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Management of neck contractures by single-stage dermal substitutes and skin grafting in extensive burn patients

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Purpose: Severe neck contracture is a problem that must be resolved by priority. We consider the best contracture treatment to be the full-thickness skin graft. However, clinicians often encounter patients, especially extensive burn patients, who have insufficient donor sites for the full-thickness skin graft. We treated extensive burn patients with neck scar contractures with a split-thickness skin graft (STSG) combined with dermal substitutes. The purpose of this study was to evaluate clinical outcomes of neck contracture treatment in extensive burn patients performing STSG with dermal substitutes as adjuvant treatment.

Methods: We analyzed the retrospective clinical and photographic records of 28 patients with severe neck contracture who were admitted to Hallym University Hangang Sacred Heart Hospital, Seoul, Korea, from January 2012 to December 2012. We performed STSG in combination with dermal substitutes to minimize the degree of contracture.

Results: The overall take rate of skin to dermal substitutes was 95.9%, and no grafts failed to affect recontracture except in one patient with a partial loss of artificial dermis who underwent a follow-up skin graft without any problems. Excellent/good outcomes were shown in 27 out of 28 patients.

Conclusion: In extensive burn patients, skin grafting in combination with dermal substitutes can be an alternative to STSG alone for contracture release.

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Key Words: Neck contracture, Dermal substitutes, Reconstruction, Burn

INTRODUCTION

Scar contractures—which cause esthetic, functional, psychological, and social problems—are common in extensive burn patients. The head and neck area is one of the commonly involved regions after burn injuries. Neck contractures lead to variable degrees of deformity of the lower lip, chin, neck, and chest. The sequelae of neck contractures may be more severe when the burned area includes joints (e.g., fingers, elbows, and axillae and popliteal areas). Neck movement limitations can also develop in neck contracture cases, and cervical spine disease or lower lip disturbance (e.g., difficulty eating) can even occur. Patients with severe neck contractures often experience difficulty with endotracheal intubation. Therefore, severe neck contracture is a problem that must be resolved by priority. The standard treatments include bioengineered dermal substitutes, tissue expanders, local or free flaps, and autologous skin grafting [1]. Most methods restore function, but they usually result in unfavorable cosmetic contours. If adjacent skin or distant skin is available, such as the inguinal area and the widest donor areas, skin grafts and variable reconstructive operations can be performed. However, extensive burn patients usually suffer deep partial-thickness burns and full-thickness burns, and there are insufficient skin donor sites for grafts and

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reconstructions. Therefore, plastic and reconstructive surgeons have difficulties managing neck burn injuries in extensive burn patients [2,3]. In addition, scar management is usually delayed, inadequate, or neglected, since the first consideration of these patients' treatment is survival rather than functional and aesthetic outcome. The application of dermal substitutes is an appropriate method to minimize scar contractures and optimize the quality of grafted areas with loss of function, elasticity, and pliability. During the last a year, we treated extensive burn patients with neck scar contractures with split-thickness skin grafts (STSGs) combined with dermal substitutes. The purpose of this study was to evaluate clinical outcomes of neck contracture treatment in extensive burn patients performing STSG with dermal substitutes as adjuvant treatment.

METHODS

We analyzed the retrospective clinical records of 28 patients admitted to Hangang Sacred Heart Hospital, Seoul, Korea, from January 2012 to December 2012. All patients had neck contractures that could not be resolved by local flaps or full-thickness skin grafts alone due to insufficient donor sites. We conducted STSGs in combination with artificial dermal substitutes (AlloDerm, Matriderm) in all patients.

AlloDerm (LifeCell Inc., The Woodlands, TX, USA) is a cryopreserved extracellular matrix tissue that originates from cadaver skin from which all cellular components have been removed. It has the advantage of reducing donor site morbidity by harvesting minimal autograft skin. Matriderm (Dr. Suwelack Skin and Health Care AG, Billerbeck, Germany) is a three-dimensional matrix consisting of collagen and elastin, comparable to the structure of human dermis. These dermal substitutes are used in a single-stage procedure and result in minimal scar formation when combined with STSG.

