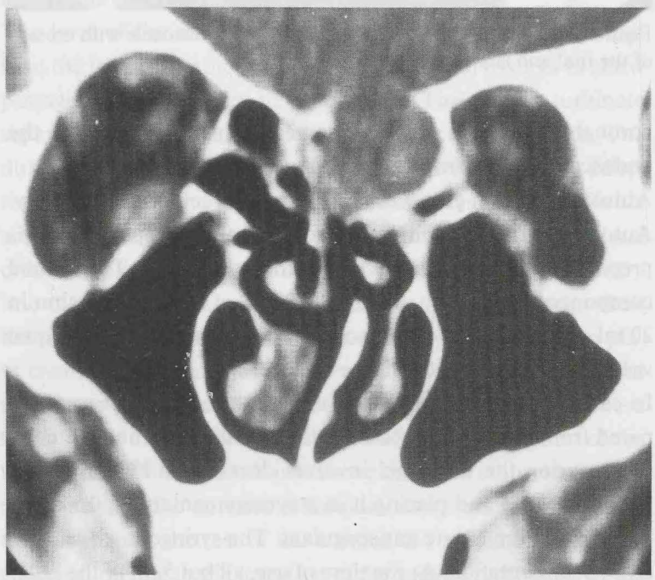

Figure 4. Coronal CT-scan of a mucocele of the ethmoid sinuses with erosion of the cribiform plate and CSF leak.

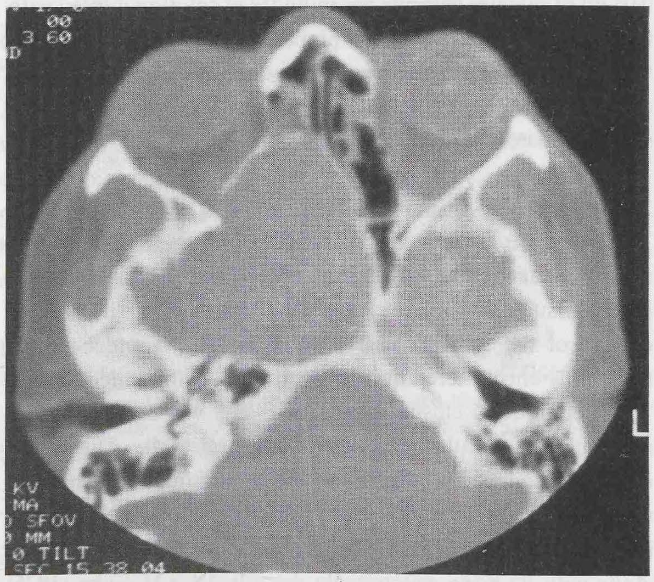

Figure 5. Axial CT-scan of a giant mucocele of the sphenoid sinus revealing erosion of the basiocciput and extending into the middle and posterior cranial fossae.

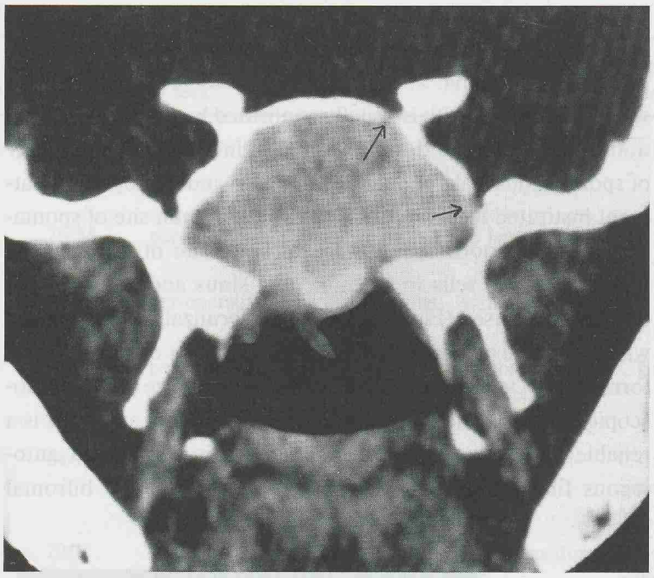

Figure 6. Coronal CT-scan of a sphenoid sinus mucocele with erosion of the roof and lateral wall (arrows).

coronal approach is usually reserved for patients who fail the endoscopic and ethmoidectomy approaches.

Autologous fibrin glue was prepared one week prior to surgery. Autologous cryoprecipitate is used as the first component and is prepared by the blood bank in a standard manner. The second component is made by mixing 20,000 IU of bovine thrombin in 20 ml of sterile water. The two components are applied in equal volumes evenly over the tissue surface.

In cases where fibrin glue was unavailable, fibrin gel was prepared from the patients blood intra-operatively. The technique of preparing the fibrin gel involves drawing 60-180 ml of the patient's blood and placing it in a syringe containing 0.5 ml of 46.7% disodium citrate anticoagulant. The syringe is set aside to allow sedimentation. At the time of use, all but 5 ml of the buffy coat of fractionated plasma is used.

