

COGRAFTS OF ARTIFICIAL DERMIS MATRIX AND AUTOGENETIC SPLIT-THICKNESS OF REPAIRED SKIN IN SEVERE HAND WOUNDS IN PATIENTS WITH DEEP BURNS

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Abstract – The aim of this paper was to evaluate the effect of using artificial dermis matrix plus autologous split-thickness skin (ADM and ASTS) in the treatment of deep-burns in hands of severely burned patients. We recruited a total of 58 patients with large area burns greater than 80% that were eschar-excised. Twenty-eight of them were treated with ADM and ASTS (test group); 30 were treated with autologous medium-thickness skin (AMTS) (control group). The healing time of the hand wound was noted, clinical and photographic evaluations were performed, and a Jebsen-Taylor hand function test was compared and analyzed in the two groups. The wound healing time in the test group (24.22 ± 3.34 days) were longer than that of the control group (13.42 ± 3.36 days) and statistically significant. The healing time of skin graft donor sites was shorter than that of the control group (7.14 ± 1.63 vs. 14.28 ± 2.37 days) and statistically significant ($P < 0.05$). The 3rd and 6th month follow-up with clinical and functional evaluations revealed no differences between the two groups. In addition, there was no obvious scar formation and less pigmentation in either group. The repair of deeply burned hands with artificial dermis matrix was beneficial to both wound healing and the donor site, and was beneficial to the whole body rehabilitation of severely burned patients.

Key words: Hands deep burn, artificial dermis matrix, autologous split-thickness skin, autologous medium-thickness skin.

INTRODUCTION

Methods for handling burn wounds have changed in recent decades; an aggressive surgical approach with early tangential excision and wound closure is being applied increasingly (van der Smissen et al., 2011). As a result, the role of rehabilitation has become increasingly important (Yue et al., 2008). Severe burn survivors often undergo a prolonged course of rehabilitation, and autografts from uninjured skin remain the mainstay of treatment for many patients in burn treatment, plastic and reconstructive surgery (Ben-Bassat et al., 2001; Ojeh et al., 2001; Vriens et al., 2008). The challenge is that burn patients invariably

lack sufficient adequate skin donor sites, which means the functional parts of patients (such as hands) cannot receive autologous skin at an early stage (Dantzer et al., 2003; Rubis et al., 2002; Yoshihiro et al., 2004), resulting in incomplete function.

The goal of wound coverage is to replace lost tissue with similar tissue to optimize functional and esthetic outcomes. Skin grafts are commonly used to cover soft tissue defects. However, it is not always possible to replace the full thickness of the skin or underlying soft tissue. Therefore, split thickness grafts are commonly used for wound coverage. In the past few years, dermal substitutes were introduced, and

these alternatives for burn wound coverage and healing are increasingly used (Halmy et al., 2008; Pena et al., 2012), which greatly alleviates the insufficiency of autologous skin source lacking in large area burn patients.

Given the successful experiences with artificial dermis matrix (Wain et al., 2012) in the treatment of deep burn patients, we used artificial dermis matrix plus autologous split-thickness skin (ADM and ASTS) to treat deep-burn hands in severely burned patients.

PATIENTS AND METHODS

Patients

The study was performed in the Department of Burn and Plastic Surgery in the Affiliated Hospital of Logistics College of Chinese People's Armed Police Forces. The study was approved and registered by our hospital Ethics Committee in January 2008, who approved the screening, treatment, and data collection of these patients. Treatment was explained to the patients and all subjects signed a written informed consent form. All works were undertaken following the provisions of the Declaration of Helsinki.

The hands of deeply burned patients with eschar excised (or shaving) were recruited in our hospital from January 2008 to January 2012 and investigated. The 58 patients were divided into two groups; 28 of them were recruited in the test group. They were treated with cografts of artificial dermis matrix and autogenetic split-thickness skin (ADM and ASTS). There were 16 males and 12 females. The average age of test group was 28.4 ± 3.6 , and the average area of the burn was $88.4\% \pm 4.3\%$ TBSA (Total Body Surface Area). Thirty patients treated with autogenetic mid-thickness skin (AMTS) were recruited in the control group. This group was comprised of 17 male and 13 female patients. Their average age was 26.8 ± 4.6 , and average area of the burn was $87.8\% \pm 3.7\%$ TBSA. There were no significant difference in sex and age between the two groups ($P > 0.05$). No head burn occurred in either group, and the depth of the burn was

deep burn. The time from injury to admission was 1 to 12 hours with an average of 4 hours.

Treatment procedure

All operations were performed under complete general anesthesia; tourniquets were used on the upper limb. For the patients with deep II degree burns (test group, $n=11$; control group, $n=14$), we mainly used eschar shaving to remove necrotic tissue. For patients with deep III degree burn, eschar excision was used. The necrotic tissue was excised from the superficial layer of the deep fasciae.

