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Closure of Recurrent Frontal Skull Base Defects with Vascularized Flaps – A Technical Case Report

K. G. Krishnan[1], **P. A. Winkler**[1], **A. Müller**[1], **G. Grevers**[2], and **H.-J. Steiger**[1]

[1] Department of Neurosurgery, Klinikum Großhadern der Ludwig Maximilians Universität München, Germany
[2] Department of Otolaryngology and Head & Neck Surgery, Klinikum Großhadern der Ludwig Maximilians Universität München, Germany

Summary

Techniques for vascularized reconstruction of the anterior cranial fossa floor defects causing recurrent cerebrospinal fluid fistula are discussed in this report. The closure employs the use of local random- or axial-pattern vascularized flaps in simple cases. In complicated cases (for instance, status after repeated exploration) the tissue of the cranial base is severely compromised and shows low potential for healing. Non-vascularized grafts only add avital scars to the already present ones leading to recurrent fistulas. Free vascularized flaps show more mechanical strength and less scar contraction, resistance to infections and survive better in a compromised surrounding, thus leading to long term sealing in such cases. The technical issues of vascularized closure of defects of the frontal skull base are discussed in this report.

Keywords: CSF rhinorrhea; skull base defects; vascularized flaps.

Introduction

Defects of the frontal skull base leading to blowout cerebrospinal fluid (CSF) fistulas often tend to recur in dynamic lesions such as synostotic syndromes, tumor regrowth etc. Closing such defects with vascularized tissue is attractive and more reliable in the long run than using avital tissue, which would add scars to already present ones [15, 16]. Various methods are described in the literature [5, 6, 9, 10, 15]. In patients who have already undergone several attempts to close such fistulas, in whom not only the frontal base, but also the areas in the vicinity, serving as donors of vascularized rotation advancement flaps, is compromised the use of a free flap is indicated [3, 14, 22, 25]. In exceptional cases a prophylactic transnasal sealing would seal off any residual leaks [26]. In some it may be necessary to treat rebound hydrocephalus by shunting procedures. The technical issues of reconstruction in such rare cases of recurrent frontal basal leaks are discussed in this short technical report. One case is described.

Technical Considerations

Autologous and non-autologous fascial grafts [24], muscle plugs [2], muco-chondral grafts [8], bone tissue as graft or as cancellous packing [23], all in combination with fibrin glue seem to be the mostly utilized material for sealing lesions of the frontal skull base [21]. Hemostyptic material and fast hardening alcoholic prolamine solution are some synthetic alternatives [17]. When the tissue surrounding the fistula is compromised, the hermeticity resulting after such methods would be short-lived, leading to recurrent blowout CSF leaks.

Vascularized tissue, either as a local pedicled flap or as a distant microvascular free flap are autonomous in their nutrition, thus potentially offering better long-term results. Vascularized flaps used for the closure of CSF fistulas of the frontal skull base may be broadly classified into three groups (also see Table 1): 1) Random pattern flaps, when the flap is based on the random intracutaneous/intrafascial microvasculature, 2) axial pattern flaps, when the flap is nourished by a vascular pedicle and 3) distant microvascular free flaps.

Areas around the craniotomy offer a wide variety of random and axial pattern local flaps. Pericranial flaps are either used separately or in combination with other tissue adherent to it such as the muscle overlying it or the outer table of the skull underlying it [9, 10]. These flaps are versatile since they may be used from any

