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ARTICLE

Management of skin graft donor site in pediatric patients with tumescent technique and AQUACEL® Ag foam dressing

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ABSTRACT

Split thickness skin graft donor sites are challenging to manage in children because of patient fear and anxiety. Therefore, strategies that minimize the frequency of dressing change are beneficial. This paper describes a technique to simplify wound care for split thickness skin graft donor sites. A tumescent solution of saline containing 0.25% bupivacaine with epinephrine is infiltrated into the graft donor site. Skin grafts are harvested with an electric dermatome. The donor sites are dressed with AQUACEL® Ag Foam, which is a sodium carboxymethylcellulose hydrofiber dressing that contains silver ions. A total of 17 split thickness skin grafts were performed with this technique. Patient age ranged from 2.4 year to 16.9 years (average 12 years). The AQUACEL® Ag Foam dressings were removed at an average of 23 days (range 11 to 31 days) at which time complete donor site epithelialization was seen in 13/17 (76.5%) patients. The remaining 4 patients had < 5% of the donor site that had not epithelialized; these went on to heal uneventfully with a brief period of petrolatum gauze dressing changes. Two patients had foul smelling discharge under the dressing that resolved promptly with dressing removal. The above technique allows the primary dressing to stay in place long enough for epithelialization to take place. The obviation of dressing changes in the early post-operative period results in patient comfort and care giver convenience.

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Skin graft; donor site; dressing; tumescent technique; epithelialization; pediatric

Introduction

Split thickness skin grafting is one of the most commonly performed procedures in reconstructive surgery. The skin graft donor site can be managed by a variety of methods [1]. Several types of donor site dressings have been described, each with their own advantages and limitations [2,3]. The ideal dressing should promote epithelialization, minimize pain, prevent infection and be user friendly. AQUACEL® Ag is a sodium carboxymethylcellulose hydrofiber dressing that is impregnated with silver ions [4]. Hydrofibers are materials that absorb fluid and turn into a gel. Silver has antimicrobial properties [5]. A multilayer version of this dressing is called AQUACEL® Ag Foam (Figure 1). The foam layer protects the wound against trauma and absorbs excess exudate. The outer semi-permeable layer is waterproof but allows evaporation of excess exudate. The silicone adhesive layer is easy to apply and is not irritating to the skin. All of these properties make it a favorable dressing for skin graft donor site management.

Donor site wound care is challenging in children because of severe anxiety with dressing changes in this patient population. Therefore, it is desirable to minimize dressing changes and simplify wound care so that patient, parent and physician anxiety can be minimized. Tumescence of skin graft donor sites with a local anesthetic-epinephrine containing solution has been previously described to decreases bleeding and improve pain control in the early post-operative period [6–8]. AQUACEL® Ag Foam dressing, due to its absorptive and antimicrobial properties, can be used to protect the wound till completion of epithelialization. We have employed the above two strategies in an attempt to simplify donor site care, improve pain control and minimize patient visits to the hospital.

Material and methods

Subjects

This is a retrospective case series of all patients <18 years of age in whom a split thickness skin graft was harvested with a tumescent technique and the donor site was dressed with AQUACEL® Ag Foam dressing. Patients were treated at a children's hospital. The study period was December 2016 to May 2019. Patients' medical records were reviewed. Collected data included age, etiology of wound, size of wound, mean duration of dressing, pain or discomfort at donor site, epithelialization at time of dressing removal and donor site infections. Photographic documentation of the donor sites was performed for all patients. Institutional review board approval was obtained for this study.

Surgical technique

The following is a description of the surgical technique:

1. The recipient site is prepared by debriding all non-viable tissue to create a clean tissue bed. Wound dimensions are measured.
2. Wound measurements are marked on the donor site. Tumescent solution is prepared by mixing 20 ml of 0.25% bupivacaine with epinephrine 1:200,000 in 250 ml of injectable saline. The tumescent solution is injected in the dermal

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and immediate subdermal planes, with an 18G needle connected to a 60 mL syringe (Figure 2(a)). The total volume of tumescent fluid injected depends on the size of the donor site, with the end point of injection being slight tissue firmness and 'peau d'orange' appearance of the skin. It is important to not exceed the maximum safe amount of local anesthetic that can be used which is based on the patients' weight. The safe upper limit for injection is 1 mL per kilogram of 0.25% bupivacaine with epinephrine 1:200,000.

