

Treatment of Friction Injury Using Enzymatic Debridement and Autologous Skin Cell Suspension

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Abstract

Friction injury occurs when a patient slides across a surface at high velocity, resulting in mechanical abrasion, laceration, and thermal burn. Mechanical abrasion removes tissue to a variable depth depending on surface texture in contact, and thermal burn devitalizes tissue to a variable depth based on contact pressure and transfer of kinetic energy. In these heterogeneous wounds, tangential excision can excise healthy tissue alongside devitalized tissue, and other debridement techniques like hydrosurgery or dermabrasion may not reach deeper crevices created by abrasion and laceration. In addition, traditional skin grafts create significant donor site morbidity. This case series presents an early experience with a novel approach using bromelain-based enzymatic debridement combined with autologous skin cell suspension. Bromelain-based enzymatic debridement acts uniformly on a wound surface despite its topography, optimizing removal of devitalized tissue while preserving healthy tissue. Autologous skin cell suspension reduces donor site morbidity. This combined strategy minimizes dressing changes, optimizing pain control and enabling outpatient management. We observe rapid healing and outstanding cosmetic outcomes, and no patients experienced wound infection or other complications or required secondary procedures for nonhealing.

Key words: enzymatic debridement; autologous skin cell suspension; road rash; friction burn; friction injury.

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INTRODUCTION

Friction injury results from high-velocity contact between skin and rough surfaces like asphalt, producing a combined thermal and mechanical injury. The thermal component mimics the pathophysiology of thermal burns with its 3-zone pattern—a central zone of coagulation and irreversible necrosis surrounded by a threatened zone of stasis and a peripheral zone of hyperemia and reversible inflammation.¹ However, contact with rough surfaces is rarely uniform, resulting in heterogeneous zone patterns. In addition, the mechanical component causes abrasions and lacerations that extend into and past the dermis, depending on the force of contact and the texture of the contact surface. Foreign bodies are also deposited into the wound bed during contact. This combined mechanism results in a wound with variable topography, where scattered areas of devitalized tissue and foreign bodies can be deeply implanted into small crevasses that are difficult to reach with standard debridement techniques.

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The need for operative treatment varies widely in published studies from 1.6% to 58%.^{2,3} Operative debridement optimizes removal of devitalized tissue but risks removing intervening viable tissue. Many patients undergoing operative debridement require split-thickness skin grafting.³ Nonoperative management may incompletely debride, and although the wounds may eventually heal, it can lead to repetitive, painful dressing changes and prolonged healing times. It remains unclear if either strategy modulates the rate of infection, which ranges from 11% to 18% in these studies.^{2,3} The gap in treatment paradigms and high rate of complications for friction burns signals an opportunity for a novel treatment strategy.

Bromelain-based enzymatic debridement (BED, NexoBrid, Vericel Corp., Cambridge, MA) is derived from the stems of the pineapple plant. Its active ingredient, anacaulase-bcdb, contains a mixture of proteolytic enzymes that target necrotic eschar while preserving viable dermis.^{4,5} Preservation of dermal appendages in intermediate-thickness wounds ultimately determines whether they will heal without split-thickness skin grafting, and one study showed a corresponding 56.3% reduction in need for skin grafting when NexoBrid was used.⁴

Autologous skin cell suspension (ASCS, RECELL, AVITA Medical, Valencia, CA) is used to reduce traditional skin grafting for thermal burns and other non-burn wounds.^{6,7} A point-of-care enzymatic digestion system produces autologous epidermal cells in suspension from a small piece of split-thickness skin that are sprayed over large areas to induce rapid epithelialization over large surface areas.^{6,7} Studies have shown reduced donor site area and pain as well as improved cosmesis with ASCS compared to traditional skin grafting.⁶⁻⁸

Combination BED-ASCS offers a novel solution to these challenging cases. Bromelain-based enzymatic debridement preserves viable tissue and prepares a healthy tissue bed that accepts ASCS remarkably well, resulting in rapid healing with minimal donor site morbidity. This case series describes our preliminary experience of treating patients with friction injury managed with this technique.

