

# Flap monitoring with Incisional Negative Pressure Wound Therapy (NPWT) in Diabetic Foot Patients

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#### **ABSTRACT**

Background: Various types of flaps are considered as reconstructive options for patients with diabetic foot ulcer (DFU). However, flap reconstruction for DFU treatment is particularly challenging because of the relatively limited collateral perfusion in the distal lower extremity. This study evaluated the efficacy and safety of a novel postoperative monitoring procedure implemented in conjunction with NPWT immediately after flap operations for treating diabetic foot.

Methods: A retrospective analysis was performed on DFU patients who underwent free flaps and perforator flaps from March 2019 through August 2021. The surgical outcomes of interest were the rates of survival and complications. On the third postoperative day, patients underwent computed tomography (CT) angiography to check for pedicle compression or fluid collection in the sub-flap plane. Monitoring time, as well as comparisons between NPWT and conventional methods, were analyzed. Statistical analysis was performed between the two groups.

Results: This study included 26 patients. Among DFU patients, the NPWT group included 14 flaps and the conventional monitoring group included 12 flaps. There was no significant intergroup difference in flap survival rate (p = 0.83). In addition, there was no significant intergroup difference in the diameters of perforators or anastomosed vessels before and after NPWT (p = 0.97). Compared with conventional monitoring, the novel NPWT monitoring system was associated with a significantly lower mean monitoring time per flap up to postoperative day 5.

Conclusion: Although conventional monitoring is widely recommended, especially for DFU management, the novel NPWT monitoring system investigated in this study enabled effortless serial flap monitoring and was associated with reduced infection risk compared with conventional monitoring. The novel flap monitoring technique was safe for DFU patients and is a promising candidate for future recognition as the gold standard for flap monitoring.

### PATIENTS & METHODS

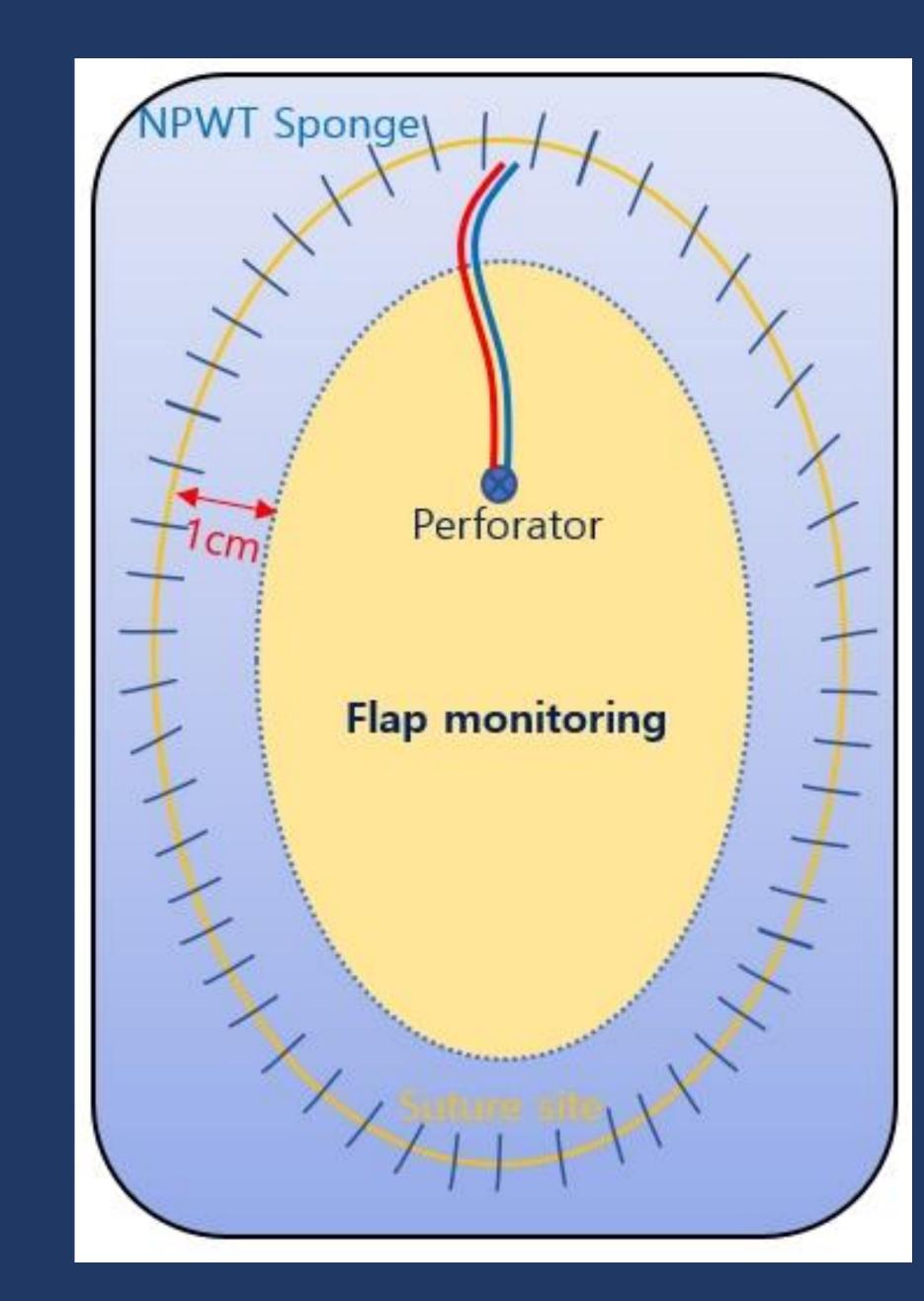
Eligible patients were those who underwent flap procedures (free flap, perforator flap) for DFU treatment from March 2019 through August 2021. This was a single-center study, and a single attending plastic surgeon performed all procedures, which were carried out using standard methods.

