



Osteocutaneous radial forearm free flap for anterior cranial base reconstruction: Technical note

William Inaki Haynes, Marie de Boutray, Titouan Kennel, Julien Boetto

► To cite this version:

William Inaki Haynes, Marie de Boutray, Titouan Kennel, Julien Boetto. Osteocutaneous radial forearm free flap for anterior cranial base reconstruction: Technical note. *Neurochirurgie*, 2021, 67 (6), pp.606-610. 10.1016/j.neuchi.2021.03.009 . hal-03666244

HAL Id: hal-03666244

<https://hal.science/hal-03666244>

Submitted on 5 Jan 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

Osteocutaneous radial forearm free Flap for anterior cranial base reconstruction: technical note

William I. Haynes¹, MBBS, PhD, Marie De Boutray², MD, Thibault Kennel³, MD, Julien Boetto¹, MD

1 Département de Neurochirurgie, Hôpital Gui de Chauliac, Centre Hospitalier Universitaire de Montpellier, Montpellier, France

2 Département d'Otorhinolaryngologie, Hôpital Gui de Chauliac, Centre Hospitalier Universitaire de Montpellier, Montpellier, France

3 Département de Chirurgie Maxillo-Faciale, Hôpital Gui de Chauliac, Centre Hospitalier Universitaire de Montpellier, Montpellier, France

Corresponding author:

William I. Haynes, MBBS, PhD

william.haynes@inserm.fr
Département de Neurochirurgie,
Hôpital Gui de Chauliac,
80 avenue Augustin Fliche,
34295 Montpellier Cedex 5,
France

ABSTRACT

The reconstruction of anterior skull base defects after carcinologic surgery is challenging. Large defects can require the use of autologous free tissue transfer. Currently, most reconstructions use soft-tissue flaps. We describe the use of an osteo-cutaneous radial forearm free flap to reconstruct a large defect secondary to a malignant paraganglioma extending into the anterior cranial fossa and both orbits. The surgical resection required endonasal and transcranial approaches. We reconstructed the defect with a free osteocutaneous radial forearm flap. We laid the bone flap across the defect, resting on the orbital roof on each side, and sutured the soft component to the edge of the dura. The pedicle was funnelled from the craniotomy to a

prepared cervicotomy and the micro-anastomoses were performed onto the facial artery and two satellites veins. Potential indications and major drawbacks of this technique are briefly discussed. Osteocutaneous radial forearm free flaps can be a valuable reconstructive option for patients with a large defect of the anterior skull base, needing both rigid support and a watertight closure.

KEYWORDS

Anterior skull base, anterior cranial fossa, free flap, radial forearm free flap, reconstructive surgery.

ABBREVIATIONS AND ACRONYMS

ALT: Anterolateral thigh free flap; CSF: cerebrospinal fluid; RFFF: Radial forearm free flap.

FUNDING SOURCE

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DECLARATIONS OF INTEREST: none.

INTRODUCTION

The anterior skull base has a crucial role in isolating the intracranial intradural space from the sino-nasal tract and upper airways. Surgery for malignant tumours in this area can result in complex defects connecting the orbital, nasal and/or intracranial spaces. Consequently, tumour removal needs to be followed by a reconstruction of the anterior skull base. In addition, the opening of the dura mater requires this reconstruction to be watertight to avoid the leakage of cerebrospinal fluid (CSF) and subsequent complications (meningitis, brain abscesses, osteomyelitis). Thus, the reconstructive strategy is central to the planning of carcinologic surgery of the anterior skull base [1, 2].

While small defects can be managed with local allogenic or xenogenic grafts, extensive defects concerning soft tissue, osseous and dural structures require alternative techniques such as vascularized tissue transplants. Defects deriving from an endoscopic endonasal approach are generally closed with mucosal vascularized flaps (e.g. nasoseptal flap) [3-5]. However, these local flaps can be insufficient in the case of very large defects (frequent with transcranial approaches) or when the nasal mucosa is unavailable (e.g. tumour invasion). In the latter case, the use of a galea periosteum flap with or without a bone graft is possible [6-8]. In the former, vascularised flaps seem most appropriate [2]. In case of recurrences, the use of a pedicled temporal muscle flap or a free vascular supplied tissue (mainly the radial forearm free flap (RFFF) or the anterolateral thigh flap (ALT)) is the last strategy.

