CASE REPORT

Treatment of Morel-Lavallée Lesions (MLLs) with Mesh Incisions Combined with Quilting Sutures and Negative Pressure Wound Therapy (NPWT)

Tao Ning, PhD; Zhen-Gang Zha, PhD

ABSTRACT

Purpose • The objective of this retrospective study was to evaluate the clinical effects of a novel treatment approach for Morel-Lavallée lesions (MLL) using a combination of suturing techniques and Negative Pressure Wound Therapy (NPWT) with mesh incisions. To summarize the clinical effects of a combination of suturing techniques and (Negative Pressure Wound Therapy) NPWT on the wall of Morel-Lavallée lesions (MLL) fibrotic pseudocapsules with mesh incisions in the treatment of MLLs. A retrospective analysis was performed on MLL patients from April 2017 to March 2021.

Methods • This a retrospective case-control study and thirteen MLL patients were included in this retrospective analysis conducted between April 2017 and March 2021, who were treated with mesh incisions on the wall of the pseudocapsule, quilting suturing to degloved soft tissues, and NPWT. Physical examination, MRI, or ultrasound before surgery confirmed the diagnosis. Wound healing, secondary infection, recurrence, visual analog scale (VAS) scores before and after surgery, and skin and soft tissue condition were observed and evaluated.

Results • The combination of mesh incisions, quilting sutures, and NPWT led to successful wound healing in 11 out of 13 cases without recurrent hematoma or secondary infection. Visual analog scale (VAS) scores significantly decreased after the operation, and the aesthetic and tactile qualities of the injured area improved. One case of skin and soft tissue necrosis infection before the operation, which healed after second-stage full-thickness skin grafting, 1 case healed after a dressing change, and the remaining 11 cases had wounds that healed by the first stage without secondary infection or recurrent hematoma formation. VAS scores decreased significantly after the operation, the appearance of the injured area was as expected, and the skin feel and elasticity recovered satisfactorily.

Conclusion • The study demonstrates that the mesh incision technique, along with mattress sutures and NPWT, presents a feasible and effective approach for treating MLL with fibrotic pseudocapsules. This could shorten healing times, reduce risk of complications, and improve patient satisfaction. (*Altern Ther Health Med.* 2023;29(8):810-815).

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INTRODUCTION

Morel-Lavallée (MLL) was first described by the French physician Maurice Morel-Lavallée In 1853 as a result of shearing violence that caused a separation of the skin and subcutaneous tissue from the muscle fascia, lymphatic and blood vessel rupture, and accumulation of necrotic fat tissue, resulting in the potential formation of a dead space.[1] MLLs represent closed injuries with internal degloving of superficial soft tissues from fascial layers. The clinical manifestations of MLL injuries are similar to those of skin and soft-tissue contusions. MLLs can occur in polytrauma patients alongside multiple and complex skeletal injuries. The main cause of MLLs is high-energy, blunt force trauma or crush injuries. These injuries are rare, which often leads to misdiagnosis or delayed diagnosis. As many as 1/3 of cases reported in the literature are missed in the initial stage.[2] Injury to rich vascular and lymphatic supply leads to accumulation of blood and lymph in this potential space generated by separation of the superficial and deep fascia. Blood products and necrotic material in turn invokes chronic inflammatory reaction. As the time progress, a capsulated lesion lined by fibrous capsule develops, which is filled with blood products, necrotic fatty tissue, debris and fibrin. In cases with multiple injuries, doctors are distracted and ignore the presence of

Table 1 Patient and injury characteristics.

NO.	Gender	Age (Y)	Mechanism of injury	Region	Time[a] (D)	Complication	Necrotity skin	Area (cm×cm)	Bacterial cultures	Follow (M)
1	Female	46	Fall injury	Right thigh	23	-	-	28×14	-	16
2	Female	68	Fall injury	Left calf	66	T2DM	+	14×6	-	6
3	Male	63	Motor vehicular accident	Left thigh	18	-	+	41×12	-	6
4	Female	73	Motor vehicular accident	left gluteal	15	T2DM,Multi-trauma	+	9×8	S. aureus,EIEC	3
5	Female	69	Fall injury	Right thigh	9	-	-	16×14	-	10
6	Female	64	Fall injury	Left calf	33	-	+	11×7	Streptococcus hemolyticus	8
7	Female	30	Motor vehicular accident	Left thigh	14	Multi-trauma	-	15×10	-	22
8	Female	32	Motor vehicular accident	Right thigh	8	-	-	32×22	-	26
9	Female	53	Motor vehicular accident	Lumbo-sacral	30	T2DM	-	26×18	-	35
10	Female	67	Motor vehicular accident	Left thigh	21	-	-	18×13	-	2
11	Male	52	Fall injury	Right elbow	15	-	+	6×6	-	3
12	Male	30	Motor vehicular accident	Right thigh	14	Multi-trauma	-	25×12	-	30
13	Male	57	Fall injury	Left gluteal	7	-	-	15×18	-	23