All scar revisions were performed in the following manner. Neck scars were fully removed until normal tissue, usually the subcutaneous fat, was exposed. Then, meticulous hemostasis with bipolar cauterization and irrigation was undertaken. Thereafter, AlloDerm or Matriderm as artificial dermal substitutes were placed on the fresh wound bed, secured at the edges with single stitches or metal clips, and covered with nonmeshed split skin from available donor sites. Then, conventional tie-over dressing was completed. All patients were positioned with the neck hyperextended and fed through a nasogastric tube in order to minimize masticating movements during five postoperative days.

Table 1. Patients' demographics and characteristics of Alloderm and Matriderm group

Variable	Total (n = 28)	Alloderm (n= 15)	Matriderm (n = 13)	P-value[a]
Age (yr)	32.4 ± 16.1 (4–69)	33.5 ± 16.2 (10–69)	31.1 ± 16.5 (4–63)	0.695
Sex				
Male/female	15/13	8/7	7/6	1.000
TBSA burned (%)	54.4 ± 10.1 (42–78)	53.5 ± 10.6 (42–73)	55.4 ± 9.8 (42–78)	0.576
Causes				0.183
FB	22	13	9	
SB	5	1	4	
EB	1	1	0	
Operation (mo)	12.4 ± 2.9 (7–18)	11.5 ± 2.8 (7–16)	13.3 ± 3.0 (9–18)	0.113
Complication	39.3%	40.0%	30.8%	0.700
None	17	8	9	
Seroma	8	5	3	
Hematoma	2	1	1	
Infection	1	1	0	
Take rate (%)	95.9 ± 5.6 (74–100)	93.9 ± 6.9 (74–100)	98.1 ± 2.0 (95–100)	0.058
VSS preoperative	9.54 ± 1.10 (7–11)	9.53 ± 1.06 (8–11)	9.54 ± 1.20 (7–11)	0.856
VSS at 1 yr later	2.36 ± 0.91 (1–4)	2.47 ± 0.92 (1–4)	2.23 ± 0.93 (1–4)	0.555
Outcomes				0.352
Excellent	18	8	10	
Good	9	6	3	
Fair	1	1	0	
Poor	-	-	-	
F/U period (mo)	16.0 ± 3.2 (12–24)	15.3 ± 3.4 (12–24)	16.9 ±2.7 (12–22)	0.193

Values are presented as mean ± standard deviation (range).
TBSA, total body surface area; FB, flame burn; SB, scald burn; EB, electrical burn; VSS, Vancouver scar scale; F/U, follow-up.
[a]Continuous variables were analyzed with the independent t-test when they were normally distributed and the nonparametric independent t-test when they were abnormally distributed. Categorical variables were analyzed with the chi-square test.

Table 2. Patients' data undergoing split-thickness skin graft using dermal substitutes

No	Sex	Age (yr)	Type	TBSA burned (%)	Dermal substitutes	Operation (mo)	Complication	Take rate (%)	VSS preop. (day)	VSS postop. (day)	Outcome	F/U (mo)
1	F	4	SB	50	Matriderm	7	-	100	10	4	Good	16
2	M	38	FB	55	Matriderm	16	-	100	10	3	Excellent	12
3	M	19	FB	45	Alloderm	13	Seroma	100	9	2	Excellent	14
4	F	34	FB	67	Alloderm	9	-	95	8	1	Excellent	13
5	M	63	FB	42	Matriderm	10	Seroma	98	9	2	Excellent	19
6	M	36	FB	72	Alloderm	11	-	93	9	3	Good	12
7	M	40	FB	62	Matriderm	14	-	100	11	1	Excellent	18
8	F	42	SB	51	Matriderm	12	-	99	9	1	Excellent	16
9	M	35	FB	57	Alloderm	16	Seroma	92	11	3	Good	24
10	F	18	FB	53	Matriderm	13	-	95	10	2	Excellent	17
11	F	11	SB	47	Alloderm	8	Seroma	93	9	3	Good	14
12	F	37	FB	52	Matriderm	9	Hematoma	96	7	3	Excellent	18
13	M	31	FB	65	Matriderm	10	Seroma	98	9	1	Excellent	19
14	F	45	FB	52	Alloderm	11	-	99	11	3	Excellent	12
15	M	22	EB	44	Alloderm	14	-	96	10	2	Good	15
16	F	5	SB	49	Matriderm	11	-	98	11	2	Excellent	12
17	F	39	FB	73	Alloderm	16	-	98	9	2	Excellent	14
18	M	12	FB	42	Alloderm	18	Seroma	99	8	1	Excellent	17
19	F	26	FB	78	Matriderm	17	-	96	11	3	Good	18
20	M	10	FB	48	Alloderm	15	Hematoma	92	9	2	Good	16
21	M	48	FB	45	Alloderm	12	-	100	9	2	Excellent	12
22	M	38	FB	51	Alloderm	9	-	100	10	2	Excellent	16
23	F	69	FB	43	Alloderm	11	Infection	74	11	4	Fair	20
24	M	20	SB	43	Matriderm	14	-	100	8	3	Excellent	16
25	F	43	FB	52	Alloderm	12	-	93	9	3	Excellent	12
26	M	46	FB	63	Matriderm	13	-	100	9	2	Good	16
27	M	34	FB	57	Matriderm	16	Seroma	95	10	2	Excellent	22
28	F	42	FB	64	Alloderm	9	Seroma	85	11	4	Good	18

