Incisional Negative Pressure Wound Therapy: Its Role in the Diabetic Foot

This treatment should be considered in high-risk patients with high-risk incision sites.

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Introduction

Surgical site infections lead to increased morbidity, mortality, length of stay, and healthcare costs. Diabetes, especially when complicated by neuropathy, is a known contributing factor that increases the risk for post-operative infection.[1-3] Limb amputation is associated with significant overall morbidity and mortality and is burdened by a high incidence of amputation stump infections and/or dehiscence. These complications often lead to surgical revision, increased morbidity, mortality, and lengthened hospital stay.

Negative pressure wound therapy (NPWT) has been a common treatment modality in the healing of both acute and chronic wounds via secondary wound healing. In the past few years, there has been a significant amount of literature accepting the use of negative pressure wound therapy to assist in healing surgical incisions by primary intention.[5]

It is suggested that applying NPWT to surgical incisions may hasten the healing of incisions, decreasing the incidence of wound healing complications, and decreasing seroma, dehiscence, hematoma and skin necrosis.[5] In a high-risk patient, prevention of wound complications should remain a high priority, leading to shorter hospital stay, improved wound condition, and decreasing post-operative complications including dehiscence and wound infection.

A Closer Look at Complications with Foot Incisions

Complication rates with lower extremity surgery vary throughout the literature. Complication rates depend on where the incision lies as well as blood flow, comorbidities, and association with trauma. Dehiscence with forefoot amputations has been reported by Dunkel, et al. to be 18%.[4] The characteristics of a patient having diabetes mellitus and age greater than 80 were significantly associated with increased rates of dehiscence. Pre-or post-amputation antibiotic administration was not found to influence stump infection or dehiscence.[4]

Mueller, et al. report complication rates following transmetatarsal amputation (TMA), including skin breakdown in 27% of patients, with 48% occurring in the first three months.[8] Pollard, et al. observed wound dehiscence in 59/101 of patients undergoing a TMA. Of these patients, 55% went on to heal the stump and 31% had chronic stump breakdown. Post-op wound infections were noted in 19 out of the 101 patient and were successfully treated with oral antibiotics and local wound care.[9]

Traumatic injuries to the lower extremity, such as pilon and calcaneal fractures, have shown a high risk of dehiscence and wound infections. There have been many studies that have looked at wound complications following open reduction with internal fixation following calcaneal fractures with a lateral extensile incision. Ding, et al. assessed the wound complication rate of calcaneal fractures, with 490 treated operatively with lateral extensile incision. They found that there was a 17.9% post-operative wound complication rate.[2]

A meta-analysis performed by Zhang, et al. looking at the risk factors for wound complications of ORIF following calcaneal fractures found that patients with diabetes were at

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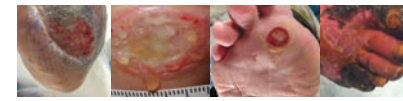

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a 9.97-times greater risk of wound complications. In addition, "no drainage" and "fracture severity" were high predictors of complication.[12] Regarding pilon fractures, it is reported that an extensive dissection to the distal tibia has been associated with significant rates of infection and wound dehiscence, ranging from 0–55%.[7]

Benefits of Incisional Negative Pressure Wound Therapy

The exact science behind the mechanism of action of incisional NPWT is not completely understood. There are multiple theories as to why this therapy is effective. Recent studies have shown multiple benefits to using this modality to aid in wound therapy. NPWT draws wounds closed by removing interstitial fluid that contains inflammatory and potentially infectious exudate. Studies have suggested the NPWT reduces seroma and hematoma. These studies have not been performed on the foot, but rather on the abdomen following abdominoplasty. Despite this, these results can be applied to support the benefit of NPWT. In comparison of NPWT vs conventional dressing, the NPWT group was shown to have reduced serous drainage and exudate, reducing the time needed for a drain to be in place and subsequently reducing the length of hospitalization.[3]

