

# WOUNDS

A Compendium of Clinical Research and Practice

Volume 14, Number 7

September 2002 Supplement E

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## Debridement: Rationale and Therapeutic Options

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# Debridement: Rationale and Therapeutic Options

**Completion Time:** The estimated time to completion for this activity is 1 hour.

**Target Audience:** This CME activity is intended for dermatologists, surgeons, internists, and physicians who treat wounds.

**At the conclusion of this activity, the participant should be able to:**

- 1) Describe the rationale for debridement of chronic wounds.
- 2) Appreciate the different types of debridement techniques.
- 3) Discuss the advantages and limitations of each debridement technique.

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Release date: September 15, 2002  
Expiration date: September 15, 2003

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**Abstract:** Debridement is commonly defined as the process of removing necrotic, devitalized tissue and foreign material from a wound. The presence of necrotic tissue within a wound may impair wound repair processes by stimulating inflammation and delaying granulation and epithelialization. However, the above definition of debridement may not tell the whole story. Debridement may additionally remove senescent cells from the wound bed and nonmigratory cells from the ulcer edge and also remove excessive or abnormal bacteria; all of which may allow for improved availability of growth factors. This supplement will review the rationale for debridement, existing clinical data supporting debridement, and the various debridement options available.

WOUNDS 2002;14(7 Suppl E):2E-7E

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## Introduction

With the advent of advanced wound care technologies, such as bioengineered tissue and topically applied growth factors, much attention is being focused on optimizing the outcomes of treatment using such technologies. Efforts to increase the value of these and other technologies, as well as improve healing of chronic wounds in general, have been aimed at addressing one or more of the factors associated with chronicity of wounds. Chronic wounds exhibit an impaired response to wound healing.<sup>1</sup> A number of factors are thought to impair wound healing including the presence of necrotic tissue and bacteria (number, species, and composition), the lack or unavailability of growth factors and/or

their receptors, the presence of increased inflammatory cytokines, the development of cellular senescence, abnormal matrix metalloproteinase regulation, and decreased perfusion and oxygenation of the wound.<sup>23</sup> The subject of this supplement is debridement, which addresses several of these factors and plays an essential role in the proper management of chronic wounds.

Debridement is commonly defined as the process of removing necrotic, devitalized tissue and foreign material from a wound. The presence of necrotic tissue within a wound may impair wound repair processes by stimulating inflammation and delaying granulation and epithelialization.<sup>4</sup> However, the above definition of debridement may not tell the whole story. Debridement may additionally remove senescent cells from the wound bed and non-migratory cells from the ulcer edge, and also remove excessive or abnormal bacteria; all of which may allow for improved availability of growth factors (Table 1).<sup>25</sup> Several methods for debridement exist including surgical, enzymatic, mechanical, autolytic, and biosurgical. This supplement will review the rationale for debridement, clinical data supporting debridement, and the various debridement options available.

## Benefits of Debridement

**Removal of bacteria.** The presence of necrotic tissue supports the growth of bacterial organisms.<sup>6</sup> It has been suggested that significant numbers of bacteria in a wound may impede healing.<sup>7</sup> The presence of microbial organisms in a chronic wound is inevitable and is not necessarily detrimental to healing. The majority of chronic wounds that heal do so in a polymicrobial environment. However, when bacteria are present in increased numbers or pathogenicity, complications may arise. Wounds exhibiting increased bacterial burden (traditionally considered greater than  $10^5$  colonies per gram of tissue) have reduced healing responses when compared to wounds containing fewer bacteria.<sup>8</sup> Whether bacterial burden is a cause or consequence of impaired healing is not entirely clear.

