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Original Article

Salvaging Complex Lower Extremity Injury with Laparoscopically Harvested Omental Flaps

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A B S T R A C T

Background: Traumatic injuries to the lower extremities are frequently accompanied by extensive soft tissue loss, combined with vascular damage or exposure of bony tissues, making it difficult to reconstruct; consequently, patients are commonly at risk of amputation. Due to its superior anatomical and biochemical properties, the omental flap has been used to reconstruct soft tissue defects for decades. However, few studies have reported the omental flap's effectiveness in treating severe and complex lower extremity deformities. We attempted to use a laparoscopically harvested omental flap in conjunction with a second-stage skin graft to reduce infections during limb preservation, increase flap survival probability, and restore the aesthetic and functional integrity of the affected extremity.

Methods: Seventeen patients with severe lower extremity wounds underwent omental flap transplantation and were followed up for 6 to 12 months to check for surgical complications, evaluate cosmetic results, and ensure proper limb function.

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Results: There were no complications, such as intestinal adhesion, intestinal volvulus, and peritonitis, with any of the omental grafts. The affected extremities were well-functioning and aesthetically pleasing.

Conclusion: Laparoscopically harvested omental flap transplantation with skin grafting is an alternative reconstruction technique for severe lower extremity injuries with massive soft tissue loss and exposed bones and tendons.

Background

In the clinical treatment of lower extremity injuries, choosing between amputation and salvage is crucial. Patients who desire and meet the criteria for salvage and reconstruction may benefit from external fixation and negative pressure therapy prior to staged definitive reconstruction.[1,2] For conventional soft tissue defects of the lower extremity, several clinical treatment options are available.[3] However, certain types of lower extremity defects have a poor blood supply and are susceptible to recurrent infections, making reconstruction extremely challenging. There is often no alternative reconstruction plan for severe lower extremity injuries with extensive soft tissue defects, multiple exposed bones, joints, tendons, and internal implants. The reconstruction of such defects can result in varying degrees of infection, which may increase the likelihood of postoperative vascular crisis. In addition, the scarcity of local tissues and the functional requirements of the lower extremity frequently necessitate the transfer of healthy tissue from a distant location using a free flap and microsurgery, for instance, the latissimus dorsi flap.[4,5] However, the selection of donor sites is constrained by the presence of large soft tissue defects and massive bony tissue exposures. Furthermore, irregularly shaped defects make it difficult for the majority of flaps to adequately fill the defects and reconstruct the extremity.

The omentum has been used as a flap for reconstructing a variety of soft tissue. In 1989, free omental tissue was used for the first time to reconstruct lower limb defects.[6] Compared to musculocutaneous and fascial flaps, the omental flap has superior antimicrobial and angiogenic properties.[7,8] Although omentum harvesting via traditional laparotomy can take a long time and increase the risk of complications,[9] this procedure has been greatly simplified and accelerated by the advent of laparoscopy. With laparoscopic omentum harvest, surgical trauma is significantly reduced, patients experience less pain, and the postoperative recovery is accelerated.[10] Here, we present a series of 17 patients who underwent laparoscopically harvested omental flap transplantation with skin grafting to reconstruct large soft tissue defects in the lower extremities.

Patients and methods

From June 2013 to June 2019, 17 patients with severe lower extremity wounds were admitted to Hanzhong central hospital. (See Table 1 for a description of patient characteristics in the clinical series.) Inclusion criteria: (1) patients with complex lower extremity injuries, whose wounds were irregular in shape with massive tissue loss, difficult to cover with conventional local or free flaps, or reconstruct with these flaps but causing great trauma to the donor site; (2) no operation history for abdominal diseases. Exclusion criteria: (1) patients and their family members refused to perform the surgery after detailed preoperative notification; (2) failure to cooperate with regular follow-up after surgery; (3) patients had a past history of associated pathologies.

After admission, sensitive antibiotics are chosen for treatment based on bacterial culture results from the patient's wound secretion. Prior to surgery, all patients were treated with vacuum-sealed

Table 1
Patients' characteristics.

