Commentary

Enzymatic Debridement Based Minimally Invasive Modality versus Standard of Care in Modern Burn Management

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Since the 1970s, the standard of care (SOC) for deep burn injuries has been dominated by early tangential excision followed by autografting, as introduced by Zora Janžekovič. This strategy, developed to prevent eschar-related complications such as infection, sepsis, and burn-induced hypermetabolism, undoubtedly improved survival and reduced hospital length of stay. However, these benefits came at a substantial cost and risk to patients. Tangential excision is inherently traumatic and non-selective, resulting in extensive removal of viable dermis, reported to exceed 70% in some series[1], significant blood loss (approximately 200–400 mL per 1% TBSA excised), donor-site morbidity, and graft-related scarring. In addition, uncertainty in early burn-depth assessment, heavy reliance on surgical resources, and dependence on operating-room availability often delay intervention and severely limit surge capacity during burn mass casualty incidents (BMCI).

The introduction of bromelain-based enzymatic debridement (NexoBrid®) has challenged this paradigm and enabled a shift toward a minimally invasive modality (MIM) of burn care. Rather than prioritizing rapid surgical excision, MIM emphasizes a biologically guided sequence based on very early, often immediate, safe, selective, non-surgical eschar removal. This approach promotes epithelialization over salvaged dermis, modulates granulation tissue, and reserves autografting for non-healing, full thickness wounds. In contrast to tangential excision, enzymatic debridement is not surgery-dependent, does not require surgical teams or operating-room infrastructure, involves minimal blood loss, and can be performed at the bedside shortly after admission. By selectively removing necrotic tissue while preserving viable dermis, enzymatic debridement exposes the true depth of injury and allows accurate visual wound assessment. This selectivity fundamentally transforms the burn wound from a primarily surgical challenge of excision and grafting into a minimally invasive process aimed at selective debridement and epithelialization over a preserved dermal wound bed.

Following early, practically immediate on admission, enzymatic debridement and prevention of eschar-related complications, the MIM strategy focuses on promoting epithelialization of all burns that retain healing potential and are not full thickness. The selectively debrided wound bed permits precise

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visual assessment and informed decision-making regarding the optimal wound closure strategy, mostly by epithelialization. Appropriate wound dressings, maintenance of moisture balance, and topical anti-inflammatory agents, including low-potency topical corticosteroids that may be employed to modulate granulation tissue, facilitate keratinocyte migration, and promote timely healing with minimal scarring. It seems that the addition of keratocyte's and/or micrografts may even further enhance such epithelialization over salvaged dermis. Under SOC, many of these mixed-depth or deep partial-thickness burns would have been routinely excised and grafted.

Evidence from randomized controlled trials and long-term clinical experience supports this minimally invasive approach. Results from Phase III adult and pediatric randomized, clinical trials comparing NexoBrid with SOC (Table 1) corroborate more than three decades of published data.[2-9] While enzymatic and surgical debridement demonstrate comparable efficacy in achieving eschar removal, enzymatic debridement consistently achieves complete debridement significantly earlier, often within the first day of admission, compared with several days under SOC that included surgical and non-surgical debridement. This early selectivity translates into a marked reduction in surgical debridement and autografting, dramatically lower blood loss, and reduced need for transfusion. Importantly, despite the substantial reduction in grafting, time to wound closure, often more than 21 days, remains comparable between groups, while long-term scar outcomes are equal or superior in the enzymatic debridement cohorts.

Paediatric patients appear to derive particular benefit from this minimally invasive approach. Reductions in time to debridement, operative exposure, and blood loss may have greater

Table 1. Comparison of bromelain-based enzymatic debridement (NexoBrid®, NXB) and standard of care (SOC) in adult and pediatric burn patients.

