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Vacuum-assisted surgical treatment of large and complex Morel-Lavallée lesions in lower extremities

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ABSTRACT

Aim: Morel-Lavallée lesion (MLL) is the separation of the skin from the deep fascia caused by shear stress after trauma and the formation of a fluid-filled cavity between the fascia layers. After the inflammation develops, a fibrous capsule develops around the serosanguineous fluid, preventing its absorption. Cavity infection, skin necrosis, and muscle, tendon, bone, and implant exposure were observed in untreated MLLs. This study presents vacuum-assisted surgical treatment for large and complex MLLs and the effects of treatment on the functionality of lower extremities.

Methods: 23 patients who were diagnosed with post-traumatic MLL in the lower extremities and underwent vacuum-assisted surgical treatment were examined. Demographic characteristics, comorbidities, smoking status, body mass index (BMI), type of trauma, anatomical location, skin characteristics of the cavity, additional injuries, duration of treatment delay, medical and surgical procedures, return to work, and social life were investigated. All cavities were evaluated using ultrasonography, and cavity volumes were measured. All patients underwent percutaneous incision drainage and radical debridement of necrotic tissues and cavities. Lower extremity function was evaluated using the lower extremity functional scale (LEFS).

Results: A total of 82.6% of patients had chronic MLLs. All patients had high-volume MLLs and functional impairment due to MMLs. *The* vacuum-assisted wound closure provided compression, drainage, and obliteration of the cavity alone in the treatment of MLL. Additionally, the positive effects of negative-pressure wound therapy (NPWT) on wound healing prevented complications such as recurrent MLLs, seroma, dehiscence, and graft loss. This method has also positively affected lower-extremity functionality during subsequent periods ($p<0.001$).

Conclusions: In treating large-volume acute and chronic MLLs, percutaneous drainage, radical debridement, cavity closure with quilting sutures, and pressure support with NPWT are reliable methods that ensure problem-free healing of MLLs. This method has also positively affected lower-extremity functionality during subsequent periods.

Keywords: Lower extremities, MLL, Morel-Lavallée lesions, negative-pressure wound therapy, vacuum-assisted wound closure.

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Introduction

The subcutaneous tissue is located between the skin and deep fascia and contains fat lobules and septa. These septa play an active role in skin stabilization. Friction injuries and trauma disrupt the integrity of the septa, causing the separation of the skin from the deep fascia and forming a potential cavity in the subcutaneous area. The lymphatic, capillary, and perforator vessels are also damaged, and their contents fill the cavities. These fluid-filled cavities were first described by Auguste-Francois Morel-Lavallée in 1853 as "Morel-Lavallée lesion" (MLL) [1]. MLLs were also named "closed degloving injury, post-traumatic soft tissue cyst, pseudocyst, Morel-Lavallée extravasation, and Morel-Lavallée effusion" in following years [2-7].

Early diagnosis of MLL is challenging because it develops in subcutaneous tissues and does not cause early signs. In patients with no symptoms other than swelling, the diagnosis of MLL may be confused with soft tissue edema, hematoma, fat necrosis, or bursitis, causing a delay. Blood in the cavity is reabsorbed, and the hemosiderin-rich serosanguineous fluid remains. After the inflammation develops, a fibrous capsule develops around the serosanguineous fluid, preventing its absorption. Cavity infection, skin necrosis, and muscle, tendon, bone, and implant exposure were observed in untreated MLLs [2,4-8].

Various treatment methods have been suggested; however, no universal consensus exists [17,9]. Acute and small-volume (<50 mL) MLLs benefit from conservative treatments, such as compression bandages, anti-inflammatory therapy, physiotherapy, and rest [3]. However, chronic or large-volume (>50 mL) MLLs that develop capsules around the cavity may require percutaneous drainage and surgical debridement in addition to compression. Especially when MMLs are accompanied by large and necrotic tissue defects, treatment becomes more difficult and additional treatments are required for both the treatment of MLLs and the preparation of tissue defects for reconstruction. *Negative-pressure wound* therapy (NPWT), also known as vacuum-assisted wound closure, can provide compression, drainage, and obliteration of the cavity alone in the treatment of MLL, and reduce edema and the bacterial load, improve tissue perfusion, and stimulate granulation in the tissue defects [6,10.

This study presents vacuum-assisted surgical treatment for large and complex MLLs and the effects of treatment on the functionality of lower extremities.

