Negative Pressure Wound Therapy with Surgical Gloves to Repair Soft Tissue Defects in Hands

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Abstract: The efficacy of negative pressure wound therapy (NPWT) in the treatment of skin defect wounds has been established, but it is difficult to apply to hand surgery because of the easy occurrence of air leaks. We report two cases of performing NPWT with surgical gloves. Case1: A 37-year-old male was injured on his right dorsal hand from a punch. He presented to our hospital three days after the injury because of swelling and pain. The wound was infected and contused, so wound lavage and debridement (W&D) were performed under local anesthesia. The infected condition didn’t improve after antimicrobial infusion, so W&D were performed again 8 days after the first visit. Then W&D were performed every day, and the infection subsided 15 days after the first visit. NPWT was initiated for the purpose of managing exudate and the wound condition, and healthy granulation tissue formed gradually. Finally, transpositional flap and full-thickness skin graft were performed on day 29. Case2: A 43-year-old male accidentally sustained a high pressure injection of oil into his dorsal hand. He presented to our hospital the next day, and W&D were performed. W&D were performed again two days after the first visit, and artificial dermis was applied over a part of the wound that was impossible to close. A decision was made to apply NPWT and a surgical glove for the purpose of reducing swelling and managing wound exudate. The swelling decreased and granulation tissue formed gradually, then nine days after the first visit a sural nerve graft was applied to bridge the defective area, and a full thickness skin graft was applied. We achieved good wound closure and hand function recovery after using NPWT and a surgical glove.

Keywords: negative pressure wound therapy, NPWT, surgical glove, hand wound, early exercise.

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Introduction

Negative Pressure Wound Therapy (NPWT) has been widely used for traumatic injuries and intractable ulcers due to its effectiveness in promoting granulation tissue formation, increasing local blood perfusion, and decreasing the size of wounds [1]. However, in cases of applying NPWT to the hand and fingers, maintaining a seal is often cumbersome and prone to air leaks. Moreover, since early stage rehabilitation is important in recovering a range of motion in the damaged fingers, it is desirable to undergo rehabilitation using
NPWT. Products other than the standard provided polyurethane film dressing may be necessary to maintain a NPWT seal around areas with difficult contours, such as the hand. Hence, we investigated the added effectiveness of applying a surgical glove with standard NPWT in maintaining a seal during NPWT treatment of two traumatic hand wounds.

**Case 1. Traumatic puncture wound on dorsal surface of hand**

A 37-year-old male received a puncture wound on his right hand from the tooth of a man he punched in the mouth. Three days after the injury, the man presented to our hospital because of swelling and pain in the dorsal aspect of his right hand. He had no particular previous medical history. No obvious traumatic signs were revealed in X-ray results on the first visit. Wound lavage and debridement were performed on the infected, contused wound on the dorsal surface of the right third phalangeal head, along with drain tube placement under local anesthesia on the same day.

A wound culture revealed methicillin-susceptible *Staphylococcus aureus* (MSSA). Antimicrobial infusion was administered and the patient’s condition was closely monitored, but pus discharge continued, and five days later wound lavage and debridement were performed again. The third metacarpophalangeal (MCP) joint was incised, a drain tube was placed inside the wound, and continuous irrigation was performed, but the symptoms of infection did not improve, so wound lavage and debridement were performed again at 8 days after the first visit. Since the extensor digitorum communis was also damaged, it was resected and removed.

The third phalangeal metacarpal and proximal phalanx progressed to osteomyelitis around the MCP joint; the wound was kept open and wound irrigation was performed continuously. Wound lavage and debridement were performed every day, and the infection subsided 15 days after the first visit (Fig. 1A). NPWT (V.A.C. ATS™ Therapy System, KCI KK, Japan) was initiated for the purpose of managing the exudate and the wound condition. The original polyurethane film dressing provided in the dressing kit was used to seal the wound, but air leaks frequently occurred via the inter-digital area when negative pressure was applied (Fig. 1B), and the NPWT system could not be used because of pressure instability.

At this point, we decided to use an air-impermeable surgical glove (Tradition™ latex powdered type size 7.5 sterilized) to fit and seal around the finger configuration. Approximately one third of each finger of the glove was cut from the distal end, and a cut was made in the same shape as the wound on the dorsal hand portion of the glove. The glove was placed over the affected side of the hand, and polyurethane foam was placed into the wound. Suction tubing and the polyurethane film dressing were applied over the surgical glove to seal the gap between the surgical glove and the skin. The suction tube was connected to the NPWT system, and continuous subatmospheric pressure of 125 mmHg was applied to the wound (Fig. 1C). Thanks to the addition of the altered surgical glove, air leaks did not occur and healthy granulation tissue formed.

Finally, a transpositional flap and full-thickness skin graft surgery with tie-over fixation were performed on day 29. Sutures were removed one week later with 100% graft survival. Slight extensible restrictions remained in the right middle finger, but the patient was able to return to work.
day 29 (Figs. 1D, E). The sutures were removed one week later with 100% graft survival. Although slight extensible restrictions remained in the right middle finger, subsequent progress was good (Figs. 1F, G) and the patient was able to return to work.

Case 2. Traumatic hand injury following high-pressure oil injection

A 43-year-old male accidentally sustained a high pressure injection of oil into his hand. The man presented to our hospital the day after the injury with a pin hole wound with mild swelling and severe pain in the dorsal aspect of the right hand. The patient had no particular previous medical history. Wound lavage and debridement were performed at presentation. Additional debridement was performed because colliquative necrosis of subcutaneous fat tissue was found when the pin hole wound was incised and it had expanded onto the right dorsal surface of the hand (Figs. 2A, B). It was also discovered that the digital nerve of the radial index was ruptured.