Table 1. *Vascularized Flaps for Reconstruction of the Skull Base*

Author(s)	Donor tissue	Blood supply	Advantages	Disadvantages
Random pattern flaps				
Argenta, 1985 Cooper, 1987 Wang, 1990	pericranial flaps	Intralimbic vessels	no special dissection required	poor vascularity at distal end of the flap
Axial pattern flaps				
Ito *et al.*, 1979	vascularized strip of dura mater	A. meningea media	good vascularity similar tissue, thin	large craniotomy mandatory
Jackson, 1985	temporalis muscle	A. temporalis superficialis	good vascularity	sometimes too short for reaching the depths, cosmetic donor defect
Hasegawa, 1995	galea frontalis with calvarial bone	A. frontalis & branches of A. temporalis superficialis	good vascularity	tedious dissection, cosmetic donor site defect
Free microvascular flaps				
Schwartz *et al.*, 1999	radial forearm fascio-cutaneous flap	A. radialis	good vascularity, relatively thin,	skin for internal reconstruction, tedious dissection when used as a fascial flap
Izquierdo *et al.*, 1993	rectus abdominis muscle flap	A. epigastrica inferior	good vascularity, could be debulked on bench	bulky
Bootz & Gawlowski, 1995	latissimus dorsi muscle flap	A. thoracodorsalis	good vascularity, could be debulked on bench	bulky
Normington *et al.*, 1996	free vascularized omentum major	A. gastroepiploica	excellent vascularity, excellent plasticity, bulk could be adjusted as needed	may not be primarily hermetic

direction [1]. The periosteum has three major sources of blood supply: 1) the proper artery to the periosteum, 2) the perforant arteries from the bone and 3) the perforant arteries from the overlying muscle. So the vascularization is abundant when the flap is used as a composite flap [10, 11].

Galea aponeurotica along with the frontalis or the temporalis muscles are reliable axial pattern flaps. Both types of flaps are extensively reported in the literature [6, 9, 10, 15]. The temporalis muscle is used unilaterally and in selected cases bilaterally, the limitation being the flap dimension [18].

When intact the dura mater has abundant vasculature through the meningeal artery, is double layered and has extraordinary regenerating capability. Ito *et al.* reported the use of vascularized dura in closure of CSF rhinorrhea in four patients [13].

Microvascular free flaps are employed in a severely scarred surrounding that prevents the use of local pedicled flaps. The radial forearm flap offers a thin layer of vascularized tissue for cranio-facial reconstructions [7]. Schwartz *et al.* reported excellent results in using the radial forearm flap for closing the frontal cranial base in a series of ten patients [25]. Bulky muscle flaps have been successfully used for cranial base reconstruction: Izquierdo *et al.* used the rectus abdominis muscle flap for reconstructing basicranial defects [14] and Bootz & Gawlowski showed the possibility of using free latissimus dorsi for immediate reconstruction of anterior cranial base after resection of tumors [3]. Latissimus dorsi is a thinner sheet of vascularizable muscle when compared to the rectus abdominis, but both muscles could be adequately debulked around their pedicles to suit the demands of the recipient site.

Plasticity of the flap used for sealing cranial base fistulas is an important prerequisite, since the flap should be able to 'flow' into the defect and seal it appropriately. Most of the flaps close the defects in the form of a 'lid', but do not enter the cavity and seal it both from inside and above. Vascularized fat tissue offers this option. Normington *et al.* reported the use of free vascularized omentum as a case report [22].

Another issue in using free vascularized flaps is the technical complexity of the method. Neligan *et al.* presented a comparative study of 90 cases of reconstruction of skull base defects, where they used either local, pedicled or free flaps and found out that the free

