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The galea frontalis myofascial flap in anterior fossa CSF leaks

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SUMMARY. **We report the clinical use of galea frontalis myofascial flaps in the treatment of anterior fossa cerebrospinal fluid leaks after trauma. This flap provides an adequately sized and vascularised barrier between the cranial and nasal cavities through which the cells of the inflammatory response reach the target area. This technique was used in 9 cases with complete success; in 5 out of 9 patients, repair of an anterior cranial base bone defect was also performed with split calvarial bone grafts, harvested from the frontal craniotomy bone. In all patients, neither recurrence of the CSF leakage nor postoperative meningitis or its recurrence were observed.**

The aetiology of an anterior fossa cerebrospinal fluid leak can be classified as traumatic and non-traumatic.

Traumatic. Head trauma is a frequent cause of anterior fossa CSF leakage. Its incidence varies from 0.56–7%, according to the series, regardless of the presence of a skull fracture, but it doubles if a skull fracture is present.[1] Most of the skull fracture patterns are frontal and frontotemporal, although anterior fossa CSF leaks may occur with skull fractures in other locations. There is not always correlation of side between the fracture and the CSF leakage.[2] Traumatic anterior fossa CSF leak is more commonly located in the ethmoid sinus region rather than the frontal sinus region (ratio 3:1), although within the ethmoid region, the cribriform plate itself is less often fractured than the ethmoid sinus roof.[3] Maxillofacial injuries, such as Le Fort II and III fractures are commonly associated with CSF leaks, with or without direct cranial trauma:[1,5] cerebrospinal fluid rhinorrhea and pneumocephalus may accompany these fractures and if carefully sought are found in at least 25% of these injuries.[6]

Iatrogenic CSF leaks can also occur and cases related to removal of nasal polyps or middle turbinate during endonasal surgery, rasping the frontal sinus and removal of ethmoid-orbital osteomas, have been reported.[7]

Non-traumatic. Tumours are another cause of anterior fossa CSF leakage, either by direct erosion or a more distant effect from increased intracranial pressure.[8,9] Inflammation is a less frequent cause, as are osteomyelitis, influenza and arachnoiditis.[10]

Meningitis is a major risk of anterior fossa CSF leakage. Incidence varies from 8.6% to 41% of cases, if a CSF leak or intracranial air or both are present. Meningitis has been reported before the clinical onset of CSF leakage and may occur in the nonleaking phase of intermittent CSF leakage.[11] A delay in the onset of CSF leakage after trauma makes the risk of meningitis accompanying the leak 2–8 times greater than if the onset of CSF leakage is immediate.[12]

Meningitis may originate from a broad spectrum of bacterial agents; however, most adult cases are produced by *Diplococcus pneumoniae* or *Streptococcus* or *Staphylococcus* organisms, with *Neisseria meningitidis* and *Hemophilus influenza* seen less often.[13]

Other less frequent complications include haematomas, usually subdural, caused by the tearing of bridging veins when cerebral tissue collapses, as intracranial pressure is kept abnormally low by CSF leak.[11]

Management

Conservative. The basis for this approach is the possibility for spontaneous cessation of the leak. Some series give incidence of such spontaneous cessation up to 80%.[15] Most leaks stop within 14 days, but longer periods (up to 7 weeks) have been reported.[16] There is no consensus regarding the length of time to be allowed for cessation of CSF leakage. Some think that 1 week is reasonable, others have waited 4–8 weeks and others believe that immediate surgical repair is mandatory.[2] The use of a lumbar subarachnoid catheter for CSF drainage is very helpful in allowing closure of a CSF nasal fistula, particularly in post traumatic cases.[2]

In our unit, when a patient presents with CSF rhinorrhea, initial management is with positioning, with head and trunk elevation. If this measure alone is not enough to stop leakage in 24 to 48 h, a lumbar catheter for CSF drainage is inserted. Like other authors, we consider it safe to keep this in place for 10 days; if leakage persists after this period, surgery is considered. There are cases in which leakage stops with external lumbar drainage, but reappears some days later in a continuous or intermittent pattern; these patients are also considered for surgery.

