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The safety and effectiveness of a self-made negative pressure suction device in the treatment of chronic wounds

He-Ping Wang[1] | Xiu-Li Hu[2] | Hua-Qin Zhou[1] | Xi-Shan Chen[1] | Meng-Xin Wang[1]

[1]Department of Nursing, The Second Affiliated Hospital Of Wannan Medical College, Wuhu, China

[2]Department of Wound Stomy Clinic, The Second Affiliated Hospital Of Wannan Medical College, Wuhu, China

Correspondence
He-Ping Wang, Department of Nursing, The Second Affiliated Hospital Of Wannan Medical College. No.10 of Kangfu Street, Jinghu District, Wuhu 241000, China.
Email: wangheping_peace@126.com

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Abstract

Introduction: Chronic wounds are wounds that are not healed or have no healing tendency for more than 1 month due to various factors. In clinical nursing, chronic wounds are often not properly treated, and the treatment efficiency is low. Therefore, it is very important to explore effective methods to deal with chronic wounds.

Objective: To explore the effect of a self-made negative pressure suction device (NPSD) in the nursing of chronic wounds in the elderly.

Methods: A total of 50 elderly patients with chronic wounds who were hospitalised in our hospital from January 2020 to December 2022 were selected as participants by convenient sampling. According to the random number table method, they were divided into a control group and an observation group, with 25 people in each group. The control group was treated with chloroplast foam dressing, debridement gel and alginate dressing. The observation group was treated with a self-made NPSD on the basis of the control group. The wound healing of the two groups was observed.

Results: After the intervention of the self-made NPSD, the granulation tissue coverage rate and wound volume reduction rate of the observation group were significantly increased ($p < 0.05$), and the positive rate of bacterial infection was significantly decreased ($p < 0.05$). After 3 months of intervention, the total effective rate of the observation group was significantly higher than that of the control group ($\chi^2 = 3.869$, $p = 0.0492$).

Conclusion: The self-made NPSD can effectively promote the healing of a chronic wound.

KEYWORDS
chronic skin wounds, healing, low-cost therapy, negative pressure suction device

1 | INTRODUCTION

Chronic wounds refer to wounds that do not heal in a timely and orderly manner to achieve anatomical and functional integrity.[1] Clinically, they are wounds that have not healed or have no healing tendency after active treatment for more than 1 month, including pressure injuries, diabetic foot ulcers, and vascular ulcers. The characteristic of chronic wounds is the long course of the disease, multiple influencing factors, difficult treatment, and easy recurrence, which increase the consumption of medical resources, social and family economic burden, and care burden.[2] In the United States, more than 6 million patients suffer from chronic wounds every year, costing the healthcare system an estimated 20 billion US dollars or more.[3] In China, 40 million people suffer from chronic wounds caused by diabetes alone every year. Chronic wounds are increasingly becoming a global health problem. Current wound nursing focuses on understanding the process and influencing factors of chronic wound healing and formulating effective programs to promote healing and shorten healing time. In clinical nursing, chronic wounds are often not properly treated, and the effective rate of treatment is only maintained at 40%–50%.[4] Therefore, it is very important to explore effective methods to treat chronic wounds.

Current wound treatment methods include mechanical debridement, physical therapy, and biological therapy. One type of physical therapy is negative pressure wound therapy (NPWT), which has been recognized as a safe and effective treatment of various acute and chronic wounds, with effective absorption of effusion, promotion of proliferation, and certain antibacterial effects. Vacuum sealing drainage (VSD), also known as NPWT, is a new type of high-efficiency drainage method that uses VSD materials and biological semi-permeable membranes as an intermediary between the wound and the outside world to isolate the wound or body cavity and apply continuous negative pressure suction on it. It is a new method of wound treatment developed in the past decade.[5] Compared with a conventional open dressing, VSD has the advantages of fast wound healing, low infection rate, less dressing changes, reduced use of antibiotics, and lower medical expenses. it is expensive and increases the economic burden on patients. Many patients discontinue VSD treatment because they cannot afford it, so few patients are treated with VSD.[6,7] Therefore, our hospital has made a simple negative pressure suction device (NPSD) to treat chronic wounds in elderly patients according to clinical needs. The NPSD that the authors designed is a self-made, low-cost negative pressure method, rather than a strict negative pressure treatment. This study analysed the efficacy and safety of self-made NPSD in the treatment of chronic wounds, aiming to provide a reference for its clinical application.

