Use of a Galeopericranial Flap for the Reconstruction of Anterior Cranial Base Defects

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Background: To evaluate the efficacy of using a galeopericranial flap for reconstruction of anterior cranial base defects.

Methods: In Linkou Chang Gung Memorial Hospital from February 1994 to November 2003, 25 patients who had tumors of the skull base underwent craniofacial resection, and a galeopericranial flap was used to reconstruct the anterior cranial base defect. The galeopericranial flap was developed and based on at least 1 side of the supraorbital or supratrochlear arteries and veins; it was only raised from the scalp after the tumor had been removed. It was then turned inwardly and intracranially and was transposed to lie between the skull base bone and the dura. No free skin or bone grafts were used.

Results: Two patients experienced flap failure, and salvage was subsequently performed using a free vastus lateralis flap for skull base repair. Thus, the flap failure rate was 8% (2/25).

Conclusions: The delicate nature and great pliability of a galeopericranial flap make it unique and competent for reconstructions of anterior skull base defects. Its ready availability, valid strength, and sufficient axial blood supply provide a satisfactory barrier for isolating the cranial cavity from the underlying respiratory tract, with minimal morbidity and mortality.

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Key words: galeopericranial flap, anterior cranial base.

Craniofacial resection by removing a tumor of the anterior cranial base via a transcranial or transfacial route creates direct communication between the sterile neurocranium and underlying dirty upper aerodigestive tract. The primary aim of reconstruction with this kind of surgery is the complete elimination of this communication by certain types of flaps.

One of the earliest reported techniques of developing pericranial flaps was described by Wolfe in 1978.(1) Pericranial flaps have been the workhorse of anterior cranial base reconstruction over the last 30 years.(2) However, we believe that the thicker galeopericranial flap may be more reliable than a pericranial flap. The dissection plane for developing the galeopericranial flap does not disrupt its vascularity. In addition, the efficacy of reconstruction in anterior cranial base surgery after postoperative radiotherapy has seldom been discussed. We present our experience of using galeopericranial flaps to repair anterior cranial base defects in 25 patients. The advantages of the galeopericranial flap, the possible reasons for its failure, and ways to improve flap viability are discussed.

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METHODS

Patients

A retrospective review was carried out on 25 patients who had skull base tumors and who underwent craniofacial resection for which a galeopericranial flap was used to reconstruct the anterior cranial base defect in Linkou Chang Gung Memorial Hospital from February 1994 to November 2003. Patient demographics, tumor histology, surgical outcomes, follow-up, and complications were recorded.

Technique

A bicoronal incision of the scalp was made directly down to the skull bone. The scalp was then raised including the galea and pericranium, with a scalp incision to at least 10 cm from the glabella (Fig. 1). A frontal craniotomy (Fig. 2) and subsequent craniofacial resection were then performed. After elevating the frontal base dura from the crista galli, we used a free pericranium graft to meticulously repair the dura in a watertight fashion. The galeopericranial flap was based on at least 1 side of the supraorbital and supratrochlear arteries and veins and was only raised from the scalp after the tumor had been removed (Fig. 3). The flap was turned inwardly and intracranially and was transposed to lie in the epidural space between the skull base bone and dura. It was fixed posteriorly by application of tissue glue, and was stabilized by nailing the flap on the sphenoid ridge or posterior wall of the sphenoid sinus. No free skin or bone grafts were used. Then the frontal bone graft was reinserted back into its position, and fixed with a miniplate (Fig. 4). The galeopericranial flap was turned inwards between the frontal bone graft and the supraorbital ridge. We left enough room between the frontal bone and the supraorbital ridge to allow an adequate blood supply. Then the scalp