Regarding maxillofacial injuries, an important point must be made that in the presence of Le Fort II and III fractures, early stabilisation should always be undertaken; it is now generally accepted that stabilisation of a mobile midface itself helps to prevent a pumping action and thereby reduces ingress of nasal secretion and infection through the dural defect and facilitates

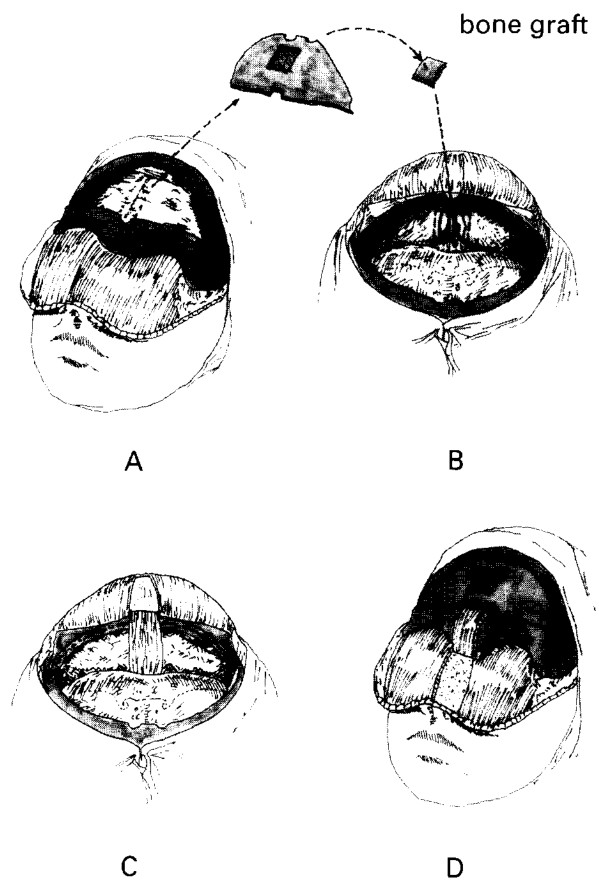

Fig. 1

Figure 1—Diagram showing the anatomical concept of the myofascial frontalis galeal flap, with or without calvarial split bone grafts, for the treatment of anterior fossa CSF leaks.

uneventful dural healing in the majority of cases of this type of injury.[17,18]

Intracranial surgical approaches. Successful intracranial repair has been credited to Dandy,[19] who sutured fascia lata grafts over bone defects. Others have also used fascia lata,[20] absorbable gelatin sponge and temporal muscle fascia.[1] Other methods have been used with different rates of success, such as the use of tibial periosteal graft,[21] pericranial fascia graft and iodine-soaked packs extradurally,[22] bone wax alone[23] and a portion of falx cerebri folded down and sutured.[24]

Since January 1988, based on the combined work of our Neurosurgical and Plastic Surgery Departments, we have evolved a surgical method for treatment of anterior fossa CSF leakage. A myofascial frontalis galeal flap can be distally based on the supratrochlear and supraorbital vessels, allowing transposition from an extracranial to intracranial position, so creating a vascularised barrier between the dura mater and the anterior fossa defect. In addition, in some of the clinical cases, calvarial bone grafts were harvested from the frontal craniotomy bone and modelled to fill the bone defect of the cribiform plate and adjacent regions (Fig. 1).

Material and methods

In this study, we include 9 patients (Table 1) with a history of previous head trauma. In all of them, an intracranial-intradural approach was performed, with transposition of a myofascial frontalis galeal vascularised flap. Repair of the skull base defect with calvarial bone grafts was performed as well in 5 of these patients. Three patients presented with evidence of CSF rhinorrhea after head trauma; all of these underwent CT head scan showing basal cranial fractures (Table 2). The remaining 6 patients showed no CSF leakage on admission, but presented later with meningitis. The time between cranial trauma and the onset of meningitis was quite variable, ranging from 3 months to 3 years. The causal microorganisms were *Pneumococcus* (5 cases) and *Haemolytic Streptococcus* (1 case). All of the 6 patients were treated with appropriate anti-