A second syringe with 40 ml of bovine thrombin is mixed with 0.04 ml of calcium chloride per millilitre of solution diluted with normal saline. The fibrin gel is prepared by mixing the two solutions in a petri dish until the mixture obtains the consistency of a gel. This is either drawn into a syringe or used with gelfoam to seal the area of the dural leak.

2) Per-operative CSF rhinorrhoea:

This category of patients include those in whom the diagnosis is confirmed at the time of surgery when the CSF rhinorrhoea is clearly visualized and the procedure warrants an immediate closure of the same. This type of CSF leak would be most frequently encountered during an intranasal ethmoidectomy.

The technique of closure of the CSF leak will depend on the availability of vascularized tissue at the surgical site. The choice of using a pedicled septal flap or middle turbinate flap for closure of the dural defect should be carefully considered prior to implementing the closure. The use of middle turbinate mucosa along with its bone was initially described by McCabe (1976) and Montgomery (1973) has popularized the use of a pedicled mucoperiosteal septal flap. If the septal flap or the middle turbinate cannot be used due to limitations of size and the arc of rotation to the defect, the choice of a sandwiched temporalis fascia with gelfoam or fascia lata with gelfoam and fibrin glue should be considered.

In patients who are at high risk for CSF leak at the time of surgery, the surgeon can plan ahead and obtain fibrin glue from the patients plasma pre-operatively which will facilitate the closure of a leak at the time of the procedure. If the leak is encountered unexpectedly at the time of surgery, autologous whole plasma fibrin gel can be prepared intra-operatively for effective closure of the leak.

3) Delayed CSF rhinorrhoea:

This category of patients include those in whom the diagnosis is confirmed from a leak which developed either seven or more days following surgery or those in whom the leak was not diagnosed until the wound healing has ensued at the surgical site. Delayed leaks following endoscopic sinus surgery should be initially managed with conservative treatment. This management includes indwelling lumbar subarachnoid drain, bedrest with head elevation (Fowler's position), and nasal precautions. The medical treatment may include the use of Diamox and the treatment plan should be re-evaluated in ten days time prior to making a surgical decision.

The successful outcome in this category of patients will depend upon the accuracy of the localization of the CSF leak (Figures 7–9). The surgical technique for closure of these types of leaks is based on the location of the leak, the type of leak, and the patient's general condition. When the CSF leak has precipitated meningitis the underlying medical condition should be treated prior to the surgical closure of the leak.

The endoscopic surgical procedure can be carried out with a 0° or a 30° 4-mm endoscope under general anaesthesia. The surgical site is usually identified by endoscopic visualization as the intracranial pulsation at the site of surgery will be associated with the CSF leak. The edges of the leak site are freshened with a curette or forceps prior to closure of the leak as this will

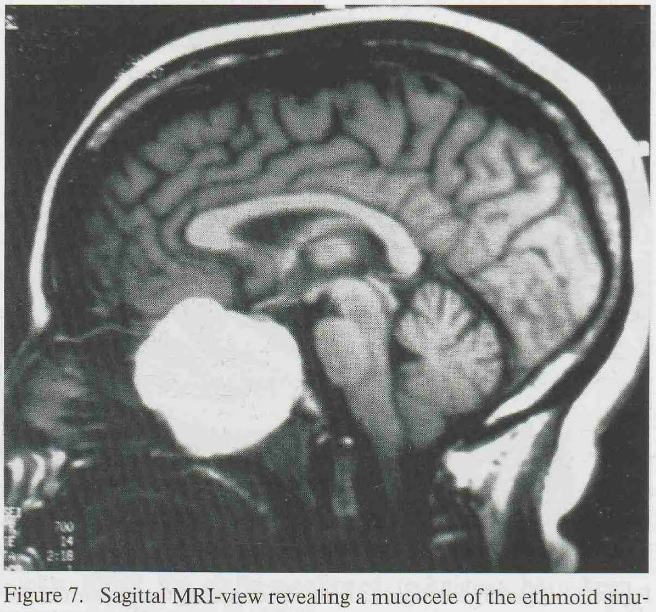

Figure 7. Sagittal MRI-view revealing a mucocele of the ethmoid sinuses with extension to the subdural space of the anterior cranial fossa.

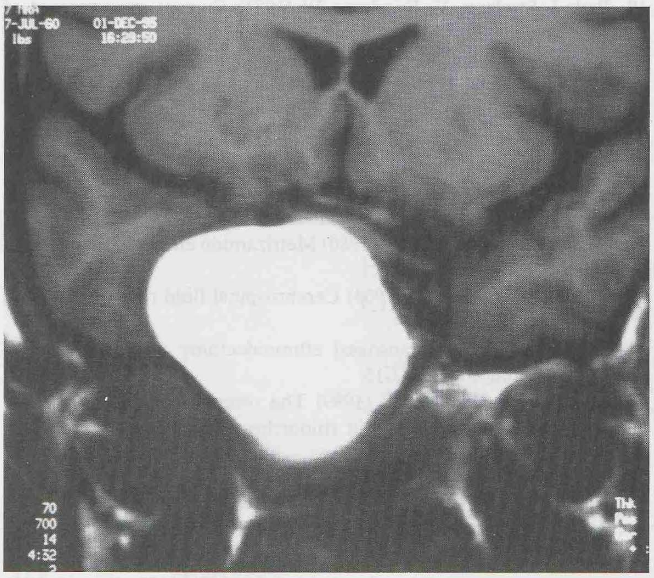

Figure 8. Coronal MRI-view of a sphenoid sinus mucocele extending into the cavernous sinus and anterior cranial fossa.

