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Original Article

Impacts of dermabrasion on deep partial-thickness burn wound's ecological organization

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Abstract: Objective: To make comparison of the impacts of dermabrasion, tangential excision and eschar reserving on the ecological organization of deep partial-thickness burn wound. Methods: Retrospective studies were applied to ninety young patients with burn area ≤30% and lower extremity deep partial-thickness burn between Jan. 2013 and Jan. 2016 in our hospital. These patients were randomly divided into three groups: 30 patients with dermabrasion as Group A, 30 patients with tangential as Group B and 30 with eschar reserving as Group C. The following data were compared among the patients in of each group: the differences of the patients' thigh circumferences on the first, third, fifth day after surgery and the first day in hospital as well as the local pain scores; bacterial quantitative detection at on the second, fifth, eighth and tenth day after surgery; the wounds' pathological sections which were on hematoxylin-eosin staining on the fifth day; the healing rate of wounds on the fourteenth day; the frequency of dressing change and mean hospitalization time. Results: There was no difference in the thigh circumferences of patients in among these three groups between the first day after surgery and the first day in hospital. But compared with the tangential excision group and the eschar reserving group, the dermabrasion group had increased differences on the third and fifth day ($P<0.05$). Less bacteria on wounds of dermabrasion group were found on the second, fifth and eighth day after surgery compared with the tangential excision group and the eschar reserving group ($P<0.05$). However, the colonization of wound bacteria on the tenth day was basically coherent. In the dermabrasion group, the wounds on hematoxylin-eosin staining showed that the epidermal structure gradually became more complete and the inflammatory infiltration was more improved than those in the tangential excision group and the eschar reserving group. The healing rate of dermabrasion group on the fourteenth day after surgery was obviously higher than those of other groups ($P<0.01$). Compared with the tangential excision group and the eschar reserving group, the mean hospitalization time was shorter and the frequency of dressing change of dermabrasion group was less ($P<0.05$). Conclusion: Local inflammation, degrees of edema, pain and wound bacteria colonization could be reduced by using dermabrasion to treat deep partial-thickness burn. Thus it is good for wound healing and shortening of mean dressing change and hospitalization time.

Keywords: Deep partial-thickness burn, dermabrasion, tangential excision, eschar reserving

Introduction

Deep partial-thickness burn is a kind of common clinical disease. The effective way to treat and repair burn wound has been the focus of medical study for a long time [1]. Microcirculatory disturbance and local inflammatory edema will occur on burnt wound after people get burnt, which will lead to progressive aggravation that which is local and systemic infection without timely treatment within 48 hours [2]. What is worse, endotoxemia and systematic inflammatory response syndrome (SIRS) may occur, causing multiple organ failure. Therefore, it is vital for burnt healing as soon as possible with timely treatment [3, 4].

Clinical treatments of deep partial-thickness burn wound at present stage consist of depollution, wounds protection, infection prevention, keeping wounds dry, slowing bacterial growth, prevention and cure of wound deepening as soon as possible and acceleration of burn wounds [5]. According to degrees of severity and sites of the burn wounds, different kinds of clinical treatment are applied. To be specific,

Table 1. Clinical data of three groups of research objects ($\bar{x}$±S, n=30)

Group	Age (years old)	Male/female	BMI
A	25.3±3.4	15/15	20.9±2.2
B	27.2±2.3	14/16	21.8±2.7
C	24.9±3.3	16/14	21.1±2.8
P value	>0.05	>0.05	>0.05

Note: BMI: body mass index.

three methods are widely used: eschar reserving, tangential excision and dermabrasion.

Traditional eschar reserving: is to reserve the sebaceous glands, sweat glands and hair follicle epithelium in the depth of wounds which has not been burnt so as to preserve the normal organization function as much as possible.

The tangential excision method: is to remove necrotic tissue by a freehand knife and reserve part of active dermis tissue and skin attachment, which can facilitate wound healing and metabolism of local skin.

As for dermabrasion, grinding device was used to rob the wounds in order to boost blood flow, improve the blood circulation and prevent the deepening of wounds. Nevertheless, the effects of three treatments are not cleared yet [6, 7].

