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Review

Fix and flap in the era of vacuum suction devices: What do we know in terms of evidence based medicine?☆

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ABSTRACT

Introduction: The concept of immediate or early fixation and soft tissue coverage of open fractures is frequently referred to as 'fix and flap,' and negative pressure wound therapy (NPWT) has had a major impact in this area. This article aims to review concepts and evidence relevant to the use of NPWT in open fractures.
Review of open fracture management: Muscle flaps in open fractures do well in part because they improve blood supply to the underlying fracture. Outcomes of muscle flaps are best when done acutely, before bacterial colonisation. The colonised subacute wound is managed with 'open-wound techniques' until it becomes a chronic localised wound, when flap coverage is again indicated. NPWT provides a useful adjunct in this process as the zone of injury is determined.
Vacuum-assisted closure review of basic and clinical science literature: Proposed mechanisms of action of NPWT include: increased blood flow, decreased oedema, cytokine release induced by mechanical stretch and increased lactate and oxygen tension in the tissue with induction of collagen transcription and angiogenesis.
Vacuum-assisted closure in open fractures: NPWT to open fractures caused early appearance of healthy granulation tissue, a reduction in wound area and allowed simpler soft tissue procedures for wound closure. NPWT also improved clinical survival of muscle flaps despite occluded flap venous outflow.
Summary: The aim in open fractures is to stabilize the fracture and achieve soft tissue coverage before infection develops. NPWT, applied as a temporizing dressing, simplifies soft tissue coverage on the 'reconstructive ladder.' The only Level-I data on that topic showed a significant decrease in infections. However, NPWT does not allow delay in soft tissue coverage. NPWT increases the 'take rate' of skin grafts, skin substitutes and composite skin grafts and allows quicker graft incorporation.

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Introduction

Management of open fractures underwent a paradigm shift with landmark work by Godina[16] and Byrd et al.[4] regarding the timing and type of wound coverage. Their work shifted the focus from allowing wounds to heal with temporary fixation of associated fractures to immediate wound coverage using aggressive debridement, early definitive internal fixation and wound coverage with muscle flaps. This concept of immediate or early fracture fixation and soft tissue coverage is frequently referred to as 'fix and flap.'[18]

Negative pressure wound therapy (NPWT) using the vacuum-assisted closure (VAC) system (Kinetic Concepts Inc., San Antonio, TX) is an adjunct in the treatment of open fractures. NPWT using the VAC has been evaluated with basic science, animal, and clinical studies that suggest that it helps wounds granulate and heal better and quicker.[1] NPWT improves the take of grafts and flaps,[2,27,28] and it reduces the complexity of surgery required to achieve wound closure.[3,9,36] It has been used successfully in a wide variety of wounds including open fractures,[9,8] soft tissue wounds,[20] burns,[27] diabetic and chronic wounds,[1,2] infected wounds, and postoperative infections with underlying hardware.[23,29]

The purpose of this article is to review concepts and evidence in published literature relevant to the use of negative pressure wound therapy in open fractures, with emphasis on its impact on soft tissue coverage over open fractures.

A review of open fracture management

Various techniques are available to provide soft tissue coverage over acute open fractures (Fig. 1), including primary closure[39], muscle and fasciocutaneous rotation flaps, skin grafting and free flaps. The ideal timing for wound debridement and fracture stabilisation is within 6 h of injury, prior to colonisation of the wound with bacteria.[15,41] However, recent work has not demonstrated an increase in deep infections when the initial debridement is delayed for 12–24 h in most open fractures.[34,36]

Muscle flaps have been used with great success[4,11,16–18,21,38] to provide wound coverage and closure (Fig. 2). The success of the procedure depends on the observation that muscle coverage improves blood supply to the underlying bone or fracture. Animal studies have shown that osteotomies and hence fractures, heal faster and better when covered by a vascularised muscle flap.[40] The muscle flap is in turn covered by a split-thickness skin graft, completing closure of the wound (Fig. 2).

Fig. 1. A grade IIIB compound fracture with extensive skin and soft tissue loss, after debridement and prior to definitive closure. The tibia was fixed with an intramedullary nail.

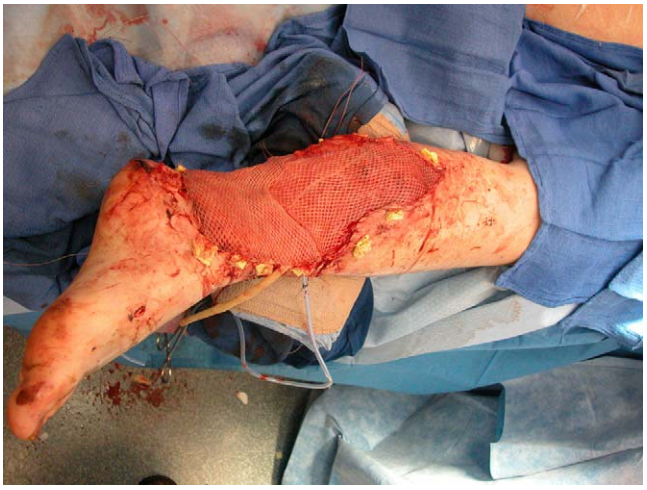

Fig. 2. Same patient as in Fig. 1, with a contralateral Latissimus dorsi free flap in place. The flap has been sutured in place and is seen to cover the fracture and the wound completely. A skin graft donor site is visible in the top right corner. Definitive coverage was achieved within 72 h of injury.

In contrast to the above studies, some authors have suggested that 'immediate coverage' or even coverage within the first 72 h may not be as critical. Pollak et al.[37] (of the Lower Extremity Assessment Project – LEAP Study Group) found that delayed wound coverage (more than 7 days) was not significantly associated with more wound problems than was early coverage. They compared short-term (6 months) wound complications associated with rotation flaps versus free flaps for open tibial fractures. In patients with high grade osseous injury (ASIF/OTA grade C), rotation flaps had a wound complication rate 4.3 times higher than that of free flaps. The authors concluded that by virtue of proximity to the zone of osseous injury, the rotation flap could have some devitalised tissue in it that was sufficient to cause wound complications that required operative intervention. There was no correlation between the location of the tibial fracture and the wound complication rate. The authors did not use NPWT in their study.

In another report on the patients in the LEAP study group, Webb, et al.[49] found that in 105 patients with grade III open tibial fractures, the timing of debridement, at 6 h as compared to 24 h after injury, had no apparent effect on clinical or functional outcome at 2-year follow-up. The LEAP study featured extremely severe soft tissue injuries in the patients enrolled. Separately, Naique et al.[35] also reported that debridement within or after 6 h of injury had similar outcomes statistically, although the absolute infection rate was higher in those debrided after 6 h. The timing of soft tissue coverage, at 3 days or less versus more than 3 days[49] to 5 days[35] after injury had no apparent impact on outcome. They advocate radical debridement and fracture stabilisation by experienced orthopaedic and microvascular surgical teams as an urgent elective procedure rather than as an emergency operation.[35] These authors did not report on the use of NPWT as an adjunct to wound care after open fractures.

Vacuum-assisted closure

The vacuum-assisted closure device consists of a black polyurethane open celled sponge with a pore size of 400–600 μm that is placed in contact with a wound or surface. The sponge can be cut to match the size and shape of the wound. The pore size allows maximum tissue in-growth. A suction tube ending