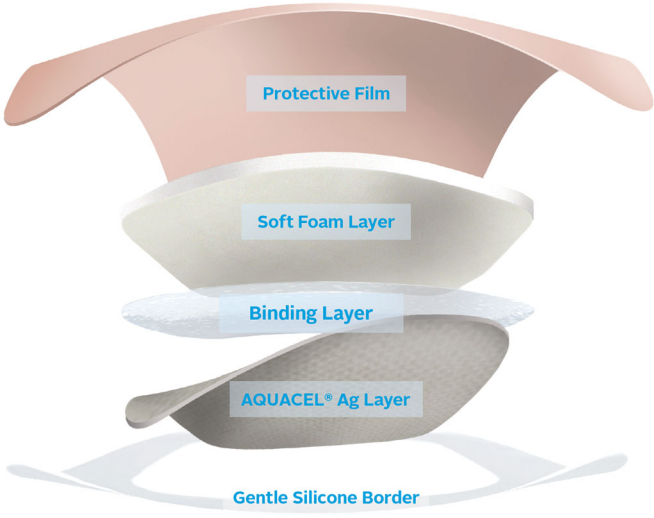

Figure 1. Components of AQUACEL® Ag foam dressing.

3. Split thickness skin graft is harvested with an electric dermatome. The typical graft thickness is 0.010 to 0.015 inches, depending on reconstructive needs. Mineral oil is used for lubrication of the donor site for ease of harvest. After obtaining the graft, a saline moistened gauze is temporarily placed on the donor site. Due to the epinephrine in the tumescent solution, there is minimal bleeding (Figure 2(b)).
4. The donor site dressing is prepared for dressing application. Mineral oil and blood are cleaned off the skin around the donor site. An AQUACEL® Ag Foam dressing of appropriate size is then applied (Figure 2(c)). The silicone adhesive layer at the borders is used to secure the dressing. No skin adhesive or tape reinforcement is necessary.

Post-operative management

Patients are typically seen at 5 to 7 days after surgery for removal of the skin graft bolster dressing. The donor site dressing is left undisturbed. It is common for blood staining of the hydrofiber to be visible through the outer cover of the dressing (Figure 3). If there is any leakage of fluid, the edge of the dressing is reinforced with tape. Patients are seen again at around 3 to 4 weeks after surgery. The donor site AQUACEL® Ag Foam dressing is removed. If epithelialization is complete, patients are instructed to apply a moisturizer twice daily to prevent the newly epithelialized skin from drying (Figure 4). If the donor site is not completely healed, petrolatum gauze dressings are applied daily until the wound is completely epithelialized (Figure 5).

