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Endonasal endoscopic repair of anterior skull-base fistulas: the Kuala Lumpur experience

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Abstract

The purpose of this retrospective study is to determine the pattern of cerebrospinal fluid (CSF) rhinorrhoea presenting to our tertiary referral centre in Kuala Lumpur and to assess the clinical outcomes of endonasal endoscopic surgery for repair of anterior skull base fistulas. Sixteen patients were treated between 1998 and 2004. The aetiology of the condition was spontaneous in seven and acquired in nine patients. In the acquired category, three patients had accidental trauma and this was iatrogenic in six patients (five post pituitary surgery), with one post endoscopic sinus surgery (ESS). Imaging included computed tomography (CT) scan and magnetic resonance imaging (MRI). Endoscopic repair is less suited for defects in the frontal sinuses with prominent lateral extension and defects greater than 1.5 cm in diameter involving the skull base. Fascia lata, middle turbinate mucosa, nasal perichondrium and ear fat ('bath plug') were the preferred repair materials in the anterior skull base, whereas fascia lata, cartilage and abdominal fat obliteration was preferentially used in the sphenoid leak repair. Intrathecal sodium flourescein helped to confirm the site of CSF fistula in 81.3 per cent of the patients. Ninety per cent of the patients who underwent 'bath plug' repair were successful. The overall success rate for a primary endoscopic procedure was 87.5 per cent, although in two cases a second endoscopic procedure was required for closure. In the majority of cases endoscopic repair was successful, and this avoids many of the complications associated with craniotomy, particularly in a young population. Therefore it is our preferred option, but an alternative procedure should be utilized should this prove necessary.

Key words: Cerebrospinal Fluid; Nasal Cavity; Ethmoid Sinus; Sphenoid Sinus; Endoscopic Surgical Procedures

Introduction

Cerebrospinal fluid (CSF) rhinorrhoea involves a communication between the subarachnoid space and the nasal cavity. This causes a potential risk of ascending infection, resulting in meningitis in 9 per cent to 41 per cent of untreated fistulas which mandate surgical repair. The risk increases with the duration of the CSF leak.[1,2]

CSF rhinorrhoea can be either congenital or acquired. It can be acquired by trauma (iatrogenic or non-iatrogenic), by tumour, or spontaneously. Spontaneous fistulas can be subdivided further: primary cases where no underlying cause can be found, or they can be secondary to intracranial pathology (high or normal pressure). High pressure leaks include tumours, benign intracranial hypertension and hydrocephalus. Normal pressure fistulas are caused by tumours, congenital defects, infection, arachnoid granulations, meningo-encephaloceles and idiopathic conditions. Most CSF rhinorrhoea are secondary to head trauma with an associated skull base fracture, with only 3 to 4 per cent being considered spontaneous. The majority of the spontaneous cases occur in adults in the fourth decade of life, with females outnumbering males (2:1). The condition is perhaps more common than one would suspect, and a high level of suspicion is required in many cases for its detection. Cases of unilateral watery rhinorrhoea with evidence of reservoir sign[3] should not be treated empirically but need further investigation. The reservoir sign is a well known physical finding used to elicit rhinorrhoea. After being supine for some time, the patient is brought to an upright position with neck

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flexed. A sudden rush of clear fluid is indicative of CSF fistula. It is a useful method for collecting CSF for biochemical analysis.[3] Most of the CSF leaks are unilateral, and only one bilateral CSF leak has been reported by Ramsden *et al.*[1] A combination of diagnostic techniques, of which imaging is most important, may be helpful.[2]

Endoscopic techniques, introduced in the early 1980s, have been extended to investigation of the intracranial and orbital interface with the sinuses. Their advantages are of particular relevance to the paediatric and adolescent population in which an intracranial approach is associated with a significant risk of anosmia, intracranial haemorrhage, brain oedema and long-term epilepsy.[4–7] With the advancement of endoscopic techniques and powered instrumentation, the extracranial approach for CSF fistula repair is fast gaining popularity as endoscopic surgeons gain experience and confidence. The use of nasal endoscopes enables the surgeon to achieve a good visualization of the site of the fistula. Intrathecal sodium flourescein allows the precise endoscopic identification of CSF fistula with avoidance of unnecessary surgical trauma.

Endoscopic repair is less suited for defects in the frontal sinuses with prominent lateral extension and for defects greater than 1.5 cm in diameter involving the skull base. Only access to the skull base limits the use of an endoscopic approach; and when this is not possible, namely on the posterior wall of the frontal sinus or due to the extensive size of the frontal defect, an endoscopic approach may be combined with alternative routes to optimize visualization.

