Negative-pressure wound therapy over surgically closed wounds in open fractures

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ABSTRACT

Purpose. To evaluate the outcome of open fracture surgery with negative-pressure wound therapy (NPWT) applied directly over surgical wounds.

Methods. Medical records of 10 men and 4 women aged 6 to 70 (mean, 43.7) years who underwent internal fixation, external fixation, or splint application for open fractures of the lower leg (n=7), foot and ankle (n=5), or knee (n=2), and NPWT were reviewed. The NPWT was applied directly over the surgical wound without a non-adherent contact layer. The foam was changed every 3 days. The standard negative pressure was 125 mm Hg. The NPWT was stopped when the wound discharge became <50 ml per day. The duration of NPWT and the level of negative pressure were recorded, as were wound condition, reasons for NPWT, and outcome.

Results. The mean duration of NPWT was 9.1 (range, 3–24) days. Four patients developed maceration of the skin, whereas 2 patients developed skin blisters under the drape. No necrosis of flap skin or infection occurred, and all the fractures eventually united.

Conclusions. Maceration of the skin was seen in some cases but did not affect the overall outcome. NPWT directly over the skin surface had no deleterious effect on wound and fracture healing.

Key words: fractures, open; negative-pressure wound therapy

INTRODUCTION

Negative-pressure wound therapy (NPWT) promotes wound healing1–3 by enabling occlusive wound coverage, oedema reduction, increased blood flow, increased bacterial clearance, removal of factors that impair cell proliferation, and by increased mechanical stress that enhances granulation tissue in open wounds.4,5 Open wounds are prone to infection and should be protected from environmental bacteria while promoting drainage. NPWT is recommended between debridements or when primary closure is not possible, to act as a bridge to definitive closure in
patients with open fractures. There have been a few studies of NPWT for surgically closed wounds. Microvascular blood flow increases significantly when NPWT is applied directly over an intact skin surface. We hypothesised that increased blood flow to injured soft tissue would decrease the risk of surgical site infection and/or necrosis. This study evaluated the outcome of open fracture surgery when NPWT was applied directly over surgical wounds without a non-adherent contact layer.

MATERIALS AND METHODS

Medical records of 10 men and 4 women aged 6 to 70 (mean, 43.7) years who underwent internal fixation, external fixation, or splint application, and NPWT between May 2010 and March 2012 for open fractures of the lower leg (n=7), foot and ankle (n=5), or knee (n=2) were reviewed (Table). Internal fixation was performed before NPWT in 10 patients and after wound healing following NPWT in 2 patients. The remaining 2 patients underwent external fixation or splint application for stable fractures of the patella and calcaneus.

The NPWT entailed a vacuum-assisted closure system (KCI, Kinetic Concepts, San Antonio [TX], USA) and black polyurethane foam, which was applied directly over the surgical wound without a non-adherent contact layer in order to maximally enhance blood perfusion. The foam was changed every 3 days. The standard negative pressure was 125 mm Hg, but in 2 patients with a flap, the pressure was 100 mm Hg, at the discretion of the attending surgeon. The NPWT was stopped when the discharge became <50 ml per day. The duration of NPWT and the level of negative pressure were recorded, as were wound condition, reasons for NPWT, and outcome.

All the wounds were at high risk of complications. The NPWT was applied with the goals: (1) to promote the viability of fasciocutaneous random pattern flaps (n=4) and reverse sural artery flap (n=1), which were used to enhance soft-tissue coverage over the open fracture site; (2) to achieve wound re-approximation (n=5) of the medial side of the distal tibia and to prevent haematoma formation secondary to dysfunction of the occlusive drain; (3) to promote wound healing following oedema (n=2); and (4) to secure degloved skin (n=2). One of the 2 patients with oedema sustained an unstable tibial plateau fracture with a small open wound on the medial side (patient 7) and underwent locking plate fixation through a...
lateral skin incision following medial side irrigation and debridement. Two incisions were made in the anterolateral and anteromedial sides of the proximal tibia. To avoid skin dehiscence and necrosis owing to subsequent oedema, NPWT was placed over the anterior side of the proximal tibia, bridging the 2 skin incisions. The other patient with oedema sustained open ankle and metatarsal fractures and underwent internal fixation, surgical skin closure, and NPWT for prevention of compartment syndrome (patient 11). Of the 2 patients with degloved skin, one was over a patellar fracture (patient 8) and the other was over a pilon fracture (patient 4). A wide area of skin was detached from the base fascia at risk of necrosis. Nonetheless, the decision was made to debride (rather than excise) the degloved skin. Apparent bleeding from the edge of the degloved skin was not noted. The degloved skin was not defatted to restore underlying circulation. Many small fenestrations were made over the degloved skin to drain the discharge, and the skin was sutured in place to cover the open fracture site. The NPWT was then placed directly over the degloved skin to secure it (Fig. 1).