TBSA, total body surface area; VSS, Vancouver scar scale; preop., preoperation; postop., postoperation; F/U, follow-up; SB, scald burn; FB, flame burn; EB, electrical burn.

We inspected the following variables: age, gender, total body surface area (TBSA) burned, cause of injury, type of artificial dermis, take rate of skin, complications, Vancouver scar scale (VSS) scores before operation and after one year, and functional and aesthetic outcome after one year. Complications were comprised of seromas, hematomas, and infections, which were considered from lower to higher risk in order. We also checked the take rate at postoperative day 14. We evaluated one-year postoperative outcomes using a simple qualitative grading system from Stiefel et al. [4]'s study. This grading system is composed of the following categories: "Excellent" (normal function, minimal scarring, near-normal skin texture and pigmentation), "Good" (near-normal function, no significant handicap, moderate scarring, moderate textural and pigmentation irregularities), "Fair" (modest improvement, moderate handicap, significant scarring/shrinking, significant textural and pigmentation irregularities), and "Poor" (no or minimal functional and cosmetic improvement). The patients were followed up for at least one year after discharge, and the VSS was used to assess pigmentation, pliability, height, and vascularity twice (before the operation and one year after discharge). We also divided patients into two groups according to artificial dermis type (AlloDerm and Matriderm) for a comparison.

All continuous variables were presented as means ± standard deviaton, and the frequencies of categorical variables were presented as percentages. Continuous variables were analyzed with the Student t-test when there was a normal distribution and the nonparametric Mann-Whitney test when there was not a normal distribution. Categorical variables were analyzed with the chi-square test. The paired t-test was used for a VSS comparison of the preoperative and one-year postoperative conditions. We evaluated the correlations among four variables (complications, take rate, VSS in a year, outcome) using Spearman's correlation. A P-value of ≤0.05 was considered statistically significant.

RESULTS

We performed STSG using artificial dermis in 28 patients with extensive burn areas. The application of artificial dermal substitutes (AlloDerm, 15 patients; Matriderm, 13 patients) was successful in all patients. There were 15 males and 13 females with a mean age of 32.4 ± 16.1 years (range, 4–69 years). The mean TBSA burned was 54.4% ± 10.1% (range, 42%–78%). The most common type of burn was flame (22 patients), followed by scald (five patients) and electrical (one patient). STSG using artificial dermis was performed 11.6 months after burn injuries on average. The mean take rate was 95.9% (range, 74%–100%), and complications occurred in 11 out of 28 patients (39.3%). Complications were mainly seromas (eight patients), followed by hematomas (two patients) and infection (one case). Focal negligible skin loss developed in 18 patients who had take rates between 90% and 99%, and they did not need additional grafts. Partial loss of artificial dermis was observed in one patient who showed a 74% take rate; this patient underwent a follow-up skin graft without any problems. The mean VSS one year later (2.36 ± 0.91) was significantly lower than that on the preoperative day (9.54 ± 1.10). Functional and aesthetic outcomes were excellent in 18 patients, good in nine patients, and fair in one patient (zero in the poor group). The patients were followed up for 16.0 months on average (Table 1). There was a significant correlation between complications and take rate ($r = 0.433$, $P = 0.021$) and between take rate and outcomes ($r = 0.504$, $P = 0.06$). However, there was no significant correlation between complications and outcomes ($r = 0.244$, $P = 0.211$). VSS score one year later was only significantly correlated with outcomes ($r = -0.536$, $P = 0.003$). Table 1 also shows a comparison of the AlloDerm and Matriderm groups' patient characteristics. Take rate was higher in the Matriderm group (98.1%) than in the AlloDerm Group (93.9%); however, no variables, including take rate, were statistically significant. Data of patients included in this study are provided in Table 2 and the following figures