Here, we report the surgical technique to reconstruct the defect from a suspected malignant paraganglioma of the anterior skull base with an osteocutaneous RFFF.

CASE DESCRIPTION

A 66-year-old patient was referred to the emergency department with left exophthalmia and a rapid left visual impairment in the context of deterioration in general condition and weight loss. Further interrogation revealed anosmia and cacosmia. The computerised tomography (CT-scan) at the emergency department showed a voluminous ethmoidal lesion which extended into both orbital cavities and upwards through the anterior skull base towards the frontal lobes. Magnetic resonance images (MRI) were in favour of an esthesioneuroblastoma or carcinoma (**Figure 1A-H**). Biopsies were performed using an endonasal endoscopic approach. The diagnosis at this stage was uncertain with an aspecific morphology, and immunohistochemistry positive for neuroendocrine markers (chromogranine A and synaptophysin), PS100, SOX10 and CD56. The lesion had a high KI67 index (40%). The pathology team concluded to a possible malignant paraganglioma. Whole body CT-scan and Octreoscan did not show secondary lesions. The case was discussed at the head and neck oncology meeting, where we decided on a surgical resection followed by adjuvant radiotherapy. An osteocutaneous RFFF with anastomoses to the facial artery and veins was selected for the reconstruction of the defect.

SURGICAL TECHNIQUE

Tumour removal: The surgery was performed by a multidisciplinary surgical team (neurosurgeon, ENT-surgeon and maxillofacial surgeon). A lumbar drain was inserted. The first stage was the resection of the tumour through a combined endonasal endoscopic (Figure 2A) and transcranial open approach (Figure 2B), using standard techniques for anterior skull base tumour resection. The dura mater appeared pathological and was excised over approximately 19 cm². Resection of the intra-orbital portions of the lesion was performed from the bifrontal craniotomy approach (**Figure 2B**).

Flap preparation: In the meantime, the maxillofacial surgeons prepared the left osteocutaneous RFFF with a long pedicle (one artery and two veins), using standard technique: 1. removal of a

5x4cm skin paddle at the distal part of the forearm, centered on the radial pedicle; 2. dissection of the pedicle along the radial periosteum over 6cm; 3 preparation of a 6cm radius sample (anterior cortical bone) stopping 4cm from the bone's distal extremity. 4. dissection of the radial pedicle up to the elbow and associated sampling of the cephalic vein for superficial venous drainage.

Receiving site preparation: A left cervicotomy was made to expose the facial artery and its satellite veins. A superior sulcal incision and small bone window in the anterior wall of the maxillary sinus was performed.

Flap positioning: The pedicle was funnelled from the craniotomy, through the maxillary sinus, the maxillectomy, and inside the cheek, to the cervicotomy using a Delbet drain folded on itself (**FIGURE 2C**). The micro-anastomoses were performed on the facial artery and two satellite veins, with good clinical and ultrasound permeability. The flap was inserted through the craniotomy with concomitant endoscopic guidance, soft component first (facing downwards). The flap was sutured to the edge of the dural defect, from the craniotomy side, with endoscopic endonasal support (**FIGURE 2D**). The bone flap was then set to lie across the skull base defect, resting laterally part on each orbital roof (**FIGURE 2E**). The dural reconstruction was strengthened by a pericranial flap, biological fibrin glue and a dural substitute (Tachosil®, TAKEDA, Tokyo, Japan) (**FIGURE 2F**). The craniotomy was closed using standard technique. The radial donor site was closed using a transitional artificial matrix (INTEGRA®, Integra Life Science Corporation, Plainsboro, New Jersey) before a secondary skin graft performed three weeks afterwards.