	NXB Adults[6]	SOC Adults[6]	NXB Pediatrics[5]	SOC Pediatrics[5]
Debridement incidence (%)	~93.3	89.3	94	93.8
Time to complete debridement (days)	1.02	3.83	1	6
Incidence of surgical debridement (%)	8.3	64.4	8.3	64.4
Area of surgical debridement (%)	4	72	1,5	48.1
Incidence of autografting DPT burns (%)	16.9	34.8	25.9	37.8
Area of autografting DPT burns (%)	9	20.4	15.9	22.8
Blood loss (cm^3)	14	815	32	203
Time to wound closure	37,8	28	32	34
MVSS at 12 months	3.07	5.8	3.83	4.86

Legend. Summary of selected clinical outcomes comparing bromelain-based enzymatic debridement (NXB) with standard of care (SOC; surgical tangential excision) in adult and pediatric burn patients. Data are derived from randomized controlled trials and pooled analyses reported in the literature.[2–5] Incidence of surgical debridement refers to the % of all the burned skin surface that was excised. Data for autografting addresses only the DPT burns demonstrating the potential of epithelialization of the salvaged dermis as the FT burns where all dermis is destroyed should be always grafted Enzymatic debridement achieves earlier complete eschar removal with marked reductions in surgical debridement, autografting, and blood loss, while maintaining comparable time to wound closure and equal or improved long-term scar outcomes.

Footnotes

1. Debridement incidence refers to successful complete eschar removal following the assigned treatment.
2. Time to complete debridement reflects the interval from admission and randomization to confirmed complete eschar removal; SOC timing may be influenced by operating-room availability and institutional practice in contrast to enzymatic debridement.
3. Incidence and area of surgical debridement represent the proportion of patients requiring surgery and the mean wound area surgically excised among those patients.
4. Autografting outcomes are reported for deep partial-thickness (DPT) burns as full thickness burns always will be grafted and reflect mean grafted %TBSA.
5. Estimated blood loss represents measured peri-debridement blood loss and is reported in millilitres (mL).
6. Time to wound closure is defined as median days from randomization to complete epithelialization or stable graft take, as reported in the original studies.
7. MVSS denotes the Modified Vancouver Scar Scale score assessed at 12 months.
8. Reported values represent pooled or mean outcomes across studies; definitions and assessment time points may vary slightly between individual trials.

physiological relevance in children due to their smaller circulating blood volumes and the challenges associated with general anesthesia and postoperative recovery. Moreover, improved scar quality is especially meaningful in this population, in whom hypertrophic scarring and contractures may impose long-term functional, aesthetic, and psychosocial burdens.

Within the MIM framework, autografting is not abandoned but redefined. Surgical intervention is reserved for clearly full-thickness burns and for wounds that fail to epithelialize despite optimized conservative management. Compared with SOC, this results in fewer grafted areas, smaller graft sizes, delayed but more accurate surgical decisions, and improved alignment between intervention and actual tissue loss. Enzymatic debridement thus reduces overtreatment of burns that might otherwise heal spontaneously while preserving the option for surgery when biologically indicated.

Beyond routine clinical care, the implications of enzymatic debridement extend to disaster preparedness. In burn mass casualty events, rapid and efficient non-surgical debridement performed outside the operating room has the potential to preserve surgical capacity and expand surge capacity and response. Recognizing this, the U.S. Biomedical Advanced Research and Development Authority (BARDA) has identified bromelain-based enzymatic debridement as a Medical Countermeasure (MCM) with potential to mitigate resource constraints during large-scale burn disasters.

In summary, compared with SOC, a bromelain-based enzymatic debridement–driven minimally invasive modality achieves earlier complete debridement with markedly reduced surgical burden and blood loss, while maintaining comparable wound-closure times and achieving equal or improved long-term outcomes. This approach represents not a rejection of established burn-care principles, but their evolution. Where SOC emphasizes completeness of excision, MIM emphasizes early-as-possible, selectivity, tissue preservation, and staged decision-making. In modern burn care, the question is no longer whether early intervention is required, but how early, how selective, and how minimally invasive that intervention can be. Minimally invasive burn management answers this question by replacing routine excision with informed restraint, preserving the patient's own regenerative capacity while maintaining safety, efficacy and good final outcome.

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