Fig. 1. (A) Preoperative image showing the split-thickness skin graft (STSG) with AlloDerm of a 39-year-old female with 73% total body surface area (TBSA) burned. Images of 3 days later (B) and 3 months later (C) after the STSG with AlloDerm of a 39-year-old female with 73% TBSA burned.

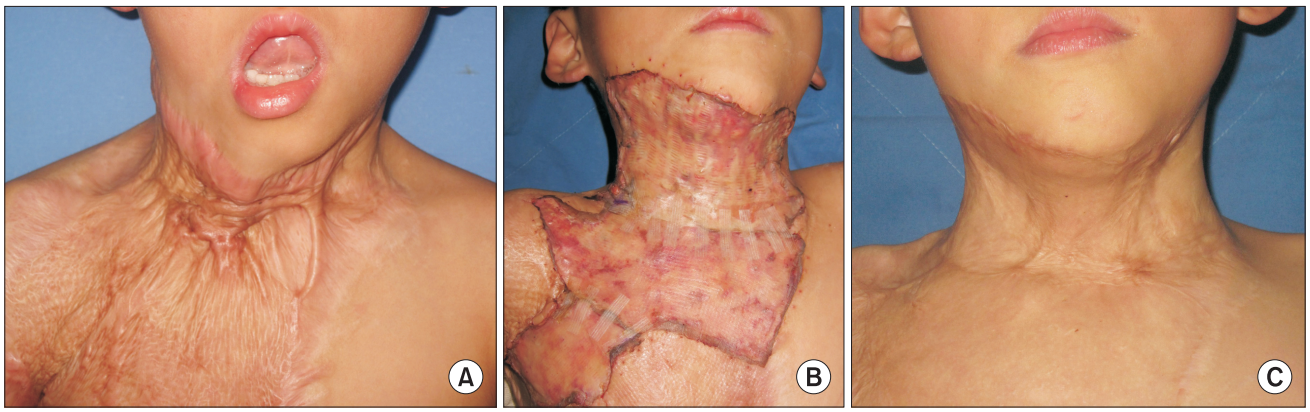

Fig. 2. (A) Preoperative image showing the split-thickness skin graft (STSG) with Matriderm of a 20-year-old man with 43% total body surface area (TBSA) burned. Images of 3 days later (B) and 1 year later (C) after the STSG with Matriderm of a 20-year-old man with 43% TBSA burned.

show the outcomes of the STSG with dermal substitutes procedures. Fig. 1 shows the STSG with AlloDerm of a 39-year-old female with 73% TBSA burned. Fig. 2 shows the STSG with Matriderm of a 20-year-old man with 43% TBSA burned.