POSTOPERATIVE COURSE

The initial post-operative period was spent in intensive care to minimise intracranial pressure and airway pressure that could compromise the flap or its sutures. The lumbar drain was

removed 3 days after surgery. The post-operative MRI showed a centimetric residue in the right orbit, reason why the patient was reoperated using an endoscopic endonasal approach to achieve a total macroscopic removal of the tumour,. This tumour residue was accessed without displacing the flap. The total macroscopic resection was confirmed by the postoperative MRI, with a good flap position (**Figure 3A-C**).

The patient was extubated at day 7 after the first surgery. Unfortunately, a compressive pneumocephalus after a respiratory effort led to a deterioration of his neurological status and readmittance into the intensive care unit. An endoscopic endonasal examination of the flap revealed a rupture in the centre of the soft tissue flap, unlike the classic suture dehiscence for pharyngeal flaps. This required a third intervention to suture the defect from the transcranial approach. Local evolution was afterwards satisfactory, with good healing of the flap. The patient was discharged from hospital with no neurological deficit and a KPS score of 80, and received adjuvant radiotherapy without any other post-operative complication at 9 months.

DISCUSSION

In our institution, anterior skull base defects are usually patched with adipose tissue grafts, synthetic material or nasopharyngeal mucosal flaps. However, we deemed these techniques insufficient given the anticipated size of the soft and hard tissue defect (19 cm², **Figure 1E-G**), and the risk of a secondary CSF leakage or brain prolapse. The extensive invasion of the nasal fossa made it impossible to use a nasal mucosal flap. In this context a free flap with a bony and soft tissue component seemed optimal to provide adequate support, airtightness and rapid closing. An additional requirement was to have a long vascular pedicle in order to make the vascular anastomoses onto cervical vessels. Indeed, the patient's temporal arteries were skinny and sclerotic, and thus inadequate as recipient vessels. The temporal muscles were hypotrophic and would not have been able to cover the entire defect.

Consequently, we chose a combined endoscopic endonasal, and transcranial approach for the resection, followed by a reconstruction using an osteocutaneous RFFF. Additional support for this choice was a pre-existing loss of function of the left superior limb due to post-traumatic bicipital retraction.

The RFFF is one of the classic flaps to reconstruct anterior skull base defects, alongside the ALT and rectus abdomini flaps [1, 9, 10]. Most often, the RFFF is used in its classic adipofascial form, with [11-13] or without [1, 10, 14-19] support from a titanium mesh depending on the size of the defect. The size of the skull base defect in our patient dictated the use of a rigid support system, because a lack of support was at risk of a brain prolapse or suture dehiscence from gravity traction, as has been established for defects extending beyond the cribriform plate to the orbital roof [9, 20]. However, using a titanium implant seemed problematic given the anticipated course of post-operative radiotherapy. Indeed, radiation therapy increases the number of wound dehiscence and decreases the quality of scar tissue, leading to exposure and chronic infection of foreign implants in this location [11, 13, 21]. Therefore, we wanted to use a free flap with an osseous component in order to provide a vascularised rigid support. Amongst the standard flaps for anterior skull base reconstruction, only the radial forearm flap provided that opportunity. This radial forearm flap is also considered more versatile in its molding to the recipient cavity [22].

Our main complication was a compressive pneumocephalus. A careful analysis of the radiologic images and an endoscopic endonasal examination of the flap revealed the appearance of a central defect in the soft tissue part, unlike classic wound dehiscence [19, 23]. It probably came from an inadvertent introduction of nasopharyngeal suction in intensive care. This complication highlights that the gastric tube should be inserted under direct endoscopic vision at the end of the procedure by the surgical team. Moreover, post-operative instructions should be carefully checked and written by the surgical team (No intranasal or pharyngeal procedures such as suction or tube replacement without endoscopic supervision, systematic

post-operative antibiotic therapy for 48h, supine position with a 30° head raise, no patient mobilization during the first two days, no anti-platelet therapy during the first days)