[a]The average time from injury to operation

MLL, which can also lead to misdiagnosis[3] This study aims to propose a novel treatment approach for Morel-Lavallée lesions (MLL) involving mesh incisions in the fibrotic pseudocapsule wall combined with negative pressure drainage therapy and mattress suturing.

Over time, the dead space gradually forms a fibrotic pseudocapsule, which leads to long-term effusion and increases the risk of tissue infection and necrosis. Patients often seek medical care because of swelling, changes in appearance, abnormal skin sensations, and fluctuating feelings. The diagnosis can be confirmed by MRI or ultrasound.[4-6] Conservative treatment is effective for early cases with small detachment areas. Most MLLs often require surgical treatment because they cannot be treated in a timely manner or because conventional treatment fails. However, there is no gold-standard surgical plan.The existence of fibrotic pseudocapsules is considered to be an essential factor in the recurrence of MLL. Complete removal of fibrotic pseudocapsules can effectively prevent recurrence.[7,8] Nevertheless, current existing treatment options for MLL have their own drawbacks and limitations. Conservative approaches could extend the length of stay while surgical approaches could cause surgical secondary injury. To address the gap in current surgical plans for MLL, we here provide a potential solution for preventing recurrence.

In this study, we propose making a mesh incision in the wall of the fibrotic pseudocapsule in combination with negative pressure drainage therapy and mattress suturing to treat MLL. There is no need to remove the fibrotic pseudocapsule tissue; the operation is simple, the effect is targeted, and an excellent curative effect is obtained. Clinically, the proposed combined approach could address the fibrotic pseudocapsule and prevent recurrence, thus leading to improved patient outcomes and reduced morbidity.

MATERIALS AND METHODS

We planned to investigate the MLL patients using a retrospective case-control study. Considering the rarity of MLL, we determined to analysis the patients from our medical center in the past five years. Specifically, from April 2017 to March 2021, 13 patients with MLL were treated with a mesh incision combined with mattress suturing and negative pressure drainage.Thirteen patients (4 males, 9 females) with a mean age of 54.15 years (range: 30-73 years) were included. The injuries were attributed to closed detachment injuries, traffic accidents, or falls. Additionally, specify the number of cases involving multiple injuries, type 2 diabetes, and flaky necrosis or scabs in the skin and soft tissue detachment area. . The injury site was in the thigh (7), calf (2), waist (1), buttocks (2), and elbow (1). A thorough review of the medical history, physical examination, ultrasound, or magnetic resonance examination confirmed the diagnosis of MLL. The last follow-up documented wound healing, infection, visual analog scale (VAS) scores, skin and soft tissue conditions, and recurrence. Case information is shown in Table 1.

Inclusion criteria

Patients diagnosed with MLL; With closed detachment injuries; Traffic accident injuries; Fall injuries. Aged 18-60. The MLL patients were diagnosed through medical history review, physical examination, ultrasound, or magnetic resonance examination.

Exclusion criteria

Patients with serious complications, such as heart disease were excluded. Patients that have already had surgery.