2 | MATERIALS AND METHODS

2.1 | Research subjects

A total of 50 elderly patients with chronic wounds who were hospitalised in our hospital from January 2020 to December 2022 were selected as participants by convenient sampling. According to a random number table method, the enrolled patients were divided into an observation group and a control group, with 25 participants in each group. The inclusion criteria were as follows: (1) the type of wound met the definition of a chronic wound; (2) the participant's age was greater than or equal to 60 years old; (3) the individual participated voluntarily and signed the informed consent form. The exclusion criteria were as follows: (1) the presence of active bleeding in the wound or exposure to large blood vessels or nerves; (2) ulcers were caused by a tumour, tuberculosis, syphilis, etc.; (3) the disease was critical, or combined with immunosuppression; (4) anaerobic bacteria infected the wound. The baseline data of the two groups of patients are shown in Table 1.

2.2 | Treatment method

Both groups were given routine treatment. (1) Systematic evaluation of patients, including nutritional status, disease status, age and medication; (2) wound evaluation, including wound site, size, stage, skin condition around the wound and pain score; (3) strengthen the treatment and nursing of primary disease, control inflammation, supplement nutrition, correct anaemia and hypoproteinaemia and perform local decompression; (4) educate the patients and their families on wound debridement, etc. Both groups were treated for basic diseases and received health guidance on diet and nutrition. Members of the wound team (specialist nurses) assessed and treated the wounds. The same measuring tools, methods and photographic techniques were used to record the wounds of both groups. Both groups were recommended to be discharged and given outpatient wound care on a regular basis when the infection was effectively controlled, the seepage was reduced and negative pressure suction was stopped. The above infection refers to the pathological reaction in which pathogenic microorganisms grow and multiply after invading the body through the wound, resulting in the destruction of the normal function, metabolism and tissue structure of the body and causing tissue damage lesions. Effective control of infection refers to when the wound swelling subsided, pain improved, there was no obvious exudation and there was new local granulation tissue growth. The control group used Comfeel foam dressing, debridement gel, alginate dressing and lipid hydrocolloid silver sulphate gauze dressing, and the number of dressing changes was based on the wound exudate. On the basis of the control group, the observation group was treated with a self-made simple NPSD.

2.3 | Self-made simple negative pressure suction method

2.3.1 | Material preparation

The materials used were Coloplast foam dressing, 3 M transparent film, a silicone disposable sputum suction tube and a centre negative pressure suction bottle.

2.3.2 | Operation method

The wound was washed with normal saline and covered with a layer of lipid hydrocolloid silver sulphate gauze dressing. According to the size of the wound, some side holes were cut into the suction tube at an interval of 0.8—1.0 cm, after which it was wrapped with an oil gauze dressing, placed along the edge of the wound and exported from 12 o'clock. In the case of a sacrococcygeal wound, the tube was fixed in a suitable position to allow the patient to turn over and avoid

TABLE 1 General data of the two groups of patients.

Project		Observation group ($n = 25$)	Control group ($n = 25$)	t/χ^2	p
Gender [n (%)]	Male	15 (60)	13 (52)	0.325	0.569
	Female	10 (40)	12 (48)		
Age		76.48 ± 8.61	79.60 ± 10.28	-1.163	0.250
Complications (%)	Hypertension	6	5	0.767	0.857
	Diabetes	5	7		
	Other	3	4		
	No	11	9		
Nutritional status(%)	Rich	14	16	0.353	0.838
	Sufficient	7	6		
	May be insufficient	4	3		

FIGURE 1 Device diagram.

slippage of the drainage tube. The upper part of the sputum suction tube was fixed with gauze and then applied with Comfeel foam dressing, and 3 M film was used to reinforce and seal the wound. The negative pressure device was connected to the outer port of the suction tube, and the negative pressure was maintained between 0.02 and 0.04 mPa. Continue to attract the infiltration after the reduction of suction. See Figure 1 for specific devices.