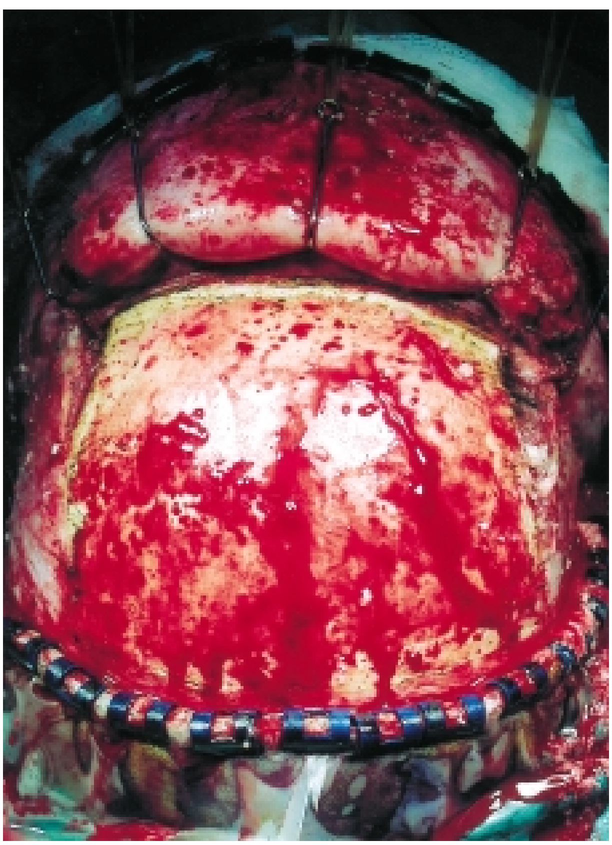

Fig. 1 After the bicoronal incision. The scalp, including the galea and pericranium, was raised, with its top at least 10 cm from the glabella.

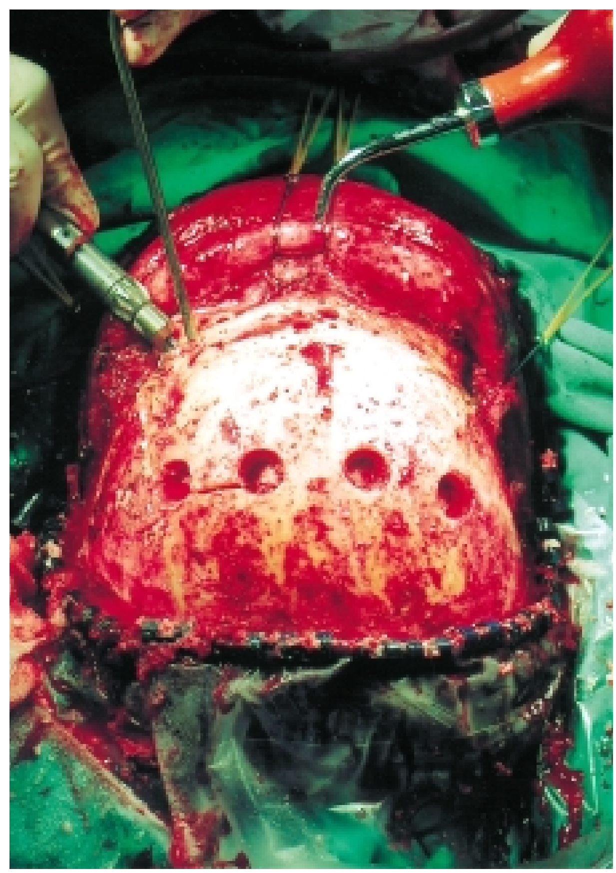

Fig. 2 Frontal bone graft developed and then temporarily removed.