Hegazy *et al.* did a meta-analysis of previous studies and concluded that endoscopic technique has a success rate of 90 per cent after the first attempt and a 97 per cent overall success rate after the second attempt.[8]

The purpose of this study is to highlight the aetiology and site of the fistula, and to outline various graft techniques employed in fistula repair, with emphasis on the 'bath plug' technique.

Materials and methods

The authors retrospectively reviewed the clinical records of 16 patients who underwent endonasal endoscopic repair of the CSF fistula from October 1988 to September 2004 at the National University Hospital, Kuala Lumpur. The repair was performed by the senior corresponding author and the success was evaluated. Patients with CSF rhinorrhoea secondary to fistula from the mastoid region and those who had intracranial repair of the CSF fistula were excluded from the study.

The patients' demographic data, and information on the aetiology of the CSF rhinorrhoea, the role of imaging and other diagnostics tests, surgical techniques employed, and the role of lumbar drains, and post-operative complication data were collected and analysed.

A majority of the patients had positive reservoir signs and samples were taken to compare the glucose levels in the specimens to blood glucose levels to confirm CSF. Patients were supplied with a sterile container that was sent to the appropriate laboratory after collection of the CSF sample. The inability to collect sufficient (or any) secretion does not prevent a diagnosis, and therefore imaging techniques and intrathecal sodium flourescein localization are helpful.

The patient's nose was initially packed with ribbon gauze soaked in a mixture of 10 per cent cocaine and adrenaline 1:1000. Infilteration was performed with ropivacaine hydrochloride (Naropin) 7.5 mg/ml and adrenaline 1:100 000 concentration. The patients were skin tested with 2 per cent sodium flourescein eye drops one day before surgery. Pre-operative intrathecal sodium flourescein is useful for diagnosis when imaging is not of much help. A lumbar drain was inserted on the day of surgery, and intrathecal sodium fluorescein 10 per cent (0.1 ml in 10 ml of CSF) was given as a slow bolus over 10 mins to identify the site of fistula. The patient was observed in the recovery area in the reverse Trendelenberg position for approximately 45 mins to an hour. The patient then returned for general anaesthesia to undergo endoscopic surgery. CSF leakage was confirmed endoscopically on noticing a bright yellow green fluid draining from the fistula. If the intrathecal sodium flourescein was not visualized then a Valsalva manoeuvre was performed with the help of the anaesthetist and blue light filter was used to give the sodium flourescein a yellow green colour.

The use of the endoscopes enabled the surgeon to achieve a good visualization of the site of the leak, by careful removal of the mucosa and fibrous tissue off the bone surrounding the defect, without significantly increasing the size of the fistula. The application of the sealing tissue was then performed under direct vision of the target area. For leaks from the superolateral wall of the sphenoid sinus, an approach via the endoscopic route transsphenoid ostia was used, but for leaks from the inferolateral wall a lateral approach via an ethmoid-sphenodotomy was beneficial.

The surgical techniques used include underlay ('bath plug' or fascia lata) and/or onlay of graft materials, namely perichondrium and/or cartilage and fat obliteration of the entire sphenoid sinus cavity if necessary. The material used in the fistula repair was fat from the ear lobe ('bath plug') in 10 patients, underlay fascia lata with fat obliteration of the sphenoid sinus in five patients, and middle turbinate flap and dural patch in one patient. The 'bath plug' technique performed by the senior author consists of the introduction of a fat plug with vicryl suture into the intradural space where, preferably, the dural defect is less than 15 mm. This technique should prevent high pressure from pushing the graft away from the defect.[11] The harvested 'bath plug' should ideally be three times the length of the fistula in order to establish a tight seal. The middle turbinate is usually preserved to help stabilize the repair and optimize nasal function. Encephalocele or meningoencephalocele, if present, is carefully removed with a microdebrider and the stump is cauterized with bipolar diathermy.