2.3.3 | Nursing during negative pressure therapy

The nursing procedures during negative pressure therapy were as follows. (1) Maintain effective negative pressure: The presence of wound 'tube shape' (central depression of dressing) is a sign of effective wound negative pressure suction treatment.[8] After the drainage tube is properly placed during the change of position, close observation is made to ensure smooth drainage, close connection at the joint and firm adhesion of the foam dressing. If there is a blockage, sterile NaCl solution can be injected into the blockage to increase attraction, which is expected to reopen the attraction, maintain negative pressure and avoid too frequent dressing replacement. If there is air leakage, it is necessary to check the leakage and paste it closed with 3 M transparent film. (2) Adjustment of negative pressure: If the wound exudate is more, the pressure can be adjusted about 0.02–0.04 mPa for continuous attraction. With the reduction of wound seepage, the negative pressure can gradually be reduced to adopt interstitial negative pressure attraction. (3) Dressing replacement frequency: During negative pressure treatment, the dressing should be kept dry, and the negative pressure drainage should be smooth. If there is a liquid trace on the surface of foam dressing up to 1/2 of the dressing, it should be replaced. In the early days, it is usually replaced once every other day. (4) Wound observation: According to the requirements of the hospital wound treatment sheet, the wound should be regularly evaluated and measured during dressing change and recorded. When the wound changes are obvious, photos should be taken to compare and observe the changes of the wound before and after treatment to provide a reference for the subsequent treatment. (5) Selection of dressings for wound surface coverage: In the yellow period of the wound, lipid hydrocolloid silver sulphate dressing can be selected as the inner filling dressing to cover the wound to effectively kill bacteria, inhibit bacterial reproduction and control local infection and inflammation; in the red phase of the wound, lipid hydrocolloid silver sulphate gauze dressing was selected as the inner filling dressing for the wound with a medium to small amount of exudate, which effectively managed the exudate, maintained the wet balance and promoted the growth of granulation tissue. According to the amount of exudate, the dressing was replaced once every 2–3 days.

2.4 | Observation index

Granulation tissue coverage: The wound area and granulation tissue area were measured before the intervention and on days 7 and 14 after the intervention when the dressing was changed. A disposable wound measurement digital ruler was used to mark the wound size by the clock method. The length of the wound along the longitudinal axis of the patient's body was the maximum advantage (12–6 points), and the width of the wound along the horizontal axis of the body was the maximum advantage (3 ~9 points). The ruler was placed 1 cm outside the wound and did not touch the skin. According to the measured length and width, the granulation tissue area and the wound area were calculated respectively to calculate the granulation tissue coverage. Granulation tissue area/wound area = length × width, granulation tissue coverage = granulation tissue area × 100%. Wound area: The length, width and vertical depth of the wound were measured before the intervention and on days 7 and 14 after the intervention, and the wound area was calculated. The vertical depth was measured by an indirect method in which the wound was explored by sterile forceps and the part that was penetrated by the sterile forceps was measured with a ruler. According to the wound area and vertical depth, the wound volume before the intervention and at days 7 and 14 after the intervention were calculated so as to calculate the wound volume reduction rate at days 7 and 14. The granulation tissue area/wound area = length × width, granulation tissue coverage = granulation tissue coverage area/wound area × 100%.

The total effective rate of treatment: Wound treatment standards were formulated according to the Criteria for the Diagnosis and Efficacy of Diseases of Traditional Chinese Medicine issued by the National Administration of Traditional Chinese Medicine. Recovery: The wound epithelium was completely covered, the scar was solid, and no ulceration occurred after observation for 1 week. Obvious effect: Wound reduction ≥75%, granulation tissue fresh, symptoms relieved. Improvement: Wound reduction ≥25%, but < 75%, granulation tissue is fresh, symptoms improved. Ineffective: The wound was fresher than before, but reduced by less than 25%, with little granulation growth. The healing time and wound cure rate from enrolment to the end of the 3 months of the study were calculated by covering the skin and applying 3% hydrogen peroxide with no local oxidation reaction (negative result). The formula is as follows: Total effective rate = (number of healed wounds/total number of wounds) × 100%.