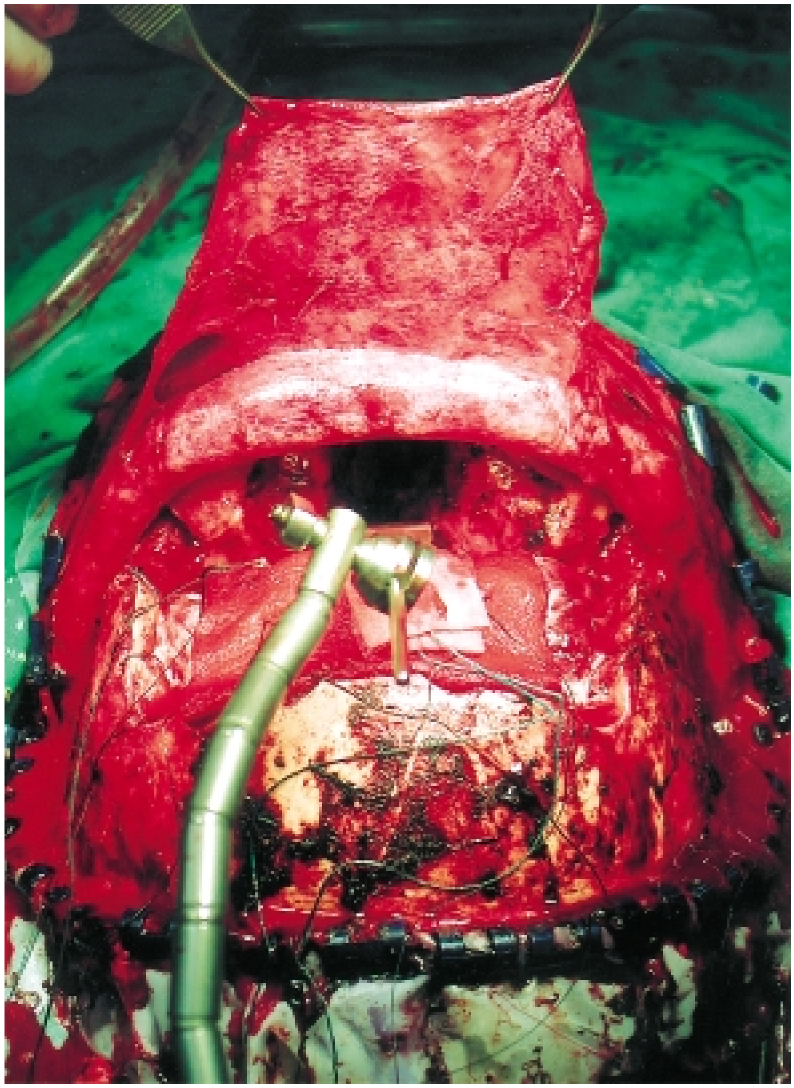

Fig. 3 After the tumor was resected. The galeopericranial flap was then developed.

was closed in a routine fashion.

RESULTS

There were 17 males and 8 females, with an average age of 48.5 (range, 15~69) years. These patients were followed-up for an average of 28.7 (range, 3~111) months. Histological examination revealed 11 olfactory neuroblastomas, 3 ethmoid sinus squamous cell carcinomas, 2 nasopharyngeal carcinomas (NPCs), 2 mucoepidermoid carcinomas, 2 neurilemmomas, 2 neuroendocrine carcinomas, 1 malignant melanoma, and 2 undifferentiated carcinomas (Table 1).

Four patients received preoperative radiation therapy, and 20 patients received postoperative radiotherapy, with doses ranging from 4680 to 6660 cGy. Among the other 5 patients who received no postoperative irradiation, 1 experienced flap failure and refused further radiotherapy; 1 patient with recurrent NPC had received a full dose of irradiation before surgery; another with a recurrent malignant mucosal