After flap inset, antibiotic ointment—coated Physiotulle (hydrocolloid-based, non-adherent wound contact layer, Coloplast, Ltd. Peterborough, UK) was used to fully protect the suture site, over which a VAC sponge was then placed. The VAC device was set to –75 mmHg on continuous mode. To facilitate serial flap monitoring, a large window—consisting of almost the entire flap—was routinely formed because the sponge margin did not cross the flap paddle more than 1 cm from the incision site. For all flaps, monitoring was conducted by serial examinations through the transparent window created by as part of the novel NPWT technique. NPWT apparatuses were disconnected after 5 postoperative days.

Some patients were categorized into a conventional monitoring group. These patients underwent standard manual dressing, along with manual monitoring carried out by an provider who used sterile surgical gloves while cleaning the suture site with saline-soaked gauze. Sterile gauze was used to loosely cover the flap's suture site after the application of antibiotic-coated Physiotulle.

Immediately postoperatively, all flaps received 4-hourly monitoring, which involved observation of flap color, temperature, capillary refill, and external Doppler ultrasonography. After 24 postoperative hours, flap monitoring was conducted every 8 h for the next 24 h. Thereafter, monitoring was conducted every 12 h until the fifth postoperative day. Postoperatively, all patients remained hospitalized until the senior surgeon (JH Park) deemed them medically and surgically suitable for discharge. The surgical outcomes of interest were the rates of survival and complications (including infection, seroma, hematoma, and flap necrosis).

On the third postoperative day, patients underwent computed tomography (CT) angiography to check for pedicle compression or fluid collection in the sub-flap plane. Pedicle diameter (before and after NPWT) was determined via visualization with a picture archiving and communication system. For each patient, the total monitoring time was recorded for 5 postoperative days, and surgical outcomes were evaluated after 1 postoperative month at the outpatient clinic. Monitoring time, as well as comparisons between NPWT and conventional methods, were analyzed using the Mann–Whitney U test. Statistical analyses were conducted using SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Statistical significance was defined by p values < 0.05.



#### **INTRODUCTION**

One-third of people with diabetes mellitus will develop at least one diabetic foot ulcer (DFU) over the course of the disease, and 5-year mortality rates associated with DFU reach high estimates of even 30%. DFUs are among the most challenging complications to manage, and treatment failure is a relatively common outcome of the limited treatment options.

NPWT has emerged as an encouraging option for wound management, particularly for wounds of the extremities, including defects resulting from diabetic gangrene, trauma, and malignancies. In recent decades, the indications for NPWT have included incisional wound management, as well as its use as an adjunctive component of skin grafting and flap salvage procedures.

The safety concerns over NPWT implementation for free or perforator flaps are reinforced by the scarcity of published studies investigating the efficacy of immediate postoperative NPWT for such flaps. Postoperatively, many surgeons are hesitant to immediately apply NPWT for DFU flaps. Another concern is the potential effect of vacuum-assisted closure on fragile calcified pedicles.

This study evaluated the efficacy and safety of a novel postoperative monitoring procedure implemented in conjunction with NPWT immediately after flap operations for treating diabetic foot. Specifically, compared with conventional monitoring, the novel monitoring system was developed to optimize efficacy and minimize the risk of infection.