Through this study, the effects of dermabrasion, tangential excision and eschar reserving were compared when they were used to treat young patients who had deep partial-thickness burn on thigh. At the same time, the therapeutic effects of whole body were compared. Then the local inflammatory reactions and wound healing effects of these three treatments were evaluated. Furthermore, the clinical effects of dermabrasion to treat deep partial-thickness burn and its therapeutic mechanisms were studied.

Materials and methods

General information

The objects of study were selected randomly. Ninety young patients with burn area ≤30% and lower extremity deep partial-thickness burn between Jan. 2013 and Jan. 2016 in our hospital were selected. These patients were hospitalized within 48 hours after the burn, aged 20 to 30 with both genders. Diagnostic criteria of deep partial-thickness burn: burn should involve dermis deep tissue, the blister on the cuticular layer should have thick blister skin and red-white-red base, and the peripheral tissue should have obvious edema but with insensitive pain of patients. Inclusion criteria: burn area should be ≤30% on thigh. Exclusion criteria: patients were with severe shock, diabetes mellitus and complications of many organs. All the patients signed informed consents before treatment. The above patients were divided randomly into dermabrasion group (Group A), tangential excision group (Group B) and eschar reserving group (Group C). The age of patients, the sexual ratio and the body mass indexes (BMI) have no statistical significance (P>0.05) (as shown in **Table 1**).

Methods

Empirical methods

Burned patients who were admitted to hospital within 48 h meet the diagnostic criteria for deep partial-thickness burn. They were specifically treated as follows. Patients of dermabrasion group were treated with general anesthesia operation, surgical area was disinfected and the dermabrasion device was used to rub wound until the dense bleeding points appeared. When the wound was deep and the necrotic tissue removal was not complete, the wound was washed after the appearance of redness of the surface, then the wound was wet by covering the gauze with biological dressing, finally the outer layer was treated with pressure dressing with nano-silver gauze. After the general anesthesia and disinfection treatment, tangential excision was performed to the wound by a roller watson knife, the wound was washed and then covered by using the same method as the dermabrasion group. The wound in eschar reserving group was rinsed with 2% iodophor, dressed by using sulfadiazine silver cream, then performed follow-up changes of dressing for wound.

Detection methods and observation indexes

The differences of the thigh circumferences between the first, third and fifth day after surgery and the time of admission as well as the local pain scores: After admission, the doctor visualized the most obvious department of edema, with meter ruler to measure the thigh

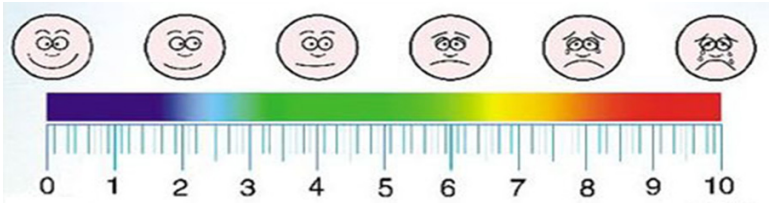

Figure 1. Pain rating scale.

circumferences of patients. On the first, third and fifth day after the treatment, the thigh circumferences of each group were measured again according to the measurement methods above, and the differences of the thigh circumferences were calculated; at the same time, according to the pain rating scale, patients estimated pain scores according to their pain degrees. The scoring standard for evaluation of 0-10 points was: 0 point for painless; 3 points below for a slight pain that patients could endure; 4 points to 6 points for pain that would affect sleep; 7 points to 10 points for a gradually intense pain, which was unbearable (**Figure 1**).

Pathological section hematoxylin-eosin staining

The burn wound tissue of three groups with the same burn severity of 2.0 cm*2.0 cm*0.3 cm was cut, respectively at the very admission time and on the fifth day after surgery. The cut tissue was washed once with normal saline, then immediately placed in 10% formaldehyde solution for 2 to 3 hours. After washing by water, transparent tissue was dehydrated and the dip wax embedding method was done. Then slice, patch, bake, dewax the chip, after Hematology staining for 5 to 15 minutes, perform eosin staining 5 to 20 seconds, dehydrate and envelope the chip, observe the histopathologic sections of the burn wounds before and five days after the treatment in 40-fold optical microscope.