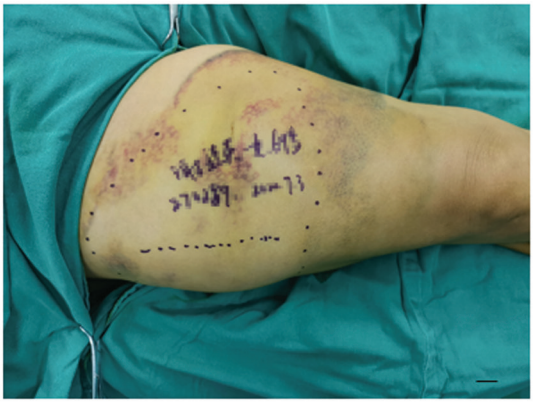
Surgical progression

General anesthesia or intraspinal anesthesia was chosen, and a suitable position was chosen according to the injured area. The cutting depth was subject to the visibility of the tissue under the capsule wall. A horizontal incision was made at the folds of the cyst wall to completely stop bleeding and flush the cyst cavity. After the operation, a continuous negative pressure of 125 mmHg was maintained, the negative pressure drainage device was removed 10 days after the procedure, and the drainage tube was removed. An elastic bandage was used to continue compressing the unwrapped area for 1 week. The suture was removed 2 weeks after the wound healed, and the mattress suture was released 3 weeks after the injury when the tissue has already healed very firmly. Strenuous activities were avoided for 1 month postoperatively.

Statistical analysis

The Wilcoxon signed-rank test or independent samples *t* test was used based on the homogeneity of variance and normal distribution of the data. The significance of survival was evaluated using the log-rank test. The correlation

Figure 1. MLL involving the anterolateral right thigh. Bar:50μm.



between two continuous variables was assessed using the Spearman correlation coefficient. All statistical calculations were carried out using SPSS statistical software. $P < .05$ were considered significant.

RESULTS

Basic information about patients

All 13 patients were followed up by telephone, with an average follow-up time of 13.8 months (2–35); 7 patients were followed up at the clinical site, and 6 patients were followed up via telephone. The average time from injury to operation was 21 (7–66) days, and the moderate skin and soft tissue detachment area was 268.54 (36–704) cm^2. Two cases involved positive bacterial cultures before the operation (1 case was Staphylococcus aureus, Escherichia coli, and 1 case was Streptococcus hemolytic), and the remaining 11 cases had negative bacterial cultures. One case healed by second-stage full-thickness skin grafting, one case healed with dressing changes, and the other 11 cases recovered by the first stage.

Injury in anterolateral right thigh

The patients had been injury in the anterolateral right thigh. A longitudinal incision was made in the center of the uncovered area. The scope of surgery was determined according to preoperative palpation and marked (Figure 1), which aimed to avoid the mistake of wrong surgeon.

Skin necrosis

In the case of a region of skin necrosis, a fusiform incision was made with the region as the center, and the necrotic tissue was completely removed. The fibrotic pseudocapsule was completely opened by exposing the comparative normal tissue, and blood, serum, and necrotic fat tissue were removed from the cyst cavity (Figure 2). Collectively, these findings highlight an effective approach to treat the skin necrosis.

Surgery treatment

The mesh incision was made in the cyst wall. The pseudocapsule wall was divided into an area of approximately

Figure 2. Fibrotic cysts formed and were filled with necrotic fat tissue and fluid. Bar:50μm.

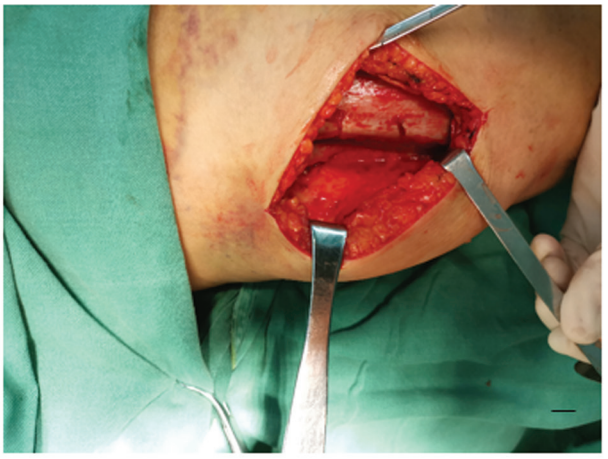


Figure 3. The wall of the fibrotic pseudocapsule was cut into small pieces, approximately 1 cm x 1 cm in size.

