The use of negative pressure wound therapy as a dual closure and splinting device is associated with rapid delayed primary wound closure in high-risk diabetic patients following digital amputation: a case series

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ABSTRACT

Diabetic foot ulcers are associated with high morbidity, preceding over 80% of amputations in diabetic patients. The application of negative pressure wound therapy (NPWT) to open diabetic wounds has been shown to improve various aspects of healing; however, its use in closed wounds remains limited. This paper describes the novel application of NPWT as a dual closure and splinting device following delayed primary closure of digital amputation sites in the foot, utilising a bridging technique to reduce potential harmful pressure effects. This technique was associated with rapid wound closure and delayed primary healing at two months in high-risk diabetic patients, with no complications such as wound infection or dehiscence. These case studies present promising findings of expedited wound healing in high-risk patients and highlight the considerable remaining scope for expanding current wound healing management therapy.

Keywords: Delayed primary wound closure; diabetic; negative pressure wound therapy; wound healing.

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INTRODUCTION

Diabetes mellitus is a major chronic disease, with increasing incidence and prevalence across the developed world. Up to one in four patients will develop a foot ulcer during their lifetime, at a rate of 2–3% per year[1]. Foot ulcers are strong prognostic markers of advanced disease, preceding over 80% of non-traumatic amputations in diabetics, particularly when infection supervenes[2]. Surgical management of ulcers, involving prophylactic or therapeutic debridement, are associated with reduced risk of limb-threatening infection; however, perioperative wound failure is still sufficiently common to warrant targeted intervention[3].

Negative pressure wound therapy (NPWT), also known as topical negative-pressure therapy, is a well-established technique frequently employed in the management of open wounds, including diabetic and non-diabetic ulcers, toe amputation sites and orthopaedic trauma[4]. NPWT involves the application of a foam dressing to the wound site, which is kept at subatmospheric pressure by means of a vacuum pump, and has been shown to expedite wound closure and decrease rates of subsequent infection and amputation versus standard therapy[5,6]. Numerous mechanisms have been proposed to explain NPWT effects, including increased blood flow[7], oedema resorption[8], growth factor expression[9], and formation of granulation tissue[10].

Although NPWT is most closely associated with the treatment of open wounds expected to heal by secondary intention, there is mounting evidence to support its role in the management of closed wounds healing by primary intention[11-13]. The application of NPWT to open diabetic wounds has been shown to improve various aspects of healing[5,14,15]. However, with respect to closed diabetic wounds, there are currently no peer-reviewed or statistically-powered reports published in the literature. The only existing publication is that of Faroqi *et al.*[16], a single-case report that describes using NPWT to encourage uncomplicated healing of a high-risk diabetic foot wound. The purpose of our investigation was to evaluate a novel technique using NPWT as a splinting closure device in high-risk diabetic patients following digital amputation.

METHODS

The method described by Faroqi and colleagues involves the application of a vacuum-assisted closure dressing tailored to the shape of the incision line following postoperative closure with sutures, staples, or tape strips[16]. We modified Faroqi's technique, allowing wounds to remain open for up to three days following surgery to ensure that surgical debridement was adequate with no further macroscopic signs of infection necessitating further debridement. During this period, wounds were packed with Prontosan® (B Braun Medical Ltd) soaked gauze twice a day. The wound was then closed with steri-strips (Smith & Nephew, NSW, Australia) (Figure 1) after two or three days, and Mepitel™ silicone dressing (Mölnlycke Australia, NSW, Australia) was applied over the closure line and the base of the remaining open wound. A thin piece of Granufoam dressing (KCl Medical Australia, NSW, Australia) was placed on top, and further sealed with the film dressing. The T.R.A.C. Pad® (KCI Medical Australia, NSW, Australia) was located away from the wound site using film as an initial contact layer on the skin and a bridging piece of granufoam dressing, in order to remove undesirable pressure effects on tissues surrounding the wound (Figure 2). This offloading of the closure site is an essential aspect of wound care and facilitates appropriate healing, particularly in diabetic patients. In this way, the V.A.C.® (KCl Medical Australia, NSW, Australia) dressing had been applied to act as a closure and splinting device. We describe the outcomes of this approach in three cases of diabetic toe amputations. Informed consent was obtained from all participants.

Figure 1: Closure of wound with steri-strips three days postoperative first and second toe amputation

Figure 2: Application of the V.A.C.® dressing with bridging of the T.R.A.C. Pad® (right of image)

RESULTS

Patient 1 presented with a two-month history of a left second metatarsal plantar ulcer, which became necrotic and suppurative over the preceding week to include the first web space. Surgical management involved extensive debridement with resection of the first and second metatarsal bones. The patient was discharged 14 days postoperatively, and ceased V.A.C.® therapy after 16 days. At the six-week follow-up, despite ongoing smoking, the wound edges were well apposed, with no exudate, erythema or evidence of wound healing complications (Figure 3).

