The Laparoscopically Harvested Omental Free Flap: A Compelling Option for Craniofacial and Cranial Base Reconstruction

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Abstract

Keywords

- ▶ free flap
- ▶ reconstruction
- ▶ omentum free flap
- ▶ craniofacial reconstruction
- ▶ cranial base reconstruction
- ▶ microvascular reconstruction

Background Management of craniofacial and cranial base tumors is a challenge due to the anatomic intricacies associated with the calvarium, the pathological diversity of lesions that present, and the potential complications. Clinical outcomes in laparoscopically harvested omentum free flaps for cranial base and craniofacial reconstruction are presented in this paper, in the largest case series to date.

Methods A retrospective single-center experience for over 10 years with laparoscopically harvested omentum flaps used to reconstruct craniofacial and cranial base defects.

Results A total of 13 patients underwent craniofacial or cranial base reconstruction using laparoscopically harvested omentum free flaps. The mean patient age was 48 years. The anterior skull base represented the most common site of reconstruction. A total of 12 of the flaps survived (92%), with one flap failure due to infection. All patients demonstrated satisfactory aesthetic and functional outcomes. There were no perioperative or intra-abdominal complications.

Conclusions The laparoscopically harvested omentum free flap is a safe and effective tool in the armamentarium of the reconstructive surgeon. It is the ideal option to treat complex, three-dimensional subcutaneous defects, such as those encountered in craniofacial and cranial base reconstruction. Its unique angiogenic and immunologic capacity makes it an excellent flap for the previously irradiated and/or infected wound bed.

Introduction

The greater omentum emerged as an intriguing reconstructive tool in the 1960s. The pedicled omentum flap was initially utilized by Kiricuta¹ to support ureteral anastomoses and repair vesical fistulas, and by Goldsmith² to address chronic lymphedema. The pedicled omentum flap was then used to cover major vessels after radical resections³ and reconstruction of breast,⁴ perineum,⁵ and chest wall defects.^{6,7} Indeed,

Kiricuta described the omentum as the only pedicled tissue flap to extend from “the head ... to the knee.”

The first omentum free tissue transfer was reported by McLean and Buncke in the setting of scalp reconstruction in 1972.⁸ Other applications of the omentum free flap in the head and neck include reconstruction of defects secondary to tumor extirpation, burns, hemifacial atrophy, and osteoradionecrosis.^{9–16} Omentum has been employed effectively in neurosurgery with the treatment of moyo-moya as well.^{17,18}

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Several studies have indicated the advantages of utilizing omentum in skull base reconstruction; these include obliteration of the dead space, delivery of immune cells, antibodies, and systemic antibiotics, and restoration of volume and contour.^{12,19–23} Still, the omentum free flap has been generally relegated as a “salvage flap” for failed reconstruction due to the perceived need for laparotomy and potential abdominal complications. The benefits of the omentum free flap in soft tissue reconstruction had to be weighed against the morbidity of a laparotomy.¹²

However, in 1993, with the introduction of the laparoscopic harvesting technique, Saltz ushered in the modern era of omentum free flap reconstruction, in obviating the need for laparotomy.^{24,25} In this publication, we present the largest case series of laparoscopically harvested, omentum free flap reconstruction in the literature and advocate the efficacy of the omentum as a compelling option in craniofacial and cranial base reconstruction that is not only harvested safely, but is also a robust flap with excellent clinical outcomes.

Greater Omentum Anatomy

The greater omentum is an apron-like mesenteric tissue suspended from the stomach protecting the intestines in the peritoneal cavity. The omentum consists of a trabecular network of vessels, adipose, connective tissue, and immune cellular aggregates. The omentum originates at the greater curvature of the stomach and crosses the transverse colon, continuing down in front of the abdominal viscera, occasionally as low as the symphysis.²⁶ According to Das,²⁷ the omentum length ranges between 14 and 36 cm and its width between 20 and 46 cm. Omentum surface area measures between 300 and 1,500 cm² and may weigh 300 to 2,000 g.

