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Case Presentation

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Shoelace Technique Plus NICE Knot in the Treatment of Difficulty in Wound Closure Following a Fasciotomy: Case Report and Review of the Literature

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Abstract

Objectives: Although there is no skin defect after fasciotomy, the wound cannot be closed even after the recession of the edema. And it often takes a long time to recover; the skin defect even needs skin grafting. Here, we report a case of shoelace technique plus NICE knot sequential treatment of difficulty in wound closure following a fasciotomy with satisfactory clinical results.

Methods: We retrospectively reviewed a case of a patient with wound closure following a fasciotomy and reviewed the relevant literature.

Results: A 60-year-old man was admitted to hospital after two hours in a car accident. The patient was in a coma after the accident and the left forearm was pinned down by an electric tricycle for 1 hour before being rescued. Immediately after admission, the left elbow joint was manual reset, plaster fixed and braked. Considering the swelling of the affected limb and long-term compression ischemia, plaster support fixation was relatively loose. Rapid intravenous infusion of mannitol was used to reduce swelling while remaining further close observation. In the progressive aggravation of the disease, once it was evaluated as acute compartment syndrome, a fasciotomy of the affected compartments to relieve tension and pressure was the only treatment. Combined shoelace technique and NICE knot, the wound healed smoothly without skin grafting and loss of limb function.

Conclusion: According to the pathological changes and natural course of acute compartment syndrome, sequential therapy can not only give full play to the advantages of the two treatment methods, which can avoid unfavourable complications, but also obtain successfully complete wound healing.

Keywords: Acute compartment syndrome; Shoelace technique; Fasciotomy; NICE knot; Skin defect

Abbreviations: ACS: Acute Compartment Syndrome; NPWT: Negative-Pressure Wound Therapy

Introduction

Acute Compartment Syndrome (ACS) commonly occurs in the muscular compartments of the extremities, especially in the calves [1]. The main cause is an ischemia-reperfusion injury, when an initial restriction of blood supply to an organ during injury is followed by rapid perfusion and concomitant reoxygenation. The muscles in the affected extremity may develop edema, resulting in fluid extravasation or inflammatory responses. The rapid increase in intracompartment pressure may lead to ACS. When muscle oedema occurs following such injury, or with muscle reperfusion following a period of ischemia, the pressure in the muscular compartments increases due to accumulation of blood and other tissue fluids. Owing to the inelastic nature of muscle fascia and other connective tissues, this accumulation of mass results in increased pressure within the compartment, which is transmitted to the thin-walled venous system, leading to venous hypertension and further transudation of fluid. Progressive tissue ischemia and necrosis ensues, with eventual irreversible ischemic injury to all of the myoneural tissues within the involved compartment [2]. If not treated in time, progressive tissue ischemia and necrosis will eventually cause irreversible ischemic damage to all muscles and nerve tissues in the affected fascia chamber. In severe cases, soft tissue necrosis and permanent disability may occur. It has been estimated that muscle necrosis may occur within 2 hours of injury in as many as 35% of patients with ACS [3]. Compared with the ACS caused by simple hematoma or fracture, the wound recovery time of ACS caused by compound injury combined with fracture, dislocation, crush ischemia and muscle injury is obviously longer. However, the wound closure methods after fasciotomy reported in the literature rarely distinguish the severity of the original injury. It seems that all cases can complete the wound with a single method. We introduced a patient with acute compartment syndrome caused by compound injury mechanism and had difficulty in wound closure after fasciotomy, and reviewed the related literature. The purpose of this paper aims to introduce a practical method for wound management after fasciotomy in patients with ACS, so as to avoid complications and obtain successfully complete wound healing.

