The Use of Dermal Substitute in Deep Burns of Functional/Mobile Anatomic Areas at Acute Phase After Early Excision and Subsequent Skin Autografting: Dermal Substitute Prevents Functional Limitations.

Kayhan Gurbuz,MD

Burn Center, Department of General Surgery, Adana City Training and Research Hospital, Adana, Turkey
drkayhang@hotmail.com

Mete Demir,MD

Burn Center, Department of General Surgery, Adana City Training and Research Hospital, Adana, Turkey
drmetedemir@hotmail.com

Koray Das, MD, Associate Professor

Department of General Surgery, Adana City Training and Research Hospital, Adana, Turkey

koraydas@yahoo.com

Corresponding author:
Kayhan Gurbuz, MD
Burn Center, Department of General Surgery
Adana City Training and Research Hospital, Adana, Turkey
e-mail: drkayhang@hotmail.com

Conflicts of Interest: None

Source of Funding: None

Abstract

We aimed to evaluate the results of dermal substitute implantation after early excision in the acute phase of major burn cases within the scope of efforts to reduce contractions and scar formation in functional anatomic areas (face, neck, axilla, elbow, popliteal). Twelve patients with major burn who were treated in the burn center between September 2017 and September 2018 were included in the study. In these patients, Nevelia® dermal substitute was implanted to 24 functional areas with deep partial or full-thickness burns after surgical debridement of the wound. Autologous split thickness skin graft was applied to these areas after 14-21 days. The patients were followed for 4-14 months (mean 6 months). Postoperative scar formation was assessed by Vancouver Scar Scale at the end of the follow-up period. A simple qualitative staging system was used for aesthetic and functional evaluation. The time from burn injury to dermal substitute implantation was 3-21 days. Skin graft take was complete in 22 of 24 regions and partial in one of them, while graft loss developed in one region. In the implantation sites, the Vancouver Scar Scale ranged from 1 to 7. Aesthetic and functional evaluation showed excellent/good results in 21 of 24 anatomic regions, moderate results in 2 regions and poor results in 1 region. The use of dermal substitute in deep burns of functional/mobile anatomic areas at acute phase after early excision and subsequent skin auto grafting has opened a new alternative area in the burn surgery arena to prevent contractures and functional limitations.

Keywords: Dermal substitute; major burn; functional areas; contracture prevention.

INTRODUCTION

Significant progress has been made in reducing burn morbidity and mortality in the last few decades with the improvements in burn and trauma management. Improvements in nutritional and metabolic supports as well as resuscitation and burn management have contributed to improved outcomes. Early excision (tangential, fascial) and early wound closure, which are considered to be the standard burn surgical treatment of today, have probably been the most contributing method to these results. With this method, shorter hospital stay, decrease in infective complications and treatment costs are observed. At the same time, rapid recovery reduces hypertrophic scar formation and joint contractures, thus enabling more effective rehabilitation.[1-7]

The basic principles of burn treatment are focused on survival. In addition, aesthetic and functional results have become increasingly important following burn injury.[1] Repair of deep partial and full-thickness burn defects with autologous split thickness skin graft (STSG) is accepted as the standard treatment method. On the other hand, autologous STSG has some limitations including undesirable cosmetic and functional results due to weak skin elasticity, hypertrophic scar formation and contracture development especially in functional areas.[8-11] Hypertrophic scars and contractures occur especially in deep partial and full-thickness burns of the contraction prone functional body parts (neck, axilla, knee, elbow, etc.).[8,12,13]

The thin, flexible skin structure and frequent movements in the functional areas make closure of these areas more complex. Inadequate closure of these areas leads to loss of mobility in the joints with persistent scar formation and contracture development leading to significant functional limitations. Dermal substitutes (DSs) have been developed to eliminate this disadvantage of STSGs.[8-10] Many studies have reported that the use of dermal substitutes in the acute phase of burn treatment increases the amount of dermal component, contributes to the prevention of contractures, and improves skin graft quality, functional and cosmetic outcomes, and quality of life.[13-16]

Therefore we aimed to improve the quality of life and minimize deformities in the acute phase of the treatment of major burn patients in our burn center, in the presence of deep partial or full-thickness burns in functional areas, with early excision followed by DS implantation and subsequent autologous STSG application. In this study, we evaluated the effectiveness of DSs in reducing scar formation, preventing contractions, and preserving functions of body areas such as neck, shoulder, knee and elbow.