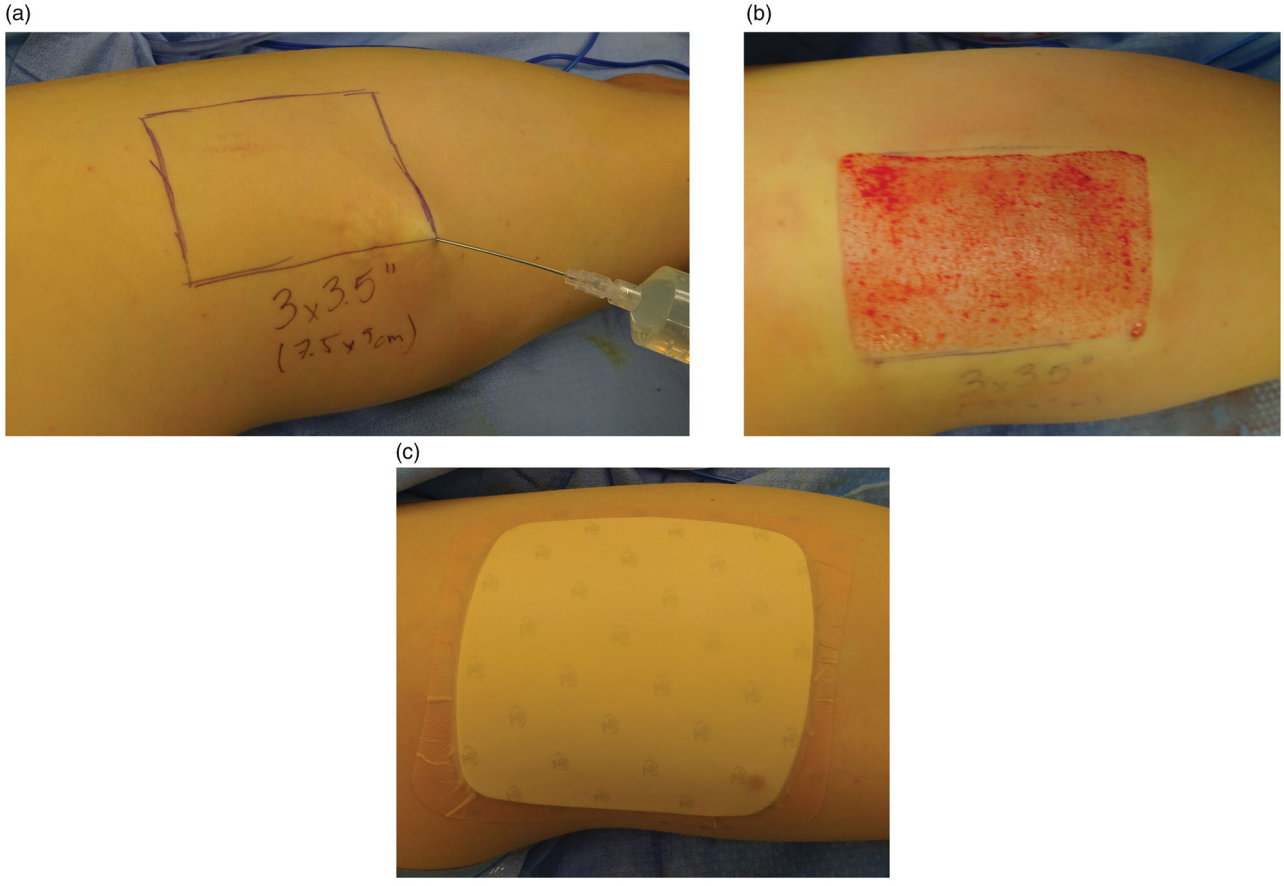

Figure 2. (a) Injection of tumescent fluid at the donor site, in the dermal and immediate sub-dermal plane. (b) Minimal bleeding from the donor site after harvest. (c) AQUACEL® Ag Foam dressing in place over the donor site.

Figure 3. Blood staining visible under the outer layer of the dressing.

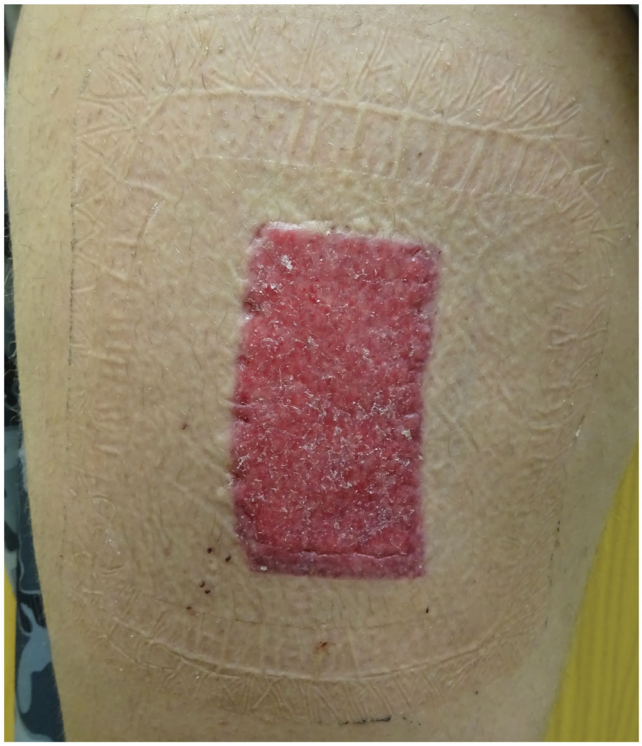

Figure 4. Removal of dressing 21 days after surgery demonstrates epithelialized donor site.