No	Gender	Age	BMI	Smoking	Mechanism	Tissue loss	Exposed
1	M	15	19.9	No	Trauma	53 cm × 21 cm	Bones & tendons
2	M	31	22.1	Yes	Trauma	30 cm × 15 cm	Bones
3	M	15	20.8	No	Burns	33 cm × 18 cm	Bones
4	M	27	20.9	Yes	Burns	42 cm × 20 cm	Bones & tendons
5	M	19	24.2	No	Trauma	20 cm × 12 cm	Bones
6	M	48	23.7	Yes	Trauma	37 cm × 16 cm	Bones
7	M	46	17.8	Yes	Trauma	44 cm × 19 cm	Bones
8	M	40	21.4	Yes	Trauma	33 cm × 15 cm	Bones & tendons
9	M	40	19.7	Yes	Trauma	40 cm × 21 cm	Bones
10	F	34	23.7	No	Trauma	43 cm × 14 cm	Bones
11	M	22	24.6	No	Trauma	42 cm × 15 cm	Bones
12	M	50	22.2	Yes	Trauma	36 cm × 16 cm	Bones
13	F	16	22.9	No	Trauma	33 cm × 12 cm	Bones & tendons
14	F	58	18.6	No	Trauma	45 cm × 20 cm	Bones
15	F	59	19.9	No	Trauma	44 cm × 12 cm	Bones
16	M	53	20.9	Yes	Trauma	38 cm × 17 cm	Bones & tendons
17	F	32	23.5	No	Trauma	46 cm × 12 cm	Bones & tendons

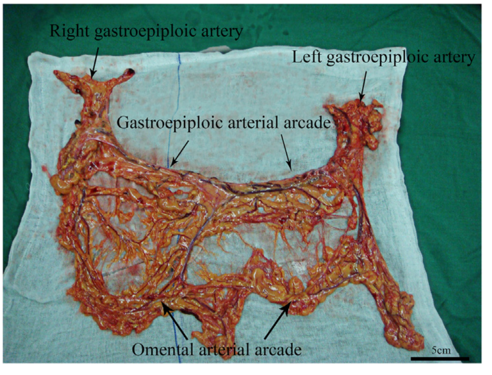

Fig. 1. A laparoscopically harvested omental flap measuring 30 cm × 24 cm is shown. The right gastroepiploic artery was dissected and will serve as the flap pedicle.

drainage following repeated debridement to ensure that the severely infected wound was transformed into a relatively clean wound.

A multidisciplinary team consisting of both the general surgery and plastic surgery teams performed the surgery. Following abdominal cavity exploration, the gastrocolic ligament was transected along the edge of the transverse colon. The right gastroepiploic vessels were dissected to their roots, whereas the left gastroepiploic vessels were divided, then ligated and transected. The greater omentum was disassociated from the left to the right along the gastroepiploic arcade to the greater curvature of the stomach (Figure 1). When the recipient area was completely set up, the free omentum was evenly distributed, placed over the wound, and fixed. Postoperatively, the omentum is routinely covered with vaseline gauze to shield exposed blood vessels, with multiple layers of gauze on the outer layer to mitigate oozing, and dressings are changed regularly. The flaps underwent controlled warming using heating devices, along with dextran anticoagulation (except in patients predisposed to hemorrhage). Concurrently, vigilant monitoring of flap perfusion was conducted, and interventions to address vasospasm were implemented as deemed necessary. Generally, the skin grafting surgery was performed two to three weeks later.

Table 2
Surgery information.

No	Omentum flap	Time for harvesting	Arterial anastomosis	Skin grafts	Complications
1	30 cm × 24 cm	1.4 hours	DBLCF	50 cm × 18 cm	No
2	22 cm × 18 cm	1.8 hours	AT	30 cm × 16 cm	No
3	25 cm × 10 cm	2.1 hours	AT	28 cm × 17 cm	No
4	32 cm × 13 cm	1.5 hours	AT	35 cm × 18 cm	No
5	20 cm × 9 cm	1.5 hours	AT	15 cm × 10 cm	No
6	30 cm × 14 cm	1.7 hours	AT	33 cm × 17 cm	No
7	35 cm × 21 cm	1.6 hours	AT	39 cm × 18 cm	No
8	28 cm × 11 cm	2.2 hours	PT	33 cm × 14 cm	No
9	32 cm × 17 cm	1.5 hours	PT	36 cm × 17 cm	No
10	30 cm × 11 cm	1.5 hours	PT	38 cm × 14 cm	No
11	35 cm × 13 cm	1.6 hours	AT	40 cm × 12 cm	Skin grafts partly necrosis
12	27 cm × 10 cm	1.3 hours	AT	35 cm × 11 cm	No
13	24 cm × 11 cm	1.1 hours	DBLCF	28 cm × 10 cm	No
14	34 cm × 18 cm	1.5 hours	PT	40 cm × 14 cm	No
15	35 cm × 12 cm	2.1 hours	PT	40 cm × 10 cm	No
16	31 cm × 14 cm	1.9 hours	AT	34 cm × 16 cm	No
17	35 cm × 10 cm	2.0 hours	AT	39 cm × 13 cm	No

DBLCF: descending branch of the lateral circumflex femoral, AT: anterior tibial, PT: posterior tibial

Fig. 2. The wound appearance after debridement and VSD treatment (*upper*). The omental flap was harvested laparoscopically and evenly distributed to cover the wound (*middle*). Two months later, the wound had recovered well (*lower*).