Despite the fact that no CSF leak occurred during the post-operative course, the compressive pneumocephalus did not resolve spontaneously and led to a second, transcranial, intervention in order to suture the defect. This complication is standard in the literature [9, 24], where pneumocephalus and CSF leak are the most frequent, if still rare (Pneumocephalus: 2 for 69 patients in the literature [9, 14, 18, 24, 25]). Vascular failures remain exceptional. The occurrence of such complications is not correlated to the size of the defect [9]. To prevent a CSF leak, we used a combined approach to ensure the watertightness of the reconstruction, adding a local pericranial flap and fibrin glue to the free flap [24, 26, 27].

CONCLUSION

The use of an osteocutaneous radial forearm free flap needs to be considered for large bony defects of the skull base when no other option is available and when a rigid support system is needed, specifically for cases with potential post-operative radiation. However, this procedure adds significant morbidity to the surgical procedure, is associated with frequent post-operative complications, and should be performed by a multidisciplinary team.

References

- [1] Wang W, Vincent A, Sokoya M, Kohlert S, Kadakia SDucic Y. Free-Flap Reconstruction of Skull Base and Orbital Defects. *Semin Plast Surg* 2019;**33**(1):72-77. <https://doi.org/10.1055/s-0039-1677881>.
- [2] Pusic AL, Chen CM, Patel S, Cordeiro PGShah JP. Microvascular reconstruction of the skull base: a clinical approach to surgical defect classification and flap selection. *Skull Base* 2007;**17**(1):5-15. <https://doi.org/10.1055/s-2006-959331>.
- [3] Hara T, Akutsu H, Yamamoto T, Tanaka S, Takano S, Ishikawa E, et al. Cranial Base Repair Using Suturing Technique Combined with a Mucosal Flap for Cerebrospinal Fluid Leakage During Endoscopic Endonasal Surgery. *World Neurosurg* 2015;**84**(6):1887-93. <https://doi.org/10.1016/j.wneu.2015.08.025>.
- [4] Liu JK, Schmidt RF, Choudhry OJ, Shukla PAEloy JA. Surgical nuances for nasoseptal flap reconstruction of cranial base defects with high-flow cerebrospinal fluid leaks after endoscopic skull base surgery. *Neurosurg Focus* 2012;**32**(6):E7. <https://doi.org/10.3171/2012.5.focus1255>.
- [5] Hadad G, Bassagasteguy L, Carrau RL, Mataza JC, Kassam A, Snyderman CH, et al. A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. *Laryngoscope* 2006;**116**(10):1882-6. <https://doi.org/10.1097/01.mlg.0000234933.37779.e4>.
- [6] Kryzanski JT, Annino DJ, Gopal HHeilman CB. Low complication rates of cranial and craniofacial approaches to midline anterior skull base lesions. *Skull Base* 2008;**18**(4):229-41. <https://doi.org/10.1055/s-2007-1003924>.
- [7] Noone MC, Osguthorpe JDPatel S. Pericranial flap for closure of paramedian anterior skull base defects. *Otolaryngol Head Neck Surg* 2002;**127**(6):494-500. <https://doi.org/10.1067/mhn.2002.129737>.
- [8] Jones NF, Schramm VLSekhar LN. Reconstruction of the cranial base following tumour resection. *British Journal of Plastic Surgery* 1987;**40**(2):155-162. [https://doi.org/https://doi.org/10.1016/0007-1226\(87\)90188-3](https://doi.org/https://doi.org/10.1016/0007-1226(87)90188-3).
- [9] Vargo JD, Przylecki W, Camarata PJAndrews BT. Classification and Microvascular Flap Selection for Anterior Cranial Fossa Reconstruction. *J Reconstr Microsurg* 2018;**34**(8):590-600. <https://doi.org/10.1055/s-0038-1649520>.
- [10] Ungar OJ, Abergel A, Safadi A, Zaretzki A, Yanko-Arzi RFliss DM. Anterior Median Skull Base Reconstruction Using a Vascularized Free Flap: Rationale, Patient Selection and Outcome. *J Neurol Surg B Skull Base* 2020;**81**(1):30-36. <https://doi.org/10.1055/s-0038-1676800>.
- [11] Thakker JSFernandes R. Evaluation of reconstructive techniques for anterior and middle skull base defects following tumor ablation. *J Oral Maxillofac Surg* 2014;**72**(1):198-204. <https://doi.org/10.1016/j.joms.2013.05.017>.
- [12] Biron VL, Gross M, Broad R, Seikaly HWRright ED. Radial forearm free flap with titanium mesh sandwich reconstruction in complex anterior skull base defects. *J Craniofac Surg* 2012;**23**(6):1763-5. <https://doi.org/10.1097/SCS.0b013e3182653f29>.
- [13] Yano T, Okazaki M, Tanaka Klida H. The Flap Sandwich Technique for a Safe and Aesthetic Skull Base Reconstruction. *Ann Plast Surg* 2016;**76**(2):193-7. <https://doi.org/10.1097/sap.0000000000000507>.
- [14] Llorente JL, Lopez F, Camporro D, Fueyo A, Rial JC, de Leon RF, et al. Outcomes following Microvascular Free Tissue Transfer in Reconstructing Skull Base Defects. *J Neurol Surg B Skull Base* 2013;**74**(5):324-30. <https://doi.org/10.1055/s-0033-1353364>.
- [15] Duchateau NC, Komen N, Dua G, Mertens MColpaert SD. Reconstruction of the median anterior skull base with an intracranial free radial forearm flap after recurrent resection of