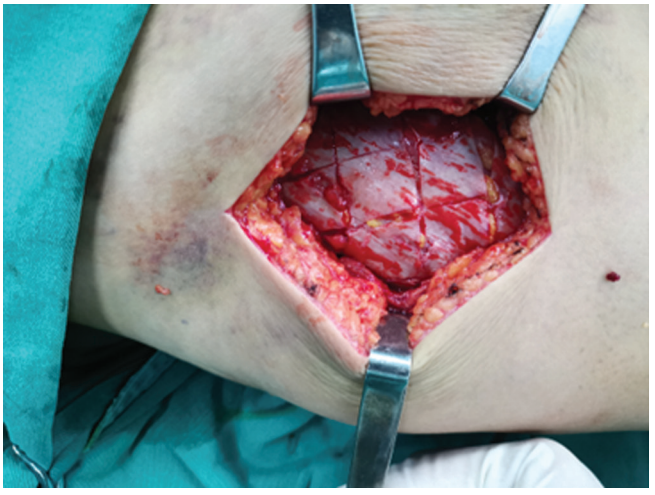


Figure 4. A drainage tube was placed at the lowest point in the detachment area with mattress suturing, with a stitch length of approximately 1-2 cm.

Figure 5. A drainage tube was placed at the lowest point in the detachment area with mattress suturing, with a stitch length of approximately 1–2 cm.

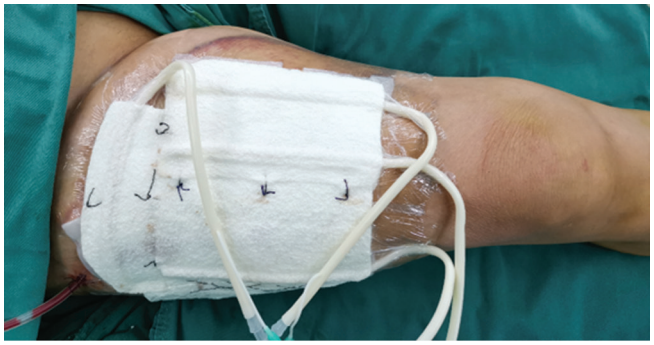
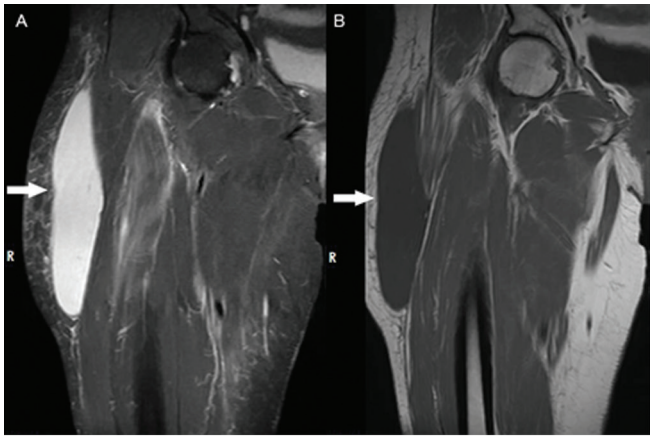


Figure 6. The appearance of the injured area and elasticity recovered well.

Figure 7. A large fusiform collection (arrows) between the subcutaneous fat and fascia lata demonstrating low signal intensity（SI）on T1 WI. **A.** and high SI on fat suppression image; **B**. in coronal plane indicating clear fluid.



1 cm × 1 cm (Figure 3). A drainage tube was placed at the lowest part of the cyst cavity. The soft skin tissue and deep fascia layer were sutured in the uncovered area with a stitch length of approximately 1-2 cm (Figure 4). The negative pressure drainage material covered the enlarged uncovered area of approximately 2 cm (Figure 5). Together, these detailed surgical steps were approved to be valid in the MLL patients, and have guiding significance for future clinical practice.

Postoperative complications

There was no secondary infection, skin necrosis, or recurrence. The appearance of the injured area was as expected. The skin feel and elasticity recovered well, and the postoperative VAS score was significantly lower than the preoperative VAS score (Figure 6). Cases with multiple injuries and diabetes were cured or improved through specialist treatment.