## RESULTS

This study included 26 patients with a mean age of 57 years (range: 41–83 years). The mean follow-up duration was 6.2 months. Among DFU patients, the NPWT group included 14 flaps (six free flaps and eight perforator flaps), and the conventional monitoring group included 12 flaps (five free flaps and seven perforator flaps). The mean flap surface area was 43.7 cm<sup>2</sup>, and the mean operation time was 296.5 min (284.9 min in the NPWT group vs. 303.8 min in the conventional group; this difference was not statistically significant). All flaps were anterolateral thigh flaps.

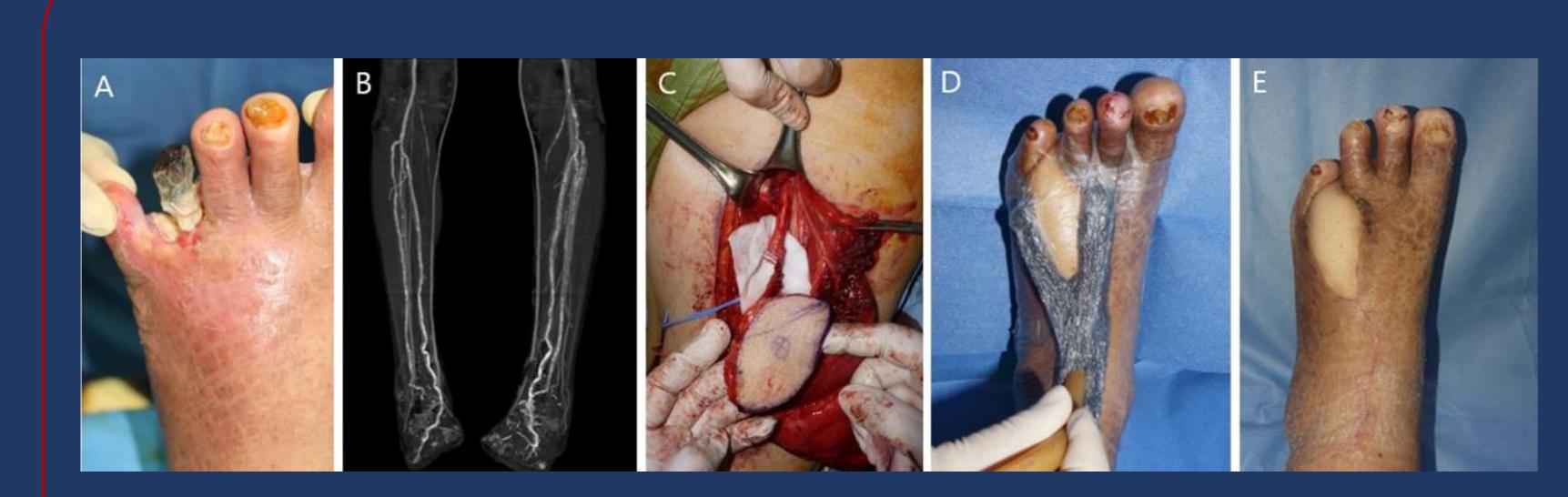
There was no significant intergroup difference in flap survival rate (92.9% in the NPWT group vs. 91.7% in the conventional group, p = 0.83). There was no significant intergroup difference in the diameters of perforators or anastomosed vessels before and after NPWT (p = 0.62).

There were no instances of postoperative complications, such as hematoma or seroma formation, or wound dehiscence. However, one flap in the NPWT group sustained partial necrosis, which was successfully managed with 1 month of serial debridement and secondary wound healing. One free flap in the conventional monitoring group sustained complete flap necrosis after signs of venous congestion; this was treated with an alternative peroneal artery perforator-based flap. Two patients in the conventional monitoring group were treated for surgical site infection after purulent discharge was observed.

Compared with conventional monitoring, the novel NPWT monitoring system was associated with a significantly lower mean monitoring time per flap up to postoperative day 5 (86.4 min in the NPWT group vs. 225.1 min in the conventional group, p < 0.05).

## CONCLUSIONS

Postoperative flap monitoring is vital for flap success. Although conventional monitoring is widely recommended, especially for DFU management, the novel NPWT monitoring system investigated in this study enabled effortless serial flap monitoring and was associated with reduced infection risk compared with conventional monitoring. The novel flap monitoring technique was safe for DFU patients and is a promising candidate for future recognition as the gold standard for flap monitoring.



Patient 1

(A) Photographic findings of 57-year-old male patient who was diagnosed with diabetic gangrene on left foot (B) CT angiography finding of lower extremities (C) Elevation of ALT free flap (D) NPWT was applied immediately after operation (E) Postoperative photographic finding; 3 months



#### Patient 2

(A) Photographic findings of 74-year-old female patient who was diagnosed with diabetic foot accompanied with necrotizing fasciitis on right lower extremity (B) Harvested ALT free flap (C) Immediate postoperative photographic finding; 7 months