The surgical area was from two sides of the opisthenar to the central line of the thenar, from finger-back to distal of the first knuckle, near to the end wrist crease. Non-damaged veins and tissues were retained to the greatest degree during surgery. Exposure of tendons was avoided. The surface of eschar shaving was first cleaned up with 3% dioxigen, isotonic Na chloride and antibiotic saline. Hemorrhage dot was treated by electrocoagulation to stop hemostasis, soaked with adrenalin hydrochloride saline gauze for 10 min and electrocoagulation was used to stop hemostasis again; the skin grafting operation was ready to start.

Large pieces of autologous skin grafts with full thickness were performed in control group, after which the hands was fixed with pressure bandaging. Seven days after surgery, the bandages were disintwined; treatment drugs were applied until the grafted skin survived (Fig. 1.A).

For the test group, we selected an artificial dermis matrix with appropriate dimensions according to the shape and area of the wound. Suture fixation was with a collagen sponge cling (Fig. 1.C). Sterile gauze was applied externally and fixed with pressure bandaging. Treatment drugs were replaced every 4 days after surgery (Fig. 1.D). A second operation was carried out 2 weeks after the first surgery. When the artificial dermis scaffold silicon layer was removed, a full of fresh granulation tissue formation could be seen (Fig. 1. B). Skin of 0.25 mm split-thickness from

the head was grafted. Periodic dressing change took place every 7 days after surgery until the grafted skin survived.

Observation methods

The wound healing time of wound and skin graft donor sites were recorded in both groups. After wound healing, patients were asked for follow up at 3 and 6 months after discharge. Clinical and photographic evaluations of the joint function and skin function were performed to evaluate skin elasticity, range of articular movement, prehensile strength, scar and pigmentation. The degrees of the hypertrophic scars (HS) of these patients were divided into mild, moderate or severe. The texture of the mild HS was slightly tough, with a thickness of less than 3 mm. The moderate HS was tensile, with a depth of 3-6 mm thicker than normal skin (NS). The severe HS was hard, with a thickness greater than 6 mm. Pigmentation was slightly more purple than normal skin, the severe cases were dark violet, and the moderate one was between purple and dark violet. Hand functions were assessed by the Jebsen-Taylor hand function test (Schneider et al., 2012).

Statistical procedures

SPSS 11.0 software was used for statistical analysis. For statistical data analysis, descriptive statistics and the Wilcoxon test were used, defining statistic significant values $p < 0.05$.

RESULTS

Four patients died during the treatment. One was from the test group and three were from the control group. One patient from the test group gave up the treatment because of financial reasons.

The wound healing time was 24.22 ± 3.34 days in the test group (N= 26) and 13.42 ± 3.36 days in the control group (N= 27). The difference between the two groups was very significant ($P < 0.05$). The healing time of the donor sites in the test and control

groups were 7.14 ± 1.63 days and 14.28 ± 2.37 days, respectively ($P < 0.05$) (Table 1).

During the follow-up period of 3 and 6 months, no obvious scar proliferation or pigmentation occurred in either group. The skin in the grafted area displayed good elasticity and a fine appearance. All subjects displayed a normal Jebsen-Taylor hand function test and exhibited no upper extremity burns. Compared with discharge, the mean Jebsen-Taylor hand function test times improved by an average of 60% ($p < 0.05$) (Table 2).

The skin donor site in the test group had an inconspicuous scar and no obvious pigmentation (Fig. 1.E); hair growth and skin regrafting were not affected. The skin donor site in the control group exhibited regional scar hyperplasia and pigmentation, and skin grafting could not be repeated.

DISCUSSION

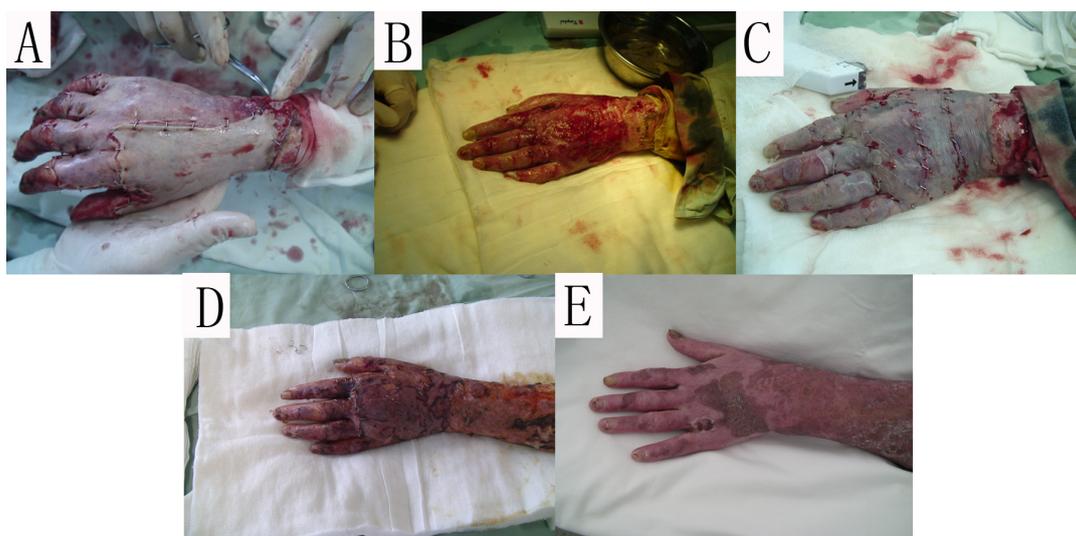
Autologous skin grafting has been limited by availability and is associated with additional scarring (Jones, et al., 2003; Pena et al., 2012; Wood et al., 2007). Severe burn patients often lack sufficient skin donor sites. This has made it necessary to seek various ways for reducing the use of autogenous skin to treat large deeply burned wounds. In addition to the lack of autologous grafting skin, the systemic condition is poor in large-area burn patients. Autogenetic mid-thickness skin could repair the hand skin to sustained hand function; at the same time, it burdens the patient's body (healing in donor site), which reduces the patient's body resistance and increases patient mortality (Kakagia et al., 2012; Wisser and Steffes, 2003; YE Qing, 2011). Although the traditional approach also can be applied to good effect, the operation is complicated, and the requirement for skin graft and donor site are high and could induce the inflammatory response syndrome, renal failure, as well as heavy pigmentation and scarring (Zhao, et al., 2008), thus limiting its clinical applications. It is for these reasons that skin substitutes are necessary.

