



# Pedicle Anterolateral Thigh Flaps for Salvage Reconstruction of Complex Abdominal Wall Defects

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## Abstract

**Background:** Extensive abdominal wall defects can arise following injury or tumor resection. Reconstruction of these full-thickness defects can be augmented with pedicle flaps, providing necessary soft-tissue when local options are inadequate. Though the pedicle anterolateral thigh (ALT) flap has been used to cover a wide range of defects, its utility in abdominal wall reconstruction has not been well described. Further, many surgeons conventionally adhere to the use of a free flap for upper abdominal defects and a pedicle flap for lower abdominal defects, yet it is our experience that a pedicle ALT flap can be used to salvage patients and reconstruct defects anywhere in the anterior abdomen up to the xiphoid process.

**Methods:** We conducted a retrospective study to assess and discuss our single institution experience with the use of pedicle ALT flaps for salvage abdominal wall reconstruction. Inclusion criteria were all patients of the senior author who underwent reconstruction of full-thickness composite abdominal wall defects with a pedicle anterolateral thigh flap from 2011-2015. Charts were reviewed for demographic data as well as outcomes measures, including fascial defect size, skin inset paddle size, acellular dermal matrices (ADM) used, underlying etiologies, and major and minor complications.

**Results:** A total of seven patients, ages 28 to 74 years, were included in this case series. All patients had recurrent hernias, infection, sarcomas and/or enterocutaneous fistulae with multiple prior abdominal operations. Mean inset skin paddle was 189 cm<sup>2</sup> and mean fascial defect size was 233 cm<sup>2</sup>. Pedicle ALT flaps were inset via a subcutaneous tunnel through the groin. There were no intraoperative complications, flap failures, or hernia recurrences. Two patients (28%) had postoperative complications of infection, with 1 reoperation within 30 days of surgery.

**Conclusion:** The pedicle ALT flap is a favorable option that should be routinely considered for reconstruction of composite full-thickness abdominal wall defects given its durable blood supply and ability to cover large cutaneous defects with minimal donor site morbidity.

## Introduction

Full-thickness composite abdominal wall defects are a common surgical problem often warranting complex reconstruction with autologous tissue, synthetic mesh and/or biological tissue matrix materials. A preferred reconstruction option involves using native components of the abdominal wall, frequently with component separation or tissue expansion [1]. However, local tissue is often insufficient in the setting of composite defects that are full-thickness with exposure of bowel or that involve attenuated musculofascial tissues. When faced with complex defects of the abdominal wall involving composite structures, it is critical to approach these defects in a multidisciplinary fashion involving both general and plastic reconstructive surgical principles.

Reconstructions of extensive abdominal wall defects can be augmented with autologous tissue in the form of a pedicle or free soft-tissue flap in a single-stage operation. While free tissue transfer can be utilized to reconstruct defects of virtually any anatomic region of the body, it is associated with increased operative time [2] and a higher risk of total flap necrosis as compared to pedicle flaps [3]. It requires microvascular expertise which is not always available and thus precludes its wide spread application. A pedicle flap allows the reconstructive surgeon to perform abdominal wall reconstruction in an efficient and expedient fashion without the need for advanced microsurgical skills.

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Pediced fasciocutaneous and myocutaneous flaps can provide necessary soft-tissue for reconstruction when local options are inadequate, yet there are limited donor sites for reconstructing large abdominal wall defects. The pedicled anterolateral thigh flap, which has been employed to cover defects as cephalad as the epigastrium, is a reliable option for abdominal wall reconstruction [4-8]. The flap provides a number of advantages over other regional flaps. For example, the tensor fascia lata flap is primarily comprised of fascia; therefore, this flap has limited bulk and is not capable of filling large defects. The rectus femoris flap, which can reach the costal margin or xiphoid, lacks a skin paddle, and, consequently, large cutaneous defects cannot be filled [9]. The anterolateral thigh flap, however, can be designed to contain large amounts of skin, adipose tissue, muscle and fascia. A combination of all of the tissue elements available in the flap can be used to reconstruct full-thickness defects of the abdominal wall. This closure is attainable by incorporating tensor fascia lata and nearly the entire anterolateral thigh [10]. The flap's vascular supply is provided by septocutaneous or musculocutaneous perforators from the descending branch of the lateral circumflex femoral artery. There are a number of venous drainage outlets for the anterolateral thigh flap, including the lateral circumflex femoral vein [11]. Harvest of the anterolateral thigh flap results in a minimal loss of postoperative functional strength [12] and is generally considered to have low donor site morbidity [3,4]. If the donor site cannot be closed primarily, a split-thickness skin graft is typically placed over exposed fascia and muscle.

