Dynamic Wound Closure for Decompressive Leg Fasciotomy Wounds

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Decompressive fasciotomy for preservation of lower extremity function and salvage is an essential technique in trauma. The wounds that result from the standard two incision four-compartment leg fasciotomy are often accompanied by a wide soft tissue opening that in the face of true compartment syndrome are often impossible to close in a delayed primary fashion. We describe a technique using a device that allows for dissipation of the workload across the wound margin allowing for successful delayed primary closure. Consecutive patients who presented to the 28th Combat Support Hospital in Baghdad, Iraq with a diagnosis of compartment syndrome of the leg, impending compartment syndrome of the leg, or compartment syndrome of the leg recently treated with fasciotomies were followed. All patients underwent placement of the Canica dynamic wound closure device (Canica, Almonte, ON, Canada). Eleven consecutive patients treated at a combat support hospital in support of Operation Iraqi Freedom underwent four-compartment fasciotomies for penetrating injuries. There were five patients that underwent a vascular repair [three superficial femoral artery (SFA) injuries and two below knee popliteal artery injuries] and six patients that had orthopedic injuries (three comminuted tibial fractures, two fibula fractures, and one closed pilon fracture). Patients returned to the operating room within 24 hours for washout and wound inspection. Mean initial wound size was 8.1 cm; mean postplacement size was 2.7 cm; average time to closure was 2.6 days. All patients were able to undergo primary wound closure of the medial incision and placement of the Canica device over the lateral incision. Ten of the 11 patients (91%) could be closed in delayed primary fashion after application of the device. In our series of patients with penetrating wartime injuries and compartment syndrome of the leg we have found the use of this dynamic wound closure device to be extremely successful and expedient.

MODERN WARTIME INJURIES are generally associated with high kinetic energy transfer, high velocity gunshot, and or fragmentation wounds and result in devastating soft tissue injuries. Many of the survivable injuries are in the extremities and result in compartment syndrome of the leg. As a result, one of the most common procedures performed on the battlefield is lower leg fasciotomy. The standard technique of two incisions is incorporated and the four fascial compartments of the leg are decompressed. Although fasciotomies are often necessary to preserve the limb, the resultant skin over the wounds cannot be approximated without tension. Generally these patients will require coverage of these large wounds with a split-thickness skin graft (STSG). Although effective in covering the wound, these are generally unsightly and insensate. In the setting of battlefield type injuries, where an entire extremity may be "peppered", skin grafting requires the creation of another wound as well as a 3 to 5 day additional hospitalization with the potential that the STSG may not take.

Numerous wound closure methods have been described to attempt delayed primary closure.[1–12] We describe a modern battlefield experience using the Dynamic Wound Closure Device (DWC, Canica, Almonte, ON, Canada) on a series of leg fasciotomy wounds.

Methods

Consecutive patients that presented to the 28th Combat Support Hospital in Baghdad, Iraq during Operation Iraqi Freedom between December 2006 and February 2007 with a diagnosis of compartment syndrome of the leg, impending compartment syndrome

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of the leg, or compartment syndrome of the leg recently treated with fasciotomies were evaluated. A standard two-incision fasciotomy was performed with the medial incision to release the superficial and deep posterior compartments and the lateral incision to release the anterior and lateral compartments. Twenty-four hours later the patient returned to the operating room for inspection, debridement, and washout of the wounds. If the skin's edges around the wound were viable and there was no gross contamination, the medial wound was closed with 3–0 interrupted nylon sutures and the DWC device was placed over the lateral wound with moist gauze under the silastic elastomers. Measurements of the initial lateral wound size from skin edge to skin edge (Fig. 1), as well as postplacement wound size (Fig. 2), were obtained and recorded. The elastomers were tightened according to the Instructions for Use with a stretch of no more than 1.5× the mark on the elastomers. Sequential tightening at the bedside or in the operating room was performed until the wound edges had been fully approximated (Fig. 3). Subsequent closure again with interrupted sutures and staples was performed (Fig. 4). American soldiers who were evacuated stateside were followed with electronic records or by direct contact with the attending surgeon. Host nation soldiers were followed until discharge from the hospital.

Results

During this time period, 11 patients underwent placement of the DWC device on the lateral incision after medial wound closure. All (100%) patients were able to undergo medial closure and placement of the DWC device on the lateral incision. There were five patients that underwent a vascular repair (three superficial femoral artery injuries and two below knee popliteal artery injuries) and six patients that had orthopedic injuries (three comminuted tibial fractures, two fibula fractures, and one closed pilon fracture). Ten of the 11 patients (91%) had successful delayed primary closure of the lateral wound. One patient failed due to the onset of heparin-induced thrombocytopenia, subsequently requiring bilateral above knee amputations.