Burn wound bacterial quantitative detection

Respectively, take the same area from the patients of three groups on the second, fifth, eighth, tenth day after treatment. Adding 1 mL PBS in to wound tissue specimens, the tissue homogenate of each group was obtained by shaking with the grinding oscillator, 10 times the gradient dilution was performed, 100 μL diluent was taken for LB medium coating plate and each wound tissue was coated with 3 pieces of LB medium and cultured at 37°C for 24 h. Colony count: Colony-Forming Units (CFU) = number of colonies * dilution ratio. Quantitatively detect the bacterial infections in the wound and then compare them.

The wound healing rate on the fourteenth day after trauma

The number of burn wounds healed in the three groups was observed and statistically analyzed on the fourteenth day after treatment. Wound healing criteria were: wound closure, epidermal integrity, no wound dehiscence, ulceration, fluid and other wound damage phenomenon occurred again after appropriate activities, the color of wound similar to the surrounding healthy skin color.

Wound dressing times and hospitalization days

The numbers of dressing changes in the three groups from the time after treatment to the discharge time were statistically analyzed and the healing of burn wound during dressing was observed. The numbers of hospitalized days were analyzed. Wound healing criteria were according to the criteria above.

Data processing and statistics

All the data were processed with SPSS 13.0 statistical software. Measurement data were shown by the mean ± the standard deviation ($\bar{x}$ ±S) and the t test was used to compare the three groups. The count data were expressed as a percentage and the groups were compared by using the χ^2 test. When $P<0.05$, the difference was considered statistically significant.

Results

The differences between the thigh circumferences on the first, third, fifth day after treatment and at admission as well as local pain scores

There was no difference between the thigh circumferences of the first day after operation