Results

Study inclusion criteria were met by 17 split thickness skin graft cases over the 2-year 6-month study period. Patient age ranged from 2 year 5 months to 16 years 11 months (average 12 years). Important data are summarized in Table 1. The donor site was the lateral or anterolateral thigh in all patients. Skin grafts were harvested at a thickness of 0.010 to 0.015 inches. The average size of the skin grafts was 106 cm^2 (range 12 to 504 cm^2). The first follow up was at 6 to 11 days (median 6 days) after surgery, at which time the skin graft bolster dressing was removed and the graft inspected. The second follow up was 11 to 31 days (mean 23 days) after surgery, at which time the AQUACEL® Ag Foam dressing was removed from the donor site. The donor site had completely epithelialized in 13(76.5%) patients. In the remaining 4(23.5%) patients, there were very small areas of incomplete healing comprising $<$ 5% of the donor site. These went on to heal uneventfully with petrolatum gauze dressing changes. Two patients had a foul-smelling discharge under the dressing, without any erythema or other signs of infection. Removal of dressing resulted in prompt resolution. The length of follow-up was a mean of 232 days (range 25 to 690 days). Hypertrophic scarring occurred in 2 donor sites. These were treated with intralesional steroid injections. The remainder of the donor sites healed well with good aesthetic outcomes (Figure 6). Pain control after discharge from the hospital was achieved with acetaminophen and ibuprofen in all patients. None of the patients required outpatient narcotic pain medication.

Figure 5. Incomplete epithelialization of donor site.

Discussion

Management of skin graft donor sites in children is challenging because of non-cooperation with wound care in this patient population. Patient, parent and provider anxiety can be decreased by keeping the frequency of dressing changes to the minimum possible. We have attempted to achieve this goal by two approaches: 1) donor site bleeding is decreased by injection of epinephrine containing solution, and 2) wound exudate is absorbed efficiently by hydrofiber in the AQUACEL® Ag dressing. These strategies have allowed us to keep the donor site dressing

Table 1. Patient data.

Case No.	Age (years and months)	Wound etiology	Wound site	Skin graft size (cm^2)	Skin graft thickness (inches)	AQUACEL® Ag foam dressing removal (days)	Percentage of donor site healed at dressing removal
1	2 years 5 months	Malignant melanoma	Dorsal foot	12	0.010	21	100
2	16 years 11 months	Flap donor site	Thigh	72	0.014	31	95
3	10 years 5 months	Flap donor site	Thigh	68	0.010	22	100
4	13 years 6 months	Burn	Leg	48	0.012	27	100
5	7 years 2 months	Trauma	Dorsal foot	35	0.012	27	100
6	4 years 1 months	Burn scar contracture	Cubital fossa	44	0.012	22	95
7	15 years 2 months	Flap donor site	Forearm	16	0.012	21	100
8	14 years 4 months	Hidradenitis	Axilla	70	0.012	25	100
9	11 years 3 months	Dermatofibrosarcoma Protuberans	Leg	74	0.014	29	100
10	13 years 7 months	Burn scar contracture	Popliteal fossa and leg	150	0.014	27	95
11	14 years 5 months	Trauma	Dorsal foot	96	0.014	27	100
12	14 years 6 months	Burn scar contracture	Thigh	360	0.014	11	100
13	13 years 7 months	Flap donor site	Leg	12	0.014	17	100
14	14 years 10 months	Burn scar contracture	Thigh	504	0.014	18	100
15	15 years	Burn scar contracture	Thigh	189	0.014	20	100
16	15 years	Burn scar contracture	Cubital fossa	42	0.014	25	100
17	8 years 8 months	Friction burn	Dorsal hand	14	0.015	23	95

in place till the wound has epithelialized. Patients are initially seen at 5 to 7 day after surgery for taking down the skin graft bolster dressing. The next visit is at 3 to 4 weeks after surgery, when the donor site dressing is removed. If skin graft and donor site healing is uneventful, the frequency and timing of future visits depends on the need to monitor the skin graft site for cutaneous scarring.