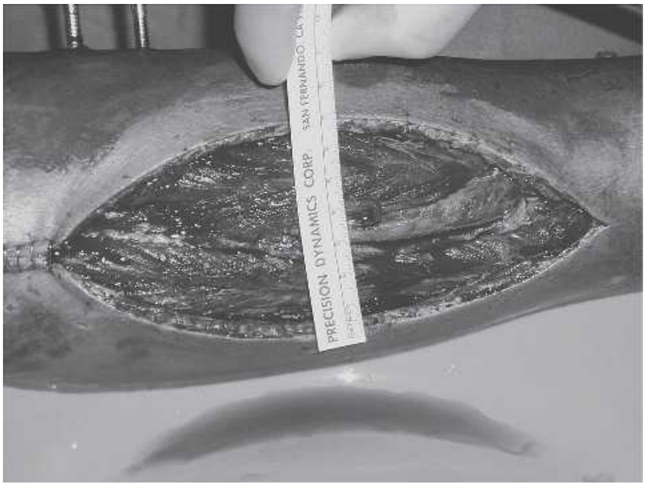

FIG. 1. Initial measurement of the lateral fasciotomy wound.

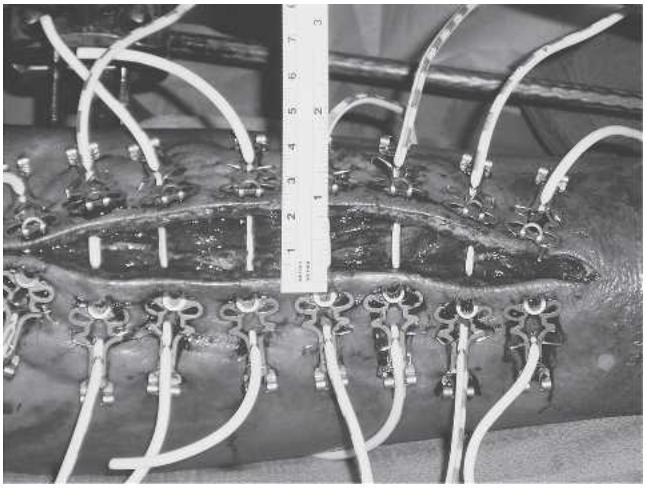

FIG. 2. Postplacement measurement of the fasciotomy wounds.

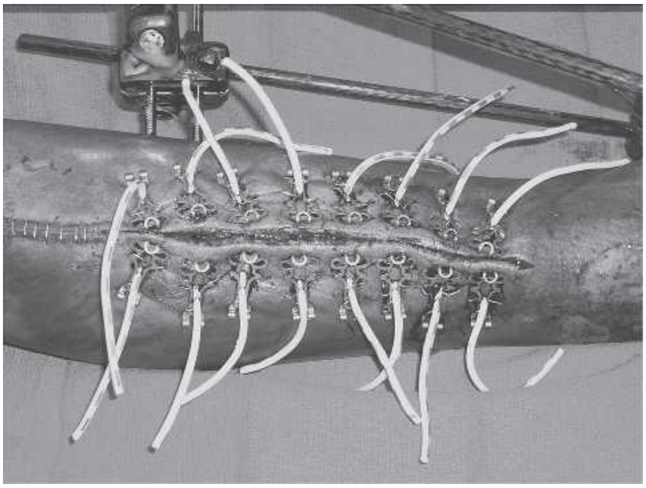

FIG. 3. Postoperative day 2: Wound approximated.

The mean initial wound size was 8.1 cm (range 6.8 to 11.5 cm) and the mean postplacement wound size was 2.7 cm (range 2.2 to 6 cm). The average time to closure was 2.6 days (range 2 to 6 days). None of these patients required an STSG.