2.5 | Laboratory test index

Western blot analysis was performed to determine platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), transforming growth factor-β (TGF-β) and protein expression.

The granulation tissue samples of the patients were obtained before and 14 days after the intervention and homogenised in the lysate. The automatic immunoblotting instrument CycleBlot48 (Zhuhai Lizhu Reagent Co., Ltd.) was used for detection. Western blot-β protein expression was used to analyse the expression of PDGF, VEGF and TGF protein. Bio-Rad's Quantity One software was used to quantitatively determine the target protein bands. The grey values of PDGF, VEGF and TGF-β were determined with β-Actin as an internal reference (Figure 2).

Before the intervention and 14 days after the intervention, necrotic tissue visible to the naked eye was removed from the wound with normal saline, and then the tissue fluid was squeezed from the wound by rotating the swab with sufficient pressure in the cleanest 1 cm^2 area of the wound bed. If the wound bed was dry, the tip of the swab was wet with normal saline first, then the wound tissue fluid was taken and a bacterial culture was performed (Figure 3).

2.5.1 | Haematoxylin-eosin staining solution

A haematoxylin-eosin (H&E) staining solution (Shanghai Xuanke Biotechnology Co., Ltd.) kit was used for staining. In the conservative sharp debridement, the soybean-sized wound tissue at the same part of the patient's wound base was taken with vascular forceps and placed in a 4% neutral formaldehyde fixative. Tissue fixation, dehydration, transparency, waxing and embedding were performed under the guidance of the chief pathologist. After the initial repair, the 3–5 μm sections were continuously inserted into the slide holder and dried at a high temperature for half an hour. The slides were put into the automatic staining sealing machine for H&E staining sealing. The type of wound tissue and inflammatory cell infiltration in granulation tissue was observed under a lighted microscope.

2.5.2 | Other indicators

(1) Wound temperature: The wound temperature of the patient was measured and recorded before the intervention and on days 7 and 14 after the intervention. According to the five-point temperature measurement method, the temperature of the patient's wound centre and around the wound at 3, 6, 9 and 12 o'clock were measured by an infrared thermometer immediately after the dressing was unwrapped. After each temperature measurement point stayed for 2–3 s, the temperature was read and recorded, and the average temperature around the wound was calculated.

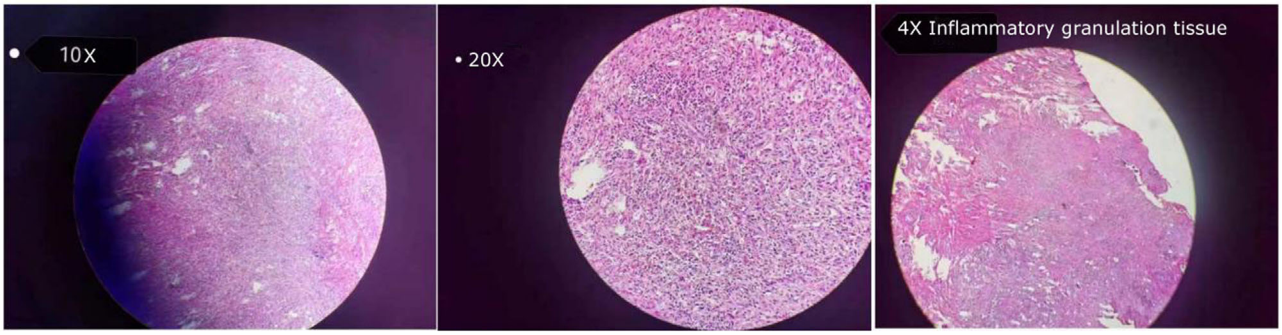

FIGURE 2 Pathological examination results.

FIGURE 3 Plate of aureus, aeruginosa and *E. coli*.

(2) Exudation pH: The pH value of the wound exudate was measured using a disposable pH test strip. The tip of the test paper was placed at the base of the wound without bleeding, and it was fully immersed in the exudate of the wound site for about 15 s. After fully reacting, the pH value was read with reference to the colourimetric card.