Table 1 Patient details

	Age	*Sex*	*CSF leakage at admission*	*Meningitis at admission*	*Time trauma-surgery*	*Bone graft*	*Follow-up*
Case 1	23	M	+		3 weeks		3.5 years
Case 2	21	M	+		3 weeks	+	2 years
Case 3	49	F	+		4 weeks		3 years
Case 4	22	M		+ pneumococcus	2 years	+	1.5 years
Case 5	20	M		+ streptococcus	3 months	+	1.5 years
Case 6	25	M		+ pneumococcus	1.5 years		3.5 years
Case 7	57	M		+ pneumococcus	3 years		1 year
Case 8	24	M		+ pneumococcus	2 years	+	1 year
Case 9	25	M		+ pneumococcus	6 months	+	1.5 years

Table 2 Patients with CSF leakage on admission

	Neuroradiological Investigation – C.T. scan	*Findings on Surgery*
Case 1	Bilateral frontal contusions Ethmoidal fracture	Bilateral ethmoidal bone defect
Case 2	Bilateral frontal contusions Multiple basal fractures	Right anterior cranial base bone defect
Case 3	Multiple basal fractures	Bilateral ethmoidal bone defect

Table 3 Patients with meningitis on admission

	Imaging techniques investigations *CTC – metrizamide cisternography*	*RIC – radioisotopic cisternography with TC99 albumin*	*Findings on surgery*
Case 4	Right ethmoidal CSF leak	Isotopic activity in both nasal fossae	Right cribriform plate bone defect
Case 5	Bilateral ethmoidal CSF leak	Isotopic activity in both nasal fossae	Bilateral cribriform plate bone defect
Case 6	Right ethmoidal CSF leak	Negative	Right cribriform plate bone defect
Case 7	Left posterior ethmoidal CSF leak	Negative	Left cribriform plate bone defect
Case 8	Negative	Isotopic activity in both nasal fossae	Left cribriform plate bone defect
Case 9	Negative	Isotopic activity in both nasal fossae	Bilateral cribriform plate bone defect

Fig. 2

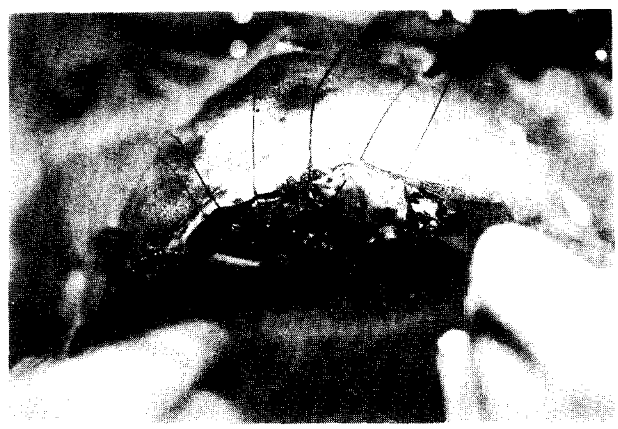

Fig. 3

Figure 2—After the extradural approach the floor of the anterior fossa and the bone defect (arrows) are clearly seen (case 4). **Figure 3**—After the intradural approach, the dural defect (arrows) is properly identified (case 5).

microbial drugs and at the time of surgery, none of them presented with any neurological deficit.

The 6 patients presenting without evidence of CSF leakage were submitted to CT scan in combination with metrizamide cisternography (CTC) and radioisotopic cisternography with TC 99 albumin (RIC) – (Table 3). It is important to note that in only two patients did these two examinations confirm the diagnosis of CSF leakage from the intracranial anterior fossa to the nasal fossa or perinasal sinuses. In two other patients, the diagnosis was established by CTC scan alone, with inconclusive RIC and in the remaining two cases, there was a positive RIC but a normal CTC. In all our cases, the presence of dural and skull defects was confirmed at surgery (Tables 2 and 3).