The greater omentum exhibits a dual blood supply within two different anatomic planes. The right gastroepiploic artery runs in an anterior plane as a branch of the gastroduodenal artery via the hepatic artery. The left gastroepiploic artery runs in a posterior plane emanating from the splenic artery. These combine to develop the subgastric arcade penetrating the mass of the omentum and providing its unique vascular anatomy. The right gastroepiploic artery is typically utilized in microvascular anastomosis and may be fashioned into a pedicle several centimeters in length. This results in a technically easier anastomosis and most importantly reduces the need for vein grafts. The rich collateral circulation of the omentum permits selective transfer of only portion of the tissue without compromising perfusion. As a result, the flap may be customized to address unique soft tissue defects, such as those encountered in craniofacial and cranial base reconstruction.

Method

Patients treated for benign and malignant skull base tumors who underwent cranial reconstruction with a laparoscopically harvested free omental flap were identified retrospectively from a database at the Center for Cranial Base Surgery at the New York Head & Neck Institute (NY, NY) from January 2004 to May 2016. Thirteen patients were identified and managed by the primary surgeon (PDC, senior author). The Institutional Review Board of

the Feinstein Institute of Medicine approved the collection of data. Patients were evaluated for sex, age, preoperative diagnosis, and indications for reconstruction. Outcome measures included perioperative complications and flap survival.

Surgical Technique

Craniofacial and cranial base reconstruction with laparoscopically harvested omentum involves a multidisciplinary approach with the possible participation of neurosurgery, head and neck surgery, plastic surgery, and general surgery teams.

The laparoscopic omentum harvest begins with standard laparoscopic technique with a periumbilical incision and careful placement of blunt tip trocar via Hasson technique. The abdomen is insufflated to a pressure of 15 mm Hg, and a 30-degree laparoscope is introduced into the abdominal cavity. A survey of the intra-abdominal contents is completed with close evaluation of the omentum health, size, and possible adhesions. A 5-mm trocar is inserted in the left upper quadrant, the right upper quadrant, and the left periumbilical distributions.

Subsequently, the omentum is mobilized and adhesions are meticulously dissected with a combination of blunt and sharp dissection. With advances in laparoscopic technique and experience, adhesions can usually be safely addressed and are typically not considered a contraindication for laparoscopic omentum harvesting.

Once adhesions are released, the omentum is directed cranially and its attachments at the transverse colon are dissected. The omentum vasculature is then evaluated, most notably the gastroepiploic vessels running along the greater curvature of the stomach. The right gastroepiploic artery and vein are usually the dominant vessels and ideal for microvascular anastomosis. Beginning on the right side the gastroepiploic vessels are mobilized sharply along the omentum with the Harmonic scalpel (Ethicon Inc., Somerville, New Jersey, United States), separating the vessels off the stomach while preserving the vascular pedicle of the omentum. This maneuver is extended beyond the splenic flexure and up the greater curvature of the stomach toward the spleen. Of note, the splenic flexure of the colon maybe partially mobilized prior to this dissection to facilitate this portion of the dissection. The omentum is then divided near the short gastric vessels and the left crus of the diaphragm.

Once dissected free, the right gastroepiploic vessels are ligated with vascular clips and divided sharply commencing ischemia time. The omentum flap is then removed through a 4-cm vertical midline port site as a wound protector is placed to allow for atraumatic flap removal. The omentum is then passed to the reconstructive surgeons for reconstruction.

The abdominal cavity is inspected with the laparoscope, and hemostasis is confirmed. Ports are then removed under direct visualization. The remaining incisions are then closed in the standard fashion. The fascial layer of laparoscope periumbilical incision and the extraction incision are closed with 1–0 polydioxanone suture.

