Abstract: Background. Outcomes following a burn injury have improved considerably in recent years due to early excision and skin grafting. Despite a reduction in late burn complications, up to 70% of patients experience long-term pain at both the injured area and the skin-grafted scar. Current therapies do not ameliorate these symptoms for a majority of these patients. This report presents initial results of a new technique using a bilayer dermal substitute (Integra™, [Integra LifeSciences, Plainsboro, NJ]) for revision of painful scars. Methods. This is a prospective cohort of six patients treated at Grady Memorial Hospital Burn Center (Atlanta, GA) from 2008 to 2009. Burn patients undergoing multi-modality pain therapy for chronic, painful burns were identified and consented for intervention. All patients underwent operative excision of the painful scar and placement of a bilayer dermal matrix (Integra). After 3 weeks the silicone mesh was removed, excessive granulation tissue was debrided, and a new split-thickness skin graft was placed on the wound. Prescription history and a patient questionnaire were used to collect data. Results. All patients noticed improvement of symptoms post-operatively. Two patients (33%) experienced complete reduction of scar pain and three (50%) discontinued consumption of pain medications. At a mean follow up of 13 months, the average amount of narcotic-based pain medications decreased from 63.3 MED ([morphine equivalent per day], range: 30–135) before treatment to 7.5 MED (range: 0–20) postoperatively (P < 0.05). Conclusion. Scar excision, interval placement of a bilayer dermal matrix, and subsequent skin grafting is a new technique that can improve, and in some cases ameliorate, burn scar related pain.

Approximately 500,000 people in the United States suffer a burn injury each year, and 40,000 require admission to a hospital or specialized burn center for acute care. Early excision and grafting of deep partial-thickness and full-thickness burns has decreased morbidity and mortality; however, up to 70% of grafted patients experience chronic pain in their burn scars and skin grafts. Severe pain at the skin graft site has devastating physical and emotional consequences for these patients.

Bilayer Dermal Matrix for the Treatment of Painful Burn Scars

Hunter R. Moyer, MD; Maksym Yezbelyev, MD; Walter L. Ingram, MD
The etiology of post-burn, hyperalgesic scar formation remains poorly understood. Multiple therapies for hypertrophic and hyperalgesic scars have been described, including excision and re-grafting, steroid injection, topical vitamin E, and prescription narcotics. Non-invasive therapies, such as pain modulators alone or in combination with local steroid injections, offer temporary symptomatic relief, but often demonstrate limited efficacy. Reconstruction surgical techniques, which include excision of painful scars and skin grafting, are associated with a high recurrence rate in the authors' experience.

Dermal matrix substitutes have become a workhorse in the treatment of wounds, ventral hernias, and breast reconstruction, as they provide an optimal framework for local tissue integration. Integra™ is a bilayer dermal substitute (BDS) comprised of a bovine collagen and glucosaminoglycan dermis and a silicone sheet epidermis that recreates an epidermal-dermal complex. The product has demonstrated excellent cosmetic results in the reconstruction of disfiguring keloids, hypertrophic scars, and burn scars. Other studies have shown the development of near normal skin in a previous scar bed treated with excision, BDS placement, and subsequent skin grafting.

Current applications of acellular dermal matrices for post-burn scarring are focused on achieving cosmetic and functional improvement. The aim of the present study was to evaluate the efficacy of a dermal substitute to relieve pain associated with hyperalgesic post-burn scars.

Revision of hyperalgesic scars was performed as a two-stage procedure. During the first procedure an incision was made along the outlined area and the scar with the underlying dermis was excised sharply down to fatty tissues. Hemostasis was obtained, and a BDS graft was placed over the excised area.

Figure 1. Revision of a painful burn scar. First stage includes excision of the painful scar and placement of a BDS graft over an excised area. A) Painful area is identified and marked preoperatively. B) Skin incision is made along the scar. C) Scar is excised sharply down to the subcutaneous fat layer. D) Hemostasis is obtained. E) After marsupialization of the wound edges, BDS graft is placed over the wound. F) Wound is dressed in a tie-over manner.