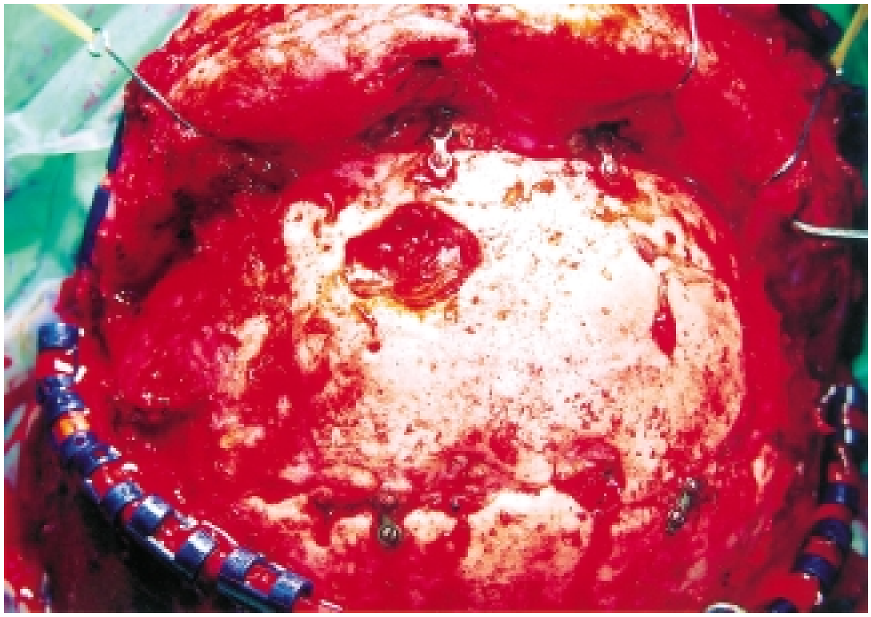

Fig. 4 Frontal bone graft reinserted back to its position, and fixed with miniplates.

Table 1. Types of Tumors in This Series

Tumor type	No.
Olfactory neuroblastoma	11
Squamous cell carcinoma	3
Nasopharyngeal carcinoma	2
Mucoepidermoid carcinoma	2
Neurilemmoma	2
Neuroendocrine carcinoma	2
Malignant melanoma	1
Undifferentiated carcinoma	2

melanoma also had preoperative full-dose irradiation; the other 2 had neurilemmomas which were benign in nature, and radiotherapy was not required.

Two patients experienced flap failure which was complicated by epidural abscess formation at from 1 to 3 months after the surgery; these patients underwent subsequent salvage with a free vastus lateral muscle flap for anterior skull base reconstruction. Possible risk factors are listed in Table 2. Otherwise no immediate crucial complications of the galeopericranial flap were found. The overall success rate was 92% (23 of 25).

DISCUSSION

The anterior cranial base includes the bilateral orbit, bilateral nasal roof, bilateral ethmoid roof, and sphenoid sinus (planum sphenoidale). Common complications of anterior cranial base surgery mainly occur due to direct communication between the cranial cavity and the underlying respiratory tract, and may result in cerebrospinal fluid (CSF) leakage,

Table 2. Basic Data of the 2 Patients Who Experienced Flap Failure

No.	Age (yr)	Gender	Tumor	Time of occurrence*	Precipitating factors	Complications†
1	62	M	ONB	1 mon	Diabetes mellitus and previous surgery	Epidural abscess
2	40	F	ONB	3 mon	Post-op RT and poor nasal hygiene	Epidural abscess and frontal bone ORN

Abbreviations: ONB: olfactory neuroblastoma; RT: radiotherapy; ORN: osteoradionecrosis.
* The time postoperatively when the complication was detected.
† Other complications combined with galeopericranial flap failure.

meningitis, encephalitis, an epidural or subdural abscess, osteomyelitis of the skull, a hematoma, pneumocephalus, or a meningoencephalocele.[3-6] The reported incidence of complications from anterior skull base surgery ranges from 6.5% to 23.5%. The most-common one is CSF leakage, which may increase the risk of ascending meningitis. Many factors may contribute to the development of CSF leaks, including the size and location of the dural resection, CSF dynamics, nutritional status, and perhaps most importantly, the technique of dural closure.[7] Thus, selection of a strong, reliable barrier for isolating the sterile cavity is critical.