METHODS

This is a retrospective case series of patients with friction injury who underwent BED-ASCS. Patients were identified from surgical case logs from 4 participating surgeons at the University of Alabama at Birmingham Hospital, from March to June of 2025. Demographics, injury patterns, treatment details, healing outcomes, and complications were collected from the institutional trauma registry and chart review under a protocol approved by the institutional review board. Photographs were taken as part of our standard care and de-identified for usage. Time to > 95% healing was determined retrospectively based on consensus review by the authors of postoperative photographs, typically taken at 7 and 30 days postop. Pain was quantified by area under the pain curve, which considers duration and intensity of pain.⁹

Therapy was not driven by a specific clinical or research protocol. In general, the following technique was used. The wound was prepared preoperatively by antimicrobial soak. Devitalized epidermis and surface debris were completely removed, and highly selective tangential excision was performed with a

Table 1. Characteristics of Study Population

Age, years, median (IQR)	27	(19-48)
Sex		
Male, n (%)	12	92%
Female, n (%)	1	8%
BMI, median (IQR)		
Mechanism of injury		
Motorcycle, n (%)	11	85%
Drug by car, n (%)	2	15%
Anatomical location of injury		
Trunk, n (%)	10	77%
Extremities, n (%)	13	100%
Face, n (%)	2	15%
% TBSA		
Total, median (IQR)	9	(8-11)
Superficial partial thickness, median (IQR)	4	(3-6.5)
Deep partial thickness, median (IQR)	5	(4-6)
Full thickness, median (IQR)	0	(0-0.5)
Injury Severity Score, median (IQR)	10	(5-12)
Injury pattern		
AIS head	2	(1.5-2.5)
AIS face	1.5	(1-2)
AIS neck	3	(3-3)
AIS thorax	3	(1-3)
AIS abdomen	1	(1-3)
AIS spine	2	(1.5-2.5)
AIS upper extremity	1	(1-2)
AIS lower extremity	1	(1-2)
AIS other/external	1	(1-1)

Abbreviation: AIS, Abbreviated Injury Scale.

Weck blade in some cases. The healthy surrounding skin was protected with Ioban. Bromelain-based enzymatic debridement powder was mixed with a gel vehicle applied as an ointment in a layer 3-5 mm thick. This was covered with a layer of Ioban to create a blister packet of ointment over the target area. The blister packet was periodically massaged to circulate fresh enzyme to the wound surface, and the room temperature was elevated to optimize enzyme kinetics. After removal of the blister packet, the wound surface was gently scraped of necrotic debris to avoid damage to the fragile layer of exposed dermis. Donor skin was harvested and processed for ASCS in standard fashion, applied to the tissue bed, and dressed with ASCS-compatible dressings.

RESULTS

Thirteen patients with friction injury were treated with BED-ASCS in the 4-month study period (Table 1). The patients were young (median 27 years, IQR 19-48 years), male (92%), and had been involved in a motorcycle accident (84%). Median combined TBSA was 9% (IQR 8-11), with extremity involvement in 100%, truncal involvement in 77%, and facial involvement in 15%. Moderate concomitant injuries were sustained in most patients (median Injury Severity Score [ISS] 10, IQR 5-12).

Patients were typically treated with BED 3-4 days after admission (median 89 h, IQR 104-113 h; Table 2). Patients

Table 2. Treatment

Time from admission to index operation, hours, median (IQR)	89	(104-113)
Number of postop dressing changes, median (IQR)	2	(1.75-2)
First dressing change		
Location		
Hospital, n/N (%)	5/13	(38%)
Clinic, n/N (%)	8/13	(62%)
IV medication required, n/N (%)	2/13	(15%)
Second dressing change		
Location		
Hospital, n/N (%)	3/10	(30%)
Clinic, n/N (%)	7/10	(70%)
IV medication required, n/N (%)	2/10	(20%)

Table 3. Outcomes

Number of patients with 95% healing at 7 days, n (%)	6	(46%)
Number of patients with 95% healing at 30 days, n (%)	12	(92%)
Pain score, area under curve, median (IQR)	46	(54.5-64.5)

were evaluated and debrided in a hydrotherapy procedural suite prior to operation. The first 2 patients in this case series received IV pain medication for their postoperative dressing changes. The subsequent 11 patients required only oral medications for postoperative dressing changes. Dressing changes were performed in the clinic setting unless the patient was admitted to the hospital for other injuries. No patients required subsequent procedures for nonhealing.

Six patients (46%) were 95% healed within 7 days of surgery. Another 6 patients (46%) reached 95% closure at their 30-day follow-up. One patient with > 1% full-thickness injury was not healed by day 30 (Table 3). The rate of 95% healing at 7 days increased over the study period. Of the 7 most recently treated patients, 86% were healed at 7 days. Figure 1 shows representative wounds at various stages of healing. Pain scores measured by area under the pain curve were 46 (IQR 54.5-64.5). There were no wound complications or infections.