2.6 | Statistical analysis

SPSS16.0 statistical analysis software was used for statistical processing. Measurement data conforming to normal distribution were expressed as ($x \pm s$). Count data were expressed as percentages and an independent sample χ^2 test was used to compare the two groups.

3 | RESULTS

3.1 | General data of patients in both groups

There were no statistically significant differences in gender, age, complications and nutritional status between the two groups ($p > 0.05$), indicating comparability, as shown in Table 1.

3.2 | Wound data

Before and after treatment, there were no significant differences in wound type, stage of pressure ulcer, wound site, granulation tissue coverage, pH value of the seepage solution, bacterial culture, wound volume, wound temperature and wound number between the two groups ($p < 0.05$), as shown in Table 2.

3.3 | Changes in general indicators

On days 7 and 14 after the intervention, the granulation tissue coverage of the two groups was significantly increased ($p < 0.05$), and the granulation tissue coverage of the observation group was significantly higher than that of the control group ($p < 0.05$). On days 7 and 14 after the intervention, the wound temperature and exudate pH of the two groups were significantly increased ($p < 0.05$). The wound temperature of the observation group was significantly higher than that of the control group ($p < 0.05$), and the exudate pH was significantly lower than that of the control group ($p < 0.05$). Compared with day 7, the wound volume reduction rate of the two groups on day 14 was significantly increased ($p < 0.05$), and the wound volume reduction rate of the observation group on intervention days 7 and 14 was significantly higher than that of the control group ($p < 0.05$), as shown in Table 3.

3.4 | Pathological examination index

Before the intervention, further histologic observation by H&E staining showed that there were more inflammatory cells and less fibroblasts and neovascularisation in the two groups before treatment. At 14 days

TABLE 2 Wound data of the two groups.

Project		Observation group ($n = 25$)	Control group ($n = 25$)	t/χ^2	p
Wound type (%)	Pressure sore	23	21	0.325	0.569
	Venous ulcer of limb	1	2		
	Diabetic foot	1	2		
Stage of pressure ulcer (%)	Phase 3	6	6	0.143	0.931
	Phase 4	15	16		
	Other	5	4		
Wound site	Sacrococcygeal	12	11	0.186	0.911
	Hip	13	13		
	Other (Back, heel and lower limb)	3	2		
Wound volume (cm^3)		24.53 ± 6.01	22.59 ± 4.81	1.883	0.060
Wound temperature		31.88 ± 0.69	31.71 ± 1.03	0.823	0.410
Number of wounds	1	22	23	0.222	0.637
	>1	3	2		
Granulation tissue coverage		12.53 ± 4.52	13.29 ± 4.95	0.765	0.445
pH value of the seepage solution		7.76 ± 0.08	7.75 ± 0.11	0.453	0.650
Bacterial culture (%)	+	11	10	0.321	0.571
	–	14	15		

TABLE 3 Comparison of wound indexes between the two groups.

Project	Observation group ($n = 25$)			Control group ($n = 25$)		
	Pre-intervention	7 days	14 days	Pre-intervention	7 days	14 days
Granulation tissue coverage (%)	12.53 ± 4.52	48.47 ± 5.64[*, a]	89.32 ± 8.73[*, #,a]	13.29 ± 4.95	43.59 ± 4.86[*]	83.19 ± 7.76[*, #]
Wound volume reduction rate (%)	–	40.03 ± 3.53[a]	79.45 ± 7.55[#,a]	–	32.13 ± 4.49	70.64 ± 6.10[#]
Wound temperature (°C)	31.88 ± 0.69	32.21 ± 0.36[*, a]	32.57 ± 0.40[*, #,a]	31.71 ± 1.03	32.19 ± 0.41[*]	32.81 ± 0.55[*, #]
Seepage pH	7.76 ± 0.08	7.40 ± 0.12[*, a]	7.17 ± 0.11[*, #,a]	7.75 ± 0.11	7.29 ± 0.09[*]	7.12 ± 0.13[*, #]

[*] $p < 0.05$, Compared with before intervention.
[#] $p < 0.05$, Compared with intervention day 7.
[a] $p < 0.05$, Compared with the control group.

after the intervention, H&E staining showed typical fresh granulation tissue in the observation group, a large number of fibroblast infiltration and the formation of a large number of new capillaries, while H&E staining in the control group showed a relatively small number of fibroblast infiltration and insignificant formation of fresh granulation tissue, as shown in Figure 2.