DISCUSSION

MLLs, or closed detachment injuries, are mainly caused by high-energy, blunt injuries.[9] Low-energy injuries can also lead to the occurrence of MLLs.[10] MLLs can occur in various parts of the body; the most common part is the greater trochanter, which may be due to its unique anatomical characteristics.[11] Vanhegan et al. reviewed the literature and reported the incidence of MLLs in various parts of the body: greater trochanter (30.4%), thigh (20.1%), pelvis (18.6%), knee (15.7%), gluteal region (6.4%), lumbosacral area (3.4%), abdominal area (1.4%), lower leg (1.5%), and head (0.5%).[12] Because MLLs are rare, the diagnosis is often missed or delayed.[13] MRI is considered to be the gold standard for the diagnosis of MLLs (Figure 7), but with the development of musculoskeletal ultrasound, ultrasound technology has been increasingly used in the diagnosis of MLLs. Nevertheless, current existing treatment options for MLL have their own drawbacks and limitations. Conservative approaches could extend the length of stay while surgical approaches could cause surgical secondary injury. To address the gap in current surgical plans for MLL, we here provide a potential solution for preventing recurrence.

Li et al. reviewed the literature and concluded that although there are many treatment options for MLLs, treatment decisions should be based on the association with the fracture, the condition of the disease, the symptoms, and the wishes of the patient,[7] but there is still no standard treatment. Nonsurgical treatment is often given priority for the treatment of MLLs. Aspiration of more than 50 mL of fluid from the lesion requires surgical intervention.[14] A sclerosing agent can promote the growth of fibroblasts and make the two layers of tissues separated by an MLL adhere, thereby resolving the MLL. Leach et al. used sclerosing agents to treat MLL successfully,[15] but there is a risk of skin necrosis and infection.[16] An elastic bandage is necessary for conservative and postoperative treatment, but its efficacy may depend on the location of the lesion.[17]

The rationale for treatment approachto surgical treatment of MLLs is to eliminate dead space, thoroughly

debride the tissue in the detachment area, remove fibrotic bursal tissue, and promote the healing of subcutaneous tissue and muscle fascia tissue.[18,19] Recently, it has been reported that the use of minimally invasive endoscopic methods for the treatment of MLLs can achieve the same goals as open debridement, but endoscopic debridement surgery has a long learning curve, requires special equipment,[20-22] and increases medical expenses. Gautam et al. used percutaneous mattress sutures to suture the skin and subcutaneous tissue to the deep fascia in 22 cases of MLL. They believed this could effectively prevent erratic movement of the two separated tissues, clear dead corners, and promote healing, but there is a risk of vascular and nerve bundle damage.[22] The existence of fibrotic pseudocapsules and dead space is considered to be an essential factor and common cause of recurrence, the dead space should be eliminated, and the fibrotic pseudocapsule tissue should be removed to prevent recurrence.[7,8,23] It is difficult to effectively and thoroughly debride the dead corner of the fibrotic pseudocapsule during minimally invasive surgery due to the limitation of the incision. Open debridement surgery enables easy removal of necrotic tissue and solves the problem of dead ends.[24,25]

We report that 13 cases of Morel-Lavallée lesions treated with a mesh incision combined with mattress suturing and negative pressure drainage technology achieved satisfactory results. Compared with traditional open debridement, our method does not require removing the fibrotic pseudocapsule tissue but rather requires a mesh incision on the cyst wall to divide the cyst wall into a size of approximately 1 cm×1 cm. In addition, the depth of the incision is limited so that the tissue under the capsule wall can be seen as the standard without further destroying the blood supply of the uncuffed skin and soft tissues and, to a certain extent, reducing the probability of secondary necrosis of the uncuffed skin and soft tissues. At the same time, a horizontal incision is made at the bursa fold, and a mattress suture[23,26] is placed in the detachment area, which helps to eliminate dead space, promote healing, and prevent recurrence. Gautam et al. used a mattress suture stitch length of 2 cm, a safe distance, and skin necrosis did not occur. According to our experience, hemorrhage at the edge of the wound should be used as the criterion to adjust the stitch length and knot tension, and the stitches should be staggered. VAC is accepted by clinicians to promote wound healing.[27,28] Dodwad[26] believes that its use in high-risk MLLs is an appropriate adjuvant treatment, and it also helps to eliminate dead ends, promotes wound healing, and prevents recurrence.[29,30] We used negative-pressure drainage materials to expand the coverage of the uncuffed area. At the same time, placing a drainage tube at a lower position in the fibrotic pseudocapsule can drain the residual effusion and encourage the formation of a new dead space after the operation and promote interstitial healing. Collectively, the proposed approach has demonstrated the effectiveness of the treatment and offers unique advantages over traditional methods.