There are several features of AQUACEL® Ag Foam that make it an excellent donor site dressing. Application of the dressing is very easy. Several sizes are available and therefore the one closest to wound dimensions can be used without any need for cutting or trimming. The outer layer is waterproof and therefore a separate secondary dressing is not required. This semipermeable layer allows evaporation of excess fluid. The adhesive silicone border allows for readjusting the dressing as needed in the operating room to allow for optimal dressing placement. This adhesive layer also serves as a barrier to fluid leakage. However, if high volume of exudate does cause some leakage, the edge of the dressing can simply be reinforced with tape without the need for dressing removal. The carboxy methylcellulose hydrofiber absorbs fluid and forms a gel. This gel provides a moist wound healing environment. Moist dressings have been shown to decrease pain and improve healing in skin graft donor sites [9]. The gel layer may also have a splinting effect on the wound, thus decreasing pain [2]. The foam layer protects the wound against trauma.

Hydrofiber dressings have been shown to beneficial in skin graft donor site management in several studies. Brenner et al. performed a randomized trial in children comparing 3 different types of donor site dressings: foam (Allevyn®), hydrofiber (Aquacel®) and alginate (Kaltostat®) [10]. Alginate had the shortest time to healing at 7.5 days, compared to 8 days for hydrofiber and 9.5 days for foam. There was no difference in leakage of exudate, pain or infection. Kalsson et al. compared Aquacel®, Allevyn® and Mediskin® I (meshed frozen pig skin) in a randomized trial [11]. They recommended Aquacel® as the dressing of choice because of significantly quicker epithelialization, least pain and easiest application. Demirtas et al. performed a randomized clinical trial of 5 different types of donor site dressings [2]. Aquacel® Ag was found to have the earliest epithelialization but was also the most expensive. On the other hand, Ding et al. in a small randomized trial found that in comparison to Aquacel® Ag, healing times were shorter with alginate silver dressings [3]. Dornseifer et al. in a randomized split patient study compared Aquacel® with polyurethrane, and reported that polyurethrane treated areas had better epithelialization and less pain [12]. Bailey et al. in their randomized comparison study found that both Aquacel® Ag and Glucan II (oat derived carbohydrate beta-glucan) were equivalent in terms of healing time, infection rates and cosmetic outcome; Aquacel® Ag however had lower pain scores at day 5 [13]. Barnea et al. performed a split wound study where half of the donor site was covered with Aquacel® dressing while the other half with paraffin gauze dressing [14]. The areas treated with Aquacel® had quicker epithelialization, less pain and better final scar. Similarly Lohsiriwat et al. reported that compared to paraffin gauze dressing, Aquacel® Ag resulted in quicker epithelialization and less pain [15]. Haith et al. compared Xeroform® (Bismuth impregnated petrolatum gauze) with Aquacel® Ag in a split wound study [16]. Areas treated with xeroform had quicker epithelialization but higher pain scores.

The AQUACEL® Ag dressing releases silver in a controlled fashion for up to 14 days [17]. Silver has antimicrobial properties [5]. Laboratory research by Jones et al. has shown that AQUACEL Ag has a broad antimicrobial spectrum which includes aerobes (S.aureus, S. pyogenes, P.aeruginosa, E.coli, E.faecalis, E.cloacae, K.pneumoniae, S.marcescens, A.baumannii), anaerobes (C.perfringens, B.fragilis, P.anaerobius, T.praeacuta, C.ramosum, C.cadeveris, C.clostridioforme), yeasts (C.albicans) and resistant bacteria (MRSA, VRE) [5]. This antimicrobial activity is desirable in management of open wounds. It allows the dressing to stay in place for a longer time period than traditional dressings. Furthermore, by keeping the same dressing till the wound epithelializes, new bacteria are not introduced into the wound.

The tumescent technique, which is commonly used for suction lipectomy, has previously been described for harvesting of split thickness skin grafts [7]. There are several advantages of tumescing the donor site. The epinephrine provides local vasoconstriction and decreases bleeding [8,18]. As a result, there is a decrease in fluid burden on the dressing, which can otherwise get overwhelmed with drainage. This is a major reason why we have been successful in keeping the dressing in place for 3 to 4 weeks. The bupivacaine in the tumescent solution provides pain relief in the early post-operative period [8]. Infiltration of fluid in the dermis and immediate subdermal areas increases the turgidity of the donor site skin, creating a tense and flat surface which makes