RESULTS

The mean duration of NPWT was 9.1 (range, 3–24) days. There was no flap or degloved skin necrosis, wound dehiscence, or deep infection. All the fractures eventually united in good positions. Four patients developed NPWT-related complications, such as maceration of the skin and/or blisters, mostly in the foot and ankle area. Maceration occurred in the contact area of the foam. The condition improved immediately after stopping NPWT. Skin blisters developed under the drape and resolved after discontinuation of NPWT (Fig. 2). Nonetheless, in accordance with our protocol, NPWT was continued until the amount of discharge was <50 ml per day, even if maceration or blister formation occurred.

DISCUSSION

Open fractures are prone to wound infection. Even after closure of open wounds, soft-tissue swelling and haematoma formation can cause high skin tension,
followed by a decrease in microvascular circulation, ischaemia, wound dehiscence, and surgical site infection. The edges of the flaps for wound closure are susceptible to breakdown and necrosis due to primary contusion. Degloved skin almost always results in necrosis because of disruption of perforators to the skin. NPWT for open wounds at the fracture site has been shown to prevent infection. There are a few studies of NPWT for surgically closed wounds. Most were in planned surgical procedures. The use of a non-adherent wound contact layer over the skin surface is recommended.

NPWT may increase blood flow in the vicinity of the open wound and contribute to granulation tissue formation and prevention of surgical site infection. NPWT with negative pressure up to 300 mm Hg and polyurethane black foam placed directly over an intact skin increases blood flow over 5-fold.

The use of a non-adherent wound contact layer is recommended to avoid skin maceration and blister formation. Nonetheless, any beneficial effect of NPWT may be obstructed by the use of a wound contact layer, even if it is meshed and thin. The present study suggests that the increase in blood flow achieved may be beneficial despite potential complications of skin maceration and blister formation, in view of the high risk of surgical site infection.

NPWT can be used as an adjunct to flaps to prevent necrosis, by reducing oedema, securing the flap, reversing venous congestion, increasing vascularity, and providing good contouring of the flap. In a study of NPWT for random pattern local flaps around the ankle, which is at high risk of flap failure due to poor blood perfusion, 10 consecutive flaps with NPWT healed without tissue compromise or necrosis. Nonetheless, caution in applying NPWT to flaps is recommended, as the optimal level of negative pressure remains unknown (high pressure may cause flap necrosis) and it is unable to monitor the flap under the foam (detection of a necrotising flap may be delayed). In our study, NPWT over the skin surface of a flap to achieve skin coverage of open fractures was effective to prevent flap failure, but judicious use and careful attention are necessary.

The optimal management of degloving injuries is immediate excision of the degloved skin and free skin grafting, using defatted skin excised from the injury site. However, degloved skin is often associated with disruption of perforators to the skin and thus skin necrosis, even if the skin is reattached and sutured in place. There are a few studies of NPWT for degloving injuries for securing a full-thickness, free skin graft or preparing the wound bed for grafting. Easier management of a degloving injury without excision of the degloved skin is also reported. In our study, NPWT provided increased blood flow, firm securing and good contouring of the degloved skin, and constant drainage from the wound bed. We suggest that the degloved skin may be retained with debridement and fenestration by applying NPWT.

One limitation of this study was that there has been no clinical evidence that NPWT enhances the blood supply through the injured skin where underlying structures may be detached. In addition, the cohort of patients was small. Owing to the retrospective nature of this study, comparison of complication rates with other studies was not undertaken. Skin maceration and skin blister formation may have detrimental effects in surgical wound healing. Nonetheless, in our patients at very high risk of wound complications, direct placement of the foam over the skin surface enabled good outcome. Larger prospective, randomised studies are warranted to determine the efficacy of NPWT in surgically closed open fracture wounds.

CONCLUSION

NPWT directly applied over the surgically closed skin surface in open fractures was effective in preventing infection, despite skin maceration in some cases.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES