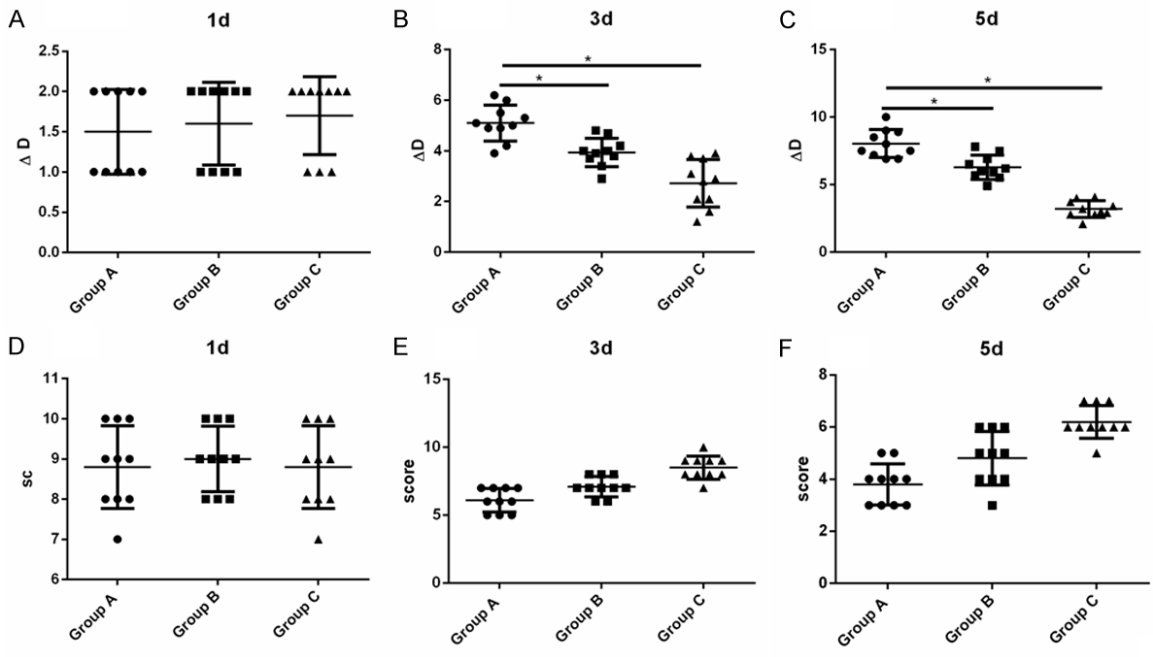

Figure 2. Differences of the thigh circumferences between the first, third, fifth day after operation and the admission time among three groups. A-C: Respectively indicated the differences of the thigh circumferences between the first, third, fifth day after operation and the admission time of Group A, Group B, Group C. D-F: Respectively indicated that the local pain scores on the first, third, fifth day after operation of Group A, Group B, Group C. After comparing two kinds of observation indexes of three groups, there was no significant difference.

and at admission in each group. The differences between the thigh circumferences on the third, fifth day after operation and at admission of dermabrasion group were larger than those of tangential excision group and the tangential excision group's differences were also larger than those of eschar reserving group. The differences were statistically significant ($P<0.05$). There was no significance existing in the local pain scores among three groups on the first, third, fifth day after operation ($P>0.05$) (as shown in **Figure 2**).

The wounds' hematoxylin-eosin staining results on the fifth postoperative day

The hematoxylin-eosin staining on the fifth postoperative day of the dermabrasion group showed that the epidermis structure was integrated, the laminated epithelium thickened, many hair follicles, sweat glands, sebaceous glands and other structures appeared, inflammatory cell infiltration was the least. The epidermal keratinization of the tangential excision group was obvious, and the structures such as hair follicles, sweat glands, sebaceous glands of this group were rare. In addition, its inflammatory cell infiltration was more than that of dermabrasion group. In eschar reserving group, the epidermis structure was not complete and the thickest laminated epithelium existed. It was rare to see hair follicles, sweat glands, sebaceous glands and other structures. Its inflammatory infiltration was the most serious (**Figure 3**).

Quantitative determination of bacteria on the wound surface on the second, fifth, eighth, tenth day after operation

The numbers of bacteria on the wound surface on the second, fifth, eighth after operation of dermabrasion group were less than those of tangential excision group ($P<0.05$), and the numbers of tangential excision group were less than those of eschar reserving group ($P<0.05$). There was no significant statistical significance in bacterial number on the wounds surface on the tenth postoperative day among three groups ($P>0.05$) (**Figure 4**).