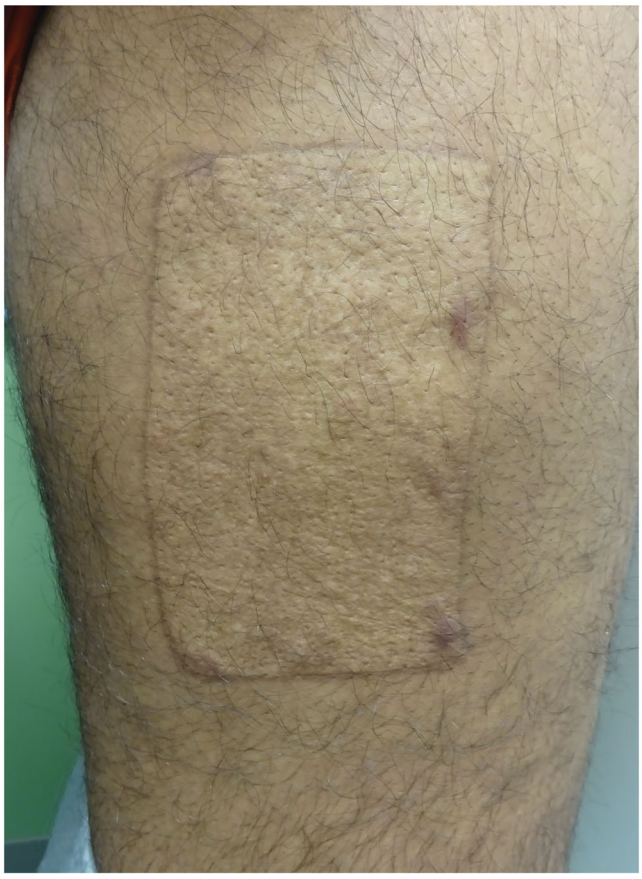

Figure 6. Long term aesthetic result at 1 year 7 months after surgery.

graft harvest easy. We have found that this also results in a more successful harvest with less jumping of the dermatome and a uniform graft thickness.

Safety is of utmost importance when infiltrating large volumes of solutions containing vasoconstrictors and local anesthetics. Cartotto et al. demonstrated that subcutaneous infiltration and topical application of epinephrine during burn surgery results in an increase in mean arterial pressure, but this does not have any clinically significant consequences [19]. No adverse effects of epinephrine were encountered in our series. Another concern with local vasoconstriction is the possible delay of wound healing. Several studies have demonstrated no impairment in would healing when donor sites are infiltrated with epinephrine containing solutions [8,20]. The most important consideration is the amount of local anesthetic that can be safely injected. The maximum dosage of bupivacaine (with or without epinephrine) that can be administered is 3 mg/kg [21]. A 0.25% bupivacaine solution contains 2.5 mg of bupivacaine per 1 ml. Thus, for ease of calculation, we consider the safe maximum dose of 0.25% bupivacaine to be 1 ml/kg. This important point should be kept in mind, especially when treating infants.

This study is not meant to show the superiority of this technique to any other method of skin graft donor site management, as there is no comparison group. Rather it presents a technique that may simplify skin graft care in the pediatric population. One downside of the AQUACEL Ag Foam is the cost, which is greater than more traditional dressings, and therefore may preclude its use in resource poor settings. However, it saves hospital visits for dressing changes and greatly simplifies wound care at home. The dressing does not need to be removed at a specified time period, which allows more freedom to schedule clinic follow up visits based on physician's schedule and patient's convenience.

Conclusions

Management of split thickness skin graft donor sites is challenging in pediatric patients due to fear and anxiety with dressing changes. A tumescent technique allows easier graft harvest with minimal bleeding, and provides post-operative pain control. AQUACEL® Ag foam, due to its absorptive and antimicrobial characteristics, can eliminate dressing changes by remaining in place until completion of wound epithelialization. This simplifies wound care and results in patient comfort.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

[1] Serebrakian AT, Pickrell BB, Varon DE, et al. Meta-analysis and systematic review of skin graft donor-site dressings with future guidelines. Plast Reconstr Surg Glob Open. 2018;6(9):e1928.