This study's advantage was demonstrating the clinical effects of a combination of suturing techniques and NPWT on the wall of MLL fibrotic pseudocapsules with mesh incisions in the treatment of MLLs. Needless to say, there are some limitations about this study. Specifically, this is a retrospective study where some evidence generated by us is needed to be verified furtherly. In other words, a prospective study, including a randomized control trial or a prospective cohort study is warranted to strength the intensity of the evidence. Moreover, the number of patients was not enough. Besides, the mechanism of this study was not clearly clarified. Further studies are needed to study more.

CONCLUSION

In conclusion, the surgical operation protected the blood supply of the skin and soft tissues of the detachment and promoted healing between the tissues, which is an effective treatment for MLLs. Future research could focus on larger studies with more patients or mechanistic studies to better understand the underlying processes.

FUNDING

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CONFLICTS OF INTEREST

The authors declare that they do not have any conflicts of interest.

DATA AVAILABILITY

The data used to support this study are available from the corresponding author upon request.

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INFORMED CONSENT

No written consent has been obtained from the patients as there is no patient-identifiable data included in this case report/series

REFERENCES

1. Dudiak GJ, Berthold JB. Ultrasound Diagnosis & Compressive Biomechanical Taping of a Lumbar Morel-Lavallée Lesion in a High School Football Player: A Clinical Vignette [published online ahead of print, 2023 Jul 18]. *Am J Phys Med Rehabil*. 2023;10.1097/PHM.0000000000002316. doi:10.1097/PHM.0000000000002316
2. Hudson DA, Knottenbelt JD, Krige JE. Closed degloving injuries: results following conservative surgery. *Plast Reconstr Surg*. 1992;89(5):853-855. doi:10.1097/00006534-199205000-00013
3. Pikkel YY, Hasan MJ, Ben-Yehuda Raz D, Ben Naftali Y, Duek OS, Ullman Y. Morel Lavallée Lesion - A case report and review of literature. *Int J Surg Case Rep*. 2020;76:103-106. doi:10.1016/j.ijscr.2020.09.158
4. Singh R, Rymer B, Youssef B, Lim J. The Morel-Lavallée lesion and its management: A review of the literature. *J Orthop*. 2018;15(4):917-921. Published 2018 Aug 28. doi:10.1016/j.jor.2018.08.032
5. Bonilla-Yoon I, Masih S, Patel DB, et al. The Morel-Lavallée lesion: pathophysiology, clinical presentation, imaging features, and treatment options. *Emerg Radiol*. 2014;21(1):35-43. doi:10.1007/s10140-013-1151-7
6. Borrero CG, Maxwell N, Kavanagh E. MRI findings of prepatellar Morel-Lavallée effusions. *Skeletal Radiol*. 2008;37(5):451-455. doi:10.1007/s00256-008-0450-7
7. Li H, Zhang F, Lei G. Morel-Lavallee lesion. *Chin Med J (Engl)*. 2014;127(7):1351-6. PMID: 24709193.
8. Takahara S, Oe K, Fujita H, et al. Missed massive morel-lavallee lesion. *Case Rep Orthop*. 2014;2014(920317):920317.
9. Gummalla KM, George M, Dutta R. Morel-Lavallee lesion: case report of a rare extensive degloving soft tissue injury. *Ulus Travma Acil Cerrahi Derg*. 2014;20(1):63-65. doi:10.5505/tjtes.2014.88403
10. Tay MRJ, Haw OJ. Morel-Lavallée Lesion of the knee after low-energy impact in a healthy non-athlete. *J Back Musculoskelet Rehabil*. 2021;34(1):39-42. doi:10.3233/BMR-200041
11. Parker K, Kweon C, Hagen MS, Gee A, Khorsand D, Porrino J. Morel-Lavallee Lesions of the Knee: *Update and Imaging Review*. PM R. 2021;13(7):792-797. doi:10.1002/pmrj.12495
12. Vanhegan IS, Dala-Ali B, Verhelst L, Mallucci P, Haddad FS. The morel-lavallée lesion as a rare differential diagnosis for recalcitrant bursitis of the knee: case report and literature review. *Case Rep Orthop*. 2012;2012:593193. doi:10.1155/2012/593193
13. Greenhill D, Haydel C, Rehman S. Management of the Morel-Lavallée Lesion. *Orthop Clin North Am*. 2016;47(1):115-125. doi:10.1016/j.ocl.2015.08.012
14. Nickerson TP, Zielinski MD, Jenkins DH, Schiller HJ. The Mayo Clinic experience with Morel-Lavallée lesions: establishment of a practice management guideline. *J Trauma Acute Care Surg*. 2014;76(2):493-497. doi:10.1097/TA.0000000000000111
15. Leach SET, Wotherspoon M, King L. Retrosacral Morel-Lavallée lesion: resolution with ultrasound-guided drainage and sclerotherapy. *BJR Case Rep*. 2020;6(3):20190120. Published 2020 May 6. doi:10.1259/bjrcr.20190120
16. Li P, Ning X, Jia L, et al. A minimally invasive incision and loop drainage technique for the treatment of lower limb Morel-Lavallée lesions: nose ring drainage technique. *Injury*. 2020;51(2):570-573. doi:10.1016/j.injury.2019.12.014
17. Li P, Ning X, Jia L, et al. A minimally invasive incision and loop drainage technique for the treatment of lower limb Morel-Lavallée lesions: Nose ring drainage technique. *Injury*. 2020;51(2):570-573. doi:10.1016/j.injury.2019.12.014