Wound lavage and debridement were performed again two days after the first visit. Because necrotic epidermis was removed from the wound and the wound was impossible to close, artificial dermis was applied over part of the wound. A decision was made to apply NPWT for the purpose of reducing the swelling and managing the wound exudate.

A surgical glove (Tradition TM latex powdered type size 7.5 sterilized) was prepared as described in the previous case, with the tips of fingers cut off and a hole cut to match the location and size of the wound. The altered surgical glove was applied to the affected side of the hand in order to prevent any air leakage. Polyurethane foam was placed into the wound, and suction tubing was applied, followed by polyurethane film dressing to seal the gap between the surgical glove and the skin. The suction tube was connected to the NPWT system and continuous subatmospheric pressure of 125 mmHg was applied to the wound (Figs. 2C, D).

As a result, satisfactory wound management was achieved without any air leakage. Nine days after the first visit, a sural nerve graft was applied to bridge the ruptured and defective digital nerve of the radial index, and a full thickness skin graft taken from the cubital region was applied to the wound (Figs. 2E–H). Postoperative progress was good and there was no limitation in the range of motion of the fingers at 18 months after surgery (Figs. 2I–K), although hyperesthesia remained on the radial index, and the quick Disabilities of the Arm, Shoulder and Hand (Q–DASH) score was 14.8 points.
Discussion

In both of the described cases, soft tissue defects on the hand could not be immediately closed, primarily due to tension and known infection. The effective use of NPWT in conditioning soft tissue defects prior to delayed surgical closure has been well described [2], and is therefore usually prescribed at our clinic in these types of cases. Unlike legs, which are weight-bearing limbs, the function of the hands is largely manipulative. Because of this, just promoting granulation and epithelial tissue formation are not enough for the treatment of injured hands. It is important to have additional coverage of healthy soft tissue over the wound cavity of the injured hand, while maintaining good muscle strength and flexibility of the tendons without adhesion formation [3].

Fortunately, since there was no risk of tendon adhesion formation in either of the two wounds described in this report, NPWT could be applied. The basic, procedural goals were to seal the area around the wound and create a subatmospheric pressure environment. However, complex, contoured regions, such as the fingers and inter-digital areas, are difficult to seal effectively with a standard polyurethane film dressing. Moreover, the features of the fingers and their many joints require early rehabilitation of the range of motion in order to prevent contracture. Because the standard polyurethane film dressing is constructed of a relatively inelastic material, the fingers are somewhat immobilized by the dressing covering the wound and hand [4]. When rehabilitation of the finger range of motion is performed while the film dressing is in place, gaps may occur in the inter-digital areas and become causes of air leaks. In both of these cases, the added surgical gloves eliminated air leaks throughout the duration of therapy, including during the rehabilitation sessions.

Kamolz and Lumenta have previously described a similar surgical glove technique to treat tissue defects with NPWT, and concluded that this method was effective and convenient [5]. This surgical glove technique has also been used with satisfactory results around contoured zones of the feet. Hasegawa et al. also reported a method employing a plastic, zippered bag to maintain NPWT [4]. Although the zippered bag dressing may be bulkier than the surgical glove technique, the zippered bag configuration allows a range of motion of the fingers while the dressing is in place. An advantage of the zippered bag is that the bag can be left on while treating the wound. However, this zippered bag procedure tends to create a foul odor. In cases of combination therapy whereby adjunctive therapies must be applied daily, such as with basic fibroblast growth factors, the method of using the zippered bag may be more convenient, but if frequent access is unnecessary, using the surgical glove is a preferred method, since it is inexpensive and easy to introduce into any hospital.

Conclusion

With respect to the NPWT treatment of the hands in the above cases, the combined use of the surgical glove achieved a leak-free subatmospheric pressure system, versus using the conventional polyurethane film dressing alone. The addition of the surgical glove also allowed rehabilitation for sufficient range of motion, which could not be achieved with the film dressing alone.

This investigation was explained and informed consent was obtained from all the patients.

Conflicts of Interest

All the authors declare that there is no conflict of interest.

References

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手部軟部組織欠損に対する手術用手袋と局所陰圧閉鎖療法を組み合わせた治療法

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要旨：陰圧閉鎖療法negative pressure wound therapy（NPWT）は皮膚欠損創の治療に有効性が確立されている。しかし、エアリークが容易に生じるため手外科分野において応用が難しい。今回手術用手袋を併用しNPWTを手部に用いて治療を行った2症例を経験したので報告する。症例1：37歳男性、人を殴って右手背部を受傷した。同日手背部創感染と診断し、局所麻酔下に洗浄・デブリドマンを行い、抗菌薬点滴を開始したが感染状態は改善せず、術後8日目に創を開放し、洗浄・デブリドマンを連日行うことで感染は鎮静化した。術後15日目に手背部開放創の管理目的にNPWTと手術用手袋を併用した。徐々に創内部より良好な肉芽形成が得られたため、術後29日目に局所転位皮弁に加えて全層植皮術を行い創閉鎖した。症例2：43歳男性、作業中にグリースを左手背部に誤って注入して受傷した。受傷翌日に当科を受診し、同日洗浄・デブリドマンを施行した。術後2日目に手術を行い、閉鎖が出来ない創に対して人工真皮でカバーした上、NPWTと手術用手袋を併用した。徐々に創内部より良好な肉芽形成が得られ腫脹も軽減してきたため、術後9日目に腓腹神経からの神経移植術とともに創閉鎖、全層植皮術を行った。手背部軟部組織欠損に対する創管理において、NPWTと手術用手袋を併用し早期リハビリを行った結果、良好な創閉鎖と手指機能回復を得た。

キーワード：陰圧閉鎖療法, NPWT, 手術用手袋, 手部創傷, 早期リハビリ

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