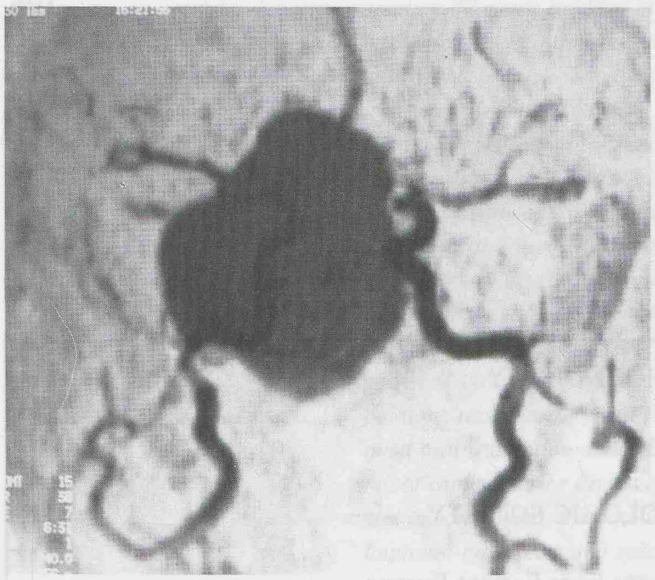

Figure 9. Digital subtraction MRI of a sphenoid sinus mucocele displacing the internal carotid arteries bilaterally.

enhance the healing process. The leaks were plugged with a tissue graft and fibrin glue. The grafts utilized were septal and middle turbinate flaps, temporalis fascia, and tensor fascia lata. Fibrin glue was applied to the graft edges after placement. In order to prevent profuse flow of CSF or obstruction of the leak by intracranial contents, a lumbar drain is instituted pre-operatively and may be followed by medicating with Diamox. At the conclusion of the closure with tissue and the fibrin glue, light nasal packing in the form of sterile xeroform gauze impregnated with an antibiotic ointment is left in place to support the closure site. This packing is removed on the 10th post-operative day under careful endoscopic visualization.

The patients are placed on intravenous antibiotics and are instructed on nasal precautions in the immediate post-operative period. The spinal drain is usually removed on the first or second post-operative day. The period of re-epithelialization at the site appears to be between 10 and 15 days. The graft site is inspected with an endoscope at weekly intervals until the wound heals satisfactorily.

The endoscopic or external ethmoidectomy approaches should be attempted prior to a craniotomy. In patients where the CSF leak can be localized pre-operatively autologous fibrin glue is prepared a week prior to surgery and used to augment the closure.

Successful avoidance of complications

The key in preventing CSF leaks during sinus surgery is in a thorough understanding of the endoscopic anatomy of the paranasal sinus and potential danger areas. CSF leaks resulting from endoscopic sinus surgery occur at the cribiform plate, the posterior ethmoid roof, the fovea ethmoidalis, the skull base above the anterior wall of the sphenoid sinus, and the roof of the sphenoid sinus (Hudgins, 1993).

The level of the cribiform plate is lower and the bone thinner than the fovea ethmoidalis. It is perforated with fissures to allow passage of the olfactory nerve endings. The middle turbinate separates the fovea ethmoidalis from the cribiform plate. The dura at the cribiform plate and fovea ethmoidalis is very adherent and if the bone is penetrated the chances of a CSF fistula are high. The insertion of the middle turbinate into the lateral cribiform plate at the point of the anterior ethmoid artery entry into the olfactory fossa is the weakest point in the anterior skull base. The olfactory nerve fibres pass through the cribiform plate creating potential sites of dehiscence which can result from traction or torque on the middle turbinate and tearing of these fibres. The other important areas include the lowest point of the fovea ethmoidalis which is just above the bulla ethmoidalis and the bone near the anterior ethmoidal artery where the bone is thinner than in the rest of the ethmoidal roof. The endoscopic approach medial to the insertion of the middle turbinates, in the vault of the nasal cavity should be discouraged, as minimal bony trauma at this site has been known to induce CSF rhinorrhoea.

CONCLUSION

The use of nasal endoscopes in sinus surgery is widely accepted, and the experience in the endoscopic approach for closure of CSF fistulas is growing. As demonstrated by this series, the endoscopic approach offers the advantage of clear identification of the source of the leak and satisfactory closure with a low morbidity. This technique has proven to be a safe and successful approach for closure of CSF rhinorrhoea.

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