METHODS

The patients who were treated in our burn center between September 2017 and September 2018 were examined retrospectively from patient files and their records in the hospital automation system. Patients with deep partial or full-thickness burn at a functional/mobile area, who subsequently underwent DS implantation (Nevelia®: Symatese Aesthetics, Lyon, France) after early tangential or fascial excision, were included in the study. Informed

consent was obtained from all patients regarding the surgical procedure. Patients who could not be administered DS in the early period due to the presence of surgical site infection or borderline burn depth was not included in the study.

Demographic and etiologic data, percentage of burned TBSA, length of hospitalization and treatment data were analyzed. Silicone membrane separation, autograft viability and complications such as infection, seroma or hematoma were evaluated. Patients who did not come to follow-up were contacted and called for control examination. Informed consent was obtained for imaging. Post-operative scar formation was assessed by the Vancouver Scar Scale (VSS). This is a score comprising various parameters: elasticity, pliability, pigmentation and vascularization. Each parameter has a score and the total score is the sum of each parameter.[17] The total value has a 0-13 score. Lower scores represent better results. Aesthetic and functional status was evaluated by simple qualitative staging system in which motion and function is evaluated as; 1-Perfect (complete, maximal or optimal restoration of motion and function), 2-Good (significant restoration of motion and function), 3-Moderate (temporary restoration of motion and function), 4-Weak (lack of motion and function).[18]

Nevelia® used in the study is a bilaminar dermal regeneration implant consisting of an absorbable type I natural (bovine) collagen matrix and polyester reinforced silicon layer with acellular structure and 3-dimensional pores.[9,19,20] It enables autologous cellular migration and proliferation as well as neo-angiogenesis through the pores it contains. After 14-21 days period with the biodegradation of the collagen in the structure of DS, STSG is applied on the neodermis formed. Early resection and careful hemostasis were performed in the acute phase of the burn between 3-21 days of burn injury. The non-meshed DS was then fixed to the wound bed with stapler metal clips or occasional continuous sutures. The first wound dressing change was performed after 72 hours and then repeated every 48 hours to check for complications. Post-operative 14-21 days, the silicon layer was removed and autograft (0.2 mm) was applied. Epidermal autografts were fixed with stapler or continuous sutures, covered with sterile paraffin gauze and compress, and dressing changed every 48 hours. In the early period, physiotherapy was started in all patients and continued for 4-9 months.

Statistical Package for Social Sciences 20.0 for Windows was used for the analysis of the data. The results were expressed as mean±standard deviation (minimum-maximum), median (interquartile range-IQR) and percent (%).

This study was not financially supported by any fund or company. Approval was obtained from the local ethics committee of our hospital for the study (Date: 27-02-2019 / Number of meetings: 29 / Decision No: 384).

RESULTS

Of the 12 patients in the study group, 9 were male and 3 were female. Patient ages ranged from 6 months to 38 years (mean age 22.62±10.99 years, median age 22.0 years). Following burn injury, DS implantation was performed between 3-21 days (11.33±5.22 days, median duration 10.5 days). Nevelia® was applied to a total of 24 anatomically important mobile

body parts of these 12 patients.The anatomical region distribution is shown in table 1.

The mean TBSA was found to be 35.42±19.13 (median 35.0, IQR 28). Flame and electrical burns were seen in 10 patients, 1 patient had chemical and 1 patient had contact burns. DS was implanted on average 10.5 days following burn injury. Complications related to DS use were seroma in 4 cases, hematoma in 2 cases and infection in 1 case. The overall take rate of skin graft was 93.75%. Minor epidermal graft problems were observed in 2 patients and healed without any problem. Only 1 patient needed re-application of epidermal graft. The mean follow-up was 193.83±84.6 days (median 180, IQR 90).