Case Presentation

A 60-year-old man was admitted to hospital for two hours in a car accident. The patient was in a coma after the accident and his left forearm was pinned down by an electric tricycle for 1 hour before being rescued and taken to hospital. X-ray showed dislocation of left elbow joint, comminuted fracture of middle part of left radius and distal radius. Physical examination showed obvious swelling and tenderness of left hand, left forearm and left elbow. Although the elbow joint was particularly swollen, the olecranon fossa could still be touched. Although the movement of elbow joint was limited, the sense of bone friction and pseudoarthrosis could be touched, and the left hand felt normal. Immediately after admission, the left elbow joint was treated with manual reduction,

plaster fixation and braking. Considering the swelling of the affected limb and long-term compression ischemia, plaster support fixation is relatively loose. The mannitol was intravenous infused rapidly to reduce swelling, and further close observation was required. With the left forearm became more swollen, the tension blisters appeared and the pain increased **(Figure 1).** Though the passive tension pain in the forearm muscles was found with further physical examination, the finger sensation still existed. Twelve hours after admission, we performed a emergency fasciotomy of the affected compartments to relieve tension and pressure and paid close attention to the condition of the patient's forearm. Three days after admission, we found that the function of the hand did not deteriorate. In order to prevent wound infection and wound skin retraction, the patient underwent wound rubber tube suture, fixation and Negative-Pressure Wound Therapy (NPWT) **(Figure 2).** On the 10th day the swelling of the patient's forearm was obvious relief, but the wound could not be closed and there was no sign of infection. At this time, the patient received open reduction and internal fixation of the left radial shaft. The fracture incision kept away from the fasciotomy wound as far as possible. The incision of the fracture operation gained primary closure and the fasciotomy incision was still fixed with small catheter suture **(Figure 3)**. At the same time, negative-pressure wound therapy was performed. On the 18th day after admission, the swelling of the affected limb was significantly reduced while the negative-pressure drainage device was removed, but it was still unable to suture. We used NICE knot to suture the wound intermittently **(Figure 4),** and tightened the NICE knot every 3 days according to the skin condition. Most of the wounds were closed at 27 days after admission **(Figure 5),** and further reduced at 34 days after admission **(Figure 6).** All the wounds healed 50 days after the injury **(Figure 7).** The function of the hand and wrist was favorable and there was no ischemic muscle contracture. The informed consent was obtained from the patient including permission to publish any associated photographs.

Figure 1: Ten hours after admission, the left forearm became more swollen, the tension blisters appeared.

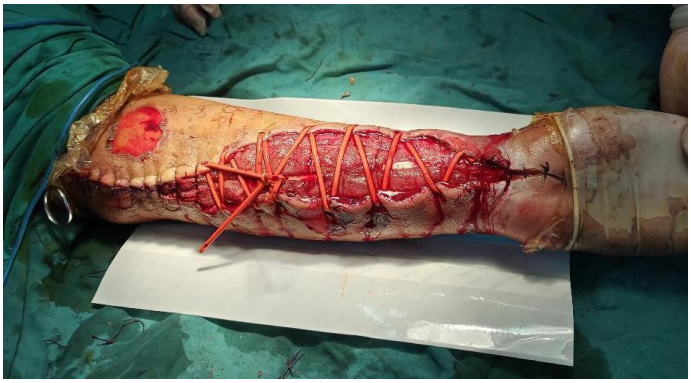

Figure 2: The third day after admission, the patient underwent wound rubber tube suture, fixation and negative-pressure wound therapy.

Figure 3: The 10th day after admission, the patient received open reduction and internal fixation of the left radial shaft. The fasciotomy incision was still fixed with small catheter suture.

Figure 4: The 10th day after admission, the negative-pressure drainage device was removed.

Figure 5: The 27th day after admission, the NICE knot was used to suture the wound intermittently, and tightened the NICE node every 3 days.

Figure 6: The 34th day after admission, the wounds were reduced.

Figure 7: The 50th day after admission, all the wounds closed.

