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ORIGINAL ARTICLE

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Clinical efficacy of chitosan-based hydrocolloid dressing in the treatment of chronic refractory wounds

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Abstract

This retrospective study aimed to explore the clinical efficacy of chitosan-based hydrocolloid dressing in treating chronic refractory wounds. A total of 80 patients with chronic refractory wounds were randomly divided into the control group (n = 40) and the study group (n = 40). The control group was given inert saline gauze, while the study group was given chitosan-based hydrocolloid dressing. After 3 weeks of treatment, the wound healing efficiency, itching pain score, changes in the wound area, dressing change frequency, and cost were measured. There was a significant difference in the wound healing effect (t = 2.738), and degree of pain (t = 4.76) between the study and control groups, after 3 weeks of treatment. Similarly, a prominent reduction in the itching frequency (t = 8.62), and wound area (t = 6.379) was observed in the study group compared to the control group ($P < .05$). Moreover, the frequency and total cost of dressing change in the study group were also lower than the control group and the difference was statistically significant ($P < .05$). To summarise, the application of chitosan-based hydrocolloid dressing in treating chronic refractory can effectively alleviate pain, accelerate wound healing, relieve itching pain, and reduce the overall cost and frequency of dressing change.

KEYWORDS

chitosan-based hydrocolloid dressing, chronic refractory wounds, itching, pain, wound healing

Key Messages

- chronic refractory wounds are often associated with the problems of the long treatment course, difficulty in treating, high cost, and repeated attacks among others that negatively affect patients' quality of life, and cause a significant financial burden on the family
- chitosan-based-hydrocolloid dressing was applied to 80 patients with chronic refractory wounds and explored its therapeutic value

Abbreviations: BMI, Body mass index; BRS, Behaviour score; VAS, Visual analogue scale.

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- the application of chitosan-based-hydrocolloid dressing displayed a better treatment outcome by prominently alleviating pain, accelerating wound healing, relieving itching pain, and reducing the overall cost and frequency of dressing change

1 | INTRODUCTION

Chronic refractory wounds refer to wounds that cannot achieve structural and functional integrity through their tissue repair process and tend not to heal after treatment for more than 1 month.[1] Clinically, the pathogenesis of chronic refractory wounds is a multifactorial process, including old age, trauma, burn, radiation injury, infection, diabetes, arteriovenous insufficiency, local tissue compression, and malignant tumour.[2-4] The wound healing process is divided into three stages, including inflammation, new tissue regeneration (proliferation), and remodelling (maturation). The inflammatory stage is the initial critical step of wound healing, and an appropriate inflammatory response is very important for wound repair.[5] However, the aggravation and prolongation of inflammation results in a diminished wound healing process and increases scar formation.[6,7] If the chronic wound is not treated appropriately, it can easily affect the muscle and bone tissue and aggravate the body function damage. In addition, chronic wounds are associated with the problems of migration, long treatment course, difficulty in treating, high cost, repeated attacks, high disability rate factors that have a negative impact on the patient's quality of life, and this condition also causes a significant financial burden on the family and society.[8-11] In chronic refractory wounds, prevention and treatment of wound infection are especially critical.

In many cases, the clinical treatment of chronic refractory wounds often implements systemic treatment or local treatment according to the patient's situation. Iodophor gauze is often used to cover or tamp the local wound to prevent infection.[12] Although it can achieve a certain curative effect, but its clinical outcomes are not satisfactory. Vigani et al[13] suggested that keeping the wound moist is conducive to healing and recommended using hydrophilic gel to cover the wound. Given the biocompatibility of hydrogel dressing, soft tissue water content, and three-dimensional porous network structure similar to the natural extracellular matrix, hydrogel is considered an ideal wound dressing material. It is not only effective in maintaining the moist environment required for wound healing, but it is also comfortable and easy to replace material that can effectively relieve wound pain and reduce wound temperature.[14] Hydrogel has been widely proved to be a good quality dressing suitable for different stages of wound healing.[15,16]

In this study, chitosan-based-hydrocolloid dressing was applied in the treatment of chronic refractory wounds to explore its therapeutic value. The application of chitosan-based-hydrocolloid dressing displayed a better treatment outcome than conventional disinfection dressing.