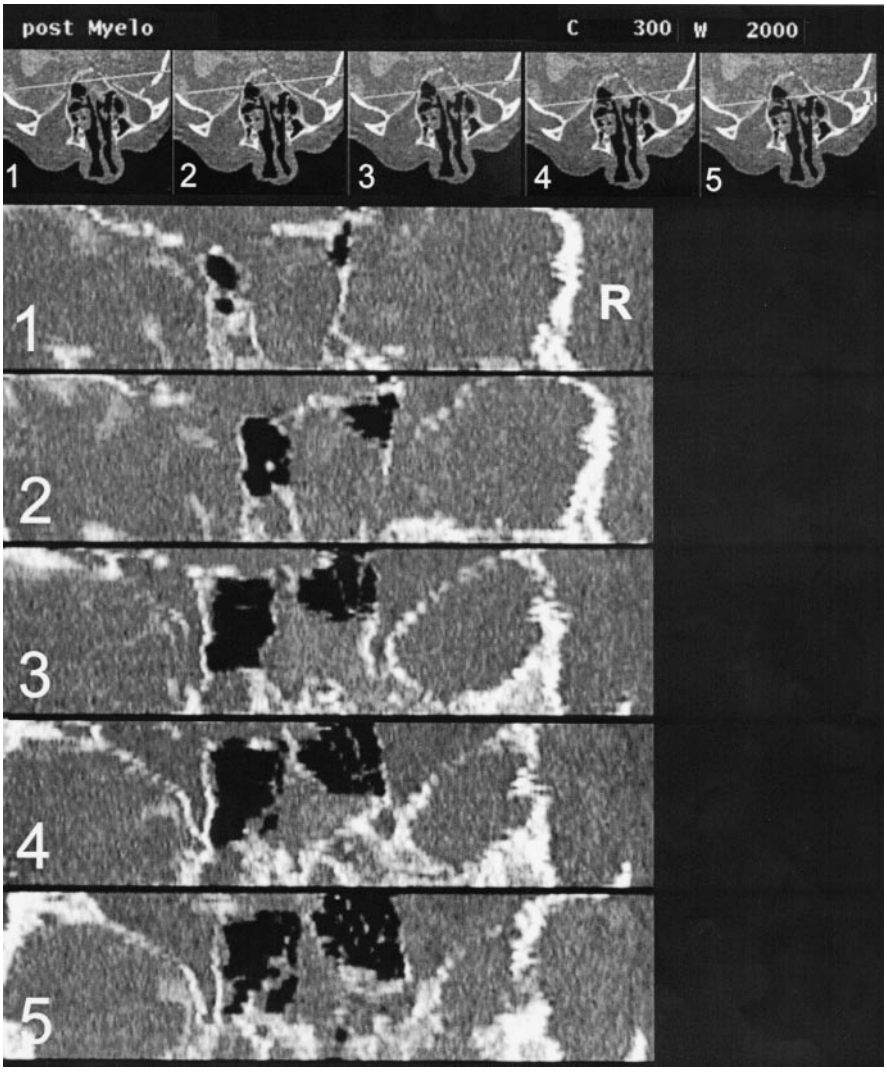

Fig. 1. Sagittal computer tomographic reconstructions of the patient

flap reconstructions exhibited a significantly higher incidence of uncomplicated primary wound healing and a much lower incidence of flap loss and late recurrent fistulas than the other options [20].

Case Report

This 55-year-old male patient had suffered untreated Crouzon's syndrome since childhood. At the age of 50 he underwent left sided optic nerve decompression for acute deterioration of vision. A year after this procedure he developed profuse rhinoliquorrhea due to a blowout CSF fistula. The defect was closed with a conventional fascia lata graft. In the past year the patient developed spontaneous CSF rhinorrhoea three times and was operated on by conventional techniques. He was admitted this time for recurrence of signs and symptoms. Diagnostic imaging showed multiple fistulous lesions (Fig. 1). Since several attempts had been undertaken to close the fistulae with repeated relapses and since his history revealed compromised tissue of the skull base, we planned the transplantation of a vascularized flap and eventually seal the fistula additionally through a transnasal approach, thereby sandwiching the lesions both from above and below.

A two-team approach was employed. One team performed the left fronto-temporal craniotomy (Fig. 3), while the other team raised the flap. After the dura flap was reflected supero-parietally, we observed that the tissue here, as expected, was brittle and scarred. Of the defects that could be visualized, the major one amounted to 1.3 cm in diameter (Fig. 2). Now the superficial temporal artery and the accompanying vein were dissected free up to about 1 cm below the zygoma. The perfusion in these vessels was quite adequate.