Figure 3: A: Ulcer at presentation; B, C: Wound following debridement and amputation of the 1st and 2nd metatarsals; D: Wound following V.A.C.® removal; E: Wound healing at 2-month follow-up

Patient 2 presented with a two-week history of a malodorous, deep necrotic foot ulcer overlying the right first metatarsal. Surgical management required debridement of the ulcer with amputation of the first metatarsal bone. V.A.C.® therapy was ceased after eight days and the patient discharged 11 days postoperatively. At follow-up after eight weeks the wound had healed.

Table 1: Patient data

Patient #	1	2	3
Gender	Male	Male	Female
Age	41	52	57
Occupation	Unemployed	Butcher	Teacher
Smoking status	Smoker	Smoker	Non-smoker
Diabetic status	DMT1 for 15 years	DMT2 for 15 years	DMT1 for 10 years
HbA1c	9.6%	5.5%	9.9%
Past medical history	Acute renal failure NSTEMI, 2012	Aortic valve replacement, 2006 IE, 1998 CVA, 2000	Hypertension Hypercholesterolaemia
Current ulcer	L 2nd metatarsal	R 1st metatarsal	R 5th metatarsal
Examination	Febrile, wet gangrene and surrounding cellulitis	Wet gangrene	Febrile, surrounding cellulitis
Wound cultures	*Staphylococcus aureus*, micro-aerophilic streptococcus, *Eikenella corrodens*, mixed anaerobes	*Streptococcus dysgalactiae*	*Staphylococcus aureus*, micro-aerophilic streptococcus
Surgical management	L 1st and 2nd toe amputation for OM	R 1st toe amputation for OM	R 5th toe amputation for OM
Open wound	3 days	3 days	2 days
VAC duration	16 days	8 days	16 days

DMT1 (diabetes mellitus type 1), DMT2 (diabetes mellitus type 2), CVA (Cerebrovascular accident), IE (infective endocarditis), OM (osteomyelitis), NSTEMI (non ST elevated myocardial infarction)

Patient 3 presented with a one-week history of a spontaneous blister on her right fifth toe, which progressed to an ulceration involving the nail bed. On presentation she was febrile, and the area was swollen, erythematous and infected with necrotic slough. Surgical management involved debridement of the ulcer with amputation of the fifth metatarsal bone. The patient was discharged seven days postoperatively, with V.A.C.® therapy being ceased after 16 days. At eight weeks follow-up, the wound was clean, warm and well perfused with no wound dehiscence or evidence of wound healing complications.

DISCUSSION

Traditionally, the use of NPWT has been used to assist the closure and healing of open wounds[4]; however, in recent years, this has been extended to a use in assisting closed wound healing[11-13]. The first reported instance of closed-wound NPWT refers to its use for serous surgical wounds, in order to provide a clean, dry environment in the postoperative period to optimise healing[17], with further descriptions being published in 2006[18,19]. Since then, comparative studies from various disciplines have been published describing improvements in closed wound care with NPWT. For example, incisional NPWT for orthopaedic surgical wounds has been shown to expedite wound healing[19], and reduce rates of infection and dehiscence[20,21], features also described in non-comparative case series[18,22]. Additionally, statistically significant reductions in closed wound complication rates have been recently published in the fields of vascular[23], cardiothoracic[24], and abdominal surgery[25-27].

In the current patient cohort, the use of NPWT as a splinting closure device following delayed closure of toe amputation sites was associated with rapid wound closure with no complications such as wound infections or dehiscence. These findings are consistent with the published literature which has demonstrated expedited wound healing and a statistically significant reduction in closed wound complications[23]. Unlike previous studies, wounds remained open postoperatively, with twice-daily prontosan® gel packs used to

mechanically debride the wound and disrupt the biofilm burden, enabling assessment for further infection before closure using the V.A.C.® device. The V.A.C.® device was used to support and immobilise the approximated wound edges, allowing for healing to occur without the use of sutures or staples. The role of NPWT in wound closure and healing is multifactorial, with proposed mechanisms including oedema resorption, increased blood flow and granulation tissue formation[7,8,10]. Given the high-risk nature of diabetic patients, reducing recovery time is imperative, and using the bridging technique helps to redistribute pressures evenly by offloading at-risk areas. The patients in this case series have the burden of cardiovascular disease and comorbidities typical in high-risk diabetic patients with the expectation of impaired wound healing.

While there is a growing body of evidence supporting the use of NPWT in the management of closed surgical wounds, only one study has been published examining its use in closed diabetic wounds. The cases presented here extend the application of NPWT, utilising the V.A.C.® dressing as a dual closure and splinting device, a technique that has not previously been described in the literature, which has resulted in optimal wound healing outcomes. Adopting this method enabled a quick closure time, which facilitated the offloading of pressure and expedited wound healing. Although we present a very small cohort, these case studies present promising findings regarding the use of NPWT in delayed closure of toe amputation sites and highlight the remaining scope to explore this avenue of wound healing management.

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