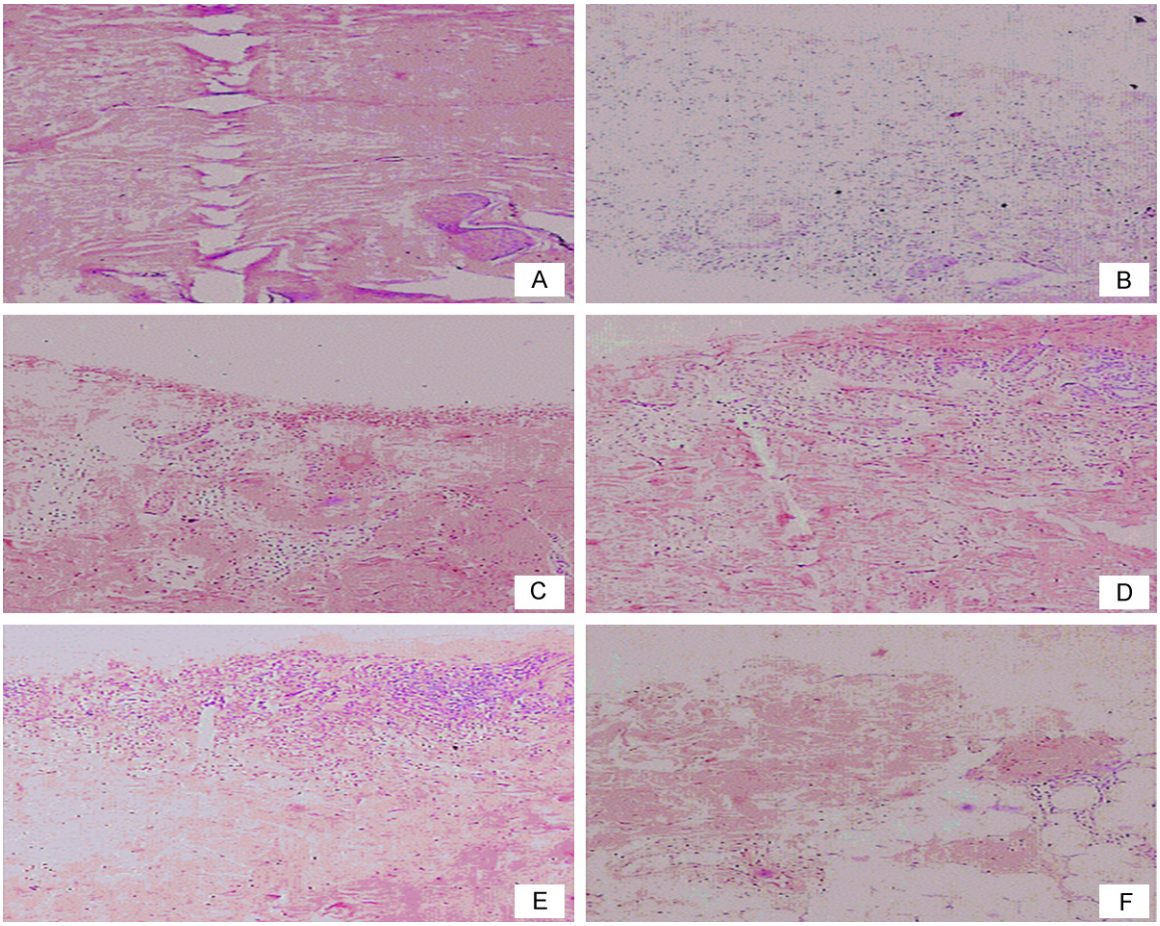

Figure 3. HE staining of the wounds. A, C, E: Respectively indicated the preoperative wound hematoxylin-eosin staining results of Group A, Group B, Group C. B, D, F: Respectively indicated the pathological section results of Group A, Group B, Group C on the fifth day after operation. The pathological section results of Group A on the fifth postoperative day showed that it was obviously close to normal skin tissue. The wound pathological results of Group B and Group C still had necrosis and unimpaired tissue.

The healing rate on the fourteenth day

According to the healing rate on the fourteenth day after operation among three groups, dermabrasion group's healing rate on the fourteenth day after operation was 80%, while tangential excision group was 50% and eschar reserving group was 40%. Obviously, dermabrasion group's healing rate on the fourteenth day was higher than those of other two groups. The difference had statistical significance ($P<0.05$) (As shown in **Figure 5**).

Mean frequency of drug administration and hospital day

Dermabrasion group's mean discharge time was 5~6 days shorter than that of tangential excision group, and was 8~9 days shorter than that of eschar reserving group. The mean dressing numbers of dermabrasion group were 4~5 times shorter than those of tangential excision group, and were 7~8 times shorter than those of eschar reserving group ($P<0.05$) (as shown in **Figure 6**).

Discussion

Deep partial-thickness burn is a kind of tissue damage which is usually caused by heat. It will mainly cause damage to skin epidermis and dermis and subcutaneous tissue [8]. As the body's largest organ, skin itself has a natural barrier. If a large area gets burnt, it will not only result in that the basic sensory, secretion, excretion, body heat regulation and other functions are lost, but also induce mononuclear phagocyte and lymphocyte to produce and

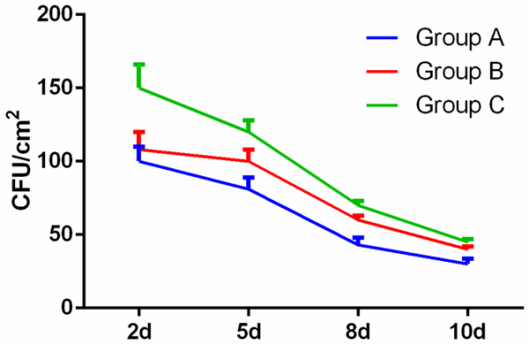

Figure 4. Quantitative determination of bacteria on wound surface. The results of quantitative determination of bacteria on wound surface on the second, fifth, eighth day after operation of Group B and Group C were significantly higher than those of Group A and the differences had statistical significance (P<0.05). There was no significant statistical significance in quantitative determination of bacteria on wound surface on the tenth postoperative day among three groups (P>0.05).

