A Novel Method for Wound Healing—Skin Suspension Accelerates Donor Site Wound Healing

Ma Dan, MD, PhD;1 Liu Ming, MD;1 Ma Bing, MD, PhD;2 Wang XiaoJuan, MD;3 Pen Yang, MD;3 Zhang Pin, MD;2 Li ChenYang, MD;2 Liu YueMing, MD, PhD;4 Wei Ke, MD;4 Xu XueFeng, MD;4 Zhan Hong, MD;2 Zhang Wei, MD;2 Liu YiLun, MD

Abstract: The purpose of this study was to apply a skin suspension to accelerate wound healing at the skin donor site. Methods. A small fragment of skin was collected after skin transplantation had been performed. The skin suspension was prepared by mixing the small fragments of skin tissue with the same volume of normal saline. The suspension was then applied to the donor site. Donor sites without skin suspension were employed as controls. Results. Faster healing was found at the donor sites that had been covered with skin suspension and with less scar formation compared to controls. Conclusion. Skin suspension prepared from residual graft skin can ameliorate donor site wound healing.

The management of the donor site after harvesting a skin graft widely applied in plastic surgery as a reconstructive technique is a subject of utmost interest in clinical practice. However, current numerous donor site dressings can cause many problems, such as pain, pruritus, scars, and even functional disturbance. Incomplete healing can be found as a result of less residual appendants or infection, which could increase discomfort and treatment costs for patients.1,2

The debate continues about what skin graft donor-site dressing can provide the best outcomes for patients at the lowest cost. In the authors’ clinical practice, small fragments of skin graft cut to the size of the wound were collected and prepared into a skin suspension. The skin suspension was applied to the donor sites, which could significantly accelerate donor site wound healing.

Methods

A total of 60 patients undergoing the split-thickness skin grafting operation between May 2006 and October 2009 were prospectively randomized into an experimental group or control group (Table 1). The ethical committee of Xinqiao Hospital, the first Affiliated Hospital of Chengdu Medical College, approved the study. The patients were assigned to the experimental or control group in a 1:1 ratio. The continuous variables were compared using the independent sample t-test, and the categorical variables were compared using the chi-square test.
College, approved the trial protocols and all the patients provided informed consent to participate.

All of the split-thickness skin grafts were harvested from the thigh using a motorized dermatome with a depth setting of 0.45 mm. The square-shaped raw surface of the donor sites was close to 1%–2% TBSA.

**KEYPOINTS**
- Small fragments of skin graft cut to the size of the wound were collected and prepared into a skin suspension.
- The skin suspension in a ratio of 1:10 of skin tissue suspension to donor site area was painted onto the skin graft donor site uniformly and then covered with monolayer petrolatum gauze and sterilized multilayer dressings.

The skin suspension was applied directly to the wound in patients from the experimental group. The residual skin tissue was collected after the wounds had been completely covered by skin graft at the skin transplantation area. The minimum ratio of skin tissue suspension to the raw donor site square was 1:10. If insufficient tissue was available, it was obtained from the border of the donor site using a roller dermatome. Next, the skin tissue suspension was soaked in 0.1% benzalkonium bromide for 5 minutes (Figure 1A). Following sterilization, the collected tissue was sheared using surgical scissors to prepare the skin suspension with the same volume of normal saline used as the solvent. The skin suspension was painted onto the donor site uniformly, and then covered with monolayer petrolatum gauze and sterilized multilayer dressings. Three days later, the external dressing was removed, and then 2% merbromin was painted onto the monolayer petrolatum gauze. However, in control group patients, there was no difference in the dressings except that no skin suspension was applied at the wound surface.

Following IRB protocol approval, the authors identified all patients who underwent donor site healing with skin suspension technique by the two senior authors (Dr. Dan, Dr. Ming) at the Third Military Medical University and the Chengdu Medical College between 2006 and 2009. Using a standardized data template, a comprehensive, retrospective chart review of these patients was performed to obtain basic demographic data, medical histories, comorbid conditions, surgical indications, specific defect characteristics including size and operation location, hospitalization complications, and follow-up care. The therapeutic effect was assessed by healing time standardized by complete wound epithelization. Additionally, the healing quality, inclusive of skin surface thickness, blister formation, and pruritus was also examined for evaluation of the clinical outcomes.