2 | METHODS

2.1 | Participants

A total of 80 patients with chronic refractory wounds from October 2018 to October 2020 who were treated in our hospital were chosen. The cases included 25 cases of pressure ulcers, 10 cases of vascular ulcers, 20 cases of diabetic foot ulcers, 11 cases of infectious wounds, 8 cases of burn wounds, 4 cases of traumatic wounds, and 2 case of radiation ulcer. The patients were randomly assigned into a control group (inert saline gauze dressing) and the study group (chitosan-based hydrocolloid dressing), 40 cases in each group, according to the numerical random table method. There were 22 males and 18 females aged from 44 to 59 years old, with a mean age of 51.66 $\pm$ 7.21 years, in the control group, while 25 males and 15 females aged from 48 to 61 years old, with a mean age of 54.31 $\pm$ 6.54 years, in the study group. This study was approved by the medical ethics committee of our hospital.

2.2 | Inclusion and exclusion criteria

Inclusion criteria were as follows: (a) wounds that did not heal for more than 1 month; (b) skin area defect that was more than 2-10 cm^2; (c) informed consent signed by patients and their families; (d) no mental illness (patients with severe cognitive and language impairments leading to noncooperation with the treatment); (e) age $\geq$18 years old.

The criteria for exclusion were as follows: (a) patients with severe heart, brain, liver, and kidney complications or primary diseases; (b) patients with coagulation dysfunction; (c) patients who were hesitant to dressing change; (d) patients who were allergic to hydrocolloid dressing.

2.3 | Sample size

The sample size was determined by G*Power analysis. To achieve 80% power with an alpha error of 5%, a minimal sample size of 52 patients (26 per group) was required to detect statistical significance between the control and study groups. Assuming 20% dropout, the minimal enrolled participant number was 66 (33 per group).

2.4 | Therapeutic methods

The chitosan-based-hydrocolloid dressing was processed from hydrocarbon resin, styrene-isoprene block copolymer, sodium hydroxymethyl cellulose, and dioctyl adipate (manufactured by Coloplast A/S Holtedam, Humlebaek, Denmark). The wound secretions of both groups were collected for pathogen examination and drug sensitivity tests. To eliminate necrotic tissue, foreign debris, eschar, and biofilm, wounds were thoroughly debrided with a scalpel and then disinfected and cleaned using 0.9% normal saline and 0.5% chlorhexidine. In addition, patients were advised to take an appropriate position, such as raising the affected limb to promote venous return. The wound dressing application was performed as previously described.[17] In patients in the control group, the wound was covered with a single layer of conventional inert saline gauze, then 3 to 4 layers of sterile gauze to protect the skin around the wound, and finally fixed with an adhesive plaster or bandage. Patients in the study group received the same routine debridement treatment as the control group. The chitosan-based hydrocolloid dressing (trimmed to 2 mm thickness) was then externally applied according to the manufacturer's instructions, then the wound was covered with 3 to 4 layers of sterile gauze, and finally fixed with an adhesive plaster or bandage. Depending on the wound's condition and secretions, the dressing was changed every other day or every day.

2.5 | Observation indexes and evaluation criteria

The wound-healing effect, degree of pain, itching pain score, changes in the wound area, the frequency of dressing change, and cost were observed and compared between the two groups 3 weeks after dressing change by the observers blinded to the treatment.

1. The overall wound-healing effect between the two groups was calculated as follows.
   Cure: no pain, normal skin colour, and complete healing of the wound.
   Markedly effective: pain was relieved, no secretion was produced, granulation tissue could be seen, and the wound healing rate was more than 80%.
   Effective: a small amount of secretion was produced, granulation tissue could be seen, and the wound healing rate was 50% ≤ 80%.
   Ineffective: pain was not relieved or even aggravated, and the wound healing rate was less than 50%.
2. Visual analogue scale (VAS)[18] was used to evaluate the degree of pain between the two groups before and after treatment. The total score was assigned 10 points. Less than 2 points indicated no pain, 2-4 points indicated mild pain, 5-7 points indicated moderate pain, 8-9 points indicated severe pain, and 10 points indicated worst pain.
3. Behaviour score (BRS)[19] was used to evaluate the wound itching. The score of patients without itching symptoms was 0, and the score of patients with itching symptoms affecting sleep and having certain persistence was 5.
4. The wound area of the patients on the first day of treatment and the 21st day was recorded using the elliptical method,[20] and the changes in the wound area were statistically analysed.
5. The frequency of dressing change and cost were recorded and calculated manually.

2.6 | Statistical analysis

All data were analysed using SPSS statistical software version 19.0 (IBM). Count data and grade data were expressed as n (%). χ^2 test was used for counting data, the rank-sum test was used for grading data, and the t test was used for measurement data. $P < .05$ was considered statistically significant.