Infected or heavily colonized wounds feature friable and hemorrhagic granulation tissue and decreased tensile strength.<sup>7</sup> The sheer number of bacteria may not tell the entire story, as the type of bacterial species present may also be important. A single species, such as beta hemolytic streptococci, or combinations of species can be harmful to a wound regardless of number.<sup>9,10</sup> In addition, recent

**Table 1.** Rationale for debridement

- Remove necrotic tissue
- Remove senescent cells from the wound bed
- Remove nonmigratory cells from the ulcer edge
- Remove excessive or abnormal bacteria
- Improve availability of growth factors

recognition of the potential detrimental effects of biofilms in wounds may also be important. Biofilms are communities of bacteria and other organisms that are embedded within an extrapolysaccharide matrix.<sup>11</sup> Different than planktonic, free-living bacteria, biofilms demonstrate increased adherence to the wound bed and increased resistance to antimicrobial agents and to the immune system of the host. Debridement may be effective in detachment and removal of biofilms from the wound bed.

Bacterial contributions to impaired healing are multifactorial. Prolonged exposure to bacteria in chronic wounds leads to an altered, often prolonged inflammatory response, resulting in the release of free oxygen radicals and various lytic enzymes that stimulate tissue damage.<sup>12</sup> Tissue hypoxia may also ensue during the inflammatory response. In a cyclical fashion, this supports further bacterial growth. Proteases released by the bacteria may attack growth factors and other tissue proteins vital to the healing process.<sup>13</sup> Excessive exudate, another consequence of increased bacterial burden, also appears to impair healing via degradation of growth factors and matrix proteins, resulting in a reduction of cell proliferation.<sup>14</sup> Therefore, by decreasing bacterial burden, debridement may ultimately reduce a number of factors that impede the healing process.

**Stimulation of growth factor activity.** Chronic wounds may be deficient in, or have reduced availability of, important growth factors, such as platelet-derived growth factor (PDGF), fibroblast growth factor (FGF), epidermal growth factor (EGF), and transforming growth factor beta (TGF- $\beta$ ).<sup>15</sup> Growth factors may be present but unavailable due to abnormal binding to matrix proteins; an example of this is the growth factor trap hypothesis, proposed as a cause for venous ulceration.<sup>16</sup> This hypothesis proposes that venous hypertension results in the leakage of macromolecules into the dermis that trap (i.e., bind) growth factors, making them unavailable for wound repair. Even if present, growth factors need to be exposed to properly functioning cells with the appropriate receptors to bind effectively. In chronic wounds, dead tissue is unreceptive to growth factors and acts as a physical barrier.

er for growth factor-receptor interaction.<sup>2</sup> Debridement may accelerate healing by clearing this dead tissue, thereby, uncovering viable receptors for growth factors to bind.

Debridement, which results in bleeding, stimulates the production of blood-borne growth factors. During the coagulation cascade, platelets control bleeding and form a platelet plug. In addition, activated platelets, through their alpha granules, release various growth factors and cytokines, including PDGF, TGF- $\beta$ , and fibronectin.<sup>17</sup> These act as chemoattractants for inflammatory cells and mitogens for fibroblasts and epithelial cells, all crucial components for proper wound healing.

In practice, debridement commonly precedes topical application of growth factors. The reason for this practice is that patients heal a greater percentage of the time when rhPDGF is combined with surgically debrided diabetic foot ulcers compared with application of rhPDGF alone.<sup>13</sup>

**Removal of senescent cells.** Cellular senescence may contribute to impaired healing of chronic wounds. Senescent (or aged) cells are cells that have markedly decreased proliferation and protein production even though they remain viable. Wounds present for a greater length of time have wound fibroblasts less responsive to growth factor stimuli. For example, TGF- $\beta$  1 and PDGF, which stimulate fibroblasts to proliferate and to synthesize and deposit collagen and proteoglycans during extracellular matrix production, do so to a lesser extent with fibroblasts derived from wounds of long duration.<sup>18,19</sup> These senescent fibroblasts have been found in a variety of chronic wound types.<sup>20,21</sup> This finding is consistent with studies that have found that wounds present for long duration are more difficult to heal.<sup>22</sup> The population of senescent fibroblasts is reduced as wound repair progresses, further suggesting the detriment of cellular senescence. Debridement has the opportunity to remove the senescent fibroblasts, leaving younger, more viable cells and a healthier environment for the wound to heal.

