Negative pressure wound therapy for skin graft fixation: A reasonable option?

Fixierung von Hauttransplantaten mit Vakuumversiegelung: Eine sinnvolle Option?

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ABSTRACT

Negative pressure wound therapy (NPWT) is meanwhile since about 20 years a standard procedure in classical wound care. Especially in wound ground conditioning of chronic wounds NPWT has an important status. In the last years, NPWT was more and more used in the fixation and postoperative wound management of skin grafts. The current review addresses the available data and evidence and demonstrates the possible use of the procedure.

ZUSAMMENFASSUNG

Die Vakuumversiegelung (VS) ist eine seit circa 20 Jahren in der klassischen Wundversorgung nicht mehr wegzudenkende Therapieoption. Insbesondere im Bereich der Wundgrundkonditionierung von chronischen Wunden nimmt sie einen wichtigen Stellenwert ein. In den letzten Jahren wird die Vakuumversiegelung auch zur Fixierung und dem postoperativen Wundmanagement nach Hauttransplantation immer häufiger eingesetzt. Die vorliegende Übersichtsarbeit beschäftigt sich mit den Daten und Evidenzen eines solche Vorgehens und zeigt Möglichkeiten der Nutzung auf.

Introduction

The treatment of complex skin wounds – whether acute or chronic – has always been a medical challenge. In addition to causal therapy, the focus of modern wound management is on wound care that is appropriate to the stage of the wound [17]. The use of split-thickness skin grafts (STSG) is one of the standard treatment procedures and enables rapid and effective closure. For graft take, it is essential that shear forces, subgraft seromas, haematomas as well as infections are averted in the first 3–5 days. The classic way to secure grafts is with a tie-over (bolster) dressing with a perforated wound contact layer. However, the distribution of pressure is generally uneven and the dressing's ability to absorb wound exudate is limited, especially with large wounds [6]. Apposition to very large, uneven or mobile wound surfaces using a conventional dressing can be difficult and leads to lower rates of graft take [23, 25]. Postoperative negative pressure wound therapy (NPWT) appears to circumvent the disadvantages of the conventional dressing. Secure, uniform and flexible fixation – even in problem regions – undoubtedly plays a crucial role in an effective management of exudate and a moist wound environment [23]. For these reasons, postoperative NPWT is being increasingly used nowadays. Despite the subjective improvement in rates of graft take, the evidence about this technique is, however, still limited.

Mechanism of action of NPWT

NPWT, or vacuum-assisted closure, was first developed in 1997 by Argenta and Morykwas and has since become a standardized, commercially available system [1]. The mechanism of action has yet to be fully elucidated and remains a field of basic research, but two important basic principles appear to play a key role. On the one hand, there is macro deformation of the wound through traction exerted in a centripetal direction on the wound edges, which in combination with the applied suction also leads to a reduction in edema. Papers by Morykwas et al. showed that NPWT thereby increases tissue blood flow [19]. In contrast, Kairinos et al. and Wackenfors et al. reported a transient decrease in perfusion that subsequently led to increased angiogenesis and cell proliferation [10, 24]. Activation of the hypoxia-induced factor 1α (HIF1α) signalling pathway is presumed to occur. In addition to macro deformation, the interaction between the open-pored polyurethane foam and the wound probably plays a decisive role. This micro deformation leads to a stretching of the cells that has been demonstrated to increase the cell proliferation rate [5]. In addition, the formation of important granulation-promoting cytokines such as VEGF, bFGF or Il-8 is increased [10, 16]. Collagen production and cell migration are also induced [9]. The latest data show that NPWT leads to the accumulation of circulating fibrocytes in wounds as well [4]. This paper demonstrates that the NPWT can additionally induce a systemic effect.

Other essential factors that contribute to an optimum wound environment are the moist surroundings with the simultaneous removal of excessive wound secretions, which often even contain factors that inhibit wound healing such as matrix metalloproteinases, as well as a constant wound temperature. In addition, some authors have postulated a reduction in the bacterial load of the wound. Thus, Wang et al. showed a relevant reduction in Pseudomonas aeruginosa under NPWT [7]. Li et al. reported similar results in respect of Staphylococcus aureus [14].