Results are expressed as means ± SD. Data were analyzed with the Student’s t test and Difference Square

**KEYPOINTS**
- The experimental group had a shorter time to epithelization and significantly thickened de novo skin compared to control group subjects.
Analysis as appropriate for the data set. $P < 0.05$ was considered statistically significant.

**Results**

**Healing.** Healing was defined as whether there was epithelial coverage or not. Donor site healing time was (10.2 ± 3) days in the skin suspension transplantation group, which was significantly shorter than that in the control group (12.5 ± 4) days (Figure 1B, Figure 2).

**Blister formation.** In order to estimate the thickness of the healing skin, the authors observed blister formation in all patients. Blisters were formed in only 6.7% ($n = 2$) of those patients with the skin suspension transplantation but in 66.7% ($n = 20$) of patients in the control group ($P < 0.05$; Figure 3A).

**Pain.** Donor site pain was evaluated by the need for analgesia. Only 40% of ($n = 12$) patients undergoing skin suspension transplantation reported considerable pain, but the percentage in the control group was as high as 90% ($n = 27$; Figure 3B).

**Pruritus.** Pruritus was one of the main indices of assessing the overall level of comfort among patients. Complaints of pruritus were found in 93.3% of ($n = 28$) patients from the control group, significantly higher than that in patients undergoing skin suspension transplantation (56.7%, $n = 17$ [Figure 3C]).

**Discussion**

Usually, thick and inflexible hypertrophic scars will form on donor site skin in Chinese people. The patients often report itchiness and pain on the scars. Some patients report that they cannot sleep well at night due to the itch severity and cannot stop scratching the scars. The scratching and subsequent infections lead to scar overgrowth. Hypertrophic scar contraction on thighs even influences how patients walk. However, this phenomenon is not found among Caucasian people. For this reason, controlling the scar from overgrowth and contraction on skin donor sites is very important for Chinese patients.

The ideal skin graft donor-site treatment would promote healing and be comfortable for the patient, impervious to infectious organisms, easily applied, and cost effective. In the authors' clinical practice, we have
found that skin suspension applied at the donor site could reduce healing times and improve healing quality. Thus, the present study may provide a new effective method for donor site management.

In the process of skin graft transplant operation, there are some conditions that should be taken into consideration. The skin grafts must be pruned to meet the requirements of the wound (e.g., an irregularly shaped wound, a thin skin graft border). Residual skin tissue can always be acquired during the operation. The authors were interested in realizing the full potential of this seemingly useless residual skin tissue.

It is known that fibroblasts could be obtained from the skin tissue suspension cultured in DMEM supplemented with 10% FCS. The skin graft donor site is always accompanied with plasmexhidrosis and the temperature is around 37˚C, so the local surrounding of the donor site is similar with that of the cell culture. Based on these views, it was presumed that planting the residual skin tissue to the donor site could obviously increase the number of fibroblasts; meanwhile, the skin tissue suspension could also be alive dependent on the plasmexhidrosis, which could notably augment the number of epidermic cells. Both fibroblasts and epidermic cells could not only excrete amount of cytokines facilitating the wound healing, but also participate in the healing process by amplifying themselves.

In the present study, the authors performed a functional study aiming at elucidation of the effect of the skin tissue suspension on the donor site. Tight adherence of the skin tissue suspension to the donor site, epidermal diffusion, and healing of the wound at the donor site could be observed at 3, 6, and 10 days after the operation, respectively. Compared with those in the control group, shorter time for epithelization and significantly thickened de novo skin could be found in the experimental group. Moreover, the skin tissue suspension applied at the donor site could enhance the skin abradability without formation of blisters.

Conclusion

The time to epithelization was positively correlated with the amount of applied skin tissue suspension. The proportion of the skin tissue suspension to the size of the donor site should be maintained at 1:10. Additionally, the flowability of the skin tissue suspension could lead to maldistribution of the tissues; therefore, the cutting instrument and the tissue vector are key problems that remain to be solved. Furthermore, further follow-up visits should be conducted in order to observe any postoperative inhibitory effects on the hyperplastic scars due to skin suspension transplantation.

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References

5. Forouzandeh F, Jalili RB, Germain M, Duronio V, Ghahary A. Skin cells, but not T cells, are resistant to indoleamine 2,3-dioxygenase (IDO) expressed by allogeneic fibroblasts. Wound Repair Regen. 2008;16(3):379–387.