3.5 | Changes in laboratory test indicators

Compared with before intervention, VEGF, TGF-β and PDGF in the two groups were increased ($p < 0.05$). And the increased value of the observation group was higher than that of the control group ($p < 0.05$), as shown in Table 4.

The difference in bacterial culture results between the two groups was statistically significant ($\chi^2 = 6.349$, $p = 0.0117$). According to the statistical analysis of the bacterial species of the patients with positive bacterial culture, a total of seven species of bacteria were cultivated, of which *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* were the most frequent. See Table 5.

3.6 | Wound cure rate

After 3 months of intervention, the total response rate of the observation group was significantly higher than that of the control group ($\chi^2 = 3.869$, $p = 0.0492$) (Table 6).

TABLE 4 Vascular endothelial growth factor (VEGF), transforming growth factor-β (TGF-β) and platelet-derived growth factor (PDGF) test result.

Project	Observation group ($n = 25$)		Control group ($n = 25$)	
	Pre-intervention	14 days	Pre-intervention	14 days
VEGF grey value	0.156 ± 0.015	0.321 ± 0.022*, a	0.151 ± 0.019	0.308 ± 0.018*
TGF-β grey value	0.103 ± 0.008	0.283 ± 0.023*, a	0.111 ± 0.009	0.256 ± 0.020*
PDGF grey value	0.107 ± 0.015	0.306 ± 0.035*, a	0.106 ± 0.009	0.259 ± 0.021*

*$p < 0.05$, compared with before intervention.

[a]$p < 0.05$, compared with the control group.

Abbreviations: PDGF, platelet-derived growth factor; TGF-β, transforming growth factor-β; VEGF, vascular endothelial growth factor.

TABLE 5 The results of bacterial culture.

Project		Observation group ($n = 25$)		Control group ($n = 25$)	
		Pre-intervention	14 days	Pre-intervention	14 days
Bacterial culture (%)	+	11	3	10	6
	–	14	22	15	19
χ^2			6.349		1.471
p			0.012		0.225

TABLE 6 Wound cure rates of the two groups.

Project	Number of wounds	Recover	Apparent effect	Void	Effective rate (%)
Observation group	28	19	7	2	92.86
Control group	30	15	7	8	73.33
χ^2					3.869
p					0.0492

3.7 | Security analysis

No serious adverse reactions were found in both groups. One patient developed eczema on the skin covered with dressings and medical membranes and was cured after 1 week of treatment with a topical ointment. One patient complained of wound pain during negative pressure treatment but could tolerate it. No pain was observed during the third or fourth negative pressure treatment.

4 | DISCUSSION

With the increasing ageing population in China, the incidence of traumatic accidents, pressure injuries, diabetic foot ulcers, lower limb vascular ulcer and other diseases, the occurrence of various acute and chronic wounds and infections are common clinical problems, but current treatment is not effective. Studies have shown that the incidence of chronic wounds in developed countries is about 1.04%–4.5%,[8] and the incidence of chronic wounds is about 0.22%, among which the incidence of chronic ulcers in lower limbs is 0.15%.[9] In China, pressure injury, unseemly surgical incisions and traumatic wounds are the main types of outpatient wounds treated, while vascular ulcers and diabetic foot ulcers are second. The high incidence of chronic wounds, especially refractory chronic wounds, often brings great economic burden, care burden and social burden.