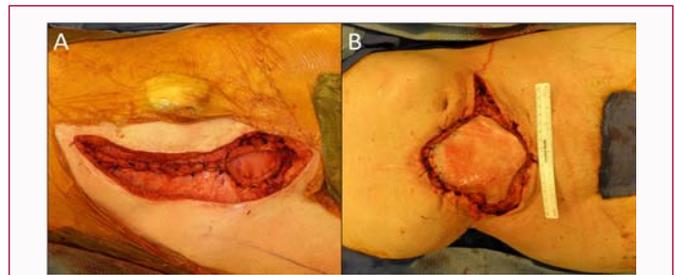
Despite the advantages of using a pedicled anterolateral thigh flap for abdominal wall reconstruction, there is currently a paucity of literature devoted to exploring this topic [2,4,7,13-17]. Utilizing the anterolateral thigh flap as a free tissue transfer for abdominal wall reconstruction is well described [2,10,18-21]. Over the past several years, we have seen that employing the anterolateral thigh in the form of a pedicled flap allows for ease of harvest, rotation, and inset into an abdominal wall defect. Our objective is to describe our single institution experience for the use of a pedicled anterolateral thigh flap when reconstructing abdominal wall defects in salvage cases.

## Methods

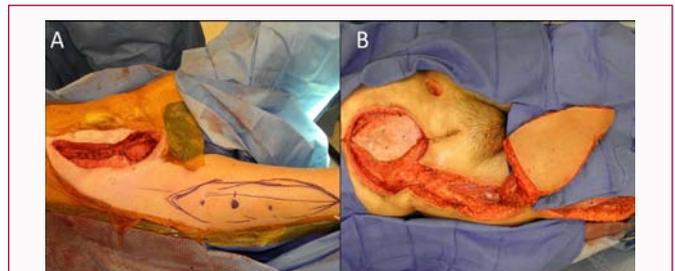
A comprehensive retrospective chart review was conducted on patients undergoing a pedicled anterolateral thigh flap for salvage reconstruction of abdominal wall defects between January 2011 and December 2015 by a single surgeon at the Johns Hopkins Hospital. The study was approved by the Johns Hopkins Institutional Review Board. The patients were referred to the senior author (JMS) for abdominal wall reconstruction secondary to full-thickness composite defects. Charts were reviewed for demographic data as well as outcomes measures, including fascial defect size, skin inset paddle size, acellular dermal matrices (ADM) used, underlying etiologies, and major and minor complications.

## Results

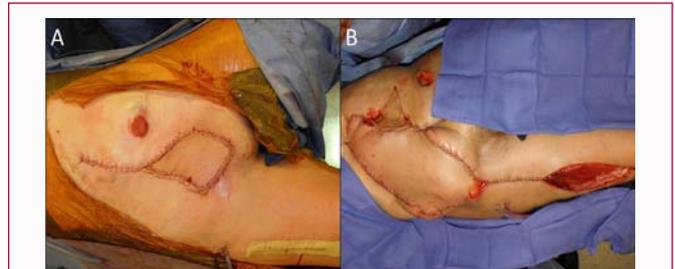
Chart review revealed seven patients who underwent salvage abdominal wall reconstruction using a pedicled anterolateral thigh flap. All patients had loss of abdominal wall domain due to recurrent hernias with infected mesh and/or enterocutaneous fistulae. Underlying etiologies included Crohn's disease, gastroschisis, colorectal cancer, sarcomas, and ulcerative colitis. All of the patients had undergone multiple abdominal operations in prior years, and underwent laparotomies by a general surgery service the day of,



**Figure 1:** Abdominal fascial defects and reconstruction. (A) Fascial defect closed primarily at the superior aspect with ADM inlay to bridge the remaining defect. (B) A 600 cm<sup>2</sup> ADM underlay and vacuum assisted closure dressing were placed during the laparotomy 10 days prior to definitive abdominal wall reconstruction.



**Figure 2:** Template and ALT flap harvest. (A) The flap was templated over the right thigh, with a skin paddle sufficient to cover an 180cm<sup>2</sup> skin defect and two vascular perforators. (B) A myocutaneous ALT flap was raised including two musculocutaneous perforators.



**Figure 3:** ALT flaps inset into the abdominal wall. (A) The flap was passed through a subcutaneous tunnel, a large portion of the skin paddle de-epithelialized and buried, and the flap inset. (B) The ALT flap was rotated and passed through a subcutaneous tunnel to the defect site, and then the tunnel opened to prevent flap and pedicle compression.

three days before, or ten days before definitive abdominal wall reconstruction. Four patients were female, with a mean age of 52 years, and three patients were male, with a mean age of 54 years. Mean length of stay was 29 days.