Regular evaluations were made for articular and functional gains. Normal functional recovery occurred in 1-3 months according to length of stay in intensive care unit and beginning time of rehabilitation. The results of articular and functional evaluation remained stable over time. Aesthetic and functional evaluation showed excellent/good results in 21 of 24 anatomic regions, moderate results in 2 regions and poor results in 1 region. The mean VSS was 3.42. The VSS assessment of the DS implanted areas is given in table 2.

Demographic and epidemiologic data as well as DS implantation and treatment results are given in Table 3.

Post operative functional outcomes are shown in Figure1 and 2.

DISCUSSION

Burn treatment is a serious undertaking and it demands the special attention of a specialized medical team to produce the best outcomes. A third degree burn injury may lead to functional and aesthetic limitations along with psychosocial issues affecting the quality of life for the person who has the injury. There are many studies about burn treatment and numerous dermal regeneration implants to achieve optimal functional outcomes after a severe burn injury.

Philandrianos et al studied five acellular dermal skin substitutes in a two-step procedure in a porcine model. Their results showed significant differences between groups in dermis incorporation and in early wound contraction, but there was no difference in wound contraction and in Vancouver scale after 2 and 6 months of healing. They also concluded that there was no long-term difference of scar qualities in their study between the different artificial dermis and also the control group .[9] Unlike Philandrianos et al there are many studies claiming the superiority of dermal substitutes in clinical outcomes. In a study vanJuijlen et al evaluated the survival of the autograft and objective parameters for scar elasticity, after dermal substitution for acute burns and reconstructive surgery. The dermal substitute evaluated was based on bovine type I collagen and elastin-hydrolysate. The dermal substitute applied in a one-step procedure in combination with a split-thickness autograft was compared with the conventional treatment, the split-thickness autograft. They claim that the skin elasticity was considerably improved by the collagen/elastin dermal substitute after reconstructive surgery.[10]

De Angelis et al studied the clinical and histological comparison of Nevelia and Integra double layer DSs in patients with post-traumatic injury wounds. In their study at long-term follow up, Nevelia showed a better clinical outcome measured as Manchester Scar Scale (MSS) score vs Integra measured as MSS. They claim that histological and immune histo-chemistry data showed Nevelia allowing faster neo-angiogenesis and tissue regeneration with neo-formed tissue architecture closer to the physiology of the skin.[20] There are other studies claiming the use of acellular dermal matrix as a good option for treating major burns to prevent scar formation after burn.[3,14,21-23] The dermis analogue used in our study (Nevelia®) is a bioengineering product designed as an acellular skeleton that supports new tissue development by enabling autogenous cellular development, proliferation and neo-angiogenesis. It is also called as bilaminar acellular dermal regeneration implant. Following the biodegradation of type 1 collagen present in its structure, the newly formed neo-dermis is very close to the normal dermis histologically and bio-mechanically.[11,20]

The overall take rate of skin graft was 93.75% in our study which is similar to other results in the literature.[2,3,8,13,14] We used VSS for the assessment of DS implanted areas. VSS is described as an important tool in the assessment of burn scars in an article byvan Zuijlen et al (24). The average VSS was found as 2.55±1.42 in a single-step wound closure technique using Matriderm in a study conducted by Demircan et al.[23] The mean VSS was found as 3.42 in our study in a two-step technique. Aesthetic and functional evaluation showed excellent/good results in 21 of 24 anatomic regions in our study. The cosmetic results were judged to be fair to good by surgeons and patients after one year's follow up in a study by Tsai et al in which they used AlloDerm(3). Seo et al claimed excellent/ good outcomes in 27 out of 28 patients in their study comparing AlloDerm and Matriderm.[13]

Scar contracture is major long-term sequelae of meshed split-thickness skin grafts in the case of full-thickness burn injuries, and especially in joint areas. An ideal therapy would not only promote rapid healing but would also act as an anti-scarring therapy. We used Nevelia® in a two-step wound closure technique. The patients were followed for 4-14 months and the outcome results were as good as other studies in the literature. Good functional and aesthetic results of our patients are promising.