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TABLE I

DEMOGRAPHICS OF PATIENT PRESENTING WITH CSF RHINORRHOEA

Number	Name	Age	Sex	Race	Diagnosis	Procedure
1	M M	33	M	Indian	CSF leak post transsphenoidal pituitary surgery	Endoscopic repair of pituitary fossa leak (tensor fascia lata, abdominal fat)
2	Z A	39	F	Malay	Spontaneous CSF rhinorrhoea	Endoscopic repair (dural patch, mucoperiosteal septal graft, MT flap)
3	A N	47	F	Malay	Post trauma CSF rhinorrhoea	Endoscopic repair (bath plug technique with MT free graft)
4	Y S F	43	M	Chinese	CSF leak post transsphenoidal pituitary surgery	Endocscopic repair (tensor fascia lata, abdominal fat)
5	D V	53	F	Indian	Spontaneous CSF rhinorrhoea	Endoscopic repair (bath plug technique)
6	R I	43	F	Malay	CSF leak post transsphenoidal surgery	Endoscopic repair (tensor fascia lata, mucoperiosteal septal flap, abdominal fat)
7	L S H	26	F	Chinese	CSF leak post transsphenoidal surgery	Endoscopic repair (tensor fascia lata, mucoperiosteal septal flap, abdominal fat)
8	M S M	16	F	Chinese	CSF leak post transsphenoidal suprasellar cyst drainage surgery	Endoscopic repair (tensor fascia lata, mucoperiosteal septal flap, abdominal fat with cystoperitoneal shunt)
9	M	51	F	Indian	Spontaneous CSF rhinorrhoea	Endoscopic repair (bath plug technique)
10	R D	14	F	Kadazan	Spontaneous CSF rhinorrhoea	Endoscopic repair (bath plug technique)
11	N T	24	M	Indian	Post trauma CSF rhinorrhoea	Endoscopic repair (bath plug technique with MT free graft)
12	R A	38	F	Malay	Spontaneous CSF rhinorrhoea secondary to benign intracranial hypertension and empty sellar syndrome	Endoscopic repair (bath plug technique with MT free graft)
13	P D	35	F	Indian	Spontaneous CSF rhinorrhoea	Endoscopic repair (bath plug technique)
14	L S S	41	M	Chinese	Fronto-orbital and planum sphenoidale fracture with CSF rhinorrhoea	Endoscopic exploration and repair (bath plug technique with with MT free graft)
15	V D	37	F	Indian	Spontaneous CSF rhinorrhoea	Endoscopic repair (bath plug technique)
16	I F	59	M	Chinese	CSF leak post ESS for inverted papilloma	Endoscopic repair (bath plug technique with MT free graft)

M = male, F = female, MT = middle turbinate, CSF = cerebrospinal fluid, ESS = endoscopic sinus surgery

The size of the defect dictates the type of material used in the repair. It is helpful to place sealant in the form of tissel; followed by hyaluronic acid, which promotes healing and gets absorbed within two to three weeks. The Valsalva manoeuvre was performed to ensure the stability of the graft intra-operatively. A light nasal merocel pack is put in place for one to two days. Avoidance of sneezing or coughing, the use of stool softeners, elevation of the head, and bed-rest in the post-operative period are essential to give the graft time to heal. Close follow up is essential to evaluate the success of the repair.

Patients were assessed regularly for a minimum of six months and success was judged by the absence of watery rhinorrhoea or meningitis, and on the appearance of the repair site during nasal endoscopy.

Results

Sixteen patients were diagnosed with CSF rhinorrhoea and underwent transnasal endoscopic repair of the CSF fistula over a six-year period at our centre. The racial distribution consisted of four Malays, five Chinese, six Indians and one Kadazan (Table I). There were 11 female and five male patients with ages ranging from 14 to 59 years (mean 37.4 years). Of the acquired fistulas, nine were traumatic (six iatrogenic and three post head injuries) and seven occurred spontaneously in adult fat/obese women (Figure 1).

The presenting complaints were clear watery rhinorrhoea in 15 patients (93.8 per cent), an associated history of meningitis in four patients (25 per cent) and asymptomatic in one patient (6.3 per cent). The latter patient had a traumatic comminuted depressed fracture of the fronto-orbital region and underwent an emergency craniotomy and elevation of the skull fracture. A CT scan performed three days post-operatively showed fluid collection within the sphenoid sinus, with evidence of fracture of the plenum sphenoid, which was subjected to endonasal endoscopic fistula repair.

The aetiology of the CSF rhinorrhoea was post transsphenoid surgery in five patients (31.2 per cent), spontaneous in seven patients (43.7 per cent), accidental trauma in three patients (18.7 per cent) and post endoscopic sinus surgery (ESS) for removal of a large inverted papilloma with extension to the skull base in one patient (6.2 per cent), as shown in Figure 2. One patient with spontaneous CSF rhinorrhoea had underlying benign intracranial hypertension with empty sella syndrome, and who had a permanent lumbar peritoneal drain which was blocked. Of the patients who underwent post transsphenoid surgery, three did so for resection of pituitary micro-adenoma and two for drainage of a suprasellar cyst of the pituitary fossa.