A 5×17 cm strip of tensor fasciae latae based on the ascending branch of the lateral circumflex femoral artery and vein was raised observing established techniques [12]. The distal end of the muscle strip contained mainly the fascial part, where the muscle runs down

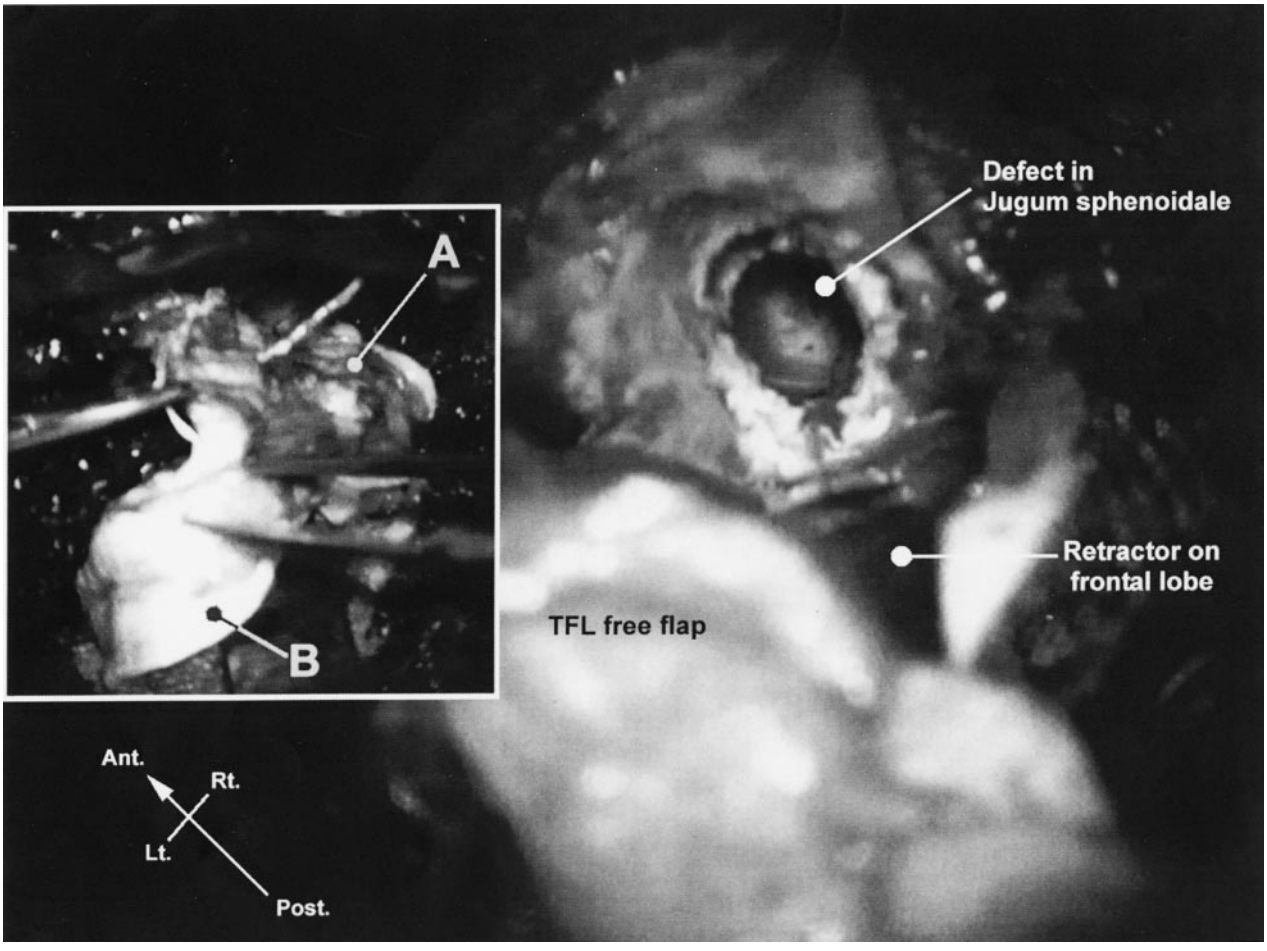

Fig. 2. Intraoperative photograph demonstrating the defect. *Inset*: The flap is being placed on the defect. Strip A is introduced into the defect in a 'bath-plug' fashion and Strip B is doubled over and sutured to the borders of the defect

as the ilio-tibial tract. The muscle was further debulked on the bench by careful dissection. The vascular pedicle was 5 cm long.