The scalp can be divided into 5 distinct layers of the skin, subcutaneous tissue, galea aponeurotica, loose areolar tissue, and periosteum. The so-called galeopericranial flap includes the galea aponeurotica, subgaleal loose tissue, and pericranium.[8] The dissection plane for harvesting a galeopericranial flap is between the subcutaneous tissue and galea, and is subgaleal for a pericranial flap. The blood supply of the galea and pericranium originates mainly from the supratrochlear, supraorbital, superficial temporal, and occipital arteries.[9,10] The galeopericranial flap we used for anterior cranial base reconstruction was mainly supplied from at least 1 side of the supratrochlear and supraorbital arteries. To our knowledge, these major vessels predominantly travel in the fibro-fatty tissue immediately superficial to the galea. Multiple perforating vessels extend perpendicularly from the galea to the pericranium.[11] In the pericranium, an extensive connecting network of vessels is directly supplemented by axial vessels and perforators from the calvarium. So when harvesting a pericranial but not a galeopericranial flap, the dissecting plane must be between the galea and pericranium and may interrupt these communicating branches. It is necessary to maintain the subgaleal fascia intact to preserve the integrity of the vascularity. On the contrary, dissection for harvesting a galeopericranial flap does not interfere with these perforators. In addition, the inclusive periosteal layer is thin but vigorous for reinforcing the flap.[12] Comparisons between the pericranial flap and the galeopericranial flap by previous authors are listed in Table 3.

Previous authors developed the pericranial or galeopericranial flap subsequent to raising a bicoronal incision of the scalp.[1,4,8,13,14] We developed the galeopericranial flap from the raised scalp only after the tumor had been completely excised. The delay in development of the galeopericranial flap may actually help prevent it from drying out. In addition, we used no free grafts on the nasal side beneath the flap. Although using free grafts may result in better epithelial migration and less crust formation, the nasal surface on the flap often granulates and then undergoes resurfacing by migration of cells from the surrounding mucosa even without a free skin graft.[2] The galeopericranial flap is strong enough to support the intracranial content and is a reliable barrier for a skull base defect, even if postoperative radiotherapy is used.[15] Furthermore, using free skin grafts for the nasal surface over the galeopericranial flap is not so reliable, and this may increase the chance of flap necrosis due to its poor vascularity, thus becoming another source of infection. An unacceptably high incidence of CSF leakage for free skin graft dural closures has also been reported.[16] Thus, the use of free grafts promotes potential bacterial overgrowth in the non-vascularized tissue, and increases the risk of an ascending infection.[4]

Some possible reasons to explain the loss of

Table 3. Comparisons of Pericranial and Galeopericranial Flaps by Previous Authors

Authors	Pericranial flap	Galeopericranial flap
Noone et al.[2]	Less risk of hair loss, forehead paralysis, or paresthesia; bony irregularities	Thicker; superior vascular supply
Tse et al.[11]	Thinner and more suitable while larger arc of rotation required	Difficult dissection in adhesions between subcutaneous tissue and the galea
Georantopoulou et al.[20]	Thinner	Thicker but still pliable; visible forehead irregularities
Har-Shai et al.[22]	Easy separation between the galea and periosteum due to the absence of fibrotic vertical bands in the subgaleal layer	Technical difficulty in finding a subfollicular dissection