Eleven patients had imaging studies performed. Three patients had the CT cisternography (CTC) performed, which was only positive in one, thereby confirming the site of the defect which correlated with intra-operative findings. The remaining eight patients had high resolution computed tomography

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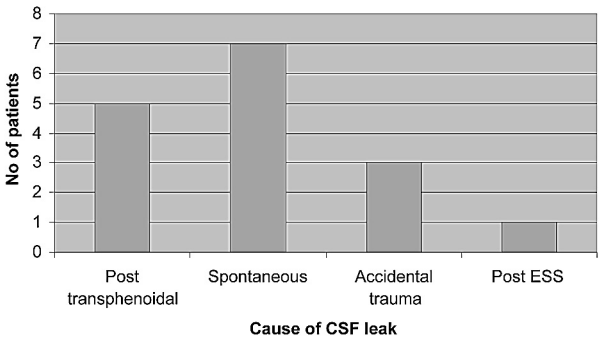

FIG. 1
Aetiology of cerebrospinal fluid (CSF) rhinorrhoea.

(HRCT) which was positive in two cases (25 per cent). In the rest of the patients and where the imaging studies were negative, intrathecal sodium fluorescein at the time of surgery helped in localizing the fistula site (Figure 3). Magnetic resonance imaging (MRI) was performed in one patient post ESS. Those who had no radiographic investigations were patients with post transsphenoid surgery, and the fistula was confirmed by nasal endoscopy with intrathecal sodium flourescein. The intrathecal sodium flourescein procedure helped to confirm and identify the site of the CSF leak in 13 patients (81.3 per cent).

In nine of the patients, the defect occurred in the sphenoid sinus region (56.3 per cent), and in the anterior skull base, involving the cribriform niche in five patients (31.3 per cent), and the ethmoid sinus roof, adjacent to the attachment of the middle turbinate or superior turbinate, in two patients (12.5 per cent) (Figure 4). Of the seven patients with spontaneous CSF rhinorrhoea, the defect was located in the sphenoid sinus in two patients (12.5

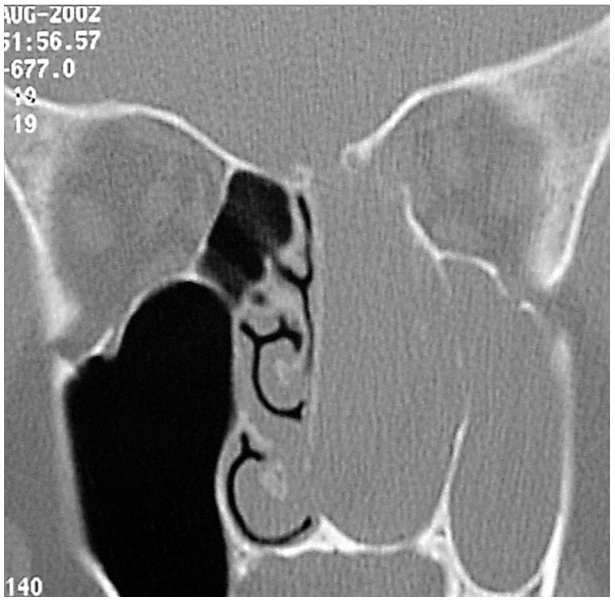

FIG. 2
Pre-operative coronal computed tomography (CT) showing unilateral opaque maxillary sinus and nasal fossa with obvious skull base defect which developed CSF leak immediately after endoscopic sinus surgery.

FIG. 3
Endoscopic view of right cribriform area showing right arachnoid cyst stained with sodium flourescein.

per cent), in the cribriform plate in four patients (25 per cent), and in the ethmoid roof in one patient (6.3 per cent). Patients diagnosed with spontaneous fistulas had evidence of congenital defects which were associated with encephaloceles and meningoencephaloces. The ages of the patients with spontaneous fistulas ranged from 14 years to 53 years (mean age of 38.1 years) at the time of referral. Of the three patients with a prior history of trauma, two had the defect in the sphenoid sinus and the other one in the cribriform plate. The sphenoid sinus fistulas occurred in post pituitary surgery (five patients), erosion within the lateral wall of pneumatized sphenoid sinus due to meningo-encephalocele (Figure 5) (two patients) and fracture involving the planum sphenoid (two patients). With one patient with post ESS the leak was from the roof of the posterior ethmoid sinus. Figure 4 shows the site of the defect in relation to its aetiology.

