Objective: To introduce a novel technique for the reconstruction of complex nasal lining defects using the free vascularized anterolateral thigh fascia lata flap.

Methods: Free anterolateral thigh fascia lata flaps were used to replace nasal lining in 5 patients with total or subtotal rhinectomy defects. We performed a retrospective medical record review.

Results: No flap failure or lining loss was observed, and harvest site morbidity was negligible. Patients achieved satisfactory nasal form and patent nasal airways without a need for repeated revisions. In 2 patients, the anterolateral thigh flap was used simultaneously to restore the midface contour or to repair anterior skull base defects.

Conclusions: In this case series, we demonstrate the novel use of vascularized fascia lata to provide viable nasal lining in total and subtotal nasal defect reconstruction. Potential advantages offered by this technique compared with more established methods include (1) single-stage replacement of nasal lining, structure, and skin coverage; (2) fewer additional stages of reconstruction to achieve functional and aesthetic results; (3) thin lining to allow for optimal airway contour; (4) less harvest site morbidity; and (5) development of composite soft tissue, cutaneous, and/or muscle flaps to repair adjacent defects.


METHODS

We obtained institutional review board approval to perform this retrospective review at the Cleveland Clinic. We identified 5 patients who underwent total or subtotal nasal reconstruction with use of an ALT free flap from July 1, 2008, through June 30, 2011. All 5 patients underwent total or subtotal rhinectomy for cutaneous or mucosal malignant neoplasms. Outcomes assessed included patient and physician satisfaction with the cosmetic and functional results, postoperative complications, flap survival, nasal airway patency and timing, and number of revisions.

Reconstruction of oncologic defects was performed at the time of resection after full tumor clearance. Two patients had basal cell carcinoma, and the intraoperative Mohs micrographic technique was performed by a collaborator in

Reconstruction of total or near-total nasal defects is challenging and requires the juxtaposed re-creation of nasal lining, cartilaginous and bony nasal framework, and external skin covering. The ideal reconstructed nasal lining should provide a vascularized underlay to support bone and cartilage grafts, restore an adequate nasal airway, and cause minimal donor-site morbidity.1

The replacement of vascularized nasal lining is typically the most difficult component of reconstruction of large defects. Fasciocutaneous free flaps have been used effectively when local flaps cannot provide adequate coverage;2-4 however, flap redundancy and thickness often mandate several additional procedures before achievement of a patent nasal airway. Use of the radial forearm free flap to recreate the nasal lining has been well described. Although this flap is one of the more pliable and thin flaps used in free tissue transfer, multiple debulking procedures are required until an adequate nasal airway may be achieved.5-7 Overall use of the anterolateral thigh (ALT) free flap for head and neck reconstruction has increased greatly during the past decade, and many surgeons now use this flap preferentially for cutaneous and mucosal replacement. Cutaneous perforators within this flap pass through and vascularize the fascia lata, thus allowing for development of a free vascularized fascia flap. We report the use of this vascularized fascia lata as a thin, pliable tissue for nasal lining reconstruction.
A total/subtotal rhinectomy was performed for malignant disease. Any nasal subunit with more than 50% involvement was removed in its entirety. Definitive nasal reconstruction was initiated only after all resection margins were confirmed to be negative for tumor. Margin assessment was determined using the intraoperative Mohs micrographic technique performed by the Department of Dermatologic Surgery collaborators or using frozen section pathological analysis.

A fusiform cutaneous skin paddle that could be easily closed with primary skin advancement was designed centered on a thigh perforator located using Doppler guidance. Medial dissection proceeded to the rectus femoris muscle, and subfascial dissection exposed fasciocutaneous or muscular perforators. Perforators and the proximal pedicle were isolated, and an appropriately sized area of overlying fascia lata was demarcated and elevated with close attention to preservation of vascularity. The harvested flap included fascia lata as well as overlying skin and fat that was later removed and/or debulked based on reconstructive needs. Fascia lata designated for nasal lining was aggressively thinned while maintaining vascularity.

Recipient vessels were isolated via minimal-access submucosal or preauricular incisions. Notably, flap perforators were harvested with minimal muscle to allow easy passage of the pedicle through a subcutaneous tunnel. The flap pedicle was passed through the tunnel to the recipient vessels, allowing microvascular anastomosis.

After revascularization, the harvested flap was altered depending on the reconstruction need. Re-creation of the nasal skeleton was performed using harvested septal cartilage, auricular conchal cartilage, and/or rib, similar to previously described techniques (Figure 1). The vascularized fascia lata was then suspended from the existing bone and the newly created framework to reconstruct the nasal lining (Figure 2). Finally, if skin was included in the resection, a paramedian forehead flap was used to provide cutaneous color and texture match. Figure 3 demonstrates the layered reconstruction.