Results

A total of 13 patients (five men and eight women) underwent craniofacial and cranial base reconstruction with a laparoscopically harvested omentum free flap. The mean patient age was 49 years, with a range of 17 to 73 years of age. A variety of defects were reconstructed via omentum free tissue transfer as listed in ►Table 1. The anterior skull base represented the most common site of reconstruction with the omentum free flap. A total of 12 of 13 (92%) omentum free flaps survived. The lone flap failure occurred 1 month after surgery due to infection with intestinal, gram-negative *Enterococcus*. The defect was ultimately repaired with a myocutaneous flap. All patients demonstrated satisfactory aesthetic and functional outcome. There were no perioperative or intra-abdominal complications.

Case Study

Patient no. 13 from ►Table 1 was a 73-year-old woman with a history of esthesioneuroblastoma of the sinonasal passages that underwent craniofacial excision via combined endoscop-

ic and open approaches. The frontal sinus was cranialized and the defect was reconstructed with an abdominal fat graft and cranioplasty utilizing the anterior table of the frontal bone and titanium mesh. The patient completed a postoperative course of radiation after excision. Subsequent to radiation treatments the patient presented with recurrent frontal sinusitis and was treated with several courses of topical and oral antibiotics. Ultimately, she was taken to the operating room for endoscopic debridement. During surgery, exposed necrotic frontal bone and titanium mesh were encountered and removed. The resultant anterior cranial fossa defect was immediately reconstructed with an abdominal fat graft, with intent for delayed repair with a patient-specific alloplastic cranioplasty implant in the future. However, the patient again developed sinonasal mucopurulent drainage and crusting with concern for necrosis and infection of the fat graft. Cultures obtained demonstrated resistant *Serratia* with sensitivity to cefepime. The patient completed a 6-week course of intravenous antibiotics with weekly in-office sinonasal debridement.

Table 1 Summary of patient data (CSF: cerebrospinal fluid)

Case	Age	Sex	Diagnosis	Primary versus secondary reconstruction	Defect repaired	Perioperative complications	Flap survival
1	50	F	Maxillary carcinoma	Secondary	Left maxilla and middle cranial fossa	None	Yes
2	49	M	Recurrent mandibular ameloblastoma	Primary	Right neck, face, middle cranial fossa	Infection and failure at 1 mo	No
3	50	F	Recurrent extracranial meningioma	Primary	Right partial mandible, maxilla zygoma, middle cranial fossa	None	Yes
4	32	F	Massive meningioma of anterior fossa	Primary	Both orbits and anterior cranial fossa	None	Yes
5	58	F	Recurrent pituitary adenoma	Secondary	Frontoparietal cranial defect with pathologic epidermal scalp thinning	None	Yes
6	42	F	Astrocytoma of frontal lobe	Secondary	Anterior cranial fossa floor	None	Yes
7	58	M	Adenoid cystic carcinoma	Secondary	Frontal bone and anterior cranial fossa	None	Yes
8	36	M	Mandibular squamous cell carcinoma	Secondary	Extensive scarring level II-III of right neck	None	Yes
9	53	M	Orbitocranial sarcoma	Secondary	Frontal bone and anterior cranial fossa	None	Yes
10	17	M	Extensive recurrent ossifying fibroma	Secondary	Anterior cranial fossa	None	Yes
11	51	F	Maxillary osteogenic sarcoma	Secondary	Right midface and middle cranial fossa	None	Yes
12	51	F	Osteoradionecrosis of frontal bone with sinodural fistula	Secondary	Frontal bone and anterior cranial fossa	None	Yes
13	73	F	Osteoradionecrosis of frontal bone with sinodural fistula	Secondary	Frontal bone and anterior cranial fossa	None	Yes

Fig. 1 (A) Left—anterior cranial fossa defect with sinodural fistula due to osteoradionecrosis of the frontal bone. (B) Right—inset omentum free flap with obliteration of the frontal sinus outflow tract and reconstruction of the anterior cranial fossa.