With the progress of science and technology and the development of material science, negative pressure closed drainage technology is a new technology developed in recent years. Negative pressure wound therapy is one of the non-drug approaches to promote wound healing. Based on the principle of wound attraction technology, it can cause macroscopic and microscopic deformation of tissues in various chronic wounds, especially complex wounds, and at the same time can remove wound effusion and increase wound blood perfusion.[10–12] Under the effect of negative pressure, local wound tissue oedema is reduced, the inflammatory response is reduced and wound effusion is removed, thus promoting the exchange of beneficial substances and tissue perfusion and providing a good wound healing environment for granulation tissue proliferation and vascularisation. In this study, a simple self-made NPSD was used to intervene in chronic wounds in elderly patients. The results showed that, compared with the control group, the granulation tissue coverage rate and wound volume reduction rate of patients in the observation group improved faster. After 14 days of intervention, the total effective rate of the observation group was significantly higher than that of the control group, suggesting that the self-made

NPSD intervention is beneficial to the recovery of chronic wounds in elderly patients. The pathological examination also verified that 14 days after the intervention, typical fresh granulation tissue was observed by H&E staining in the observation group, showing a large number of fibroblast infiltration and formation of a large number of new capillaries, while in the control group, H&E staining showed a relatively small number of fibroblast infiltration and insignificant formation of fresh granulation tissue, which confirmed the effectiveness of the self-made NPSD.

Wound temperature and wound pH are closely related to the recovery of chronic wounds.[13] Due to the damaged blood supply and abnormal tissue oxygenation, the temperature of a chronic wound is about 5°C lower than the core body temperature.[14] The low temperature of the wound will also cause vasoconstriction and reduced blood flow and delay wound healing, evident by pale tissue and low temperature. In this study, at 7 and 14 days after the intervention, the wound temperature of the two groups was significantly increased, and the wound temperature of the observation group was significantly higher than that of the control group. Furthermore, the pH value is one of the indicators of the microenvironment of chronic wounds. The pH value of normal skin tissue is between 4 and 6, which can inhibit bacterial and fungal infection.[15,16] The wound's acidity also promotes the proliferation of wound granulation tissue and the proliferation and migration of keratinocytes and fibroblasts. When the skin integrity is damaged, the local pH value will reach 7.4, or even as high as 8–9,[17–18] at which point the wound is more likely to become infected with Staphylococcus aureus, Pseudomonas aeruginosa and other bacteria biofilm, leading to protein decomposition and delaying healing. In this study, on days 7 and 14 after the intervention, the pH of the two groups was significantly decreased, and the pH of the observation group was significantly lower than that of the control group, indicating that the self-made negative pressure device could improve wound temperature and reduce the pH of the effusion to a certain extent, thus promoting wound recovery.[19] For the clinical practice, there was another device used to improve wound recovery. NPSD treatment and hyperbaric oxygen wound (HOW) therapy are two methods of treating chronic wounds, such as diabetic foot ulcers or venous ulcers. NPSD treatment involves applying a vacuum to the wound through a sealed dressing, which removes excess fluid and stimulates blood flow and healing. HOW therapy involves exposing the wound to 100% oxygen at high pressure in a chamber, which increases oxygen delivery to the wound tissue and promotes healing.[20] A paper reported the clinical treatment using the HOW therapy, they showed that HOW therapy significantly improved the wound healing condition and ^{31}P magnetic resonance spectroscopy was useful for the study of biochemical changes associated with wound healing.[20] However, comparing that device with the current study, our self-made NPSD cost much lower to patients for treating chronic wounds. And our device was much smaller than the HOW chamber. Overall, our self-made NPSD was efficient and low-cost.

However, there are some shortcomings in this study. Patients were required to rest in bed during negative pressure treatment, which limited their activities. During the study period, one patient in the observation group developed eczema on the skin covered by dressing and medical film, and the patient healed after 1 week of ointment external application according to the doctor's advice. One patient complained of pain in the wound when negative pressure was applied but could tolerate it, and no pain was felt at the 3rd–4th negative pressure treatment. The negative pressure tube was taken out when the patient turned over in the process of using negative pressure and replaced. The transparent patch became loose in one patient and was replaced in time.

The self-made NPSD utilises the principle of local negative pressure to effectively promote the healing of chronic wounds; therefore, it is a simple, economical and effective method to treat chronic wounds in the elderly.

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Not applicable.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of The Second Affiliated Hospital Of Wannan Medical College, and informed consent was obtained from all participants.

CONSENT FOR PUBLICATION

Not applicable.

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