galeopericranial flaps of the 2 patients in this series are that first, the underlying diabetes mellitus and previous surgery for the anterior cranial base tumor surely compromised the vascular supply to the reconstructed flap in a 62-year-old male. Second, the “3H” effect (hypovascularity, hypoxia, and hypocellularity) of radiation in a 40-year-old female potentially decreased the vascularity of the flap and may have further delayed the healing process.(17) In addition, she did not receive regular follow-up for local treatment. Maintenance of good nasal hygiene plays an important role in better epithelialization of flaps. Furthermore, the room between the frontal bone graft and the supraorbital ridge might not be sufficient to allow an adequate blood supply due to the imperfect fixation of the reinserted frontal bone graft to the surrounding skull. Therefore, there are some situations for which we would recommend a galeopericranial flap not be used for anterior cranial base defect reconstruction: too large of a defect that includes the bilateral orbits or which extends beyond the posterior wall of the phenoid sinus; those who have received previous radiotherapy or surgery;(18) and cases in which a great bulk is needed during the reconstruction (such as bilateral orbits, infratemporal or middle cranial fossa, or maxillary sinus, for which we would use a soft-tissue flap such as the temporalis muscle or a free soft-tissue flap for reconstruction).(19-21) In addition, we advocate that during reinsertion of the frontal bone graft back, it is better to leave enough room for the flap to pass through in order to ensure a proper blood supply. In addition, rigid fixation of the reinserted frontal bone graft to the surrounding skull is crucial to avoid any instability which might actually pinch or compress the flap and thus further decrease its vascularity.

However, separation of the galea from the skin requires dissection immediately subjacent to the hair follicles, which risks hair loss.(22) In addition, forehead paresis or paresthesia and bony irregularities are also possible complications. The frontal branch of the facial nerve can be protected by not including the anterior branch of the superficial temporal artery, as the nerve travels under and with the anterior vessel above the zygoma.(23) Scalp necrosis is also a potential complication when the vascularity of the flap is interrupted while dissecting the galea from the skin, especially for those who have received prior radiotherapy or previous surgery, or who have a larger surgical defect. Fortunately, none of our patients experienced these side effects. In those who had scalp necrosis, the graft was successfully salvaged with a subsequent free vastus lateral muscle flap. Overall, the outcomes of using the galeopericranial flap for reconstruction of anterior cranial base defects seem to be reliable. Certainly, a larger series and a longer follow-up are needed for valid conclusions.

In conclusion, craniofacial resection is now a standard approach for tumors of the anterior cranial base. Thus, the lack of a generally accepted repair method has become a popular subject. Reconstruction of the surgical defect with a reliable and vascularized barrier is crucial. The galeopericranial flap has a reliable axial vascular supply; it is a thicker, stronger barrier, and its ready availability in the surgical field makes it a workhorse of reconstruction for anterior cranial base defects. Even without a free skin or bone graft, a galeopericranial flap is strong enough to support the intracranial content as a sling. The major risk of anterior cranial base surgery is the creation of a communication between the sterile cranial cavity and the underlying respiratory tract. A galeopericranial flap, with its delicate nature and great pliability, is another reliable and competent alternative for reconstruction of anterior cranial base defects.

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利用帽狀顱骨膜皮瓣修補前顱底之缺損

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背 景：評估利用帽狀顱骨膜皮瓣來修補前顱底之缺損之成效。

方 法：回顧並分析自1994至2003年在林口長庚醫院25位前顱底腫瘤接受經顱顏腫瘤切除並接受帽狀顱骨膜皮瓣來修補前顱底之缺損的病人。帽狀顱骨膜皮瓣以至少一邊的眶上或滑車上動脈及靜脈作血液供應，而且是當腫瘤切除後才開始分出皮瓣；然後把皮瓣安插在硬腦膜及顱底骨中間。過程中並沒有使用任何皮膚或骨頭的自由皮瓣。

結 果：有2位病人經歷皮瓣壞死，並以股外側自由皮瓣成功地修補前顱底缺損。帽狀顱骨膜皮瓣之失敗率爲8% (2/25)。

結 論：帽狀顱骨膜皮辦具精細的特質及極高的可塑性，使得它成爲修補前顱底缺損一個獨特且可靠的選擇。方便的可取性、堅強的硬度及豐富的血液供應，使得它成爲一個令人滿意的屏障，用以隔離顱腔與上呼吸道。

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關鍵字：帽狀顱骨膜，前顱底。

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