Materials and methods

Twenty-three patients with post-traumatic MLL in the lower extremities who underwent vacuum-assisted surgical treatment between 2018 and 2022 were retrospectively reviewed. Patients with pre-traumatic lower extremity functional limitations, post-traumatic bone fractures in the lower extremities, mental problems, or conservatively treated MLL were excluded. All patients enrolled provided written and verbal informed consent before surgery. The study was conducted in compliance with the principles of the Declaration of Helsinki and approved by the local ethics committee (Ethics number: 2023/224).

Demographic characteristics, comorbidities, smoking status, body mass index (BMI), type of trauma, anatomical location, skin characteristics of the cavity, additional injuries, duration of treatment delay, medical and surgical procedures, return to work, and social life were investigated. All cavities were evaluated using ultrasonography, and cavity volumes were measured (Table 1).

All patients underwent percutaneous incision drainage and radical debridement of necrotic tissues and cavities. The cavity space was closed using quilt sutures. Deep-tissue cultures were then obtained. Two sessions of NPWT were applied at 3 days intervals. Seven days after

Table 1. General characteristics of patients, trauma, defects, and surgeries.

Case	Sex	Age (year)	Comorbidities	BMI (kg/m^2)	Etiology	Location	Skin characteristics	Treatment delay (day)	Additional injuries	Cavity Volume (cm³)	LEFS Score (pre-op)	LEFS Score (post-op 12th (month)
1	M	65	HT	29,7	MVA	Left, thigh lateral	Localized necrosis and ulceration	14	-	300	8	74
2	M	77	DM, S	35	CI	Right, knee	Localized necrosis and ulceration	35	-	165	10	80
3	M	6	-	17,4	CI	Left, trochanter	Total necrosis	21	-	80	6	80
4	F	41	S	27,5	CI	Right, crus lateral	-	29	-	200	8	80
5	M	15	-	20,2	MVA	Left, knee	Localized necrosis and ulceration	24	-	200	6	80
6	F	37	S	29,2	CI	Right, knee	-	32	-	220	5	80
7	F	35	S	34	MVA	Left, gluteal	-	21	-	125	8	80
8	F	69	CA, DM, HT	30,1	MVA	Right, gluteal	Ecchymosis	40	-	280	10	80
9	M	35	S	29	CI	Right, trochanter	-	35	-	180	7	80
10	M	7	-	16	MVA	Right, thigh anterior	Total necrosis	25	-	256	3	80
11	M	50	HT, S	33,2	CI	Left, crus lateral	Total necrosis	19	Rib fracture	230	7	77
12	F	15	-	22	CI	Left, thigh antero-lateral	Total necrosis	22	-	120	5	80
13	M	17	-	28,1	MVA	Left, trochanter	Total necrosis	34	-	345	7	80
14	M	12	-	20	CI	Right, knee	Localized necrosis and ulceration	32	-	120	5	80
15	M	29	S	35	MVA	Left, thigh antero-lateral	Total necrosis	21	Right ulna fracture	780	8	75
16	M	22	S	23,4	MVA	Right, crus lateral	Total necrosis	37	Rib fracture	450	8	80
17	F	18	-	21,3	MVA	Left, thigh antero-lateral	Ecchymosis	35	-	245	8	80
18	M	57	HT	32,2	MVA	Left, thigh anterior	Total necrosis	18	-	322	7	74
19	M	47	DM, S	33,5	MVA	Left, thigh lateral	-	46	-	145	13	76
20	M	18	S	27,1	MVA	Left, trochanter	Localized necrosis and ulceration	14	-	285	8	80
21	M	55	S	33,5	MVA	Left, trochanter	Ecchymosis	32	Rib fracture	305	10	75
22	M	16	-	23	CI	Left, knee	Localized necrosis and ulceration	27	-	155	8	80
23	F	24	-	28	CI	Right, thigh lateral	Localized necrosis and ulceration	30	-	250	5	80

debridement, 15 defects were closed with primary suturing, and eight with extensive tissue loss were closed with a split-thickness skin graft (STSG). All patients were discharged on postoperative day 1 and followed up for at least 12 months.

Lower extremity function was evaluated using the Lower Extremity Functional Scale (LEFS) [11,12]. preoperatively and 12-month postoperatively.

Statistical analysis: Statistical analyses were performed using the SPSS version-22 software for Windows (IBM Corporation, Armonk, NY, USA). Patients' preoperative and 12-month postoperative LEFS scores were assessed using paired sample t-tests. The relationship between cavity volume and skin necrosis was evaluated using the Mann-Whitney U test. With 95% confidence intervals (CIs), p<0.05 were considered statistically significant.

Results

Sixteen patients were male, seven patients were female, and the mean age was 33.3±20.9 years. Four patients had hypertension, three had diabetes mellitus, and one had chronic asthma; eleven were smokers.