DISCUSSION

This is, to our knowledge, the first report of combination therapy with BED-ASCS in friction injury. Friction injury results in mixed-depth wounds with scattered areas of devitalized tissue among viable tissue, leaving the surgeon with a difficult choice. Tangential excision can be tedious to minimize removal of viable intervening tissue, and complete avoidance of viable tissue is impossible. Weighed against the fact that most of these injuries will eventually heal without operative intervention, management patterns vary substantially.^{2,3}

A strategy that selectively debrides devitalized tissue, conserves viable tissue, and minimizes donor site morbidity—while facilitating rapid healing with low complication rates and acceptable cosmetic and functional outcomes—is highly attractive. Our experience highlights the synergistic benefits of BED and ASCS. These treatments have been shown individually to reduce time to wound healing and limit donor site morbidity in thermal injuries.^{6,7,10} Our results suggest that ASCS works best when a layer of dermis resides in the wound bed to provide a scaffold for the suspended epidermal cells. Bromelain-based enzymatic debridement minimizes removal of viable dermis, which optimizes the wound bed for ASCS. In our experience, BED produces a very clean wound bed, even in friction injury, which can be complicated by deeply implanted foreign material. We believe the enzymatic preparation accounts for the absence of any wound infections in this case series.

Bromelain-based enzymatic debridement-ASCS is most impactful in deep partial-thickness friction injury. The previous standard of care at our institution for these wounds included aggressive mechanical debridement and hydrotherapy under monitored anesthesia care, followed by split-thickness skin grafting for nonhealing wounds. Although most of these wounds eventually heal nonoperatively, daily wound care is often necessary to manage exudate burden and treat infections that arise. Other centers have noted high injury severity associated with friction injury,¹¹ so inpatient stay may be necessary for the patient's total injury burden. In contrast, our center sees a high number of patients with significant friction injury (median % TBSA 9, IQR 8-11), but overall mild to moderate ISS (median 10, IQR 5-12), where daily dressing changes are the only limit to discharge. Bromelain-based enzymatic debridement-ASCS appears to shorten stay compared to our prior approach, which may offset device costs. We noticed that patients with a higher degree of epithelialization have less pain with dressing takedown. During this experience, we learned that keeping surgical dressings in place for up to 7 days allows ASCS maximum time to epithelialize. In patients with 7-day surgical dressings, 6 out of 7 patients (86%) were 95% healed at first dressing takedown. All patients who qualified for discharge from the standpoint of other injuries underwent first dressing takedown in clinic with PO pain medications. Notably, some friction injuries clearly exhibit substantial areas of full-thickness wounds. Our previous and current management of full-thickness friction injury is tangential excision and grafting, usually in a staged approach.

Some evidence suggests that treatment with ASCS is more effective the sooner it is applied.¹² As we refine this technique, we have begun to perform this procedure sooner. In this study, we relied on assessment of the wound in hydrotherapy before scheduling an operative date for BED-ASCS, which normally took 3-4 days from admission to BED-ASCS. While we routinely apply BED in our hydrotherapy suite, a current project aims to outfit our hydrotherapy suite for ASCS to allow immediate delivery of BED-ASCS to patients identified to benefit. It is also possible that BED therapy extends the effectiveness of ASCS therapy. Our theory is that BED optimizes adherence of suspended skin cells by removing devitalized dermis, which may improve efficacy of ASCS whether applied immediately or in a delayed fashion.



Figure 1. These Are Representative Images of the Healing Process of Friction Injury in Multiple Patients at Preoperative Evaluation, Postoperative Day (POD) 7, and POD 30.

Patients had a median area-under-the curve pain score of 46 (IQR 54.5–64.5) during their hospital admission. This outcome considers the duration as well as intensity of pain.⁹ Scores are therefore higher when pain is experienced for longer. This is an inherently attractive characteristic of this method and will be particularly helpful in future studies comparing different treatment strategies.

Friction burns by nature tend to concentrate on bony prominences like joints and facial structures, which emphasizes the importance of an optimal treatment strategy. Studies evaluating minimally invasive debridement (enzymatic or hydrosurgical) combined with ASCS in thermal burns have showed improved healing and cosmetic and functional outcomes, particularly in hand, foot, and facial burns.^{13,14} Our results show that BED combined with ASCS leads to similarly good healing and outstanding cosmetic and functional outcomes in friction injuries.

Further studies should continue to evaluate the effectiveness of this strategy in terms of patient satisfaction, wound healing, pain, and scar quality compared to standard approaches. Cost-effectiveness of this approach also remains a top priority in our future work. The upfront cost associated with the product may be mitigated by reduction in length of stay and complications. A cleaner wound bed and simplified wound care may also lead to reduced infections, which can be costly. Finally, in cases involving face, joints, hands, or feet, a higher cost may be justified to improve cosmetic and functional outcomes.

CONCLUSION

This case series reports the initial experience of a promising, novel approach to friction burns. Future studies should address

the cost-effectiveness of this approach and aim to define its healing outcomes, complications, and cosmetic and functional benefits.

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