At the time of reconstruction, synthetic or biologic mesh, previously placed over the fascial defect, was removed except in two cases where an acellular dermal matrix underlay placed during the immediately preceding laparotomy was left in place. The average fascial defect was 233 cm<sup>2</sup> (range 150 – 450 cm<sup>2</sup>) and porcine or human acellular dermal matrix was inserted as an underlay for three patients (Figure 1).

A template of the anterolateral thigh flap was then drawn onto the right thigh according to the size of the abdominal wall skin defect and centered over the perforator zone (Figure 2A) [22]. Skin and fascial incisions were made, and the vascular pedicle was traced between the vastus lateralis and the rectus femoris muscles. Two septocutaneous perforators extending into the skin paddle were included in all seven



**Figure 4:** Complete progress of case (intra-operative and post-operative photographs). (A) The tumor can be seen bulging from the patient's right lower abdomen. (B) Due to the severity of the tumor, much of the abdominal wall is removed. (C) After placing biologics (ADM), the pedicled ALT flap is harvested. (D) The soft tissue is inset into the defect and a drain is placed on the donor site. (E) Post-operative 4 month follow-up photograph displays progress. (F) Post-operative 1 year follow-up photograph displays completely healed wounds.

flaps. The raised flaps consisted of skin, adipose tissue, fascia, and a minimal segment or cuff of vastus lateralis muscle (Figure 2B). All flaps were tunneled under the proximal portion of the rectus femoris muscle in order to increase the arc of rotation.

Subcutaneous tunnels, several fingerbreadths wide, were created between the donor site and the abdominal wall. In one patient, extensive scarring from previous operations prevented sufficient enlargement of the soft-tissue tunnel to allow safe passage of the flap without undue flap compression. As a result, the tunnel was converted to two skin flaps, which were then closed over the pedicle (Figure 3B). The vastus lateralis was sutured to the underlying fascia or acellular dermal matrix. Large close-suction drains were placed in donor and recipient sites prior to closure. Skin paddles were then secured to the edges of the defect using absorbable sutures or skin staples (Figure 3). The average skin paddle size was 189 cm<sup>2</sup> (range 150-300 cm<sup>2</sup>). In one case, a significant portion of the skin paddle was de-epithelialized and buried under native abdominal wall tissue (Figure 3A). Another patient required an additional 35 cm<sup>2</sup> full-thickness skin graft, which was harvested from the anterolateral thigh flap, to place over exposed adipose tissue on the abdominal wall (Figure 3B).

Regarding the anterolateral thigh donor site closure, one case allowed for primary closure (Figure 3A), while the other six required closure with split-thickness skin grafts, ranging from 150 cm<sup>2</sup> to 350 cm<sup>2</sup>. All skin grafts were harvested from the medial thigh or contralateral thigh (Figure 3B). Subsequently, the skin grafts were covered with vacuum-assisted closure devices. In one case, a vacuum-assisted closure device was also placed on the abdominal wall along the incision lines to help reduce edema and manage fluid egress.

There were no intraoperative complications, flap failures, or hernia recurrences. Two patients (28%) had postoperative complications of infection and/or abscess, with one reoperation (14%) within 30 days of surgery. One patient experienced an abdominal wall abscess, for which the patient received broad spectrum antibiotics and underwent drain placement by interventional radiology. Another patient developed a flap abscess and was taken back to the operating room on postoperative day 6 for drainage.

## Discussion

Though use of the anterolateral thigh free flap has been well-described, abdominal wall reconstruction with the pedicled anterolateral thigh flap is infrequently reported in the literature [6]. The seven cases in this report highlight the operative flexibility provided by the pedicled anterolateral thigh flap. In these cases, a pedicled anterolateral thigh flap was rotated, tunneled deep to the rectus femoris muscle proximally [20], and inset into the respective abdominal wall defect. In one instance, scarring from previous operations did not allow passage of the flap through the tunnel. Flap and pedicle compression often leads to venous congestion; therefore, skin flaps on the lower abdomen were raised, opening the tunnel and preventing compression. Though tunneling under the rectus femoris allows for increased flap excursion, subcutaneous tunneling may be clinically advantageous by avoiding pedicle compression by the rectus femoris. If pedicle length restricts the ability for the flap to reach all aspects of the defect, the flap can be readily converted into a free flap [2]. However, in this situation, recipient vessels need to be explored. Options in this situation can include the ipsilateral or contralateral deep inferior epigastric vessels. Vein grafts can be used to help create pedicle length for free-tissue transfer. An arterio-venous loop, using a saphenous or cephalic vein graft, can be anastomosed to the deep inferior epigastric vessels in an immediate or delayed setting to help prepare for eventual free-tissue transfer of the ALT flap. The superior epigastric vessels a continuation of the internal mammary vessels can be used as recipient vessels, although the caliber of these vessels can be diminutive and they are found in an intramuscular course in the rectus muscle. Vein grafting to the internal mammary vessels can be considered although this typically requires removal of a chondral segment of a rib in order to gain access at vessels. Description of free-tissue transfer is evidence enough to consider a pedicled flap as a first option for large soft-tissue reconstruction of the abdominal wall.