[2] Demirtas Y, Yagmur C, Soylemez F, et al. Management of split-thickness skin graft donor site: a prospective clinical trial for comparison of five different dressing materials. Burns. 2010;36(7):999–1005.

[3] Ding X, Shi L, Liu C, et al. A randomized comparison study of Aquacel Ag and Alginate Silver as skin graft donor site dressings. Burns. 2013;39(8):1547–1550.

[4] ConvaTec. AQUACEL® Ag Foam. 2019. [cited 2021 Feb 02]. Available from: https://www.convatec.com/wound-skin/aquacel-dressings/aquacel-ag-foam/.

[5] Jones SA, Bowler PG, Walker M, et al. Controlling wound bioburden with a novel silver-containing Hydrofiber dressing. Wound Repair Regen. 2004;12(3):288–294.

[6] Sinha S, Schreiner AJ, Biernaskie J, et al. Treating pain on skin graft donor sites: review and clinical recommendations. J Trauma Acute Care Surg. 2017;83(5):954–964.

[7] Field LM, Hrabovszky T. Harvesting split-thickness grafts with tumescent anesthesia. Dermatol Surg. 1997;23(1):62.

[8] Gacto P, Miralles F, Pereyra JJ, et al. Haemostatic effects of adrenaline-lidocaine subcutaneous infiltration at donor sites. Burns. 2009;35(3):343–347.

[9] Brown JE, Holloway SL. An evidence-based review of split-thickness skin graft donor site dressings. Int Wound J. 2018;15(6):1000–1009.

[10] Brenner M, Hilliard C, Peel G, et al. Management of pediatric skin-graft donor sites: a randomized controlled trial of three wound care products. J Burn Care Res. 2015;36(1):159–166.

[11] Karlsson M, Lindgren M, Jarnhed-Andersson I, et al. Dressing the split-thickness skin graft donor site: a randomized clinical trial. Adv Skin Wound Care. 2014;27(1):20–25.

[12] Dornseifer U, Lonic D, Gerstung TI, et al. The ideal split-thickness skin graft donor-site dressing: a clinical comparative trial of a modified polyurethane dressing and aquacel. Plast Reconstr Surg. 2011;128(4):918–924.

[13] Bailey S, Carmean M, Cinat M, et al. A randomized comparison study of Aquacel Ag and Glucan II as donor site dressings with regard to healing time, cosmesis, infection rate, and patient's perceived pain: a pilot study. J Burn Care Res. 2011;32(6):627–632.

[14] Barnea Y, Amir A, Leshem D, et al. Clinical comparative study of aquacel and paraffin gauze dressing for split-skin donor site treatment. Ann Plast Surg. 2004;53(2):132–136.

[15] Lohsiriwat V, Chuangsuwanich A. Comparison of the ionic silver-containing hydrofiber and paraffin gauze dressing on split-thickness skin graft donor sites. Ann Plast Surg. 2009; 62(4):421–422.

[16] Haith LR, Stair-Buchmann ME, Ackerman BH, et al. Evaluation of Aquacel Ag for Autogenous Skin Donor Sites. J Burn Care Res. 2015;36(6):602–606.

[17] Bowler PG, Jones SA, Walker M, et al. Microbicidal properties of a silver-containing hydrofiber dressing against a variety of burn wound pathogens. J Burn Care Rehabil. 2004;25(2):192–196.

[18] Ho CWG, Kok YO, Chong SJ. Photographic evaluation of different adrenaline-containing tumescent solutions on skin graft donor site bleeding: A prospective randomised trial. Burns. 2018;44(8):2018–2025.

[19] Cartotto R, Kadikar N, Musgrave MA, et al. What are the acute cardiovascular effects of subcutaneous and topical epinephrine for hemostasis during burn surgery? J Burn Care Rehabil. 2003;24(5):297–305.

[20] Blome-Eberwein S, Abboud M, Lozano DD, et al. Effect of subcutaneous epinephrine/saline/local anesthetic versus saline-only injection on split-thickness skin graft donor site perfusion, healing, and pain. J Burn Care Res. 2013;34(2): e80–e86.

[21] Local anesthetics. In: Butterworth JF, Mackey DC, WAsnick JD, editors. Morgan and Mikhail's clinical anesthesiology, 5e. New York, NY: The McGraw-Hill companies; 2013, p. 264–276.