After the completion of vascular anastomoses (in order to establish meticulous hemostasis before bringing the flap into the cranium) the distal end of the flap was cut into two strips longitudinally. One strip was soaked in fibrin glue and introduced into the defect and the other was doubled and placed over it. The borders of this superficial strip were sutured overlapping the borders of the defect in a double layer fashion (Figs. 2 and 3).

A week later, the skull base was rhinoscopically examined for additional leakages after injecting 5 mL of Fluoroscine® in the lumbar drain 30 minutes prior to the procedure [4]. Pieces of autologous fascia lata were introduced into the sphenoidal cavity in several layers, applying fibrin glue between each layer until the cavity was totally packed.

Following sealing of the CSF leak ventricular enlargement occured. In order to prevent increased intracranial pressure, which might lead to further blowout, a ventriculo- peritoneal shunt was implanted. The patient has remained symptom free ever since (22 months follow-up). Two months after the operation the patency of the microvascualr anastomoses was confirmed by transcutaneous duplex microdoppler sonography.

Discussion

In the reported case all the local flap options discussed were excluded, owing to the patient's surgical history. The temporal muscle as well as the dura mater was roughly scarred. Moreover his cranial dimensions were bizarre with a skull transversely spread-out due to untreated coronal synostosis. Hydrocephalus with increased intracranial pressure is one of the major contributing factors that causes recurrent blowout fistulas in patients with synostotic syndromes. All these factors prompted us to use such an aggressive approach to sandwich the lesions of the skull base and reduce the intracranial pressure in order to prevent further blowout by inserting a ventriculo-peritoneal shunt.

The tensor fascia lata musculo-fascial free flap is an excellent source of a vascularized muscle which con-