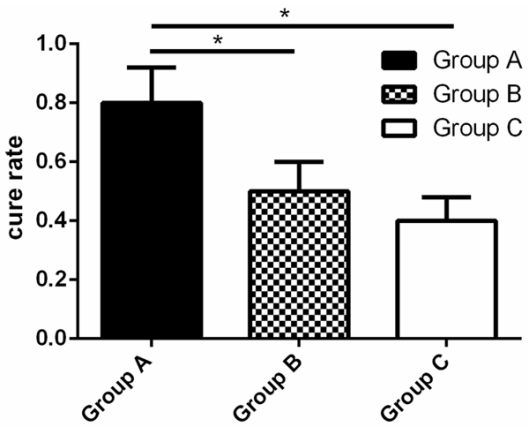

Figure 5. The healing rate on the fourteenth day. The cure rate of the fourteenth day in dermabrasion group was significantly higher than those of tangential excision group and eschar reserving group. *P<0.05, it had statistical significance.

release multiple inflammation mediators, at last which will cause systemic inflammatory response syndrome [9]. Burn wounds can also cause local serious adverse consequences. The possible reasons include: necrotic tissue will produce free radicals, cytotoxicity factors and inflammatory cell infiltration after burn, toxin release after local bacterial infection and wound microcirculation disorder will lead to affusion inadequacy, congestion and edema [10]. And the necrotic tissue on the surface is also an important cause of wound healing. If the necrotic tissue continues to exist, local tissue damage will further aggravate and then wound infection will continue to occur [11, 12]. So removing the burn wound necrotic tissue as early as possible and retaining the organization with normal function as much as possible is an important therapeutic tool to promote wound healing [13, 14].

The degrees of burn local edema can evaluate inflammation. In this study, we measured the circumferences of the burnt thigh after treatment of dermabrasion, tangential excision group and eschar reserving group on the first, third, fifth day, then compared them with the thigh circumferences when the patients were admitted to hospital, and then we obtained the conclusion that the differences between the thigh circumferences of the third and the fifth day after dermabrasion and those of on admission were obviously increased, illustrating that dermabrasion could significantly relieve local inflammation compared with tangential excision group and eschar reserving group. Luzon J and other authors have showed that, to remove necrotic tissue by dermabrasion could effectively cover the burnt wound and reduce the exudation of pus when compared with the tangential excision group [15]. It was consistent with the experimental results.

Burnt skin pathological section can evaluate wound healing [16, 17]. The epidermis, hair follicle, sweat gland and sebaceous gland of the normal skin pathological section have complete structure. The burnt local skin section shows the destruction of epidermal structure integrity, the disappearance of the stratified epithelium, the hair follicle, sweat glands, sebaceous glands and other structures are not complete, as well as the infiltration of inflammatory cell. A large number of experimental studies showed that the pathological features of deep partial-thickness burn wound were the formation of three concentric semilunar zones, namely coagulation necrosis zone, stasis zone and hyperemia zone. The coagulation necrosis zone is irreversible damage due to the complete cessation of microcirculation. Stasis zone is caused by the progressive aggravation of microcirculation injury, usually in the deep or surrounding of the coagulation necrosis zone. The hyperemia zone is caused by microcirculation expansion congestion, which can gradually