To reduce the potential of contracture and to create a skin-lined nasal vestibule, a split-thickness skin graft (STSG) covering was applied at the caudal aspect of the fascial flap. Proximally, the flap was allowed to mucoselize by secondary intention. The STSG was sutured to the nasal vestibule and then draped into the nose. Modified Doyle splints or nasal trumpets were placed within the newly created nasal cavity, facilitating adhesion of the STSG to the fascia lata.

Figure 1. The reconstructive skeletal framework for a total or near-total defect. Harvested septal, costal, and/or auricular cartilage are used to recreate the nasal ala and sidewalls. A rib graft is used for the dorsal and caudal supports. Vascularized anterolateral thigh fascia lata is secured to these grafts, and the vascular pedicle is tunneled subcutaneously to the facial artery notch of the mandible for microvascular anastomosis. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

Figure 2. Harvested rib is carved such that it articulates distally to create an L-strut. This L-strut provides a nasal framework along with dorsal and caudal support. Vascularized fascia lata is interwoven and suspended around the rib graft to establish an underlying nasal lining. Because the grafts are surrounded by vascularized tissue, cartilage and bone graft survival is promoted. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.
The following detailed case reports depict the clinical histories and surgical results of our 5 cases.

CASE 1

A 59-year-old woman had been referred for further evaluation and management of recurrent basal cell carcinoma of the left nasofacial sulcus and nose (case 1). For the previous 8 years, she had undergone extensive treatment at an outside institution, including previous radiotherapy (60 Gy) and multiple resections with reconstructions that included previous left alar reconstruction with nasolabial and septal flaps. She had a septal perforation presumably related to the previous reconstruction. She also underwent anterior and medial maxillectomy. Reconstruction of the nasal lining was performed using free vascularized fascia lata and septal cartilage, and a paramedian forehead flap provided external skin coverage. Anterolateral thigh flap subcutaneous fat was sculpted to recreate the maxilla and cheek contour. A cervicofacial advancement flap was used to provide additional skin coverage.

The patient underwent a wide-margin resection with intraoperative tumor clearance using the intraoperative Mohs micrographic technique. Her defect included a full-thickness left heminasal resection with a cutaneous defect sparing only the right ala, partial tip, and columella. She also underwent anterior and medial maxillectomy. Full-thickness cheek resection from the nasofacial sulcus to 1 cm lateral to the left infraorbital foramen was required (Figure 4A).

Reconstruction of the nasal lining was performed using free vascularized fascia lata (Figure 4B and C). The nasal skeleton was reconstructed with auricular and septal cartilage, and a paramedian forehead flap provided external skin coverage. After flap inset, an STSG graft was secured to the caudal aspect of the reconstructed alar rim and draped intranasally against the fascia with use of a nasal splint. More proximally, ALT flap subcutaneous fat had been maintained and was sculpted to recreate the maxilla and cheek contour. A cervicofacial advancement flap was used to provide additional skin coverage (Figure 4D).

Three weeks later, the patient underwent paramedian flap pedicle takedown and debulking. She has had 2 subsequent procedures to debulk the supra-alar sidewall. She is pleased with the functional and aesthetic outcome at 1 year (Figure 5A and B). She reports no difficulties with nasal obstruction or crusting. She has patent bilateral nasal passageways lined with healthy mucosa (Figure 5C and D).
CASE 2

A 54-year-old man was treated for desmoplastic melanoma of the nasal skin and anterior nasal septum. He underwent a subtotal rhinectomy and partial septectomy (Figure 6A). Reconstruction of the septum and nasal defect was achieved using autogenous ear and costal cartilage for the nasal framework (B), vascularized anterolateral thigh fascia lata for septal reconstruction and nasal lining (C), and a paramedian forehead flap for the skin envelope (D). Local cheek advancement flaps provided bilateral coverage lateral to the nasofacial sulcus. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

The patient's postoperative course was uneventful, and he was discharged to home 4 days after surgery. Subsequent stages of revision included paramedian forehead flap takedown 3 weeks after the initial reconstruction, nasal sidewall debulking 2 months later, left nostril revision with debulking, and an auricular composite graft 3 months after debulking. All of these procedures were performed on an outpatient basis. At 10 postoperative months, the patient has an excellent functional nasal airway bilaterally and is pleased with his aesthetic outcome (Figure 7A-C). Endoscopic evaluation demonstrates a completely intact septum with widely patent and mucosalized nasal cavities (Figure 7D).