The size of the defect was recorded in 12 patients whilst these data were not available for the others. The size of defect ranged from 0.3 to 1.5 cm. A combination of graft materials was used to repair the defect in each case. The materials used were free grafts such as abdominal fat (31.2 per cent), turbinate mucosa and/or bone (37.5 per cent) and, less commonly, tensor fascia lata (31.2 per cent). A pedicled flap based on the nasal septum was used in

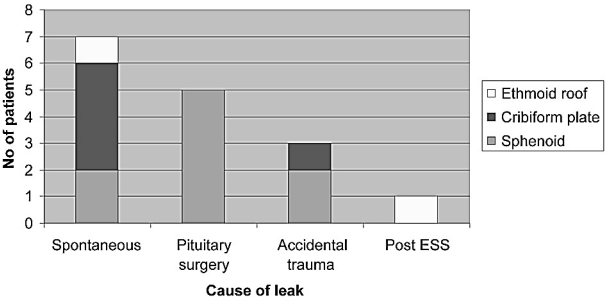

FIG. 4
Site of the crerbrospinal fluid (CSF) fistula.

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two cases. However most patients had more than one type of material used. Intra-operatively, these grafts were fixed using tissel in 13 patients (81.3 per cent). Surgical techniques varied, but the 'bath plug' technique was employed in 10 (62.5 per cent) of the patients. Nine of the 10 patients who primarily underwent 'bath plug' repair did so successfully (90 per cent).

Successful repair with primary endonasal endoscopic procedure was observed in 14 patients (87.5 per cent), including one patient who had a previous endoscopic repair performed elsewhere. The other two patients had secondary endonasal endoscopic repair which failed subsequently. Both were diagnosed with empty sella syndrome, based on CT scan findings, and one was associated with benign intracranial hypertension.

Patients were given peri-operative antibiotics which were continued for a week post-surgery. Lumbar drains were removed on days 3 to 6 (mean 4.2 days) post-operatively. No major complications were encountered, except for post lumbar headaches in one patient. The average follow-up period was 18 months (range from 6 to 72 months).

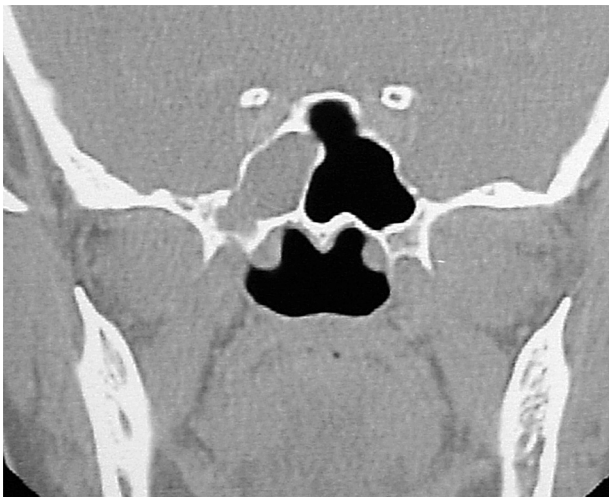

FIG. 5

A coronal computed tomography (CT) scan showing defect in the most lateral compartment of the opacified right sphenoid presenting with unilateral spontaneous watery rhinorrhoea which intra-operatively was diagnosed as meningoencephalocele.

Discussion

The most frequent cause of leakage is iatrogenic or traumatic, although this series included a significant number of spontaneous leaks occurring mainly in fat/obese women. It is likely that these cases represent a pre-existing defect in the skull base, which was unmasked by raised intracranial pressure accompanying the significant weight gain.

The aetiology of a CSF leak can be compartmentalized into traumatic and non-traumatic causes.[4,9] The traumatic causes can be due to accidental or iatrogenic trauma. Closed head injury from accidental trauma is related to CSF leaks in 1 to 3 per cent of patients.[10] The most common iatrogenic cause is post ESS and combined ENT neurosurgical procedures, namely transsphenoid pituitary surgery. In our series 56.3 per cent of patients had previous trauma, that is 31.3 per cent post transsphenoid surgery, 18.7 per cent post accidental trauma and 6.2 per cent post ESS. Non-traumatic causes for CSF leakage can be due to skull base tumours, congenital defects or the spontaneous type. Seven of our patients had spontaneous CSF rhinorrhoea pertaining to those with no possible aetiology for the CSF leak. There has been recent evidence of raised intracranial pressure in spontaneous CSF leakage. One of our patients with spontaneous CSF rhinorrhoea had benign intracranial hypertension with empty sella syndrome which proved difficult to treat. She was a middle-aged obese female with the commonly described symptoms of pressure headaches and CSF rhinorrhoea.[1,4,6]

The presenting complaint of patients with CSF rhinorrhoea is the presence of clear watery unilateral nasal discharge which worsens when stooping forwards or straining (93.8 per cent). These may have a history of single or repeated episodes of meningitis,[7,11] and a quarter (33 per cent) of our patients had documented meningitis. This is similar to previous reported rates of meningitis of between 9 and 41 per cent in untreated CSF fistulas.[12,13]