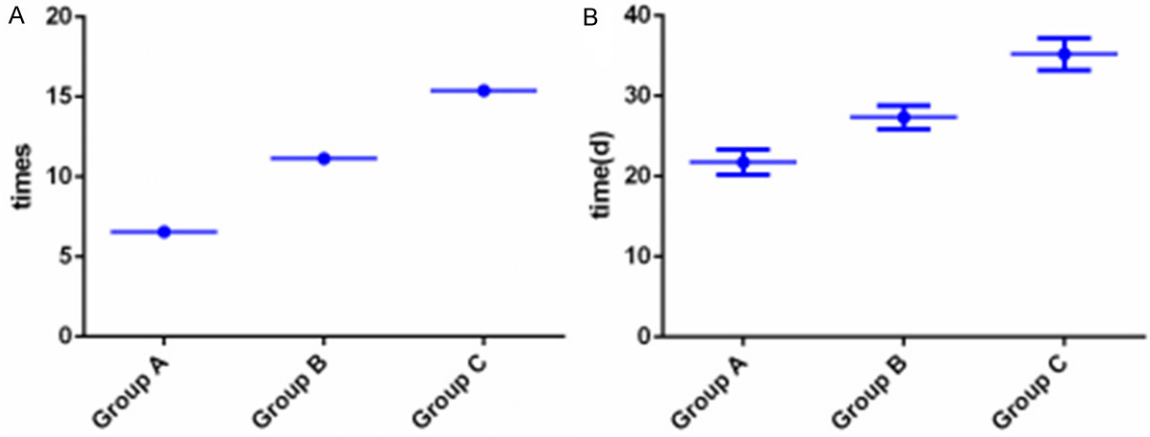

Figure 6. Mean frequency of dressing numbers and discharge time. A: The mean dressing numbers of Group B and Group C were higher than those of Group A and the difference was statistically significant ($P<0.05$). B: The mean discharge time of Group B and Group C was higher than that of Group A and the difference was statistically significant ($P<0.05$).

restore normal function. The stasis zone is the zone of determining the severity of burn, because it is located in the parabiosis [18]. When the blood flow of stasis zone was improved at the early stage of burn, it could reduce further damage and narrow the damage range [19].

Bacterial quantification of wound tissue homogenate is also a good index for evaluating burn wound healing. Sun and others have found that the bacterial content in the burn wound of the dermabrasion group was significantly lower than that of the control group by culturing quantificationally wound tissue homogenate of the dermabrasion group and control group [20]. The experiments also got consistent conclusions. Dermabrasion treatment could remove necrotic tissue in as short a time as possible and retain not-burnt parts of the deep dermis. And it was conducive for the recovery of immune function, which also reduced the amount of burn wound bacteria and the absorption of toxins and prevented the occurrence of further burn wound infection, so as to avoid systemic infection, endotoxemia and systemic inflammatory response syndrome.

Studies have shown that dermabrasion could improve burn wound healing better than tangential excision. But what is the specific mechanism of dermabrasion to promote wound healing? Related researches have demonstrated that dermabrasion could make use of dermabrasion knife with rough surface by means of friction and shearing force to remove necrotic tissue until wound base bleeds like a needlepoint. It could keep healthy tissue and the denatured dermal tissue, reduce the possible of deepen wound infection and systemic infection, so as to reduce inflammation, improve microcirculation, promote tissue regeneration and wound healing [5, 21]. But this method, also considered as a traumatic surgery, would have extensive friction extrusion to the wound, and whether it would produce two strikes on the body was still not clear. Therefore, it was limited to use widely in deep burn patients. Dermabrasion needed further improvement and concern, with biological dressings and other methods which were conducive to burn wound healing.

Because of the inadequacy of clinical experiment sample, this study only selected 90 cases of young patients with lower extremity deep partial-thickness burn as experimental objects, which had some limitations. So, more samples should be needed to confirm that the dermabrasion treatment could accelerate the deep partial-thickness burn wound healing.

In conclusion, dermabrasion treatment could alleviate local inflammation, the degrees of edema and pain, reduce the wound bacterial colonization rate, reduce the mean dressing changing frequency and the duration of hospitalization, and when compared to tangential

excision and eschar reserving, the treatment of dermabrasion was more conducive to deep partial-thickness burn wound healing.

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Disclosure of conflict of interest

None.

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References

[1] Ma F. Accumulative eschar after burn. Clin Case Rep 2015; 4: 151-153.

[2] Kim S and Kwon J. Thymosin beta 4 improves dermal burn wound healing via downregulation of receptor of advanced glycation end products in db/db mice. Biochim Biophys Acta 2014; 1840: 3452-3459.