CONCLUSION

The main goal of the burn treatment is survival but the lifelong post-burn scar revisions and reconstructive needs of burn patients should not be ignored and quality of life should be improved. Dermal substitute implantation followed by STSG, after early resection in deep burns involving functional/mobile body areas is a good option for preventing hypertrophic scar formation and functional losses in the post-burn period.

ACKNOWLEDGEMENTS

None declared

REFERENCES

1. Wainwright DJ. Use of an acellular allograft dermal matrix (AlloDerm) in the management of full-thickness burns. Burns 1995;21:243-8.

2. Callcut RA, Schurr MJ, Sloan M, Faucher LD. Clinical experience with Alloderm: a one-staged composite dermal/epidermal replacement utilizing processed cadaver dermis and thin autografts. Burns 2006;32:583-8.

3. Tsai CC, Lin SD, Lai CS, Lin TM. The use of composite acellular allodermis-ultrathin autograft on joint area in major burn patients--one year follow up. Kaohsiung J Med Sci1999;15:651-8.

4. Lofts JA. Cost analysis of a major burn. N Z Med J 1991;27:488–90.

5.Atiyeh BS, Gunn SW, Hayek SN. State of the Art in Burn Treatment. World J. Surg. 2005;29:131-48.

6. Gajiwala K, Gajiwala AL. Evaluation of lyophilised, gamma-irradiated amnion as a biological dressing. Cell Tissue Bank 2004;5:73-80.

7. Atiyeh BS, Hayek SN, Gunn SW. New technologies for burn wound closure and healing-Review of the literature. Burns 2005;31:944-56.

8.Juhasz I, Kiss B, Lukacs L, Erdei I, Peter Z, Remenyik E. Long-term followup of dermal substitution with Acellular Dermal Implant in burns and postburn scar corrections. Dermatol.Res. Pract. 2010;2010:210150.

9. Philandrianos C, Andrac-Meyer L, Mordon S, et al. Comparison of five dermal substitutes in full-thickness skin wound healing in a porcine model. Burns 2012;38:820-9.

10. van Zuijlen PP, van Trier AJ, Vloemans JF, Groenevelt F,Kreis RW,Middlekoop E. Graft survival and effectiveness of dermal substitution in burns and reconstructive surgery in a one-stage grafting model. PlastReconstrSurg 2000;106:615-23.

11. Burke JF, Yannas IV, Quinby WC, Bondoc CC, Jung WK. Successful use of a physiologically acceptable artificial skin in the treatment of extensive burn injury. Ann Surg 1981;194:413-28.

12. Serghiou M, Cowan A, Whitehead C. Rehabilitation after a burn injury. ClinPlastSurg 2009;36:675-86.

13. Seo D-K, Kym D, Hur J. Management of neck contractures by single-stage dermal substitutes and skin grafting in extensive burn patients. Ann SurgTreatRes 2014;87(5):253-9.

14. Yigitbas H, Yavuz E, BekenO E, et al. Our experience with dermal substitute Nevelia® in the treatment of severely burned patients. Ulus TravmaAcilCerrahiDerg 2019;25:00-00

15.Machens HG, Berger AC, Mailaender P. Bioartificial skin. Cells Tissues Organs 2000;167:88–94.

16. Nguyen DQA, Dickson WA.A review of the use of a dermal skin substitute in burns care. Journal of Wound Care 2006;15(8):373–6.

17. Sullivan T, Smith J, Kermode J, McIver E, CourtemancheDJ. Rating the burn scar. J Burn Care Rehab 1990;11:256–60.

18. Stiefel D, Schiestl C, Meuli M. Integra Artificial Skin® for burn scar revision in adolescents and children.Burns 2010;36:114-20.