Once the infection was treated adequately, the patient underwent reconstruction via laparoscopically harvested, omentum free tissue transfer to the anterior cranial fossa. The head and neck surgery team provided the exposure to the anterior cranial fossa defect (**Fig. 1A**) and debrided any remaining debris from the frontal sinus outflow tract. The omentum was harvested laparoscopically by the general surgery team in ~75 minutes despite considerable adhesions from previous intra-abdominal surgery. A large omentum flap was procured with a long right gastroepiploic pedicle suitable for microvascular anastomosis (**Fig. 2**) in the same fashion detailed in the “Methods” section above. Microvascular anastomosis was performed by the plastic surgery team. The right gastroepiploic artery was sown end-to-end to the recipient left superficial temporal artery with 8–0 nylon sutures. The right gastroepiploic vein was connected end-to-end to the left superficial temporal vein with a 4-mm vein coupler. An implantable doppler was employed to monitor the flap postoperatively. The omentum flap was trimmed and customized to obliterate the frontal sinus and augment the frontal volume deficit (**Fig. 2B**). A drain was positioned under the scalp and the bitemporal incision was closed in multilayer fashion. There were no intraoperative complications.

Fig. 2 Laparoscopically harvested omentum free flap with right gastroepiploic vascular pedicle.

Fig. 3 (A, B) Preoperative frontal and lateral views, respectively, with frontal contour deformity. (C, D) Postoperative frontal and lateral views, respectively, with frontal contour restoration.

The patient was monitored in the intensive care unit postoperatively and was discharged 1 week after surgery with an unremarkable postoperative course. 3-month postoperative photographs were taken with excellent contour and patient satisfaction (**Fig. 3**). The patient has not had any signs of further infection.

Discussion

Treatment of patients with craniofacial and cranial base tumors is a challenge due to the anatomic intricacies associated with the calvarium, the pathological diversity of lesions that present, and the potential complications. The goal of craniofacial and cranial base reconstruction is to create a safe wound: obliteration of intracranial dead space, covering vital structures (i.e., great vessels, dura, nerves) with well-vascularized tissue and cranializing the frontal sinus when necessary. Additionally, the reconstructive surgeon must attempt to maximize postoperative function (vision, mastication, speech) while restoring optimal aesthetics with adequate long-term structural support. Free tissue transfer offers several advantages: dead space obliteration; delivery of immune cells, antibodies, and systemically administered antibiotics; and volume/contour restoration.²⁰ This is especially vital in the setting of the previously irradiated and infected wound bed. Myocutaneous free flaps can be used to provide vascularized tissue; however, over time, muscle atrophies due to denervation and substantial resorption is not uncommon.²⁸ Conversely, the omentum flap undergoes minimal atrophy and is more pliable than any other autologous tissue, making it an ideal reconstructive option in the setting of craniofacial and cranial base reconstruction, which is often characterized by complex, three-dimensional defects.^{20,21} We advocate omentum free flap reconstruction as the optimal procedure in the setting of craniofacial and cranial base defects with primarily subcutaneous tissue loss. The flap effectively

addresses contour defects, as illustrated in the *case study* above. The omentum free flap also provides a long vascular pedicle (15 cm or longer) that facilitates microvascular anastomosis especially when recipient vessels may be relatively distant in the neck.²⁹

This case series of 13 patients represents the largest number of reported laparoscopically harvested omentum free flaps used in the reconstruction of any part of the body in the literature. To the best of our knowledge, the largest series prior to this investigation included eight patients utilized in the reconstruction of progressive hemifacial atrophy.³⁰ In this study, the omentum free flap was successfully utilized to address craniofacial and cranial base defects in all but one patient. The lone failure was related to flap infection with intestinal gram-negative *Enterococcus* 1 month after surgery and represents a potential outlier. This may have been the result of inadequately sterilized laparoscopic equipment following its use in other abdominal surgeries. There were no additional reports of infection following the implementation of disposable laparoscopic harvesting equipment.