3 | RESULTS

3.1 | Basic clinical characteristics

A total of 80 patients were enrolled in this study from October 2018 to October 2020. The mean age was 54.31 (SD 6.54) years in the study group and 51.66 (SD 7.21) in the control group. There were 25 (62.5%) males and 15 (37.5%) females in the study group and 22 males (55%) and 18 (45%) females in the control group. The mean course of the disease in the study group was 3.32 ± 0.63, and 3.16 ± 0.45 in the control group. The average body mass index (BMI) in the study group was 23.25 ± 1.96, and 22.72 ± 2.18 in the control group. The average wound area in the study group was 6.31 ± 1.78, and 5.76

± 1.23 in the control group. When we compared the baseline clinical characteristics of the patients, there was no significant difference in age, gender, BMI, course of the disease, and wound area between the two groups before treatment intervention ($P > .05$; Table 1).

3.2 | Wound status

After 3 weeks of treatment, the wound healing effect of the study group (chitosan-based hydrocolloid dressing) was better than that of the control group, and the difference was statistically significant ($P < .05$; Table 2).

3.3 | Degree of pain

Before treatment, there was no significant difference in the VAS scores between the two groups indicating no change in the degree of pain ($P > .05$). However, on the 21st day after treatment, the VAS scores of both the groups decreased significantly compared to before treatment ($P < .05$). Notably, the VAS score of the study group was significantly lower than that of the control group ($P < .05$; Table 3).

3.4 | Wound itching

In terms of the degree of wound itching, there was no significant difference in the BRS scores of the two groups before treatment ($P > .05$). However, after treatment, the BRS scores of the two groups significantly reduced ($P < .05$). Interestingly, the BRS score of the study group was considerably lower than that of the control group, and the difference was statistically significant ($P < .05$; Table 4).

3.5 | Changes in wound area

There were no considerable changes in the wound area between the two groups before treatment ($P > .05$). However, the wound area of the two groups gradually decreased with the continuous progress of treatment, and the wound area in the study group was significantly

TABLE 1 Comparison of baseline characteristics between the two groups

Groups	Course of the disease	Gender (n)		Age (y)	BMI (kg/m^2)	Wound area (cm^2)
		Male	Female			
Study group	3.32 ± 0.63	25 (62.5%)	15 (37.5%)	54.31 ± 6.54	23.25 ± 1.96	6.3 1 ± 1.78
Control group	3.16 ± 0.45	22 (55.0%)	18 (45.0%)	51.66 ± 7.21	22.72 ± 2.18	5.76 ± 1.23
t/χ^2	1.57	0.46		1.13	1.04	0.30
P	.12	.50		.26	.30	.19

TABLE 2 Comparison of wound healing efficacy between the two groups

Groups	N	Cure	Markedly effective	Effective	Ineffective
Study group	40	25 (62.5%)	8 (20.0%)	5 (12.5%)	2 (5.0%)
Control group	40	15 (37.5%)	7 (17.5%)	8 (20.0%)	10 (25.0%)
χ^2			2.738		
P			.006		

TABLE 3 Comparison of VAS scores between the two groups

Groups	N	Before treatment	After treatment	t	*P*
Study group	40	7.03 ± 2.18	2.56 ± 1.02*,#	9.68	<.0001
Control group	40	7.25 ± 2.31	4.18 ± 1.34*	7.00	<.0001
t		1.19	4.76		
P		.24	<.0001		

*Indicates significance for $P < .05$ between before and after treatment. #Indicates significance for $P < .05$ between the control and study groups.

Groups	N	Before treatment	After treatment	t	P
Study group	40	4.12 ± 0.56	1.12 ± 0.38*,#	9.88	<.0001
Control group	40	3.98 ± 0.44	1.95 ± 0.51*	10.67	<.0001
t		0.344	8.62		
P		.73	<.0001		

TABLE 4 Comparison of BRS scores between the two groups

*Indicates significance for $P < .05$ between before and after treatment. #Indicates significance for $P < .05$ between the control and study groups.

Groups	N	Before treatment	After treatment	t	P
Study group	40	6.31 ± 1.78	2.11 ± 0.85*,#	4.35	<.0001
Control group	40	5.76 ± 1.23	3.22 ± 0.59*	6.43	<.0001
t		1.39	6.379		
P		.17	<.0001		

TABLE 5 Comparison of changes in wound area between the two groups

*Indicates significance for $P < .05$ between before and after treatment. #Indicates significance for $P < .05$ between the control and study groups.