Discussion

Previous studies have shown that early fasciotomy and decompression is the key to obtain the best prognosis when ACS occurs [4-9]. The only effective treatment of ACS is immediate decompressive fasciotomy, wherein the skin and muscle fascia of the involved compartment are incised the length of the compartment so as to

release the tense soft tissues and increase the volume of the muscle compartment, thereby resulting in immediate reduction of compartment pressure and restoring perfusion. In a fasciotomy, the retraction of the skin prevents primary closure from going forward. Many skin closure techniques have been described, such as skin traction, skin grafts, NPWT assisted skin closure, and shoelace technique **[10,11].** The shoelace technique was first described in 1986, in which vessel loops were cross-stitched 48 hours after fasciotomy **[12].** Subsequently, skin nails were used to fix the edge of the wound and the vessel loops were tightened regularly every 48 hours. Because the pain caused by traction may lead to intravenous analgesia during tightening. There have been occasional reports of cases in the literature related to the shoelace technique plus NPWT closure in fasciotomy wounds, especially in recent years. Kakagia et al. **[13]** stated that both NPWT and the shoelace technique are effective, safe, and reliable methods for closure of fasciotomy wounds. Although the shoelace technique is safe, cheap and least disruptive to activity, it lacks sufficient strength to close large wound gaps. And in high tension areas, staples may fall off, resulting in fixation failure. On the other hand, the vessel loops were prone to aging and fracture, and it needs to be replaced again when it breaks or the elasticity disappears. Galois et al. used a wide drainage tube with sutures to increase the contact area between the muscle and the suture and prevent muscle injury. The drainage tube is in contact with the muscle and tightens regularly on the skin **[14].**

Compared with shoelace technique, a single NICE knot fails due to skin cutting, which only needs local suture under local anesthesia and does not require all devices to be replaced under complex anesthesia. Under the action of mechanical stress, skin and soft tissue can stimulate the regeneration of some tissue cells due to slow and continuous tension. This technique of obtaining "extra" tissue by external force stimulation is called tissue traction regeneration technique **[15-17].** NICE knot, similar to skin retractor, uses this principle to repair skin and soft tissue defects, by slowly contracting the skin, maintaining proper skin tension, and promoting tissue regeneration to repair defective skin and soft tissue **[18].** NICE knot is a kind of self-locking sliding junction, which is adjustable and can be tightened in the process of unidirectional sliding, and the anti-skid strength is high. Hill et al. **[19]** believe that NICE knots are not only higher in fixed strength than other thread knots, but also better in preventing slippage. Through the biomechanical analysis of the NICE knot, Collin et al. **[20]** found that the knot has a good sliding locking effect, can reduce the risk of rope elongation under the action of dynamic stress. It has a good fixation effect, and can effectively reduce the loosening rate of the knot after operation. Therefore, according to the natural pathological changes and the course of disease, the effective combination of shoelace technique and NICE knot can prevent complications and reduce additional surgical intervention. Multi-factor complex cases, edema degree, edema time and detumescence time are obviously different from simple cases, resulting in suture brittleness and greater possibility of cutting. In this case, the shoelace technique needs to be replaced repeatedly under anesthesia because of incision brittleness, failure, rubber tube aging and other reasons. If NICE knot is used at the beginning, it is inevitable due to continuous swelling and suture binding effect, which lead to further ischemia of the affected limb and cause a vicious circle. At present, there is no consensus on the best technique of fasciotomy incision closure **[21].** However, it seems more reasonable to choose wound sealing technique according to the pathological changes and natural course of ACS. Therefore, we consider the use of rubber leather tube on the basis of shoelace technique, plus NICE knot for sequential treatment. In the early stage of limb swelling and microcirculation disturbance, rubber continuous traction with less interference on blood supply and small cutting force should be chosen to avoid the difficulty

of wound closure caused by skin retraction, while cooperating with NPWT to promote the improvement of blood supply. In the regression period of swelling, NICE knot suture can be used to tighten regularly. The shoelace technique involves the placement of tensioning devices across the wound (elastic vessel loops or sutures) that provide a continuous pull on wound margins and are intermittently tightened without replacement or the need for anesthesia **[22].**

Conclusion

This article aims to present a useful method involving both techniques for wound management following a fasciotomy. According to the pathological changes and natural course of fasciotomy, continuous traction with shoelace technique in the early stage after operation, and sequential treatment with NICE knot in the later stage, which have an effective clinical recovery and less complications.

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