The mean BMI was 27.3±5.8 kg/m^2. Motor vehicle accidents (n=13) and crush injuries (n=10) were the etiologies for MLLs. Three patients had rib fractures, and one had an ulnar fracture. The mean delay time for treatment was 27.9±8.4 days after trauma. Lesions were localized to the left gluteal (n=1), left trochanteric (n=4), left thigh anterior (n=1), left thigh lateral (n=2), left thigh anterolateral (n=3), left knee (n=2), left crus lateral (n=1), right gluteal (n=1), right trochanteric (n=1), right thigh anterior (n=1), right thigh lateral (n=1), right knee (n=3), and right crus lateral (n=2). (Table 1).

The primary complaints were swelling, pain, and functional limitations. Ecchymosis (n=3, figure 1), localized necrosis and ulceration (n=7, figure 2), and total necrosis (n=8, figure 3) were observed in the skin over the cavity. No skin findings were found in five patients. On ultrasonography examination, the patients had fluid collections containing fat lobules between the facial planes without foreign bodies, suppuration, or abscess formation, with mean cavity volumes of 250.3±144.5 cm³. Cavity volumes were 298.8±204.3 cm³ in patients with skin necrosis and 213.1±59.5 cm³ in those without skin necrosis, and no statistical relationship was found between cavity volumes and skin necrosis (*p*=0.33706). (Table 1).

Figure 1. (Case 8). (Above, left) A 69-year-old female with hypertension, diabetes mellitus, and chronic asthma presented with ecchymosis on the right gluteal area 40 days after a motor vehicle accident. (Above, right) Fat lobule and fluid in the cavity are seen during drainage and debridement (Below, left). Despite the small ecchymosis on the skin, it shows extensive cavity margins. (Below, right) Twelve months after primary closure, the patient was satisfied without functional limitations.

Staphylococci (n=4) and streptococci (n=2) grew in the cultures of six patients; they were sensitive to penicillin and were treated with the available antibiotics. Patients were treated with primary suturing (n=15) or STSG (n=8) on day 7 after debridement. Surgical areas healed uneventfully. The mean time to return to work and social life after reconstruction was 29.25±4.3 (22–35) days in eight patients treated with STSG and 23.1±4.5 (16–33) days in 15 patients treated with primary suturing (Figure 1-3).

Figure 2. (Case 10). (Above, left) A 7-year-old male presented with 4x10cm^2 skin necrosis on the right thigh anterior 25 days after a motor vehicle accident. The white arrow indicates contour deformity resulting from fluid-filled cavity formation. (Above, right) The patient underwent drainage through a percutaneous incision and radical debridement of all necrotic tissues and cavities. (Below, left) Two sessions of negative-pressure wound therapy were applied with 3 days intervals. (Below, right) Twelve months primary closure. The patient was satisfied without functional limitations.

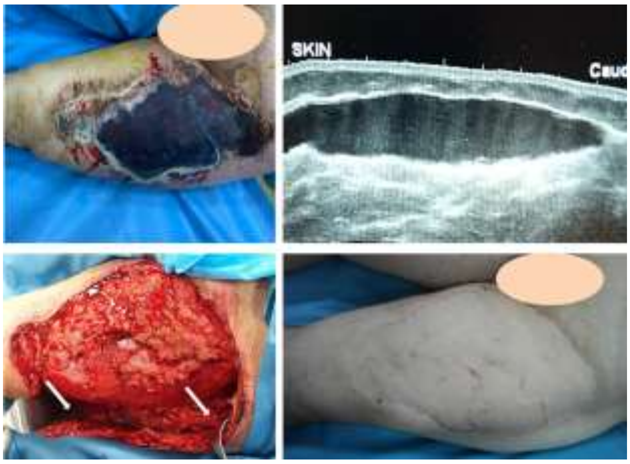

Figure 3. (Case 15). (Above, left) A 29-year-old male with a smoking history and obesity presented with 40x25 cm^2 skin necrosis on the left thigh anterolateral 21 days after a motor vehicle accident. (Above, right) Ultrasonographic examination showed an approximately 780 cm^3 fluid-filled cavity containing fat lobules. (Below, left) The patient underwent radical debridement of all necrotic tissues and cavities. The white arrows indicate a degloving zone under viable skin. (Below, right) Twelve months after reconstruction with split-thickness skin graft after two sessions of negative-pressure wound therapy. The patient was satisfied with the form and functional outcomes.