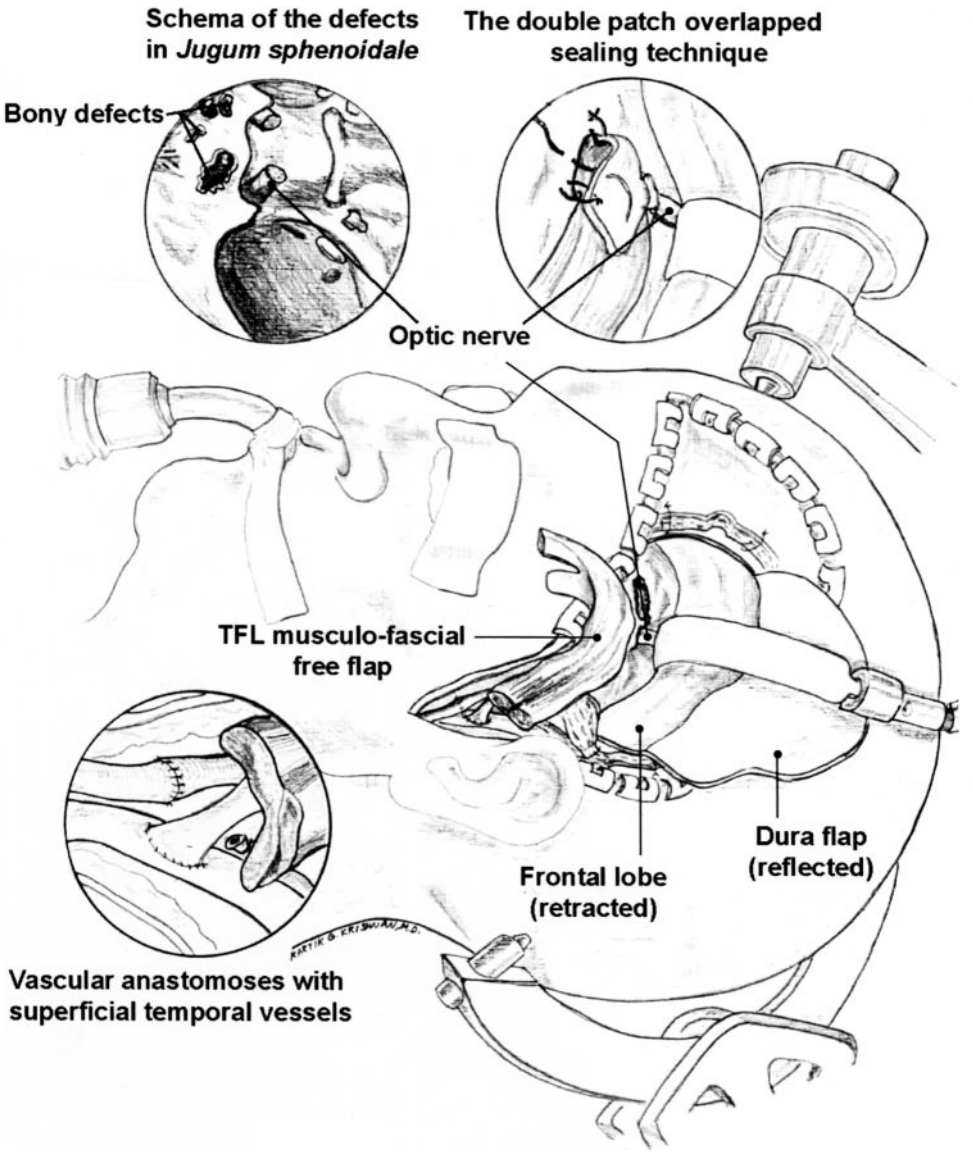

Fig. 3. A schematic representation of the technique used to close the dominant fistula through the *jugum sphenoidale*. The distal end of the flap was split into two strips. One strip was soaked in fibrin glue and was introduced into the cavity and the other was superimposed and fixed overlapping the borders of the defect

tinues down as the ilio-tibial fascial tract. It was first described by Hill *et al.* in 1978 as a musculo cutaneous flap [12] and is extensively used for reconstructing various defects of the body surface [19]. The vascular anatomy is reliable, the diameter of the nourishing vessels is in the order of 2 mm and the flap could be debulked around the vascular pedicle to obtain the required dimensions.

The use of flaps with independent blood supply for closing fronto-basal CSF fistulas might augur well for good long-term results especially in a severely compromised surrounding. When simpler methods like the local pedicled flaps are not available a free flap could be the next alternative. In complicated recurrent cases where the diagnostic localization of the fistula also proves to be challenging, the lesions may be sandwiched from both the cranial and nasal side, with subsequent rerouting of the cerebrospinal fluid to prevent increase in intracranial pressure.

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Comments

This concerns a clearly written and interesting technical report on treatment procedures for closing frontal skull base defects – an important, complicated and often frustrating subject. The manuscript is based on a case report with an excellent and extensive overview of operative techniques and their technical considerations.

A. Maas

The manuscript deals with a case report. In the case of a repeated anterior cranial fossa floor defect following a Crouzon operation for the decompression of the optic nerve, recurrent cerebrospinal fluid fistulas (CSF) occurred, which in the first instance was closed using conventional methods. Finally the defect was closed by means of a microvascular anastomosed musculo-fascial free flap from the tensor fascia lata muscle, using a socalled "Sandwich technique". The free flap was placed onto the defect intracranially, doubling its end. In addition, several layers of endonasal free autologous fascia lata were placed on the defect of the sphenoidal cavity, fixed underneath with fibrin glue.

The surgical technique is demonstrated distinctly. The various possibilities of closure of cerebrospinal fluid fistulas were described thoroughly, limiting the indication for a free flap of persistent recurrent cases. The pictures clearly illustrate the surgical technique.

J. E. Hausamen

Correspondence: Kartik G. Krishnan, M.D., Dr. med., Fiedlerstrasse 33, D-01307 Dresden, Germany.