While there can be inconsistencies in perforator anatomy and some difficulty in perforator dissection [23], the major factor limiting the use of the pedicled anterolateral thigh flap for abdominal reconstruction is the location of the defect. Some authors have described the strict use of a free flap for upper abdominal defects and a pedicled flap for lower abdominal defects [2]. Sacks et al. [6]

**Table 1:** Key Patient Demographics and Clinical Outcomes.

Subject	Gender	Age at Time of Surgery	Length of Stay	Wound Defect Size (cm <sup>2</sup> )	Inset Skin Paddle Size (cm <sup>2</sup> )	Type of Biologic Used	Flap Failure	Complications
1	F	36	42	156	156	ADM	No	None
2	M	55	84	225	300	ADM	No	Abscess, SSI
3	M	63	21	200	188	None	No	None
4	M	43	16	180	180	None	No	None
5	F	70	12	150	150	ADM	No	None
6	F	28	21	450	200	ADM	No	Abscess
7	F	74	12	270	150	ADM	No	None

however, described the ability to use the pedicled flap for a defect almost anywhere in the anterior abdomen [6], and Ting et al. [4] reported using a pedicled anterolateral thigh flap to reconstruct an epigastric defect. Certain limitations in pedicle length can be overcome by submuscular tunneling; however, perforator selection is also an important factor. Maxhimer et al. [3] reported increasing excursion of the flap to the abdomen by designing a distal skin island and a higher point of rotation [3]. In addition, restricting hip joint range of motion in the perioperative period and slowly introducing hip extension allows for increased cranial placement of the flap [4]. By the orienting the skin paddle of the ALT flap on distal perforators of the descending lateral circumflex perforator system one can optimize the length of the pedicle flap to use. When the skin paddle placement is performed appropriately the ALT flap can be used to cover defects of the abdominal wall as high as the xyphoid.

There is recent evidence that the pedicled anterolateral thigh flap is as reliable for complex abdominal wall reconstruction. Kayano et al. [2] showed that the only significant difference between use of a free and pedicled anterolateral thigh flap for abdominal wall reconstruction was a longer mean operative time for the free flap surgeries [2]. With the ability to maximize flap excursion and the numerous advantages of reconstructing with vascularized pedicled autologous tissue, the pedicled anterolateral thigh flap is a viable reconstructive option for a wide range of anterior abdominal wall tissue defects.

The pedicled ALT flap is a reliable and robust flap from the adjacent thigh that allows full-thickness abdominal wall defects to be reconstructed in an immediate fashion. Variable amounts of skin, adipose tissue, fascia and vastus lateralis muscle can be used to reinforce composite defects of the abdominal wall that would not be able to be reconstructed without free-tissue transfer. This flap allows both the general and plastic surgeon to collaborate and reconstruct the most complex abdominal wall defects. Using this collaborative approach, patients with loss of domain, fistulae and/or both can be approached in a straightforward manner. A staged approach is favored for patients with fistula with bowel resection followed by primary fascial closure with or without a biological matrix underlay. If primary fascial closure is not obtained, then a biological matrix or synthetic mesh underlay can be used to partition the enteric contents from the wound. Wound contamination and surgeon preference will determine the use synthetic and/or biological matrix placement. Once wound contamination is controlled, full-thickness abdominal wall defects can subsequently be reconstructed using well-vascularized tissue from the thigh in a pedicled fashion. This technique allows even the most complex of abdominal wall defects to be reconstructed in a straightforward, systematic and safe fashion.

## Conclusion

With our single-institution experience, the pedicled ALT flap is a favorable option that should be routinely considered for salvage reconstruction of composite full-thickness abdominal wall defects, given its durable blood supply and ability to cover large cutaneous defects with minimal donor site morbidity. Utilizing a well-organized, multidisciplinary approach, large composite defects of the abdominal wall that involve muscle, fascia, adipose tissue and skin can be reconstructed in a systematic and safe way.

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