Surgical technique. The operative technique has seven main stages which can be clearly demarcated:

1. A bicoronal flap and a bifrontal craniotomy are used for surgical approach to the anterior fossa.
2. The bony defect is explored by an extradural approach.
3. The dural tear is defined by an intradural approach.
4. The dural defect is repaired with lyophilised dura.
5. The frontal sinus is cranialised by removal of the posterior wall and all mucosa.
6. The galeal flap is used to reinforce the dural repair.
7. If required the bony defect is corrected using an inner or outer table calvarial bone graft.

The intracranial approach to anterior fossa CSF leaks includes an extradural inspection of the anterior fossa floor and an intradural dissection for correct identification of the final dural defect. The extradural exposure of the anterior fossa is performed from lateral to medial and normally the dura separates easily, except in the paracribriform and cribriform areas, particularly in post traumatic cases (Fig. 2). There, it may be necessary to release by sharp dissection the dural projections from the cranial to the nasal cavities and a ragged dural defect is always created (Fig. 3). The intradural dissection is achieved via a formal dural opening transversely and enables ligation of the superior sagittal sinus and retraction of the frontal lobes, which allows identification and dissection of the posterior aspect of the dural defect. The dural defect is then repaired with lyophilised dura and interrupted sutures are placed around the dural defect, in order to create a watertight closure. The frontal sinus is cranialised by removal of its posterior wall and mucosa.

If the anterior fossa cranial bone defect is small, a galeal frontalis myofascial flap is raised and transposed. The flap is raised from the deep aspect of the

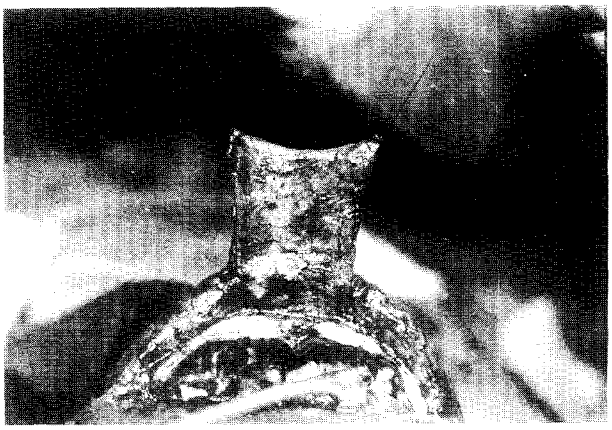

Fig. 4

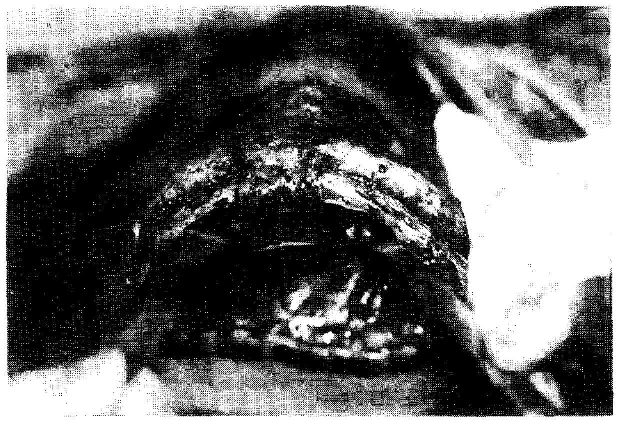

Fig. 5

Figure 4—Harvesting of the galeal frontalis myofascial flap (case 6). **Figure 5**—The transposition of the myofascial flap from extracranial to intracranial - extradural environment (case 5).