NWPT procedure after split-thickness skin grafting

The first study on the use of NWPT in more than 100 chronic wounds was published by Schneider et al. in 1998 [22]. This was the first time that the method and the procedure were fully described. More detailed analyses of the patient data were not performed, but it was merely stated that graft failure occurred in only two patients. The procedure described in the paper is – with individual modifications – still practiced today (▶ **Fig. 1a**-▶ **Fig. 1e**). NPWT can considerably simplify the securing of the split-thickness skin graft, especially in difficult locations (e. g. in the area of joints, genital/inguinal/axillary region) and can also safely protect the wound surface from contamination (▶ **Fig. 2a**–▶ **Fig. 2f**). In the various papers the suction applied was between 75–125 mmHg. A thin silicon wound contact layer is recommended between foam and graft (▶ **Fig. 2d**). The vacuum-assisted closure remains in place for 5 days (3–7 days) and the functioning system does not need to be changed during this period. Because the wound edges are readily visible, wound infections can be immediately detected. In this case, NWPT must be ended and treatment switched to classic dressings.

Controlled randomized studies

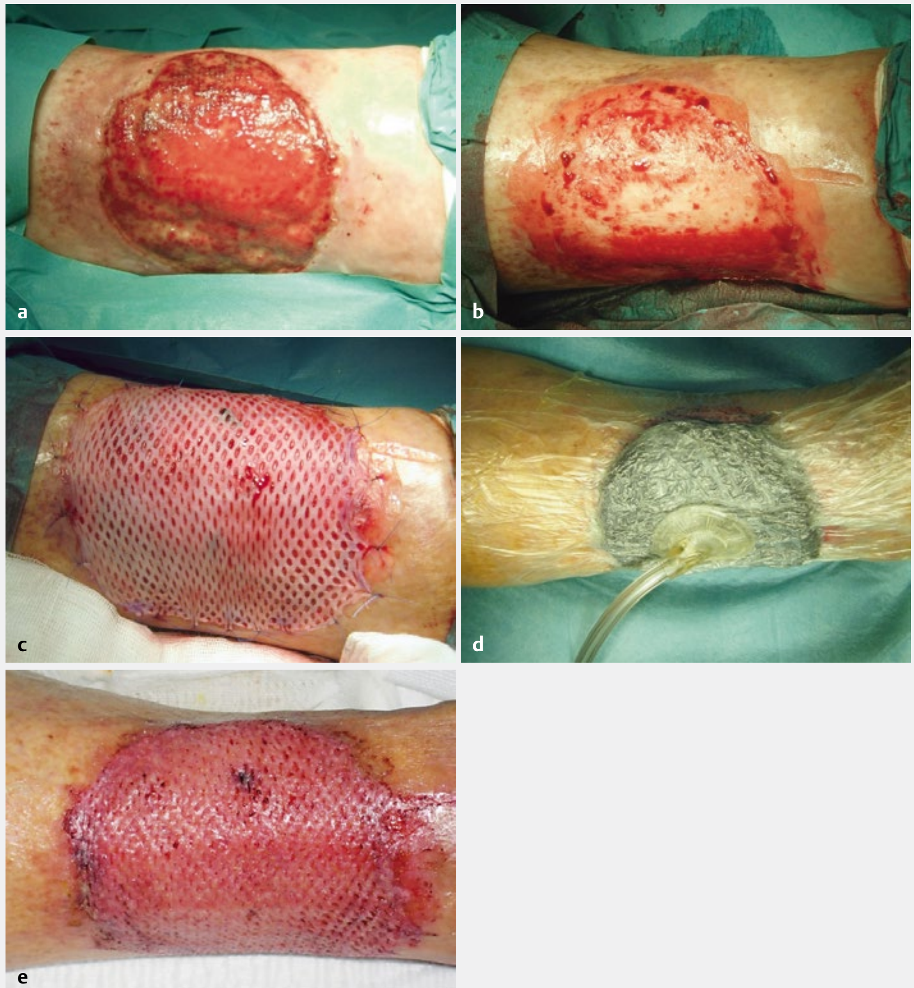
Unfortunately, there are only very few published studies on this method. The majority are not controlled or randomized and most are only retrospective. Nevertheless, there are some papers that provide very good evidence that the treatment is effective.