- tumour. *J Plast Surg Hand Surg* 2014;**48**(3):222-4. <https://doi.org/10.3109/2000656X.2013.779795>.
- [16] Aksu AE, Uzun H, Bitik O, Tuncbilek GSafak T. Microvascular Tissue Transfers for Midfacial and Anterior Cranial Base Reconstruction. *J Craniofac Surg* 2017;**28**(3):659-663. <https://doi.org/10.1097/SCS.00000000000003448>.
- [17] Pangrazi PP, De Francesco F, Di Rienzo ARiccio M. Adipofascial Radial Forearm Free Flap for Anterior Skull Base Reconstruction in Complicated Forebrain Oncological Surgery. *Journal of Craniofacial Surgery* 2019;**30**(6):1724-1729. <https://doi.org/10.1097/scs.00000000000005559>.
- [18] Schwartz MS, Cohen JI, Meltzer T, Wheatley MJ, McMenomey SO, Horgan MA, et al. Use of the radial forearm microvascular free-flap graft for cranial base reconstruction. 1999;**90**(4):651. <https://doi.org/10.3171/jns.1999.90.4.0651>.
- [19] Weber SM, Kim JHWax MK. Role of free tissue transfer in skull base reconstruction. *Otolaryngol Head Neck Surg* 2007;**136**(6):914-9. <https://doi.org/10.1016/j.otohns.2006.12.030>.
- [20] Yano T, Okazaki M, Tanaka K, Iida H, Aoyagi M, Tsunoda A, et al. A new concept for classifying skull base defects for reconstructive surgery. *J Neurol Surg B Skull Base* 2012;**73**(2):125-31. <https://doi.org/10.1055/s-0032-1301402>.
- [21] Smith JEDucic Y. The Versatile Extended Pericranial Flap for Closure of Skull Base Defects. *Otolaryngology–Head and Neck Surgery* 2004;**130**(6):704-711. <https://doi.org/10.1016/j.otohns.2004.01.004>.
- [22] Besteiro JM, Aki FE, Ferreira MC, Medina LRCernea C. Free flap reconstruction of tumors involving the cranial base. *Microsurgery* 1994;**15**(1):9-13. <https://doi.org/10.1002/micr.1920150105>.
- [23] Neligan PC, Mulholland S, Irish J, Gullane PJ, Boyd JB, Gentili F, et al. Flap selection in cranial base reconstruction. *Plast Reconstr Surg* 1996;**98**(7):1159-66; discussion 1167-8. <https://doi.org/10.1097/00006534-199612000-00005>.
- [24] Chepeha DB, Wang SJ, Marentette LJ, Thompson BG, Prince METeknos TN. Radial Forearm Free Tissue Transfer Reduces Complications in Salvage Skull Base Surgery. *Otolaryngology–Head and Neck Surgery* 2004;**131**(6):958-963. <https://doi.org/10.1016/j.otohns.2004.05.029>.
- [25] Weber SM, Kim J, Delashaw JBWax MK. Radial forearm free tissue transfer in the management of persistent cerebrospinal fluid leaks. *Laryngoscope* 2005;**115**(6):968-72. <https://doi.org/10.1097/01.mlg.0000163335.05388.8e>.
- [26] Yeo IS, Kim S-H, Park MC, Lim H, Kim JHLee IJ. Successful Reconstruction of Irradiated Anterior Skull Base Defect Using the Dual Flap Technique Involving Local Pericranial Flap and Radial Forearm Free Flap. *Journal of Craniofacial Surgery* 2014;**25**(4):1376-1378. <https://doi.org/10.1097/scs.0000000000000858>.
- [27] Califano J, Cordeiro PG, Disa JJ, Hidalgo DA, DuMornay W, Bilsky MH, et al. Anterior cranial base reconstruction using free tissue transfer: changing trends. *Head Neck* 2003;**25**(2):89-96. <https://doi.org/10.1002/hed.10179>.