Preoperative and 12-month postoperative LEFS scores were 7.3±2.1 and 78.7±2.2, and improvement was statistically significant (figure 4, p<0.001) (Table 1) (Figure 4).

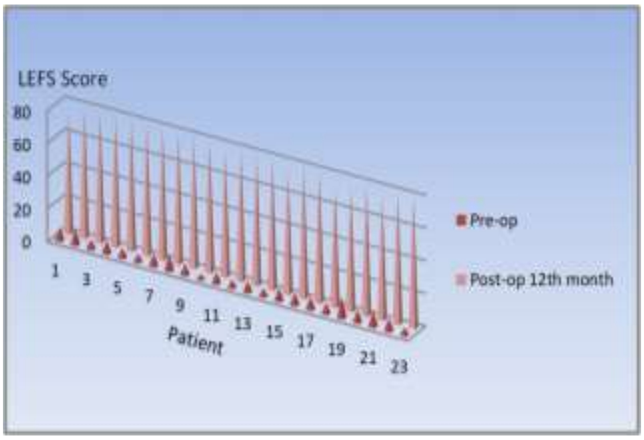

Figure 4. Preoperative and postoperative 12-month LEFS scores of the patients.

Discussion

MLL is the separation of the hypodermis from the deep fascia caused by shear stress after trauma and the formation of a fluid-filled cavity between the fascia layers [1,2,4]. A majority of MLLs are caused by high-energy and blunt trauma such as motor vehicle accidents, crush injuries, falls, and contact sports (football, wrestling) [3-5,7,13-15]. MLL can be iatrogenic secondary to operations, including breast surgery, abdominoplasty, and large-volume liposuction [7,8,14].

Early diagnosis of MLL is crucial for successful treatment and avoids late complications such as infection or skin necrosis. However, it can be diagnosed months or even years after trauma with only swelling or contour abnormalities [2,9,16]. Lesions diagnosed in the first 3 weeks are considered acute MLLs, and those diagnosed after 3 weeks are considered chronic MLLs [10]. The initial finding may vary depending on the lesion’s location, size, and extent. Although some patients are asymptomatic in the early period, others experience skin hypermobility, hypoesthesia due to damage to cutaneous nerves, swelling in soft tissue, contour deformity, and fluctuation in the traumatic area [2-5,7,8,13-17]. In our study, traffic accidents (56.5%) and crush trauma (43.5%) were responsible for the cases and 82.6% and 17.4% were chronic and acute MLLs, respectively. The main complaints were swelling, pain, and functional limitation, which differed individually and were unrelated to cavity volumes and localization.

Skin necrosis and infection are late complications of MLLs. Skin necrosis may occur due to trauma or increased cavity diameter, and pressure impairs skin circulation due to delayed diagnosis [2,3]. In our study, 15 patients had localized or total skin necrosis, of whom six had infections with positive-bacterial cultures. There was no relationship between the cavity volume and skin necrosis, which was thought to develop secondary to trauma.

Secondary risk factors for the development of MLL include sex and BMI. Hak et al. [2] reported a high percentage of female patients, which was attributed to fat distribution patterns in females. Singh et al. [5] reported that MLL was more common in male patients, just like in all multi-trauma cases. Nickerson et al. [18] did not find a female-male sex ratio difference. In our study, approximately 69.6% of patients were male. Another factor predisposing to MLL is a BMI >25 kg/m^2 [8,17,19]. The mean BMI of our patients was 27.3±5.8 kg/m^2; 30.4% were overweight, and 34.8% were obese.

MLLs were most frequently observed unilaterally on the trochanteric regions and hip due to the protruding and large surface, mobile and lax skin structure, and dense capillary network. Conversely, MLLs were less frequently observed in the thigh, pelvis, knee, gluteal, lumbosacral, abdominal wall, lower leg, and head regions with decreasing frequency [2,4,5,7,16,19]. In our study, MLLs were located in the trochanteric and thigh regions in 56.5% of patients, and the lesions were primarily chronic and unilateral.