The first randomized, controlled study that investigated the comparison between NPWT and a standard bolster dressing, was published by Moisidis et al. in 2004 [18]. A total of 20 patients were included and an intra-individual comparison was used, in which half of the skin defect was treated with a classic dressing and the other half treated by NPWT. Overall, the defects did not differ in terms of quantitative rates of graft take, but NPWT achieved a significantly better outcome in the quality of the successful grafts. Although this was an interesting design, it is questionable whether the two parts of the wound could really be considered independently from each other, since even from a distance of 2–3 cm, the NPWT is known to affect the microcirculation, and systemic factors such as the mobilisation of circulating fibrocytes under NPWT also play a role in wound healing.

To date, the study of Llanos et al. is the best and most comprehensive prospective, randomized and controlled study [15]. 60 patients divided into two groups – one NPWT and one control group treated with a dressing alone without suction – were investigated. The authors showed significantly smaller areas of skin graft loss in the NPWT group than in the control group. In addition, the time from grafting to discharge was reduced from an average of 12 to 8 days. Regrafting was needed in 12 (40 %) patients in the control group, but only in 5 (17 %) in the NPWT group. Interestingly, there was a direct correlation in the control group between the size of the grafted area and the probability of graft loss, where no such relationship was present in the NPWT group. This might be due to the considerably better and more even fixation over the wound surface with NPWT, which is more difficult to ensure for large wound areas with the conventional dressing.

Similar data to that obtained by Llanos were reported from another randomized, prospective, controlled study by Petkar et al., which included 21 burn injury patients in the NPWT group and 19 in the control group [20]. Again, a significantly better graft take rate of 97 % versus 88 % (NPWT versus control) was achieved and the time to complete removal of the dressing could be reduced from 11 days in the control group to 8 days in the NPWT group.

Although a more recent RCT by Hsiao et al. with a total of 28 patients (14 in each group) was unable to show a significant difference in graft take, the patients suffered significantly less pain (on average up to 4 points on the visual analogue scale) under NPWT [8]. The patients were also significantly more satisfied with the treatment and outcome compared to the standard dressing. The less severe pain and considerably higher mobility that is possible under NPWT undoubtedly contributed to this assessment. The in-



▶ **Fig. 1** Negative pressure wound therapy of a split-thickness skin graft after ulcer shaving in the area of the lower leg. **a** Preoperative venous leg ulcer; **b** After ulcer shaving; **c** Split-thickness skin graft secured with a few fixation sutures; **d** Fixation of the graft using vacuum-assisted closure; **e** Following removal of the vacuum-assisted closure after 5 days.

creased mobility in particular should not be underestimated, since it means that not only patient satisfaction and independence can be maintained, but also an active thrombosis prophylaxis can be undertaken at the same time.

Another up-to-date investigation from New Zealand examined the effects of NPWT on increased mobility and hence the earlier possible discharge of patients in a randomized controlled study [11]. All the 49 patients enrolled in the study had received a split-thickness skin graft in the region of the lower limb. One group of 28 patients received NPWT and were discharged on the same day; the second group (21 patients) received a bolster dressing and were immobilized in hospital, in the traditional manner, for 5 days. The outpatient care of the patients given NPWT led to an average halving of costs, with the same clinical outcome.

Retrospective case series

In addition to the randomized controlled studies, the literature also contains a large number of retrospective case series of differing quality. The most important series with more than 20 patients is discussed below.

The largest study was undertaken by Blume et al. in 142 patients who had undergone surgery in the foot and ankle region [2]. 87 patients were assigned to the NPWT group and 55 to the control group who received a traditional bolster dressing. The graft take rate of 96 % in the NPWT group was significantly better than the 83 % in the control group. Furthermore, there were fewer complications such as seroma, haematoma or wound infections under NPWT (3 % versus 16 %). On the other hand, the hospitalisation times of patients in the two groups did not differ significantly.

The retrospective study of Körber et al. investigated 74 mesh grafts in 54 patients with chronic leg ulcers [13]. 28 of the grafts were managed with NPWT, 46 with the standard dressing technique. The rate of graft take in the NPWT patients was 93 % and 67 % in the control group. These results suggest that NPWT appears to be particularly superior to the standard dressing technique in chronic, poorly-healing wounds and is thus especially suitable for problem wounds.