The omentum free flap has been considered a salvage flap due to concerns of donor site morbidity associated with a laparotomy. Hultman et al.¹² reported 135 omentum flaps (64 pedicled and 71 free tissue transfer) for complex extra-peritoneal wounds over a 25-year period utilizing an open, laparotomy technique. With the open technique common abdominal complications included abdominal wall infection, wound dehiscence, ventral hernia, prolonged ileus, and transient gastric outlet obstruction. A strong predictor of abdominal, donor site complications was use of a pedicled flap. In fact, 33% of the pedicled flap group developed donor-site complications, whereas only 5.6% of the free flap group experienced such complications. The only reported death in the literature associated with intra-abdominal complication after an omentum flap was due to volvulus in the setting of a *pedicled* omentum transfer.³¹ Free tissue transfer permits definitive closure of the peritoneal cavity, thus significantly reducing the risk of abdominal donor site complications.

Furthermore, the laparoscopic procurement of the omentum flaps has made the surgery even safer. Multiple studies have demonstrated significant reduction in morbidity when employing a laparoscopic harvesting approach compared with the open laparotomy approach.^{32–34} Laparoscopic harvesting is associated with less postoperative pain and a considerably shorter time until resumption of bowel function. It permits enteral nutrition and ambulation the day after the operation. A series by Zaha et al.³⁵ examined 96 laparoscopically harvested omentum flaps, which included 89 pedicled and 7 free flaps. The median operative time for harvesting the omentum flap was ~1 hour and blood loss attributable to laparoscopic procedures was typically negligible. Adhesiolysis was performed laparoscopically and the conversion rate to an open laparotomy was 0%. The single late laparoscopic-associated complication was a case of epigastric hernia, in which the volume of the omentum flap was extremely large, and a wider extraction incision was needed to withdraw the flap from the abdominal cavity. Otherwise no other late laparoscopic-associated complications (e.g., small bowel obstruction) were

identified. Clearly, omentum flap harvest has benefited from advances in laparoscopic technologies, which has reduced the risk of donor site morbidity to a minimum in the hands of an experienced laparoscopic surgeon.

In addition, the omentum demonstrates unique robust angiogenic and immunologic properties that resist infection and promote wound healing even in the setting of prior radiation and/or infection. The omentum secretes vascular endothelial growth factor, fibroblast growth factor, epidermal growth factor, and platelet-derived growth factors that promote neovascularization and wound healing.^{36–38} The omentum maintains abundant lymphatic capacity and contains fat-associated lymphoid clusters, which appear as “milky spots” macroscopically. These lymphoid aggregates consist of macrophages and lymphocytes, serving a protective immune function with bactericidal qualities in the presence of acute and chronic infections.^{39–41} Our *case study* patient suffered from frontal bone osteoradionecrosis with sinonasal biofilm. She has done considerably well after omentum free flap reconstruction with no evidence of further infection.

However, the omentum free flap has several disadvantages. Logistically, multiple surgical disciplines are involved which may make scheduling difficult. Likewise, teams may need to work in series, as opposed to concurrently, due to limitation of space. Although this may not be as much of a concern in craniofacial or cranial base reconstruction as the proximity of the donor site to the recipient maybe far enough to work in tandem. The most critical disadvantage of the omentum flap is that preoperative estimation of the omentum volume and vascular anatomy is not currently possible. A diagnostic laparoscopy is required to assess the size and viability of the omentum as a free flap. Thus, the patient must be informed of the possibility of an alternative free flap option. Future investigations involving this promising free tissue technique may include studies to radiologically assess the size and vascular anatomy of the omentum. In addition, much like the evolution of laparoscopic technique at the end of the last century, robotic-assisted surgery may represent an even less invasive method to safely procure an omentum free flap.

The laparoscopically harvested omentum free flap is a safe and effective tool in the armamentarium of the reconstructive surgeon. It is the ideal option to treat complex, three-dimensional subcutaneous defects, such as those encountered in craniofacial and cranial base reconstruction. Its unique angiogenic and immunologic capacity makes it an excellent flap for the previously irradiated and/or infected wound bed.

Disclosures

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