Clinical evidence of clear watery discharge when a patient bends forwards should raise the suspicion of CSF rhinorrhoea for the attending clinician. Further evidence by halo sign and endoscopic examination should further substantiate such a diagnosis. A sample of the fluid (0.5 ml) can be sent for β2-transferrin studies which are highly specific and cost effective.[4,6,15,16] Although this provides a means of confirming CSF leak it does not assist in localizing the site of the defect. β2-transferrin has become a diagnostic test for CSF fistula with a sensitivity nearing 100 per cent and specificity of 95 per cent. It was not available at our centre and we would like to state that it is not absolutely necessary. CT scanning is the primary imaging modality in the management of CSF rhinorrhoea. Fine-detailed coronal cuts of 1–2 mm thickness through the anterior skull base are preferable to minimize partial volume averaging, although axial cuts are occasionally required to assess the posterior walls of the frontal sinus. CT scanning with sections of 1–2 mm thickness through the anterior skull base was used to show small defects and fractures in this region. Although traumatic fractures and congenital defects may occur at any point in the skull base, the cribriform niche adjacent to the vertical attachment of the middle turbinate anteriorly and the superior and lateral walls of the sphenoid are the most common sites for congenital defects. Similarly the anterior skull base is the most frequent site for iatrogenic defects. The main drawbacks of CT scans are their high radiation to the lens, and the bony defect may not correspond to the site of dural tear. CTC, which used to be the gold standard, is fast being replaced by HRCT. HRCT scans have been advocated as the non-invasive radiological investigation of choice. In the

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presence of frequent or constant CSF rhinorrhoea, a CTC can be helpful in defining the exact site of leak. The disadvantages of CTC are that it is invasive and time consuming, and requires a lumbar puncture and intrathecal injection of contrast. The side effects include headaches, seizure and infection.[16] Studies have shown that HRCT has a sensitivity and specificity of 87 per cent,[15] and others have quoted an even higher sensitivity and specificity rate.[17] HRCT axial and coronal images should be able to detect most bony defects and the presence of pneumocephalus. In other cases it may show the collection of CSF in specific sinuses or evidence of mucosal oedema, which may suggest the location of such a CSF leak. CTC is more helpful with leaks in the sphenoid or frontal area, as these sinuses act as reservoirs in the case of persistent but not intermittent leaks. MRI is useful if soft tissue mass is present in the sinus to differentiate between mucosal oedema or tissue herniation such as meningocele or meningoencephalocele. It is not necessary in the setting of trauma as it does not image bone very well.[1,9,11,15,17] The role of MRI in the evaluation of patients with CSF fistula results from its superior demonstration of CSF and its continuity through dural fistula with the paranasal sinuses or the middle ear. It is non-invasive and has no radiation risk. However due to the inability of MRI to show bony defects, CT scan remains a useful adjunct.

In our series only those patients with CSF rhinorrhoea post transsphenoid surgery had their diagnosis confirmed by nasal endoscopy alone. The rest of them underwent either CTC or HRCT. Due to our small sample of patients we cannot determine which imaging was superior. However for those whose imaging studies were negative the use of intrathecal sodium fluorescein assisted in localizing the site of the defect intra-operatively.

Intrathecal sodium fluorescein is commonly used by endoscopic otolaryngologists for localizing skull base defects, although it has not received the US Federal Drug Administration (FDA) approval for such purposes. The same vial of intravenous sodium flourescein is routinely used by ophthalmologists for eye angiograms, which is FDA approved. Rainer *et al.*[19] studied 420 intrathecal sodium fluorescein applications and concluded that at concentrations of 5 per cent or less the side effects are transient. The complications of intrathecal sodium fluorescein seem to be dose-dependent. They reported two cases of grand mal seizures which could be secondary to a simultaneous intrathecal radiographic contrast medium.[19]