19. Leclère FM, Casoli V. Use of bioartificial dermal regeneration template for skin restoration in combat casualty injuries. Regen Med. 2016;11:359-60.

20. De Angelis B, Orlandi F,D'Autilio MFLM, et al.Long-term follow-up comparison of two different bi-layer dermal substitutes in tissue regeneration: clinical outcomes and histological findings. Int Wound J. 2018;1–12.

21.Yim H, ChoYS ,Seo CH et al.The use of AlloDerm on major burn patients: AlloDermprevents post-burn joint contracture.Burns 2010;36:322-8.

22.Tang B, Zhu B, Liang Y-Y, et al. Early escharectomy and concurrent composite skin grafting over human Acellular Dermal Matrix Scaffold for covering deep facial burns.Plast.Reconstr. Surg. 2011;127:1533-8.

23.Demircan M, Cicek T, Yetis MI. Preliminary results in single-step wound closure procedure of full-thickness facial burns in children by using the collagen–elastin matrix and review of pediatric facial burns. Burns 2015;41:1268-74.

24. van Zuijlen PP, Angeles AP, Kreis RW, Bos KE, Middelkoop E. Scar assessment tools: implications for current research. PlastReconstr Surg. 2002;109(3):1108–22.

Table 1: Nevelia® Dermal Substitute Implant Areas

Implantation areas	n	%
Axilla	6	25
Elbow	6	25
Wrist	4	16.7
Neck	3	12.5
Knee	2	8.3
Face	2	8.3
Ankle	1	4.2

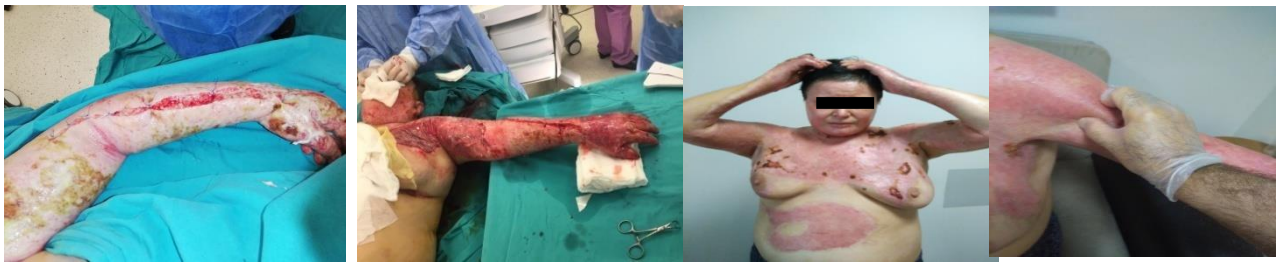
Table 2: The VSS assessment of the DS implanted areas

Parameter	**Finding**	**n**	**%**
Pigmentation	Normal	10	42
	Hypopigmentation	3	12
	Hyperpigmentation	11	46
Vascularity	Normal	18	75
	Pink	3	13
	Red	2	8
	Purple	1	4
Pliability	Normal	13	54
	Flexible	7	30
	Semi flexible	2	8
	Not flexible	1	4
	Band	1	4
	Contracture	0	0
Height	Flat	4	17
	0 - <2 mm	12	50
	≥2- <5 mm	7	29
	≥5mm	1	4

Table 3. Demographic and epidemiologic data, DS implantation and treatment results