Table 1. comparison of healing times in the control and treated groups.

	Case number	Wound healing time (day)	Healing time of donor sites (day)	P value
Control group	26	24.22±3.34	7.14±1.63	<0.05
Test group	27	13.42±3.36	14.28±2.37	<0.05

Table 2. the comparison of Mean Jebsen-Taylor Hand Function Test times (second) in test group and control group.

	Mean discharge data	3 rd month follow up data	6 th month follow up data	P value (compared with discharge)
Test group	77±16	42±8	38±6	<0.01
Control group	74±21	46±7	37±5	<0.01
P value (compared with control)	>0.05	>0.05	>0.05	



Figs. 1. Deeply burned hands were repaired with artificial dermis matrix plus autologous split-thickness skin (ADM & ASTS) and autologous medium-thickness skin (AMTS). **A**, control group – the entire thick skin in the uninjured parts was grafted at the escharectomy area in the back of the right hand; **B**, experimental group – the artificial dermal layer of silica gel was removed after transplantation of the artificial dermis matrix 2 weeks later and granulation tissues filled the left hand; **C**, Experimental group – the artificial dermis stent granulation matrix grafts in the head split-thickness skin. (Left hand); **D**, experimental group – dressing was changed every 4 days; the situation of skin graft on the 10th day (left hand); **E**, experimental group – the appearance, scar hyperplasia and pigmentation in the left hand at 3 months after the operation.

Common scaffold materials include agarose, alginate, chitosan, collagen, fibrin, gelatin and hyaluronic acid (HA) etc. (Drury and Mooney, 2003; Gerlach et al., 2011), in which collagen is the most widely used. Yannas and colleagues (Yannas and Burke 1980; Yannas et al., 2004) invented bilayer artificial skin, composed of a temporary silastic epidermis and a porous collagen-chondroitin 6-sulfate fibrillar dermis. Ani-

mal and human trials proved the artificial skin regenerates the dermis. The artificial dermis has been used for the treatment of full-thickness skin defects resulting from burns and injuries (Shariff et al., 2007; Yannas et al., 1982; Yannas et al., 1981).

The artificial dermis used in our study was a new dual-structure artificial skin, based on Integra[®],

which comprised an outer silicone layer and an inner collagen sponge layer. It can repair full-thickness skin defects caused by disease or wounds and cover up exposed bone and tendons (Chen et al., 2009; Mardini et al., 2009). Its main advantages are: (1) the outer silicone membrane of the artificial dermis can protect the wound from contamination by external bacteria; (2) the collagen sponge, which is the major ingredient of artificial dermis, has low antigenicity, accelerating collagenase vascularization. Artificial dermis can effectively establish sufficient blood circulation in early post transplantation. After 2-3 weeks, phase II split-thickness autologous skin transplantation can be performed; (3) there was no wound contraction after the surgery, no obvious hypertrophic scarring and pigmentation. The second skin graft grows well, has a good appearance and does not interfere with functions of hands with high survival rate.

The results of this study show that artificial dermis could solve the problem of taking autogenous skin when treating patients with extensive burns. This also provides favorable conditions for subsequent treatment. Patients do not need split thick auto skin (TTS) to cover wound surface at the early stage. Although this surgical treatment delays the healing time of hands, the solution is more beneficial in increasing the systemic comprehensive treatment and the successful rate of avoiding grafting medium thick skin. After the second-stage operation, there were no visible flaws in appearance and joint function compared to traditional surgery. The deficiencies of this procedure are the need for two operations, prolonged wound healing time and high cost.

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