**Removal of hyperproliferative, nonmigratory tissue.** One role of debridement is to remove the callus often surrounding chronic wounds, especially neuropathic or pressure ulcers.<sup>23</sup> In addition to callus, the edge of a chronic wound may be thickened or hyperproliferative. This finding may be accentuated to a degree that the wound edge can take on, histologically, a pseudocarcinomatous appearance.<sup>24</sup> Unfortunately, epithelial proliferation and migration are two distinct biologic phenomena.<sup>25</sup> A hyperproliferative epithelium is nonmigratory and thus slows healing. Debridement can remove this hyperproliferative, nonmigratory edge.

This allows remaining cells to undergo normal proliferation, migration, and healing.

## Types of Debridement

**Surgical/sharp debridement.** Surgical debridement is the removal of necrotic, devitalized tissue by using a sharp instrument, such as scalpel, scissors, curette, or forceps. Recently, debridement with lasers, which both cuts and cauterizes, is a high-tech alternative. Wounds with large quantities of necrotic debris are good candidates for surgical debridement,<sup>5</sup> but given the theoretic advantages of debridement, it is possible other wounds may benefit as well. Certainly, when necrotic tissue in a wound poses a serious threat to the patient (e.g., sepsis or cellulitis), surgical debridement is the method of choice, as debridement must occur as quickly as possible. Although surgical debridement is rapid, it is also considered nonselective, since viable tissue lying adjacent to the dead tissue may be excised as well.<sup>26</sup> Control of pain during the procedure is important and can be accomplished with anesthesia. Pain after the procedure may occur and needs to be managed with analgesics. If frequent debridement is required, associated pain is a limitation. Surgical debridement should be performed by trained individuals.<sup>5</sup> It may be performed at the bedside and, in more extensive cases, in an operating room. The latter increases the cost of the procedure but may be prudent in extensive cases to decrease the risk of secondary infection.

**Mechanical debridement.** Various methods may be used for mechanical debridement including application of wet-to-dry dressings, high-pressure irrigation, and whirlpool baths, among others.<sup>27</sup> Wet-to-dry debridement involves covering a wound with a saline-moistened dressing and allowing it to dry. After it has dried, the dressing is removed and the necrotic tissue that has adhered to the dressing is also removed. This method is nonselective and painful as it also lifts away some viable tissue present in the wound.<sup>28</sup> High-pressure irrigation and whirlpool baths debride wounds using water, but these methods may also result in periwound maceration.<sup>29</sup> Theoretically, waterborne pathogens may cause infection or contamination of the wound bed. In practice, wet-to-dry debridement may still be the most commonly employed technique, but this method of mechanical debridement is outdated and should be avoided if other options are available.<sup>30</sup>

**Autolytic debridement.** Autolytic debridement

uses the body's own enzymes to dissolve necrotic tissue within the wound. A moist environment accelerates the autolytic process.<sup>31</sup> Occlusive and semi-occlusive dressings allow better contact between the necrotic debris and lysosomal enzymes in the wound.<sup>32</sup> Hydrocolloids, hydrogels, transparent films, and alginate are moist interactive dressings that can be used for autolytic debridement. This method is selective and causes little or no pain. However, autolytic debridement may be slow.

**Biosurgical debridement.** Biosurgical debridement involves the use of maggots to remove nonviable tissue from a wound. Sterile maggots from the species *Lucilia sericata* (greenbottle fly) are applied to a wound, then covered by a dressing. Within the wound, the maggots liquefy necrotic tissue and then ingest it.<sup>29,33</sup> The maggots are left inside the wound for approximately one to three days.<sup>34</sup> Additionally, maggots demonstrate the ability to consume bacteria—including certain antibiotic-resistant strains—decreasing the patient's risk of developing clinical infection.<sup>31,35</sup> Larval secretions have been shown to promote the growth of human fibroblasts *in vitro* and may enhance the effects of debridement for stimulating granulation.<sup>36</sup> Patients that experience pain with maggot therapy are treated with analgesics. In some cases, patients are uncomfortable with the notion of maggot debridement, and this must be considered when choosing the best treatment for a patient. In addition, lack of widespread availability of this treatment choice is a consideration.