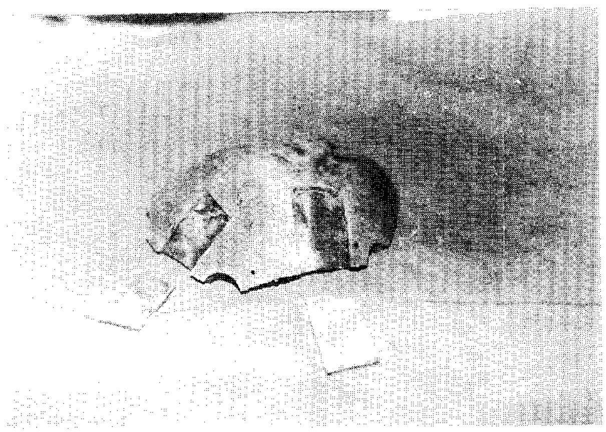

Fig. 6

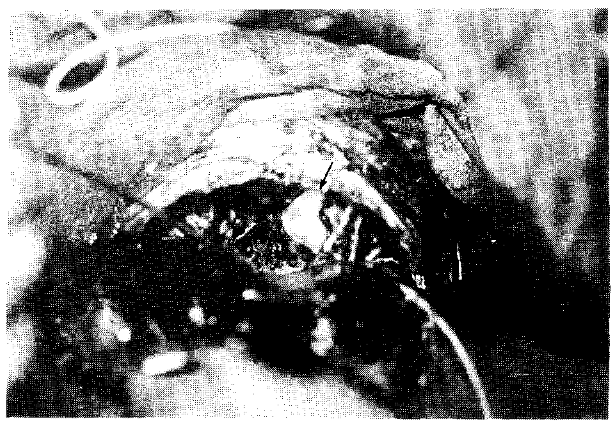

Fig. 7

Figure 6—Harvesting of the outer table split bone grafts from the frontal craniotomy bone (case 4). **Figure 7**—Bone graft (arrow) for reconstruction of the right anterior cranial base defect (case 2).

bicoronal flap. Two longitudinal myogaleal incisions are performed about 6–8 cm apart, until the subcutaneous tissue is visualised and by sharp knife dissection, the myofascial flap is carefully raised, including the supraorbital and supratrochlear vessels (Fig. 4). After careful haemostasis, the muscle flap is ready for transposition to the anterior cranial base, normally through a slit-type bone window created in the frontal bone flap (Fig. 5).

However, if the anterior cranial base bone defect is considered large (more than 5 mm width), a split thickness bone graft is harvested from the frontal craniotomy bone flap (Fig. 6). After careful modelling of the bone graft, its fixation is usually possible by finger pressure (Fig. 7). Then, the frontalis myofascial flap is performed as described above. Although we have been using an outer table cranial bone graft, the contour defect of the frontal bone has not been a problem.

The transverse dural incision is closed with continuous non-absorbable suture, transcutaneous intradural and extradural drains are inserted, the frontal bone flap is repositioned and fixed and all wounds are closed.

Follow-up

The time of follow-up was between 1 and 3.5 years. We have observed neither recurrence of CSF leakage nor any episode of meningitis.

Discussion

The intracranial surgical approach is the method of choice for treatment of anterior fossa CSF leaks; it gives a wide exposure of the anterior cranial base, transforming an inaccessible area to an easily accessible one and enabling the surgeon to perform the necessary extra and intradural dissections to identify the dural defect which can be properly repaired.

Whitaker *et al.*[25] considered CSF rhinorrhea following transcranial surgery as a dangerous complication with a high risk of meningitis. Dural tears and CSF leaks have also long been implicated as strong associates of meningitis and David *et al.*[26] recommended that in conditions requiring transcranial surgery, all dural tears be meticulously repaired, the preferred method being to insert a generous graft of lyophilised dura, temporal fascia or pericranium into the subdural space and suture the margins of the tear to this graft. Jackson[27] has recommended the use of free vascularised flaps of omentum for large cranial base defects and it has been stated[28] that the single most effective step to reduce the incidence of infections in transcranial cases was use of the vascularised galea frontalis myofascial flap. This flap is easy and quick to elevate, provides adequate size for nasal-cranial separation in most cases and leaves an inconspicuous donor defect. It can be used after the resection of skull base tumours and frontofacial advancements.

Following this, we have been using this flap as an anatomical and immunological barrier in the treatment of anterior fossa CSF leaks. Anatomically, the galea frontalis flap creates a barrier between the dura and the anterior cranial base, avoiding future dural adherence and invagination into the cribiform plate and paracribriform areas. Immunologically, the galea frontalis myofascial flap, being a well vascularised tissue, acts as a bridge along which the blood factors and cells of the inflammatory response can reach the target field.

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