CASE 3

A 74-year-old woman presented with a nearly 40-year history of multiple recurrent basal cell carcinomas of the nasal skin. During this time, she had undergone multiple resections and radiotherapy to the central face. The most recent resection was 5 years before presentation to our institution. At that time, the nasal resection defect was reconstructed with a scalping flap. She presented with a massive recurrence of the nasal skin involving the nasal dorsum, lobule, septum, and bilateral nasal lateral walls. The evaluation with magnetic resonance imaging did not reveal any orbital, intracranial, or peripheral nerve involvement.

The patient underwent a wide-margin resection of the nasal mass (Figure 8A). Tumor margins were assessed using the intraoperative Mohs technique, and resection was performed until all margins were negative for tumor. Her defect included the central upper lip, right and left medial cheeks, total nasal septum, and total external nose. Figures 1 through 3 schematically demonstrate the reconstruction required for this total rhinectomy defect.
Free vascularized fascia lata was harvested for reconstruction of the nasal lining. The columella was recreated with a nasofacial island flap. The nasal dorsum was reconstructed with rib bone, the sidewalls and ala were rebuilt with costal and conchal cartilage, and costal cartilage was used for tip support at the columella. The skin segment of the ALT flap was removed and used for an STSG. This segment was sutured to the fascia lata to create a lined vestibule. Distal fascia lata was inset to create a fascia-lined pocket around the columellar skeletal construct (Figure 8B). A paramedian forehead flap provided skin coverage (Figure 8C). At 3 postoperative months, takedown of the paramedian forehead flap was performed (Figure 8D). This procedure had been delayed owing to medical issues surrounding a recent diagnosis of rectal cancer, of which she died soon thereafter. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

Free vascularized fascia lata was harvested for reconstruction of the nasal lining. The columella was recreated with a nasofacial island flap. The nasal dorsum was reconstructed with rib bone, the sidewalls and ala were rebuilt with costal and conchal cartilage, and costal cartilage was used for tip support at the columella. The skin segment of the ALT flap was removed and used for an STSG. This segment was sutured to the fascia lata to create a lined vestibule. Distal fascia lata was inset to create a fascia-lined pocket around the columellar skeletal construct (Figure 8B). A paramedian forehead flap provided skin coverage (Figure 8C).

Postoperatively, the patient had partial loss of the distal forehead flap at the right alar margin, resulting in minor cartilage exposure. The forehead flap was advanced without pedicle division to provide coverage, and flap takedown was delayed. Six weeks after her surgery, the patient was admitted to the hospital for a newly diagnosed large occult rectal carcinoma. After significant delay owing to medical issues, the forehead flap was taken down 3 months postoperatively under local anesthesia with satisfactory nasal aesthetics and function (Figure 8D). Unfortunately, she subsequently died of complications related to her rectal cancer.

**CASE 4**

A 76-year-old man diagnosed with melanoma involving the right caudal nasal septum mucosa presented after undergoing subtotal excision at an outside facility. For complete resection of the mucosal melanoma, a near-total septectomy and infrastructure rhinectomy were performed via an open rhinoplasty approach. His extirpative defect included the central and caudal septum, medial and intermediate crura, nasal tip cartilage, and mucosa of the vestibule and adjacent nasal floor (Figure 9A). Nasal skeleton reconstruction was accomplished with rib and auricular cartilage grafts. An anterolateral thigh fascia lata flap was used to recreate the mucosal lining. The flap pedicle was tunneled via a minimally invasive incision at the facial notch (Figure 9B). Nine-month postoperative photographs demonstrate a sustained reconstructed nasal architecture in the anterior (C) and lateral (D) views. In addition, the patient had no functional nasal complaints. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

**Figure 8.** Photographs of a 74-year-old woman presenting with a massive basal cell carcinoma recurrence of the nasal skin involving the nasal dorsum, lobule, septum, and bilateral nasal lateral walls (case 3). She underwent a wide-margin resection of the nasal mass with a resulting defect including the central upper lip, right and left medial cheeks, total nasal septum, and total external nose (A). Reconstruction was performed with a nasofacial island flap for the columella, rib bone for the nasal dorsum, and costal and conchal cartilage for the sidewalls and ala. Vascularized fascia lata was used to create inner lining. Specifically, the fascia lata created a lined vascularized pocket around the columellar skeletal construct (B). A paramedian forehead flap provided skin coverage (C). At 3 postoperative months, takedown of the paramedian forehead flap was performed (D). This procedure had been delayed owing to medical issues surrounding a recent diagnosis of rectal cancer, of which she died soon thereafter. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