With the above technique, intrathecal sodium fluorescein gave an accuracy of 81.3 per cent. It not only confirmed previous positive radiological findings but also helped to localize the defect site where the pre-operative imaging was negative. Other centres practise a similar procedure for intrathecal sodium fluorescein and have obtained an accuracy of 92–96 per cent.[4,6,18,19] There were no associated major complications with the use of intrathecal sodium fluorescein in our study. One patient did complain of a throbbing headache which was attributed to low pressure headache subsequent to lumbar puncture. Complications such as numbness and weakness of the lower extremities, opisthotonus and seizures were usually related to high doses of intrathecal sodium fluorescein (>500 mg), rapid injection and suboccipital punctures.[23] At intrathecal sodium fluorescein doses of below 50 mg there is rarely any associated reaction.[4,18] The potential side effects of intrathecal fluorescein have been described[21] but the risk of these is negligible if a careful protocol is adhered to as described by a number of authors.[2,22] Intrathecal sodium fluorescein was combined with the endoscopic approach to repair the defect using a modified protocol quite similar to that described by Stammberger.[22] No complications occurred as a result of these pre-operative investigations but considerable caution should be taken to minimize the potential risks of this procedure. Complications are rare and related to impurities and usage of improper dosages. Mattox and Kennedy[23] recommended 0.2 ml of 10 per cent sodium flourescein, while Wormald and McDonough[11] recommended that 0.25 ml of 5 per cent concentration could be used safely for the procedure. The authors feel that 0.1 ml should be a safer dose for smaller stature Asians.[24] Intrathecal sodium flourescein can precisely locate the site of the fistula by illuminating the CSF in light greenish yellow. Sodium fluorescein may be detected in small fistulas associated with low intracranial pressure; and this may be enhanced by the use of a blue light filter, which is sensitive to dilutions of up to 1 in 10 million.

The precise pre-operative localization of CSF fistula is essential for surgical repair. The site of the CSF leak is often related to its aetiology. In traumatic leaks, the leak is usually at the cribriform plate and fovea ethmoidalis areas where the bone is thin. In post ESS, the lateral lamella, cribriform plate and posterior ethmoid roof is sometimes accidentally breached. In neurosurgical procedures CSF leaks may occur less commonly after transsphenoidal hypophysectomies.[9,25,26] In spontaneous leaks, a study done by Lopatin *et al.* on 22 cases showed that nine cases (40.9 per cent) had defects in the sphenoid sinus, and defects in the ethmoid and cribriform plate were present in six cases each (27.2 per cent).[12] In our series, nine out of 16 cases had sphenoid fistula (56.2 per cent). The size of the bony defect, degree of dural tear and associated brain parenchymal damage differ between accidental and iatrogenic trauma. Blunt trauma usually results in fine cracks in the skull bone whereas surgical trauma causes bigger bony and dural defects.[1,4]

Over the years many types of graft materials have been used to repair these anatomical defects. They can mainly be divided into pedicled grafts, and free grafts which may be simple mucosal grafts or composite grafts. These grafts may be laid individually or commonly in a multilayer fashion. Tissue adhesives such as tissel or fibrin glue have also been used to maintain the position of these grafts with or without degradable packing substance such as Gelfoam and Surgicel. The aim is to avoid displacement of the grafts during removal of nasal

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packing post-operatively. Many studies have shown that there are no statistical significant correlations between the success rate of CSF leak repair and the types of graft material, location or size of defect, aetiology and surgical technique.[4,17,27] Larger defects (usually more than 1.5 cm) may require onlay cartilage or bone in addition to underlay fascia lata.

Surgical techniques for the closure of defects can be employed by underlay or onlay techniques or by obliterating the affected sinus.[27] The general guideline is that once the defect is identified the surrounding mucosa should be stripped before the laying of grafting material because sinus mucosa contain mucus-producing glands which can lift the graft from the recipient bed.[10] In our series we used various types of grafting materials, usually in multilayers and fixed with tissue glue. When operating in the sphenoid sinus all of its mucosa is stripped, and once the defect is closed the sinus should be obliterated by fat. This is to prevent the formation of mucocele by any mucosal remnants. The 'bath plug' technique was performed in 62.5 per cent of our cases and was successful in 90 per cent of these cases after the first attempt. This technique employs the basis of an underlay of fat to plug the defect.[11] As with all underlay techniques the principle of use is advisable when there are no important structures such as cranial nerves or major vessels in the surrounding area of the defect, because the adjacent dura has to be freed and the graft laid between the dura and the inner surface of the skull bone.