Focusing on major injuries or hemodynamic instability in emergencies may delay the diagnosis of MLLs in traumatized patients [3]. It may take time for lesions to reach a noticeable size and cause symptoms [9]. In order not to miss diagnosis, open or closed skin lesions should be carefully examined in traumatized patients. Ecchymosis, abrasion, dry ulcerated areas, and necrosis of the skin are possible in post-traumatic MLLs. Skin and subcutaneous examinations should be performed to minimize morbidity due to MLL, particularly in high-severity traumas where fractures develop in the extremities. Soft tissue ultrasound, computed tomography, or magnetic resonance imaging (MRI) can be used for the diagnosis, and MRI can be used for the classification of MLLs [4-8,16,17,20]. Contrast-enhanced MRI is specific for diagnosis, especially when a definitive diagnosis cannot be made [21]. In our study, patients' mean delayed diagnosis and treatment was approximately 27.9±8.4 days, and all patients had functional impairment due to MMLs. A total of 82.6% of patients had chronic MLLs, and they all had high-volume MLLs; thus, the diagnosis could be made by anamnesis, physical examination, and ultrasonography. Rapid, inexpensive, and less invasive soft tissue ultrasound was used for differential diagnosis and cavity analysis.

Various techniques are used for MLL treatment. In acute and small volumes, MLLs may benefit from conservative treatments, such as compression bandages, anti-inflammatory medication, physiotherapy, and rest. In particular, the extremities effectively benefit from compression bandages. However, effective compression is difficult in the trochanteric and pelvic regions where MLLs are common, and percutaneous drainage should be added to treat MLLs that have large volumes and do not benefit from compression [4-8,10,17,21]. MLLs diagnosed before capsule formation benefit from percutaneous aspiration as well as acute treatment modalities. However, the recurrence rate of percutaneous aspiration alone is high, especially in patients with cavity volumes >50 mL. Percutaneous aspiration alone is insufficient, and in the treatment of lesions that do not benefit from percutaneous aspiration, sclerosis with doxycycline, ethanol, and talcum powder has been used successfully in the treatment of cavities through fibrosis [8,17,22-24]. Open surgical debridement is recommended for patients with cavity volumes >50 mL [5]. In our study, four patients presented with acute MLLs, and due to the high cavity volumes (mean 284.25±39.2 cm^3) of these patients, they were treated with percutaneous incision, surgical debridement, and NPWT before reconstruction.

Open surgical debridement is required for capsule formation and chronic MLLs. After debridement, fibrin sealant, quilting sutures, and low-suction drains are used to drain and obliterate the dead space [6-8,10,17]. Jones et al. [25], after the excision of the MLL cavity on the knee and distal thigh, performed lymphatic mapping with the injection of Patent blue dye into the dermis of the foot, revealing ligated lymphatic vessels that filled the cavity with fluid, and single suction drain and absorbable quilting sutures used for the obliteration of dead space. Adding bandages to treatment increases the success rate [20]. Hak et al.[2] recommended a delayed primary closure after debridement to reduce the risk of complications [21].

NPWT has been successfully used as a treatment option for acute and chronic MLLs. Morris et al. [26] drained the hematoma and applied NPWT to continuously remove the hematoma or cavity fluid, promoting closure of the potentially dead space between the subcutaneous tissue and muscle fascia, new blood vessel ingrowth, and accelerated wound healing; finally, the defects were closed primarily. Meara et al.[27] reconstructed tissue defects by combining full-thickness skin grafts and NPWT in five patients to eliminate movement, remove fluid, reduce edema, and increase graft viability. NPWT also provides effective compression and continuous drainage, prevents the accumulation of new fluids, and decreases the frequency and complexity of dressing changes [7,10,26-29].

In our study, percutaneous drainage, radical debridement, and NPWT were applied for acute and chronic MLLs with large volumes. By performing cavity debridement through an incision made for percutaneous drainage, the wound floor was converted to the acute phase, and the wound healing process resumed. Cavity death spaces were obliterated with quilted sutures to increase adhesion, and this treatment is also an effective and successful method in patients who smoke and have additional comorbidities. It was observed that vacuum-assisted wound closure stabilized the wound, reduced necrosis and edema, improved tissue perfusion, and stimulated granulation tissue, especially in cases accompanied by tissue defects.

Our study obtained successful results through radical debridement, two sessions of NPWT, and reconstruction surgery. Positive effects of NPWT on wound healing prevent complications such as recurring MLLs, seroma, dehiscence, and graft loss. In addition, MLL-related functional limitations improved. However, in our study, the cost of NPWT was not investigated, its effectiveness could not be evaluated in MLLs after major bone fractures, and a control group for comparison with other treatment protocols was not included.

Conclusions

MLL is a severe post-traumatic separation of the subcutaneous tissue from the underlying fascia that creates a cavity filled with hematoma and liquefied fat. Untreated MLLs can cause serious functional and workforce losses. In treating large-volume acute and chronic MLLs, percutaneous drainage, radical debridement, cavity closure with quilting sutures, and pressure support with NPWT are reliable methods that ensure problem-free healing of MLLs. This method has also positively affected lower-extremity functionality during subsequent periods.

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