Methods

Patients. Patients with hyperalgesic or painful burn scars who underwent scar excision and interval BDS placement at Grady Memorial Hospital Burn Center were reviewed with approval of the local Institutional Review Board. Selection criteria included post-burn scar related pain or increased sensitivity to pain (hyperalgesia) despite continuous multimodal medical treatment. Failure of medical management was considered as persistent pain despite administration of more than one symptoms-controlling therapy after at least 3 months after initial surgery or injury. Records were analyzed for patient and treatment factors. Patient factors examined included age, gender, location of the scar, mechanism of burn injury, total body surface area (TBSA) of the burn, and comorbidities. Treatment factors included type of non-surgical pain management, type of grafting, operative time, and duration of postoperative hospitalization. Outcomes examined included amount of postoperative pain at revised area and consumption of narcotic-based medications per day.

The two endpoints of this analysis were: 1) the level of postoperative pain at revised area and 2) consumption of narcotic-based medications per day.

Key Points

- Current applications of acellular dermal matrices for post-burn scarring are focused on achieving cosmetic and functional improvement. The aim of the present study was to evaluate the efficacy of a dermal substitute to relieve pain associated with hyperalgesic post-burn scars.
- Revision of hyperalgesic scars was performed as a two-stage procedure. During the first procedure an incision was made along the outlined area and the scar with the underlying dermis was excised sharply down to fatty tissues. Hemostasis was obtained, and a BDS graft was placed over the excised area.
of postoperative pain and 2) the amount of narcotic-based medication consumed by patients before and after scar revision. A pain scale (where 0 is no pain and 10 is unbearable pain) was used for assessment of subjective pain level. Patients were asked to rate his or her level of daily pain on optimal pain regimen before and after scar revision. Postoperative pain assessment, examination of wound healing, and revision of pain control regimen was performed during routine weekly clinic visits. All narcotic-based medication before and after surgery were transferred to a daily morphine equivalent dose (MED) using an established calculator.

**Surgical technique.** Painful or hyperalgesic areas of the burn scar were identified by dull and sharp tactile testing using the soft and broken end of a cotton swab. Testing proceeded from the area of maximal pain outward until areas of skin with normal sensitivity were reached. These areas were marked for excision (Figure 1A).

Revision of hyperalgesic scars was performed as a two-stage procedure. During the first procedure an incision was made along the outlined area and the underlying dermis was excised sharply down to fatty tissues. Hemostasis was obtained, and a BDS graft was placed over the excised area (Figure 1B, D). Marsupialization of the wound edges can be performed using interrupted 3-0 vicryl sutures prior to placement of BDS. The graft was then secured to skin edges with continuous chromic sutures or metal skin staples (Figure 1E). Either a bolster tie-over dressing or V.A.C. Therapy (KCI, San Antonio, TX) can be applied as a dressing (Figure 1F). Petroleum-based wound bandages should be avoided; splints can be applied as needed. Patients were discharged home when adequate control of postoperative pain had been achieved.

The first wound examination was performed on postoperative day 4. Thereafter, inspections and dressing changes were performed during weekly clinic visits. During inspection, the wound was assessed for signs of infection, retention of BDS graft, and development of neodermis. Normal saline soaked TELFA Clear Wound Dressing (Covidien, Mansfield, MA), Acticoat Antimicrobial Barrier Dressing (Smith & Nephew, Hull, UK), and bulky wet gauze dressing were used in this series.

The second stage of scar revision was performed once neodermis with adequate vascularization (pink tissue usually 3 weeks after implantation) had developed (Figure 2A). At this point, the patient was taken to operating room where the superficial (silicone) layer of the matrix was removed. If needed, excessive neodermis can be excised sharply or with a dermabrader. A thin, split-thickness skin graft (approximately 8/1000” meshed) was placed over the new dermal layer (Figure 2B). The skin graft was fixed with metal skin staples or continuous absorbable sutures and covered with moist TELFA Clear, Acticoat, and wet gauze. Traditional postoperative management of STSG can be used. Liquid 5% sulfamylon solution was applied over the dressing every 8 hours for the first 3 postoperative days. On postoperative day 4, the dressing was removed and graft take was examined. Conventional postoperative wound care was performed thereafter. After discharge, the wound was examined during clinical visits (Figure 2C).

**Data Analysis**

A two-tailed Student t test set for a type I error of 5% (alpha = 0.05) was used to determine significance for continuous variables. All analyses were performed using SPSS 16.0 statistical software (SPSS Inc., Chicago, IL).