▶ **Fig. 2** Negative pressure wound therapy of a split-thickness skin graft in an asymmetric and mobile region after excision of an axillary hidradenitis suppurativa. **a** Excision defect of the left axilla; **b** After 7 days of vacuum-assisted closure prior to grafting; **c** Split-thickness skin graft secured with a few fixation sutures; **d** Silicon separation mesh between graft and foam; **e** Vacuum-assisted closure over the graft; **f** After 5 days of negative pressure wound therapy.

Carson et al. studied 50 patients with chronic wounds of various causes [3]. A control group was not evaluated. All patients had been treated prior to the split-thickness skin graft with NPWT to induce granulation, then grafted and given NPWT postoperatively. Graft take was 100 %.

Scherer et al. studied 34 patients with split-thickness skin grafts and postoperative NPWT with various types of defect [21]. 27 patients given bolster dressings were used as the control group. A superiority of NPWT was also shown in this study, as demonstrated by the fact that regrafting was necessary in only 3 % of patients given NPWT, compared to a repeat operation in 19 % of the control group. There were no differences between the two groups with regard to the length of hospital stay or the percentage area of graft take.

Studies on NPWT in combination with a dermal substitute and split-thickness skin grafting

Dermal substitutes (bilayers of artificial skin) such as Integra® or AlloDerm® are increasingly used for exposed tendons, very deep defects or at sites where excessive contraction must be avoided. To enable rapid covering, dermal substitutes and split-thickness skin are often grafted together in a single operation.

In a prospective, controlled study, Kim et al. investigated whether the percentage of graft take, the time to complete healing and the number of dressing changes required, were better in the NPWT group [12]. A total of 47 patients were studied, 37 in the NPWT group and 10 in the control group. Graft take rates after 5 days in the NPWT and control groups were 98 % and 84 % respectively. Complete healing was observed after an average of 5.8 days in the NPWT patients and after 8.9 days in the controls. Apart from final dressing removal, no extra dressing change was necessary with NPWT, whereas an average of three dressing changes were required in the control group. This study is the first to show that a combination of dermal substitute, split-thickness skin graft and NPWT is not only possible, but also leads to very good rates of graft take.

Conclusion

Evidence for the use of postoperative NPWT after spit-skin grafting is overall still very limited, even if a recently published meta-analysis of the available data by Yin et al. showed that the rates of graft take are significantly improved and that fewer re-operations take place [26]. Nevertheless, even larger and well-conducted randomized, prospective, controlled studies are needed to enable final conclusions to be drawn and the considerably higher costs of the inpatient setting to be justified. Hence it is certainly not the case that every uncomplicated split-thickness skin graft with a well-perfused wound bed has to be treated with NPWT. However, postoperative NPWT should definitely be considered for chronic wounds, poorly-healing wound beds, haemodynamically-impaired local factors, as well as in highly mobile regions. The significantly better ability to mobilise patients can also offer a great advantage for the patient's general situation and also reduce the risk of thrombosis.

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Argenta LC, Morykwas MJ. Vacuum-assisted closure: A new method for wound control and treatment: Clinical experience. Ann Plast Surg 1997; 38: 563–577

[2] Blume PA, Key JJ, Thakor P et al. Retrospective evaluation of clinical outcomes in subjects with split-thickness skin graft: Comparing V. A. C.® therapy and conventional therapy in foot and ankle reconstructive surgeries. Int Wound J 2010; 7: 480–487

[3] Carson SN, Overall K, Lee-Jahshan S et al. Vacuum-assisted closure used for healing chronic wounds and skin grafts in the lower extremities. Ostomy Wound Manage 2004; 50: 52–58

[4] Chen D, Zhao Y, Li Z et al. Circulating fibrocyte mobilization in negative pressure wound therapy. J Cell Mol Med 2017; 21: 1513–1522

[5] Chin MS, Ogawa R, Lancerotto L et al. In vivo acceleration of skin growth using a servo-controlled stretching device. Tissue Eng Part C Methods 2010; 16: 397–405

[6] Dainty LA, Bosco JJ, McBroom JW et al. Novel techniques to improve split-thickness skin graft viability during vulvo-vaginal reconstruction. Gynecol Oncol 2005; 97: 949–952