**Figure 9.** Photographs of a 76-year-old man with melanoma who underwent a near-total septectomy and infrastructure rhinectomy with intact external skin cover via an open rhinoplasty approach (case 4). This defect included the central and caudal septum, medial and intermediate crura, nasal tip cartilage, and mucosa of the vestibule and adjacent nasal floor (A). Nasal skeleton reconstruction was accomplished with rib and auricular cartilage grafts. An anterolateral thigh fascia lata flap was used to recreate the mucosal lining. The flap pedicle was tunneled via a minimally invasive incision at the facial notch (B). Nine-month postoperative photographs demonstrate a sustained reconstructed nasal architecture in the anterior (C) and lateral (D) views. In addition, the patient had no functional nasal complaints. Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.
A 58-year-old man diagnosed with squamous cell carcinoma involving the nasal septum, ethmoid sinus, and anterior skull base mucosa underwent anterior craniofacial resection via a lateral rhinotomy approach. Left medial maxillectomy and total septectomy were performed, along with mucosal resection extending to the ethmoid air cells and anterior skull base. Bilateral nasal bones and left nasal sidewall, including the upper and lower lateral cartilages, were also included in the resection (Figure 10A and B). Intraoperatively, a cerebrospinal fluid leak was noted and repaired during the reconstruction.

An ALT fascia lata flap was used to repair the anterior skull base defect and reconstruct the nasal mucosal lining to provide a vascularized underlay for structural grafts. The pedicle underwent revascularization using the facial vessels accessed via a nasolabial subcutaneous tunnel and a small incision at the facial artery notch of the mandible. Nasal dorsum and left sidewall support were reconstructed using rib and auricular cartilage grafts, respectively (Figure 10C). The patient had a patent nasal airway after removal of nasal stents. Postoperatively, he has maintained nasal structure and cosmesis (Figure 10D). He underwent postoperative radiotherapy without structural or functional compromise of the vascularized nasal reconstruction.

Figure 10. Photographs of a 58-year-old man with squamous cell carcinoma who underwent anterior craniofacial resection via a lateral rhinotomy approach (case 5). The resection included a left medial maxillectomy, total septectomy, bilateral nasal bones, left nasal sidewall, and the upper and lower lateral cartilages (A and B). The nasal dorsum and left sidewall were reconstructed using rib and auricular cartilage grafts, respectively. An anterolateral thigh fascia lata flap was used to repair an anterior skull base defect and reconstruct the nasal mucosal lining to provide a vascularized underlay for structural grafts (C). A photograph at 1 postoperative year depicts maintained nasal structure and cosmesis in addition to airway patency (D). Reprinted with permission, Cleveland Clinic Center for Medical Art and Photography ©2012. All rights reserved.

A total nasal defect is defined as bilateral loss of the 3 layers of the nose, including the internal nasal lining, skeletal support, and external skin cover. The basic principle of successful aesthetic and functional reconstruction of total and near-total rhinectomy defects centers on the reestablishment of any and all of the resected layers using tissues similar to the native nasal tissues. To accomplish this, the reconstructive surgeon may require the combined use of locoregional and distant flaps.

Methods of nasal reconstruction are thought to have developed in India more than 2600 years ago. This development is likely linked to the practice of rhinokopia (nasal amputation) as a form of punishment. The ancient Indian text Sushruta Samhita, thought to be transcribed in approximately 600 BC, provides detailed descriptions of the surgical tools and methods required in nasal reconstruction. In this text, the author first described the use of a pedicle flap. He used a pedicled cheek advancement flap to reconstruct nasal defects. Use of the forehead flap for nasal reconstruction is also thought to be described in the Sushruta Samhita.

Current reconstructive techniques for rhinectomy defects merge these ancient principles with recent technical advances to restore the form and function of the reconstructed nose.

Nasal reconstruction requires the juxtaposed re-creation of all 3 nasal layers. The skin envelope is most often reconstructed using the well described forehead flap. Repair of large defects has been described using distant skin via free tissue transfer, most commonly the radial forearm free flap. The nasal skeleton is manufactured most often from autogenous costal, septal, and auricular cartilages and bone placed during
the primary or intermediate reconstruction. Appropriate coverage and inner lining to nest the reconstructed nasal skeleton are essential to provide graft nourishment and survival. A lack of inner nasal lining leads to contracture of the entire nasal construct.\(^4\) Therefore, although it is the most difficult layer to reconstruct, the inner nasal lining performs critical and essential roles to promote nasal airflow and sustain structure of the reconstructed nose.