**Keypoints**

- The average postoperative follow up was 13.0 ± 4.3 months (Table 2). All patients described a decreased level of subjective pain (Figure 3A). Two of six patients became pain free, and one patient has only a pain level of 1/10. Of the remaining three, two patients dropped 3 points on the pain scale, while one patient had a minimal improvement of symptoms with a residual pain level varying between 8 and 9.
Results

Between September 2008 and November 2009 six patients (3 men and 3 women) with painful burn scars were treated with BDS grafting (Table 1). Patients' ages ranged between 34 to 59 years (mean 44.3 years). Three patients (50%) presented with baseline comorbidities including liver cirrhosis, cardiovascular disease, and chronic obstructive pulmonary disease. Painful scars were located most commonly on the extremities (50%) and the trunk (16.7%). The total body surface area (TBSA) of the initial burn ranged from 1% to 33% (median 10.5%). The most common mechanism of burn was flame injury (3 patients) followed by grease, gasoline, and scald burn.

Five patients defined their pain as a 10 on the pain scale, and one patient characterized the scar pain ranging from 7 to 10. Initial pain management regimen in addition to narcotic-based pain medications included topical local anesthetics in four patients, gabapentin in two patients, and injection of local steroids (triamcinolone) in one case (Table 2). All patients received more than one pain treatment modality prior to surgery. Two patients were undergoing more than one more pain management modalities without sufficient improvement. The duration of medical treatment after initial burn to inclusion in the study ranged from 5 to 9 months (average 7 ± 1.6 months).

The initial burn injury averaged 1500 cm² ± 832 cm² while the average painful scar was 412.0 cm² ± 492.0 cm². In two cases, the entire initial burn scar was excised. Painful or hyperalgesic areas in scars of the remaining patients were significantly smaller than the initial injured area. Painful scars were located most commonly on the upper and lower extremities. After BDS grafting, patients remained in the hospital an average 5.1 ± 4.9 days. No postoperative complications were observed over the next 3 weeks as the wounds granulated. Subsequent skin grafting to the BDS wound bed approximated the initial excision area (425.8 cm² ± 468.8 cm²). All patients received 8/1000” split-thickness skin grafts meshed 2:1. Patients remained in the hospital a mean of 3.5 ± 2.1 days. No major postoperative complications were observed after skin grafting.

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KEYPOINTS

- All but one patient reported a decreased level of pain and half of the patients are now completely off narcotic medication. It is noted that the patients with the highest MED of narcotic pain medicines preoperatively received the most benefit post grafting.
- On average, $4800 worth of product was used in the present study in addition to the multiple operating room costs and recovery costs. Although it is difficult to sum the costs of lost work production, prescription medications, and healthcare burden for patients with chronic pain, the authors believe that the operative and product cost are justified in patients who become pain free, return to work, and regain fruitful lives.
MED (range: 30–135) prior to surgery to 7.5 MED (range: 0–20) postoperatively ($P < 0.05$).

**Discussion**

This report details a novel approach for the management of chronic, debilitating burn scars. This technique includes excision of the painful scar, placement of a bilayer dermal matrix, followed by interval grafting with a thin split-thickness skin graft. The authors’ initial experience using this approach has been positive.

Chronic pain in healed burns is poorly understood and remains a frequently under-reported complication of burn injuries.5,16 The pathophysiology of sensory disorders is currently under investigation. Studies have shown that painful, hypertrophic scars demonstrate a greater number of nerve fibers compared to normotrophic scars.17,18 One theory points to the formation of an abnormal dermal scar layer with an increased density of afferent nerves and neuroinflammatory mediators.18,19 Moreover, several pain neurotransmitters, including calcitonin gene-related peptide and substance P, are over expressed in the sensory nerves of hypersensitive scars.20

In theory, surgical excision of an abnormal scar and engraftment of dermal matrix on the wound allows for the orderly accumulation of a new dermis instead of granulation tissue. This new layer has an ordered collagen ar-

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**Table 1. Clinical and demographic characteristics**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age</th>
<th>Sex</th>
<th>Comorbidities</th>
<th>Location</th>
<th>TBSA (%)</th>
<th>Mechanism of burn</th>
<th>Pain Scale (0–10)</th>
<th>Previous therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>F</td>
<td>None</td>
<td>L arm</td>
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<td>Grease</td>
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<td>Lidocaine patch</td>
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<td>2</td>
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<td>F</td>
<td>COPD*, Cirrhosis</td>
<td>Trunk, B arms</td>
<td>20</td>
<td>Flame</td>
<td>10</td>
<td>Lidocaine patch</td>
</tr>
<tr>
<td>3</td>
<td>59</td>
<td>M</td>
<td>CAD†, HTN‡, Depression</td>
<td>Trunk, B arms, B legs</td>
<td>33</td>
<td>Flame</td>
<td>10</td>
<td>Lidocaine patch</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>M</td>
<td>None</td>
<td>R arm</td>
<td>5</td>
<td>Flame</td>
<td>10</td>
<td>Lidocaine patch, Gabapentin</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
<td>M</td>
<td>Cirrhosis</td>
<td>B legs</td>
<td>7</td>
<td>Gasoline</td>
<td>10</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>34</td>
<td>F</td>
<td>None</td>
<td>R flank</td>
<td>16</td>
<td>Scald</td>
<td>7–10</td>
<td>Steroid injection, Gabapentin</td>
</tr>
</tbody>
</table>