[3] Milner CS and Brindle NPJ. Burn induced SIRS/sepsis-The role of Endothelial Tie receptors in mediating the anti-inflammatory effects of Angiopoietin-1. British Journal of Surgery 2011.

[4] Chiu HW, Chen CH, Chang JN and Hsu YH. Far-infrared promotes burn wound healing by suppressing NLRP3 inflammasome caused by enhanced autophagy. J Mol Med 2016; 94: 1-11.

[5] Akbari H, Fatemi MJ, Iranpour M, Khodarahmi A, Baghaee M, Pedram MS, Saleh S and Araghi S. The healing effect of nettle extract on second degree burn wounds. World J Plast Surg 2015; 4: 23-28.

[6] Kang BK, Choi JH, Jeong KH, Park JM, Suh DH, Lee SJ, Shin MK. A study of the effects of physical dermabrasion combined with chemical peeling in porcine skin. J Cosmet Laser Ther 2015; 17: 24-30.

[7] Mosier MJ and Gibran NS. Surgical excision of the burn wound. Clin Plast Surg 2009; 36: 617-625.

[8] Zhang Y, Bai X, Wang Y, Li N, Li X, Han F, Su L and Hu D. Role for heat shock protein 90α in the proliferation and migration of HaCaT cells and in the deep second-degree burn wound healing in mice. PLoS One 2014; 9: e103723.

[9] Estebanvives R, Choi MS, Young MT, Over P, Ziembicki J, Corcos A and Gerlach JC. Second-degree burns with six etiologies treated with autologous noncultured cell-spray grafting. Burns 2016; 42: e99-e106.

[10] Venter NG, Marques RG, Santos JS and Monte-Alto-Costa A. Use of platelet-rich plasma in deep second- and third-degree burns. Burns 2016; 42: 807-814.

[11] Wu Q, Wang JH, Li ZQ, Ren JL and Wu YH. Expression of vascular endothelial growth factor in deep second-degree scald wounds in rats. Zhongguo Yi Xue Ke Xue Yuan Xue Bao 2014; 36: 650-653.

[12] Zeng M, Zhi Y, Liu W, Zhang W and Xu J. Clinical study on local application of low-dose insulin for promoting wound healing after operation for deep burns. Exp Ther Med 2016; 12: 3221-3226.

[13] Yontar Y, Coruh A, Dinc N and Kontas O. Steel wool-aided dermabrasion of deep partial-thickness burns. J Burn Care Res 2016; [Epub ahead of print].

[14] Macri LK, Singer AJ, Mcclain SA, Crawford L, Prasad A, Kohn J and Clark RA. Immediate tangential excision accelerates wound closure but does not reduce scarring of mid-dermal porcine burns. Ann Burns Fire Disasters 2016; 29: 54-61.

[15] Luzon J. Dermabrasion devices and systems: US. 2014.

[16] Camacho-Alonso F and López-Jornet P. Clinical-pathological study of the healing of wounds provoked on the dorso-lingual mucosa in 186 albino rats. Otolaryngol Head Neck Surg 2007; 136: 119-124.

[17] Guo ZQ, Qiu L, Gao Y, Li JH, Zhang XH, Yang XL, Peszel A and Chen XL. Use of porcine acellular dermal matrix following early dermabrasion reduces length of stay in extensive deep dermal burns. Burns 2016; 42: 598-604.

[18] Yan Z, Xiao NK, Liu CL, Xiao TY, Hu JY, Chen B, Chen BH, Yang GC and Liang LP. Study on the effect of Salvia miltiorrhiza on microcirculation of burn wounds in early stage. Medical Journal of Defending Forces in Northwest China 1999; 20: 100-2.

[19] Yin ZG, Huang YS and Li BX. Changes and relations between heart function and organ blood flow in rats at early stage of severe burn. Zhonghua Shao Shang Za Zhi 2010; 26: 10-13.

[20] Sun XF. Study on the mechanism of controlling deep second degree burn wound infection and promoting healing by electric power. Guangxi Medical University 2006.

[21] Allemann IB and Hafner J. Dermabrasion. 2012.