FIGURE LEGENDS

Figure 1: Pre-operative images of the lesion. (A) and (B): coronal T2 weighted sequences and (C) and (D) axial T1 weighted images after injection of gadolinium showing an extensive mass extending into the ethmoid, both orbits and the anterior cranial fossa. (E-H): CT scan images showing the bony defect and the defect surface calculation. (E) sagittal image along the orange plane in G, (F) axial image along the purple plane in E&G, and (G) coronal image along the blue plane in E, (H) same section as G with a bone window.

Figure 2: Intraoperative images of the procedure. (A) Sub frontal endoscopic view of the posterior edge of the defect at the level of the planum sphenoidale and the left optic nerve penetration through the optic canal. The orbit and the maxillary sinus are also visualized. *MS*: Maxillary sinus. *ON*: Optic nerve. *Or*: Orbit. *PISD*: planum sphenoidale dura. (B) Superior view through the transcranial approach, showing the post-resection defect of the anterior fossa. (*) indicates both orbital roofs. The soft palate is visible beneath the osseous defect.

(C) Intraoperative images of the reconstruction: Tunnelling the path of the pedicle with the Delbet drain: From the sub frontal area to the maxillary sinus, anterior maxillectomy, jugal space (second step to the cervical incision not shown). (D): The flap's soft tissue (*) is sutured to the edge of the dural defect from the cranial side with endoscopic endonasal support. The bony component is reclined posteriorly (arrow). (E) Positioning of the bone flap across the skull base defect, lying on each orbital roof laterally. (F) Final dural reconstruction by the apposition of an pericranial flap, biological fibrin glue and dural substitute (TachoSil®, Takeda, Tokyo).

Figure 3: Post-operative images. (A) CT scan: 3D vascular reconstruction of the pedicle (white arrows) running from the facial vessels (bottom arrow) through the jugal space, and entering the

maxillary sinus through the anterior maxillectomy (top arrow). (B) Coronal images of CT scan showing the position of the bony flap. (C) T1 weighted images after injection of gadolinium showing positioning of the bony (*) and soft tissue flap (arrow). (D) Picture of the osteocutaneous radial free flap. The radial bone is on the underside and figured by black dotted lines; A sufficient length of arterial (black asterisk) and venous (white arrow) pedicles is necessary to allow neck anastomoses without tension.ss