A lumbar drain is routinely used by us in the management of CSF leaks and we had only one patient who suffered from spinal headache. No major complications were encountered. We practise judicious use of peri-operative antibiotics (ceftriaxone) for about a week or 10 days in all patients. Its prophylactic purposes outweigh the possible emergence of a resistant pattern. The lumbar drain is left in place for 2–4 days in the post-operative period. Its draining chamber is placed at the level of the tragus and the upper end of the patient's bed is elevated by 30 degrees. This reduces the intracranial pressure at the anterior skull base to encourage a seal and prevent displacement of the graft.[9] However, some authors did not use a lumbar drain in any of their cases and still achieved similar high success rates.[9,28,29] Therefore its role is still debatable and its use is a matter of surgical preference. However, others maintain that it is useful in patients with long-standing CSF fistulas since it may lead to high CSF pressures being generated post-operatively and hence an increase risk of failure.[23] Post-operative lumbar drain may be necessary in high pressure leaks or recurrent leaks. Many argue that a lumbar drain just lengthens the hospital stay and increases the risk of ascending meningitis.[6] Some authors advocate a drain for 24–48 hrs, particularly when lumbar puncture has been performed to instill fluorescein, with the recommendation that 10 to 20 ml of CSF should be run off when the graft is placed in position. In some individuals with congenital or long-established leaks, a lumbar peritoneal drain might be considered to offset an initial raised intracranial pressure, particularly if the leak recurs. Wormald and McDonough[11] recommend the use of a lumbar drain for a few days in an attempt to maintain a normal CSF pressure in patients who have choroid villi hypertrophy and are producing large amounts of CSF from ongoing long-standing chronic leakage.

There are no specific guidelines on the timing of surgical repair of CSF leaks. However it is sensible to repair such fistulas once the diagnosis is confirmed and the site of leak is identified. Such early repair should reduce the possibility of meningitis. However in cases of CSF leak due to accidental trauma a more conservative approach is preferred. This is because the majority of these cases should resolve by conservative management alone, i.e. by bed rest, head elevation and avoidance of straining within seven days of the trauma. Of those with persistent CSF leak, some should resolve with a lumbar drain, leaving a small percentage of patients needing surgical intervention.[9]

The risk of major complications from a transnasal endoscopic approach for CSF leak repair is less than 1 per cent.[11] These include meningitis, subdural haematoma, intracranial abscess and pneumocephalus.[8,14,15] We had no reported incidence of major complications in our series. The minor complications in our series included adhesions (12.5 per cent) and septal perforations (8.3 per cent).

The success rate of primary transnasal endoscopic CSF leak repair in our institution is 87.5 per cent, which is still a commendably high rate. The two failures we encountered were two female patients with spontaneous CSF leak with empty sella syndrome who still had recurrences after a second attempt. One of them had benign intracranial hypertension which raised the intracranial pressure with the defect in the sphenoid sinus. The other had right spontaneous CSF rhinorrhoea with the defect in the right cribriform plate, and later presented with left spontaneous CSF rhinorrhoea with a new defect in the left cribriform plate. Both patients refused a third surgical attempt. This correlated with the previous observation that benign intracranial hypertension with an empty expanded sella has a higher rate of recurrence than with other aetiologies.[4] Studies have noted that the presence of hydrocephalus, defects located at lateral extensions of the sphenoid sinus and the presence of high pressure hydrocephalus were significantly related to poor surgical outcomes. In cases of high pressure hydrocephalus ventriculoperitoneal shunt insertion are advocated at the time of endoscopic repair to improve the outcome.[7,13,27]

The endoscopic approach with its short hospital stay, minimal morbidity, preservation of olfaction and the possibility of revision by the same route, along with its limited disadvantages, is regarded by many as the 'gold standard' in the treatment of anterior skull base defects.

The overall success rate generally is in excess of 90 per cent, and in many cases approaches 100 per cent, although the follow-up times vary considerably.

Schick *et al.*[30] reported the longest follow-up series of 3–218 months (mean 67 months) with a success rate of 95 per cent. Generally failure occurs within the first year, usually within six months, and in some series the sphenoid sinus appears to be the most difficult area, perhaps for technical reasons.[31]

- **This paper describes a series of 16 patients presenting with anterior skull base CSF fistulas**
- **Intrathecal sodium flourescein helped to confirm the site of the leak in 81 per cent of patients. The technique and use of a lumbar drain in selected patients is discussed**
- **For anterior defects in the cribriform plate endoscopic repair with a 'bath plug' fat graft was preferred. Defects in the sphenoid sinus were repaired with cartilage, fascia lata and abdominal fat**

Conclusion

CSF leak requires a high index of suspicion for diagnosis. A detailed history, endoscopic examination and appropriate investigations are important to confirm the diagnosis. A less invasive endonasal endoscopic technique has become the standard approach for CSF fistula repair of less than 1.5 cm, with an excellent initial success reported in the literature, thus avoiding many of the complications associated with craniotomy, particularly in a young population. The precise surgical technique may vary, although with an equal success rate, but common features include clear endoscopic visualization and localization, proper selection of graft material and careful post-operative surveillance. The senior author's preferred option at his referral centre is the 'bath plug' technique for endonasal endoscopic repair of anterior skull base fistulas, although surgeons and patients must be prepared for alternative procedures should these prove necessary.

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