*Chronic obstructive pulmonary disease; †Coronary artery disease; ‡Hypertension.

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**Table 2. Preoperative pain management.**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Narcotics-based pain medications</th>
<th>Additional treatment modalities</th>
<th>Duration of medical therapy (months)</th>
<th>Postoperative follow up (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oxycodone</td>
<td>Lidocaine patch</td>
<td>9</td>
<td>16</td>
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<tr>
<td>2</td>
<td>Oxycodone, Morphine</td>
<td>Lidocaine patch</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Hydrocodone, Oxycodone</td>
<td>Lidocaine patch</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
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<td>12</td>
</tr>
<tr>
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<td>None</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Oxycodone, Morphine</td>
<td>Steroid injection, Gabapentin</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
rangement, neovascularization, and is devoid of abnormal neural structures. BDS was developed for and has been widely used to provide primary coverage of acute burns. Its bilayered structure of bovine collagen, shark chondroitin-6-sulfate, and an outer silicone sheet facilitates the formation of a full-thickness dermal complex that is prepared for skin grafting. Unlike placing the skin graft over excised acute burns, the BDS wound bed is ordered and stable for grafting, and the patient is not undergoing a systemic inflammatory response.

This is a report of initial results, thus there may be a subset of scars that do not respond favorably to this technique. We did not experience complications with BDS grafting. Should the graft not take or infection set in, the surgeon is now managing an open wound in previously healed skin. Patients must fully understand both the potential complications and the resultant pain, morbidity, and time necessary to complete this two-step surgical intervention.

The cost of BDS is $61.25 per square centimeter for the larger 8-in x 10-in sheet to $412.50 per square centimeter for the smaller 2-in x 2-in sheet. On average, $4800 worth of product was used in the present study in addition to the multiple operating room costs and recovery costs. Although it is difficult to sum the costs of lost work production, prescription medications, and healthcare burden for patients with chronic pain, the authors believe that the operative and product cost are justified in patients who become pain free, return to work, and regain fruitful lives.

All but one patient reported a decreased level of pain and half of the patients are now completely off narcotic medication. It is noted that the patients with the highest MED of narcotic pain medicines preoperatively received the most benefit post grafting. The authors surmise that these may be the patients in the most pain from their initial graft scars and are not simply dependant on pain medication. In support of this, the two patients with the least preoperative MED curtailed their medication the least and had the least subjective pain relief. Going forward, the addition of a pain specialist to the preoperative assessment may help select the patients most likely to benefit from this intervention.

The authors plan to continue this therapy with the intent of reporting more accurately the early and long-term postoperative results and the incidence of complications. To the authors’ knowledge, there are no data available about the application of other techniques, such as flaps or skin grafts, for the treatment of painful burn scars. Comparative analysis of the results of dermal grafting versus alternate techniques needs to be performed to determine if this protocol is efficacious and cost effective.

**Conclusion**

Scar excision, interval placement of a bilayer dermal matrix, and subsequent skin grafting is a new technique that can improve, and in some cases ameliorate, the symptoms of burn scar related pain.

**References**


**Table 3. Treatment characteristics.**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Initial grafting</th>
<th>Integra grafting</th>
<th>Final grafting</th>
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</thead>
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<tr>
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<td>Graft</td>
<td>HD</td>
</tr>
<tr>
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<td>Sheet</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>1750</td>
<td>STSG (2:1)</td>
<td>29</td>
</tr>
<tr>
<td>3</td>
<td>2850</td>
<td>STSG (2:1)</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>1600</td>
<td>Sheet</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>1450</td>
<td>STSG (2:1)</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>1200</td>
<td>STSG (2:1, 3:1)</td>
<td>10</td>
</tr>
</tbody>
</table>

*in cm²
HD: hospitalization days