[7] Guoqi W, Zhirui L, Song W et al. Negative pressure wound therapy reduces the motility of Pseudomonas aeruginosa and enhances wound healing in a rabbit ear biofilm infection model. Antonie Van Leeuwenhoek 2018; 111: 1557–1570

[8] Hsiao SF-Y, Ma H, Wang Y-H et al. Occlusive drainage system for split-thickness skin graft: A prospective randomized controlled trial. Burns 2017; 43: 379–387

[9] Hsu C-C, Chow S-E, Chen CP-C et al. Negative pressure accelerated monolayer keratinocyte healing involves Cdc42 mediated cell podia formation. J Dermatol Sci 2013; 70: 196–203

[10] Kairinos N, Solomons M, Hudson DA. The paradox of negative pressure wound therapy – in vitro studies. J Plast Reconstr Aesthet Surg 2010; 63: 174–179

[11] Ker H, Al-Murrani A, Rolfe G et al. WOUND Study: A Cost-Utility Analysis of Negative Pressure Wound Therapy After Split-Skin Grafting for Lower Limb Skin Cancer. J Surg Res 2019; 235: 308–314

[12] Kim EK, Hong JP. Efficacy of negative pressure therapy to enhance take of 1-stage allodermis and a split-thickness graft. Ann Plast Surg 2007; 58: 536–540

[13] Korber A, Franckson T, Grabbe S et al. Vacuum assisted closure device improves the take of mesh grafts in chronic leg ulcer patients. Dermatology 2008; 216: 250–256

[14] Li T, Wang G, Yin P et al. Effect of negative pressure on growth, secretion and biofilm formation of Staphylococcus aureus. Antonie Van Leeuwenhoek 2015; 108: 907–917

[15] Llanos S, Danilla S, Barraza C et al. Effectiveness of negative pressure closure in the integration of split thickness skin grafts: a randomized, double-masked, controlled trial. Ann Surg 2006; 244: 700–705

[16] Lu F, Ogawa R, Nguyen DT et al. Microdeformation of three-dimensional cultured fibroblasts induces gene expression and morphological changes. Ann Plast Surg 2011; 66: 296–300

[17] Messerschmidt A, Meissner M, Kaufmann R et al. Local treatment of chronic wounds. Phlebologie 2016; 45 (2): 106–112

[18] Moisidis E, Heath T, Boorer C et al. A prospective, blinded, randomized, controlled clinical trial of topical negative pressure use in skin grafting. Plast Reconstr Surg 2004; 114: 917–922

[19] Morykwas MJ, Simpson J, Punger K et al. Vacuum-assisted closure: State of basic research and physiologic foundation. Plast Reconstr Surg 2006; 117(7 Suppl): 121S–126S

[20] Petkar KS, Dhanraj P, Kingsly PM et al. A prospective randomized controlled trial comparing negative pressure dressing and conventional dressing methods on split-thickness skin grafts in burned patients. Burns 2011; 37: 925–929

[21] Scherer LA, Shiver S, Chang M et al. The vacuum assisted closure device: a method of securing skin grafts and improving graft survival. Arch Surg 2002; 137 (8): 930–933

[22] Schneider AM, Morykwas MJ, Argenta LC. A new and reliable method of securing skin grafts to the difficult recipient bed. Plast Reconstr Surg 1998; 102: 1195–1198

[23] Valesky EM, Kaufmann R, Meissner M. Special indications for negative pressure wound therapy in dermatologic surgery. Hautarzt 2013; 64 (8): 585–591

[24] Wackenfors A, Sjogren J, Gustafsson R et al. Effects of vacuum-assisted closure therapy on inguinal wound edge microvascular blood flow. Wound Repair Regen 2004; 12: 600–606

[25] Weinfeld AB, Kelley P, Yuksel E et al. Circumferential negative-pressure dressing (VAC) to bolster skin grafts in the reconstruction of the penile shaft and scrotum. Ann Plast Surg 2005; 54: 178–183

[26] Yin Y, Zhang R, Li S et al. Negative-pressure therapy versus conventional therapy on split-thickness skin graft: A systematic review and meta-analysis. Int J Surg 2018; 50: 43–48