Discussion

Delayed primary closure of fasciotomy wounds is preferable, not only for cosmetic reasons, but for functional aspects as well. Several techniques have been developed in attempt to achieve this goal. Simple techniques such as subcuticular prolene sutures have been described in a small series by Chiverton and Redden.[10]

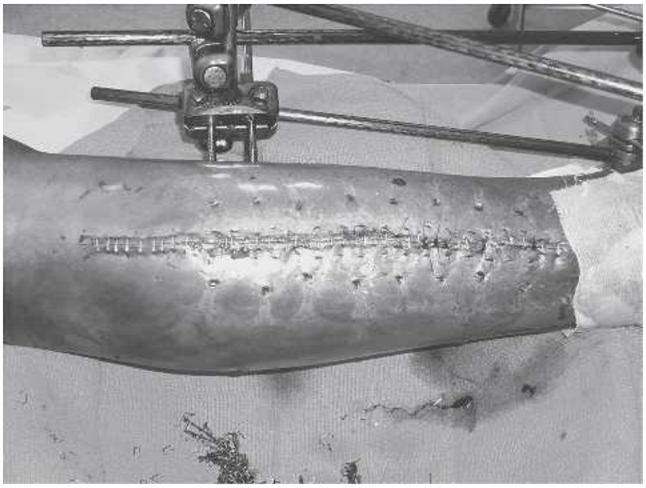

FIG. 4. Postoperative day 2: DPC.

The technique is appealing because it is simple, but we have found in our experience the wounds we encountered were large and attempts at any suture approximation was not successful. The vessel loop or shoelace technique is a commonly performed technique and has been described by Berman et al.[11] It involves using silastic vessel loops and interlacing it over the wound through staples placed at the skin edges. This method has become very common, however, it does have the disadvantage of difficulty in dressing changes and the potential of having the staples dislodged from the skin edges during tightening. In addition, another shortcoming is that it does not allow for equal distribution of force across the wound edges, as it is one continuous vessel loop.

The wound vacuum assisted closure device (VAC) (KCI Medical, San Antonio, TX) has revolutionized wound care and has the concept of negative pressure therapy. One observation we have noted is that in these young trauma patients is the profound granulation tissue that occurs in the span of 48 hours. The wound VAC is excellent for preparing a patient for an STSG, but we have found that it “freezes” the edges and does not promote delayed primary closure (DPC) unless there is some sort of traction on the wound as described by Van der Velde and Hudson.[12] In their series of patients they were able to use a suture bootlace technique and the wound VAC to achieve closure of 12 of 14 wounds.[12]

The common philosophy of all of the above techniques is the concept of maintaining elasticity of the skin over these wounds that over a period of time would allow for delayed closure. The design of the skin anchors allows for a stable platform to pass the elastomers for equal dissipation of force across the wound. In addition, the anchors also allow for eversion of the skin edges. In their early results of the DWC device, Taylor et al.[13] described some of the properties of the system in a small series of patients that had undergone upper and lower extremity fasciotomies. All were able to be closed after placement of the device. They described the concepts of mechanical creep, which is the skins ability to stretch beyond its normal limit when a load is placed. The skin will increase in length over time and it will require less force. In addition Concannon and Puckett[14] has found that tissue hydrostatic pressure increases when this force is exerted over the skin edges and facilitates the resolution of edema.

In our series, we have found the DWC device to be an effective and efficient way of DPC. Our technique of early medial closure with interrupted suture and placement of the device on the lateral wound worked in 10 of the 11 patients. Closure of the medial side generally increases the wound separation on the lateral aspect of the leg, which makes it ideal for the device. We found that our initial wound size, which was 8.1 cm, decreased to 2.7 after placement of this device and that this equal distribution of force brought the skin edges closer without causing the medial side to open further. In addition, the placement of a moist dressing over the muscle is readily performed and the device can easily be retightened. Our average closure days were 2.6 days, which was shorter than that described by Taylor.[13] In their series, the average time to closure was 9.8 days. The difference we noted is that we placed our device earlier than in their series, where patients were treated with some other form of therapy before using the DWC. We believe early placement of the device is the key to success and placement on the day of surgery or on postoperative day 1 will allow for the skin approximation to occur faster. The fear of placing this early and causing a recurrent compartment syndrome should not be a factor as the device can be placed loosely and loosened as needed. Simply applying the device early and allowing for skin approximation will facilitate the mechanical creep.

Obviously there are limitations to our study. First, we did not randomize the patients, which in a battlefield situation is difficult to accomplish. Second, we did not have a formal control group, but during this time period, many fasciotomies were performed and the other above-mentioned techniques were used to treat the wounds and primary closure was rarely accomplished. Unfortunately due to the rapid evacuation of United States soldiers, it would be difficult to track many of these patients other than the small group in which we used the device. Given the difficulties in adjusting tension over the wound edges from fasciotomies, we do believe this is a superior technique to those previously described.

In this small series of battlefield injuries we have

found that patients with fasciotomies benefit from the DWC. In addition to primary closure, we avoided the need for creating additional wounds in patients subject to multiple injuries. In conclusion the DWC is a useful adjunct in the wound therapy system. Obviously, a larger study would be required to see whether this success could be extrapolated over a broader population.

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