DISCUSSION

Hypertrophic scars and contractures frequently occur in deep-dermal or full-thickness burn injuries, and the mobile portions, like the neck and axilla, are especially vulnerable to contracture. The main causes are inadequate initial treatment and physical therapy [5]. The fact that the head and neck are usually exposed makes the area highly vulnerable to initial burn injury, and subsequent scar deformities cannot be camouflaged with clothing [6]. Resultant scars and burn deformities may cause the patient to withdraw from society and family and ultimately him/herself [6]. The amount of contracture occurring in a full-thickness burn of the neck usually depends on several factors. The looseness of the cervical skin, as well as the range of mobility of the neck, may favor wound contraction during healing [7]. Reconstructive methods of postburn scar contractures include skin grafts, local advancement flaps (Z-plasty, K-plasty, or their combination), distant flaps, and free flaps [8]. STSG remains the standard treatment of deep-dermal and full-thickness burns; however, the delivered dermis is sometimes insufficient to prevent functional and cosmetic disability [9]. Many studies have reported that artificial dermal substitutes improve the quality of skin grafts [10], that the amount of the dermal component contributes to the prevention of contractures [11], and that the application of a dermal substitute such as AlloDerm or Matriderm is an effective option in reconstruction [12]. The principal advantage of these is that they provide a dermal source and produce a comparable skin graft recipient site with the harvesting of a much thinner autograft [9]. Moreover, in extensive burn patients, there is rarely sufficient skin to harvest from uninjured sites for skin grafts and flaps. Thus, we have no choice but to perform STSGs with artificial dermis in extensive burn patients as an alternative method of reconstruction.

In our study, 11 of the 28 patients were healed without an operation, and 17 patients recovered by STSG alone during the early period of treatment, because all patients were at risk of critical situations such as systemic inflammatory response syndrome, pneumonia, acute renal failure, and sepsis. In this situation, we had to consider the best way to save patients' lives; we determined that it was the application of wide meshed skin grafts without the use of artificial dermal substitutes for skin coverage. Then, STSGs using dermal substitutes were performed on average 12.4 months after the burn. On average, patients had 54.4% of TBSA burned, and patients were burned in the inguinal area and other harvesting areas for full-thickness skin grafts. We used AlloDerm and Matriderm as dermal substitutes for single-stage operations. AlloDerm is cell free and based on human dermis preserved by freezing. As it is cell free, it is not rejected, and it is incorporated into the wounds. However, AlloDerm can cause a low-grade inflammatory response, and immunogenic rejection can occur rarely [13]. There have been some case reports using this material to date, but so far, these have just shown that it is acceptable for wound management [14]. Matriderm is a highly porous dermal substitute, which consists of a collagen matrix cross-linked to an elastin hydrolysate. It may be employed in a single-stage procedure with immediate STSG [15,16]. One animal study reported that Matriderm showed a better rate of integration compared to other dermal substitutes [17]. We showed a 95.9% take rate, which is similar to another study that included burn patients with full-thickness skin defects in the hand region and reported a 96% take rate of dermal matrix to skin graft through single-stage operations [18].

In our study, the take rate was a bit higher in the Matriderm group ($P = 0.058$) and correlated with complications such as

seromas, hematomas, and infections. We had just one case of infection and 11 cases of seromas and hematomas, which were not actually complications that affected outcomes. The overall complication rate was 39.3%, and there was just one infection case (1/28, 4.6%). Generally, to reduce complications, meticulous preparation of the scar bed, bleeding control, aseptic handling, and careful postoperative care are essential. Heimbach et al. [19] reported invasive and superficial infection rates of 3.1% and 13.2%, respectively, and an overall take rate of 76.2%, while Stiefel et al. [4] reported a 17.6% complication rate and a 94% take rate through results from Integra. However, there are no comparative studies comparing the complications and take rates of AlloDerm and Matriderm.

For scar evaluation, we compared VSS scores before and after operations. Our result was similar to another study showing that VSS scores improved after surgery [20], and it was a bit higher than another study that showed an overall VSS of 1.71 ± 0.80 in a group grafted with Matriderm [18]. The VSS scores also significantly decreased one year after grafting with dermal substitutes, and excellent/good long-term outcomes (i.e., improvement of function and cosmetic skin texture) were shown in 27 patients. Even though our study has limitations such as a single-center analysis and population which included only patients who were performed STSG with dermal substitutes, we considered that our study was worth reporting it as the largest and unique burn center for the lack of this kind of study in Korea.

In summary, even though we found no studies on performing STSG using dermal substitutes in extensive burn patients in our research, our results are very favorable. In extensive burn patients, it is not adequate to apply simple STSGs that are characterized by "recontraction" due to their limited dermal tissue content. Therefore, the proper use of dermal substitutes combined with STSGs can reduce contractures and restore normal movement. The results of our study indicate that a dermal regeneration template provides an alternative technique for contracture release procedures.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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