Groups	N	Dressing change times	Dressing change fee
Study group	40	3.28 ± 0.76	436.56 ± 35.63
Control group	40	6.02 ± 1.56	782.68 ± 67.26
t		5.714	7.494
P		<.0001	<.0001

TABLE 6 Comparison of dressing change frequency and cost between the two groups

smaller than that of the control group after 3 weeks of treatment ($P < .05$; Table 5).

3.6 | Frequency and cost of dressing change

After 3 weeks of treatment, the frequency and cost of dressing change in the study group were appreciably less than those in the control group and the difference was statistically significant ($P < .05$; Table 6).

4 | DISCUSSION

Chronic refractory wounds can be induced directly by trauma and burns. They can also be caused by metabolic diseases and senile diseases such as diabetic foot ulcers and pressure injuries caused by bedridden status.[3,7] The prevalence of this disease gradually increases with age. Chronic refractory wounds have become a substantial burden on patients, families, and society as the population ages.[10] The mechanism of chronic refractory wound healing is complicated. At present, related studies have proposed the following theories: local blood circulation disorders leading to ischaemia and hypoxia,[21] cutaneous environmental disorders in diabetes mellitus,[22] and bacterial biofilm formation.[23]

Patients with chronic refractory wounds often have a long course of the disease, and the disease is repetitive, which has a serious impact on patients' psychology.[24] In the early stage of the disease, the main symptoms are itching and pain and scab gradually with the disease progress. In terms of clinical treatment of chronic refractory wounds, the main principles are thorough debridement, wound closure, and appropriate radical treatment.[1,25] In addition, traditional dressing changes are mainly filled or covered with Iodophor gauze. However, frequent cleaning of gauze and cotton balls damages the new granulation tissue and metastatic epithelium, and the stimulation of nerve endings during dressing changes also increases pain sensation in patients.[26]

Studies have shown that moist wound healing can provide a suitable microenvironment for the wound by controlling the wound exudate to heal the wound quickly.[27,28] The hydroxymethyl cellulose used in the hydrogel dressing has good viscosity and can be firmly applied to the skin around the wound, thus forming a good, closed space environment, cutting off the aerobic environment needed for the growth and reproduction of anaerobic bacteria, and

effectively inhibiting the inflammatory reaction.[29] Many endogenous enzymes in hydrogel dressings can improve the activity of macrophages, accelerate the phagocytosis of inflammatory cytokines, facilitates the clearance of necrotic tissue, and promote wound healing.[30] At present, many hydrogel dressing products made of natural or artificial polymer materials have been used in clinical applications, including AQUACEL, TegaGel, and NuGel.[31,32] A recent study indicated that chitosan-based hydrogels alone can be used to treat hydrofluoric acid burns and prevent infection.[33] Similarly, chitosan-based hydrogels act as thermosensitive hydrogels for drug delivery.[34] The chitosan/calotropis procera-based hydrogels were able to stimulate the formation of granulation tissue and angiogenesis in wound healing applications.[35] In the present study, we used chitosan-based hydrocolloid dressing in the treatment of chronic refractory wounds. In agreement with the results of previous publications, the results of our study also showed that hydrocolloid adjuvant treatment was better than the conventional dressing for treating chronic refractory wounds. After 3 weeks of treatment, wound healing efficacy, degree of pain, and wound itching status of patients treated with chitosan-based hydrocolloid dressing were better than those in the control group treated with conventional dressing. In addition, the frequency of dressing change, and the cost of dressing were significantly lower in the chitosan-based hydrocolloid dressing study group compared to the control group.

Despite the fact that we saw the most anticipated improvements in wound healing, our study has a number of limitations that should be considered. A major limitation of our study is that patients with a variety of wounds of different aetiologias were included; therefore, we were unable to present subgroup analysis of different wound types. Further study should be conducted to classify wounds into distinct categories depending on a variety of pathogeneses. Furthermore, this study is limited by the small number of participants; however, the observational data do provide insight into the efficacy of this treatment. In addition, more objective and precise assessment indices should be employed to explore the complicated biological processes involved in wound healing using chitosan-based hydrocolloid dressing.

5 | CONCLUSIONS

For the treatment of chronic refractory wounds, hydrocolloid adjuvant dressing can efficiently lower the frequency and cost of dressing, relieve pain, reduce wound itching, and accelerate the process of wound healing. Thus, it might be considered an ideal disinfection dressing for treating chronic refractory wounds.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. Jing Liu contributed to the data acquisition, analyses, interpretation, and manuscript draft. Hong Shen contributed to the data acquisition, analysis, and critically revised the manuscript. All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

Ethics approval was obtained from the Institutional Review Board Ethics Committee of Nantong Third People's Hospital (Approval No. 20180917L). All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all the participants.

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