Several options are available for nasal lining reconstruction, including mucosal and skin grafts, local flaps, and free flaps. The native mucosal nasal lining is a thin, highly vascularized tissue that is keratinized at the nasal vestibule and then transitions to respiratory epithelium within the nasal cavity. Burget and Menick\(^1\) have advocated using similar tissues, such as nasal mucosal flaps, in the reconstruction of nasal lining defects. Ideally, reconstruction with similar tissue should allow for improved functionality of nasal lining to provide a patent nasal airway, humidification of inhaled air, and mucociliary transport. However, in cases of total and subtotal nasal defects, donor-site tissues are often insufficient to accomplish this. Therefore, use of several similar reconstructive tissues has been described.

Full-thickness skin grafts and STSGs have been used in reconstruction of the nasal lining. Although both grafts are thin to facilitate a patent nasal airway, surgical disadvantages include unpredictable viability and the inability to nourish skeletal grafts unless multiple subsequent operations are performed to insert the skeletal support. Functionally, the keratinized surface of the grafts can cause nasal dryness and crusting within the nasal cavity.\(^7\)

Endogenous nasal mucosal grafts provide an ideal reconstructive source for similar tissue; often in total nasal reconstruction, however, enough tissue for full reconstruction of the nasal lining is lacking. Intraoral mucosal flaps, particularly the facial artery musculomucosal flap, may be used, but these flaps are typically thick and require extensive subsequent thinning procedures. A patent nasal airway often depends on the bulk of the reconstruction, particularly of the ala. Local flaps, including the nasal turn-in flap, nasolabial flap, and forehead turn-in flap (hinged flap), may be used for reconstruction of the nasal lining, but these flaps are also bulky and provide only limited amounts of reconstructive tissue.\(^1,7\)

Walton et al\(^1\) and Moore et al\(^3\) have extensively demonstrated the use of free flaps for total nasal reconstruction. The most commonly used flap in these series is the radial forearm free flap. This flap has robust vascularity, a long vascular pedicle, large vessels, and a relatively thin layer of subcutaneous fat. An appropriately designed flap will provide ample tissue for reconstruction of the nasal lining. Despite its many advantages, the thickness of this flap is still greater than the endogenous nasal lining and often requires multiple revisions to thin the flap. In addition, pliability of the flap is limited secondary to its thickness.\(^7\)

Fascial flaps have several advantages to fasciocutaneous flaps for nasal lining reconstruction. Fascial flaps are thin and pliable and do not bear keratinized squamous epithelium. Winslow et al\(^5\) have shown in a previous case report the effective use of a radial forearm fascial flap to reconstruct the nasal lining. The flap was partially lined with turbinate mucosa remnants to facilitate healing. The authors reported that their patient had an excellent functional nasal outcome.

We demonstrate the use of free-tissue transfer of the ALT fascia lata to recreate the nasal lining. Use of this flap has several advantages compared with the radial forearm free flap. This flap provides a greater source of the fascia than the radial forearm free flap because we conservatively used areas of 6×10 cm of fascia lata in this series. The donor-site morbidity of this flap is minimal. In addition, vascularized components of the ALT free flap, such as subcutaneous fat and skin, can be easily and concurrently harvested to provide further reconstructive tissues for complex central face defects.

An STSG was used for skin coverage of the reconstructed nasal vestibule. This graft lines the vestibule appropriately, and it reduces contracture at this narrowest and most mobile segment of the nasal airway.

By using the fascia lata for nasal lining, no further procedures were required to remove excessive tissue bulk obstructing the nasal airway. Further revisions centered on contouring of the nasal envelope and addressing any areas of tissue breakdown. All patients had excellent intranasal healing and patent nasal airways and expressed satisfaction with their nasal airway. None of the patients had excessive crusting within the nasal cavity.

In conclusion, this case series demonstrates the effective use of fascia lata to reconstruct the nasal lining in total and subtotal nasal reconstruction. The fascia lata is a broad, thin, pliable, and vascularized tissue that provides an ideal substitute for nasal lining. Patients in this series achieved adequate nasal patency and required a minimal number of revisions. Given the advantages of less tissue bulk and less donor-site morbidity compared with standard, local, and distant reconstructive methods for nasal lining, vascularized fascia lata appears to hold promise in complex nasal reconstruction.

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Correspondence: Michael A. Fritz, MD, Division of Facial Plastic and Reconstructive Surgery, Head and Neck Institute, Cleveland Clinic, 9500 Euclid Ave, Desk A71, Cleveland, OH 44195 (fritzmi@ccf.org).
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REFERENCES