Results

The surgical procedures of 17 patients were successful. (See Table 2 for a description of surgery information.) The average operative time for harvesting of the greater omentum was 1.66 hours. The resected area of greater omentum ranged from 25 cm × 10 cm to 30 cm × 24 cm. The right gastroepiploic artery and vein were anastomosed end-to-end with the recipient vessels in all cases, resulting in the survival of all omentum grafts survived. There were no complications such as intestinal adhesion,

Fig. 3. The wound appearance after debridement and VSD treatment (a). Transplantation of a free omental flap was performed. The right gastroepiploic artery was anastomosed with the anterior tibial artery (b). Two weeks later, the omentum graft had survived (c). The skin graft was transplanted to the wound. Two months later, the wound had recovered well (d, e).

intestinal volvulus, or peritonitis, and all small abdominal incisions healed well with inconspicuous scars.

The skin grafts of 16 patients survived, ranging in size from 36 cm × 8 cm to 45 cm × 22 cm. One patient's skin graft developed a small area of necrosis, which healed after symptomatic treatment. All patients were followed up for 6 to 12 months after surgery. The affected extremities appeared proportioned, with no obvious edema. In all cases, in addition to a satisfactory recovery of the skin with a soft texture and good abrasion resistance, the functional recovery of the affected limbs was good and to the satisfaction of the patients.

case 1

A 15-year-old male was admitted to the hospital with an injury to his left lower extremity. The anterior tibial vessels were damaged. The tibia, fibula, Achilles tendon, and the ankle joint were exposed.

After repeated debridement and vacuum-assisted closure (VSD) treatment, the wound (53 cm × 21 cm) was relatively clean. The omental flap (30 cm × 24 cm) was harvested laparoscopically. The right gastroepiploic artery was anastomosed end-to-end with the descending branch of the lateral circumflex femoral artery, and the right gastroepiploic vein was anastomosed with the vein accompanying the lateral circumflex femoral artery. Two weeks later, the omentum graft had survived. The wound was covered with a 50 cm × 18 cm medium-thick skin graft (0.3-0.4 mm) harvested from the back. Two months later, the wound had recovered well (Figure 2).

case 2

A 31-year-old male was admitted to the hospital with a fracture of the right tibia and fibula. After repeated debridement and VSD treatment, the wound (30 cm × 15 cm) was relatively clean. Transplantation of laparoscopic harvested free omental flap (22 cm × 18 cm) was performed. The right gastroepiploic artery was anastomosed end-to-end with the anterior tibial artery. Two weeks later, the omentum graft had survived. A medium-thickness skin graft (30 cm × 16 cm) from the right thigh was transplanted to the wound. Two months later, the wound had recovered well (Figure 3).

Discussion

In our procedure, we found that the omentum is sufficiently thin to provide adequate coverage with minimal bulk, resulting in a more aesthetically pleasing outcome. Compared to other flaps, omental flaps have a lower propensity to atrophy, and their greater flexibility ensures that the postoperative appearance of the affected limb will be preserved over time.[11]

In our experience, secondary skin grafting surgery is beneficial for observing the condition of the omentum flap, thereby optimizing survival conditions for the skin grafts and reducing the likelihood of omentum and skin graft necrosis.

In addition to the anterior/posterior tibial artery and vein, there are two instances of anastomosis with the descending branch of the lateral circumflex femoral artery and its accompanying vein in our case series. In all cases, the appearance and function of the injured limb recovered well without any long-term complications. This shows that the right gastroepiploic artery is a versatile pedicle that permits a diverse array of anastomosis vessel options at the recipient site.

The limitation of our study is that we did not evaluate the feasibility of previous abdominal surgery or intraperitoneal adhesions in patients. Therefore, our study lacks guiding significance for the widespread use of this surgery.

In summary, the omental flap has many advantages, as discussed, and it has become a reliable reconstructive tool due to its ability to correct wounds in multiple anatomic regions from multiple etiologies. With the near universality of laparoscopic harvesting, the omental free flap should be used more frequently to reconstruct soft tissue defects.

Declaration of competing interest

All authors declare they have no conflict of interests to declare.

Disclosure

The authors have no financial interest to declare about the content of this article. As the corresponding author, we have full access to all the data in the study and final responsibility for the decision to submit for publication.

Ethical approval

This study was approved by the Medical Ethics Committee of the Hanzhong Central Hospital.

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Author contributions

XFZ (lead surgeon) developed the protocol for surgery and patient care, TZ coordinated the research team, and reviewed the manuscript. FM and YMK reviewed the clinical data and helped to prepare the manuscript. JHZ and HW performed surgical procedures and participated in preoperative assessment and postoperative follow-up of patients. EY summarized the clinical data, wrote and revised the manuscript. QHX and BHK participated in article retrieval and evidence summary. All authors contributed to the final version of the paper.

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