Another benefit is that incisional NPWT allows an additional protective layer in order to aid in preventing infection. In 2012, Stannard, et al. assessed the use of NPWT versus control in patients with high-risk lower extremity fractures. Calcaneal, pilon, and tibial plateau fractures have been associated with high infection rates as well as wound dehiscence. The Stannard study found that the infection rate was 1.9% higher in the control group compared to the NPWT group. They also found that there was a lower incidence of dehiscence in the NPWT group. It was concluded that NPWT should be considered in patients who experience severe trauma with high-risk wounds.[10]

Incisional NPWT has also been shown to reduce stressors to the incision. A study performed by Wilkes, et al. concluded that the use of incisional NPWT reduced tension on the tissue as well as bolstered appositional forces on the incision. Wilkes, et al. also concluded that the force to disrupt an incision was increased by about 50% with use of incisional NPWT. They concluded that the use of NPWT creates a stronger incision site while reducing tension on the incision.[11]

In a study performed by Kalpadi, et al., they compared closed incision with application of NPWT to closed incision with abdominal pads. Forty days post-incision, they obtained a biopsy of the incision site. It was found that the incision site with the NPWT had a narrower scar area of the deep dermis compared to the abdominal pad group as well as higher mechanical properties in the NPWT group. They concluded that NPWT on a closed incision improves wound healing via better apposition of the incision site.[6]

Horch investigated the micro-circulatory component of incisional NPWT. Investigators assessed the oxygen saturation levels and blood flow with application of NPWT vs without. They found that both blood flow and oxygen saturation levels were increased with NPWT. This has also been supported by Atkins, et al. in 2011. They assessed presternal perfusion after cardiac surgery with NPWT vs. a control with a standard dressing. In this study, it was found that perfusion increased among the patients who underwent negative pressure therapy and decreased among the controls.[5] Atkins, et al. also assessed mammary artery harvest in which mammary artery harvesting reduced presternal perfusion by 25.7% in the controls, but negative pressure increased perfusion by 100% after mammary harvesting.[1]

Case Presentation #1

A 72 year old patient with a medical history of diabetes and peripheral vascular disease presented with gangrene and non-healing ulcerations. On 6/6/13, this patient was admitted with evidence of wet gangrene to his right 4th and 5th toes. He underwent an angiogram which revealed occlusion to the popliteal artery. An above-the-knee popliteal to distal posterior tibial bypass on 6/14/13 and amputation of his 4th and 5th toes was performed four days later.

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On 7/11/13, he was found to have worsening ischemia and a thrombosed bypass graft, and subsequently was taken to the OR on 7/12/13 for a revision of his bypass.

Following this, his amputation sites were noted to be non-healing and he was taken back for multiple debridements of these sites. He then returned to the OR on 4/15/14 due to gangrene and underwent amputation of the 1st–3rd rays through the metatarsophalangeal joints with pathology demonstrating evidence of gangrene and acute osteomyelitis. He underwent further debridement on 4/17/14 to include resection of the metatarsal heads. In September of 2014, he developed a new ulceration overlying the 4th and 5th metatarsals, which resulted in resection of the 5th metatarsal.

In January 2015, he developed an ulceration with exposed bone overlying the 1st metatarsal. He again was taken to the operating room in February for further resection of the 4th metatarsal as well as resection of the 1st metatarsal. Over the next month, he underwent 40 treatments with hyperbaric oxygen, but the ulceration to the 1st metatarsal persisted. It was then recommended that he undergo a below-knee amputation. At this point the patient presented to the author for a second opinion.

On exam, the patient was noted

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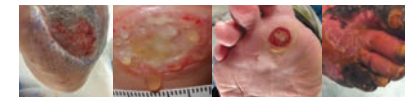

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to have a deep probing wound but no overt signs of infection. X-rays and a magnetic resonance imaging study showed possible osteomyelitis, but it was felt that this was a false positive. It was recommended to the patient to attempt additional debridement of the 1st metatarsal and excision of the ulceration with closure as well as placing incisional negative pressure wound therapy. (PICO/Smith and Nephew) This was performed on 4/9/2015 (Figures 1–3). He was seen back in our clinic one week post-operatively, at which time incisional wound therapy was removed and discontinued.

The patient was monitored weekly over the next month with a well-coapted incision site noted. At one month, the sutures were removed with no evidence of dehiscence. His incision site remained stable with no evidence of breakdown. At his most recent visit on 8/24/15, over 4 months since his procedure, the patient's right foot has remained stable with no subsequent breakdown (Figure 4).