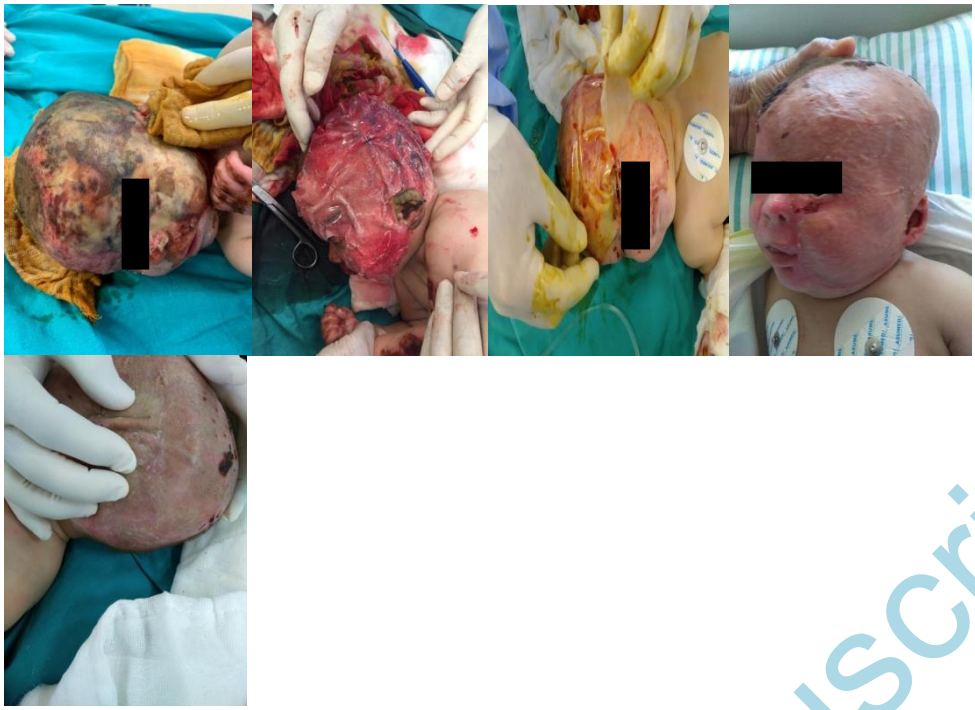
No	Age (years)	Gender	TBSA (%)	Burn Etiology	Functional Area of Implantation	Area of Nevelia® Implanted (cm2)	Nevelia® İmplantation time (day)	Complication	Follow up time (day)	Involvement of Nevelia® (%)	Aesthetic and Functional Outcome
1	0,5	M	35	Flame	Face	190	10	None	12	100	Perfect
2	19	F	8	Chemical	Face	270	11	None	90	100	Perfect
3	37	F	52	Flame	Right knee	170	9	Seroma	85	100	Good
4	18	M	22	Flame	Right axilla Right Elbow	300	14	Seroma None	150	100 100	Good Good
5	34	M	72	H.V.E.B.	Right axilla Left knee Left ankle Left wrist	1150	16	None None None Seroma	180	100 100 100 75	Good Good Good Moderate
6	38	M	40	Flame	Right axilla Right wrist Right elbow	580	8	None None None	180	100 100 100	Good Good Good
7	21	M	25	Flame	Neck Right wrist Right elbow	550	9	None None None	420	100 100 100	Good Good Good
8	23	M	46	Flash electrical burn	Neck Right axilla	330	5	Infection Seroma	240	- 50	Weak Moderate
9	10	F	35	H.V.E.B.	Right axilla Right elbow	250	18	Hematoma None	180	100 100	Good Good
10	27	M	6	Contact	Left wrist Left elbow	220	3	None None	120	100 100	Perfect Perfect
11	17	M	30	H.V.E.B.	Neck Right axilla	360	12	None None	270	100 100	Good Good
12	27	M	54	H.V.E.B.	Left axilla	290	21	Hematoma	190	100	Good

H.V.E.B.: high voltage electrical burn,TBSA: burned total body surface area



A ***B*** ***C*** ***D***

Fig. 1- A-12th day after burn, B-DS implantation after tangential excision, C- Postoperative 75th day, D-Functional outcome



A B C D E

Fig. 2- A-10th day after burn, B-DS implantation after tangential excision, C- Delamination of the silicon membrane and newly formed neo dermis on day 22, D- Postoperative 60th day, E-Functional outcome (pliability)