18. Cho JS, Huh U, Song S, Bae M. Surgical treatment of massive Morel-Lavallee lesion: A case report. *Asian J Surg*. 2021;44(2):498-499. doi:10.1016/j.asjsur.2020.11.025
19. Shen C, Peng JP, Chen XD. Efficacy of treatment in peri-pelvic Morel-Lavallee lesion: a systematic review of the literature. *Arch Orthop Trauma Surg*. 2013;133(5):635-640. doi:10.1007/s00402-013-1703-z
20. Koc BB, Somorjai N, P M Kiesouw E, et al. Endoscopic debridement and fibrin glue injection of a chronic Morel-Lavallée lesion of the knee in a professional soccer player: A case report and literature review. *Knee*. 2017;24(1):144-148. doi:10.1016/j.knee.2016.10.017
21. Liu M, Liu L, Zhou X, et al. A Novel Surgical Technique for treatment of Morel-Lavallée Lesion: Endoscopic debridement combined with percutaneous cutaneo-fascial suture. *Injury*. 2018;49(8):1630-1633. doi:10.1016/j.injury.2018.06.003
22. Kim S. Endoscopic treatment of Morel-Lavallee lesion. *Injury*. 2016;47(5):1064-1066. doi:10.1016/j.injury.2016.01.029
23. Kumar G, Pandiyan A, Theruvil B. Percutaneous Quilting Technique for the Treatment of Morel-Lavallée Lesion. *Indian J Orthop*. 2020;54(5):580-586. Published 2020 Apr 5. doi:10.1007/s43465-020-00097-4
24. Kumar S, Kumar S. Morel-Lavallee lesion in distal thigh: A case report. *J Clin Orthop Trauma*. 2014;5(3):161-166. doi:10.1016/j.jcot.2014.07.002
25. Jameel J, Kumar S, Zahid M, Ahmad S. Delayed presentation of Morel-Lavallee lesion. *Saudi Med J*. 2014;35(7):750-752.
26. Dodwad SN, Niedermeier SR, Yu E, Ferguson TA, Klineberg EO, Khan SN. The Morel-Lavallée lesion revisited: management in spinopelvic dissociation. *Spine J*. 2015;15(6):e45-e51. doi:10.1016/j.spinee.2013.08.023
27. Huang C, Leavitt T, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. *Curr Probl Surg*. 2014;51(7):301-331. doi:10.1067/j.cpsurg.2014.04.001
28. Khodaee M, Deu RS, Mathern S, Bravman JT. Morel-Lavallée Lesion in Sports. *Curr Sports Med Rep*. 2016;15(6):417-422. doi:10.1249/JSR.0000000000000306
29. Steiner CL, Trentz O, Labler L. Management of Morel-Lavallee Lesion Associated with Pelvic and/or Acetabular Fractures. *Eur J Trauma Emerg Surg*. 2008;34(6):554-560. doi:10.1007/s00068-007-7056-y
30. E. Eldenburg, M. Pfaffenberger, A. Gabriel,"Closure of a Complex Lower Extremity Wound With the Use of Multiple Negative Pressure Therapy Modalities," *Cureus*, vol.12,no.(7),pp.2020. doi:10.7759/cureus.9247