Figure 3: Application of incisional negative pressure wound therapy device.

Figure 1: Intra-operative appearance showing no signs infection.

Figure 4: Complete closure at 4 months post-op.

Figure 2: Full thickness closure.

This example demonstrates that incisional negative wound therapy may be a valuable adjunct in healing a patient's wound that has had multiple incidences of failing debridements and closures. With just one application of incisional negative wound therapy in conjunction with a debridement and closure, we have been able to salvage this patient's limb and prevent a below-knee amputation.

Case Presentation #2

A 60-year-old male with a history of severe arterial insufficiency presented with gangrene of his right forefoot. In addition, he had a history of hypertension, hyperlipidemia, coronary artery disease, congestive heart failure, alcohol abuse, and neuropathy. He initially presented with gangrene of his forefoot in June 2014 (Figure 5a and 5b) and underwent a superficial femoral endarterectomy on the right side, along with a right distal SFA to anterior tibial artery bypass with reversed saphenous vein, a balloon angioplasty of the distal anastomosis, and a patch angioplasty of the common femoral artery. Following this he had amputation of the 4th and 5th toes, debridement of the right hallux and a heel and lateral malleolus ulcer. He subsequently did well and presented on 11/6/14 for definitive procedure (Figure 6), where he underwent a transmetatarsal amputation using incisional negative pressure wound therapy (Prevena/Acelity) (Figures 7–9). He tol-

Figures 5a and 5b: Prior to initial procedure, 4th and 5th toe amputation with debridement of great toe.

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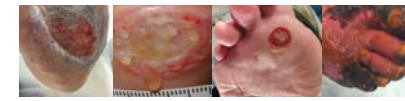

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erated this well and was last seen in October 2015 where he has remained healed (Figure 10).

Conclusion

Wound complications remain an unfortunate possibility after any surgical procedure. Incisional negative pressure wound therapy has become a viable option for treating diabetic ulcers and as an aid in the healing of high-risk incisions. Podiatric surgeons are constantly looking for innovative ways to reduce dehiscence and wound complications in high-risk patients. Studies have clearly shown the effectiveness of incisional negative pressure wound therapy in reducing the incidence of infection and seroma, as well as increasing strength and apposition of incisions.

Figure 6: Immediately prior to TMA

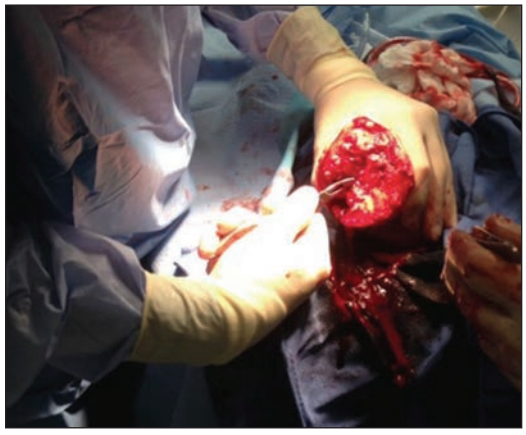

Figure 7: Intra-op showing adequate bleeding at surgical site

Figure 8: Immediately post-op

While there is limited literature regarding the use of NPWT in foot and ankle surgery, the premise and theories as to why NPWT has been successful in other parts of the body can be applied to incisions within our profession. Studies continue to be performed, and there is compounding evidence that negative pressure wound therapy should be considered in high-risk patients with high-risk incision sites. Incisional negative pressure wound therapy offers the possibility of reducing the incidence of surgical site dehiscence and infections, which can be catastrophic for the high-risk patient.

At our institution, we have found promising results for the use of incisional negative pressure wound therapy. It is a treatment modality that should be considered in our high-risk patient population. Still more studies are needed addressing this modality to confirm its benefits in lower extremity surgery. **PM**

Figures 9a and 9b: After application of incisional negative pressure wound therapy

Figures 10a and 10b: Eleven months following TMA

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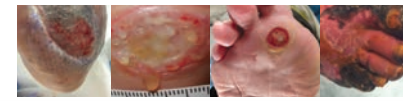

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