**Enzymatic debridement.** In many cases, debridement that is faster than autolytic debridement as well as more conservative than surgical debridement is desired. In these instances, enzymatic debridement has become a well-accepted method.<sup>37,38</sup> Several different enzyme preparations are available, each of which provides a unique set of chemical activities, which should be considered when choosing the proper enzymatic debriding agent. The two most widely used products today are topical preparations of collagenase (Collagenase Santyl<sup>®</sup> Ointment, Smith & Nephew<sup>®</sup>, Largo, FL) and papain/urea (Accuzyme<sup>®</sup> Papain-Urea Debriding Ointment, Healthpoint<sup>™</sup>, Fort Worth, TX). The collagenase product is a partially purified preparation of collagenase derived from bacteria. In addition to collagen, it appears other enzymatic activities are also associated with this product giving it the ability to degrade substrates other than collagen. Hebda and Lo recently reported that this collagenase preparation is capable of the *in-vitro* action of the following substrates: heat denatured porcine skin,

elastin, and, to a much lesser extent, fibrin.<sup>37</sup> The papain-based product is comprised of papain (purified from papaya fruit) mixed with a chemical agent, urea. The mixture of the enzyme with urea provides more effective debriding than papain alone. Hebda and Lo demonstrated the efficacy of the papain/urea mixture against heat denatured porcine skin but with significant efficacy against fibrin, a common component of eschar. Previous work demonstrated that both collagenase and papain/urea were decidedly more effective against denatured (devitalized) proteins than against nondenatured (native) proteins.<sup>37,38</sup> This finding translated into the effective digestion of devitalized tissue in animal injury models without an adverse impact on surrounding healthy tissue;<sup>37</sup> the papain/urea mixture provided typically rapid digestion of the devitalized tissue.<sup>39</sup> Clinical assessments have also been carried out to examine the efficacy of these two products. Collagenase enhances removal of devitalized tissue compared to the vehicle containing heat-inactivated enzyme.<sup>40</sup> Variable results have been obtained when comparing collagenase against other active agents and debridement formulations.<sup>41,42</sup> Papain/urea mixtures have also been examined for their efficacy in wound debridement and have yielded consistently positive results.<sup>43-46</sup> Recently, examination of the two debriding agents was carried out, and the interim results were reported by Alvarez, et al.<sup>47</sup> Subjects with stable pressure ulcers were randomized to treatment with either papain/urea or collagenase. Several parameters associated with debridement were examined. The interim report concluded that debridement was more rapid with the papain/urea formulation. Rapid debridement was positively correlated with rapid appearance of granulation tissue. The interim outcomes of this study also provided evidence of the specificity of papain/urea to devitalized tissue. Neither preparation was associated with any substantial adverse events.

## Evidence of the Benefit of Debridement

The use of debridement as a standard procedure for proper wound management is based largely on expert consensus as opposed to randomized clinical trials. However, some clinical trial evidence for debridement does exist. One landmark trial supporting its use in chronic wounds was published in 1996 by Steed, et al.<sup>13</sup> In this study, which was part of the data that led to the approval of rhPDGF for diabetic neuropathic foot ulcers,

higher healing rates were observed in those treatment centers that performed more frequent surgical debridement of diabetic foot ulcers compared to other centers that did not debride as often. Other data from clinical series exist. For example, in one study, 26 out of 30 refractory ulcer patients showed successful healing following two-stage surgical debridement.<sup>48</sup> For biosurgical debridement, one study demonstrated a 68-percent decrease in the mean area of slough and necrotic tissue in leg ulcers following maggot therapy, while the area of granulation tissue increased by 26 percent.<sup>49</sup> There was also a reduction in the amount of exudate, odor, and bacteria present. Collagenase and papain/urea formulations have been demonstrated to have degrading effects on wound components, such as collagen, fibrin, and elastin both *in vitro* and clinically.<sup>37,47</sup> A recent study showed that collagenase *in vitro* was capable of degrading both collagen and elastin, while papain/urea was effective for fibrin and collagen degradation.<sup>37</sup>

However, given the theoretic advantages of debridement based upon proposed mechanisms of chronicity of wounds, more and better data is needed to document the efficacy of debridement. Debridement for most wound types is considered the standard of care, and this standard should be based upon well performed randomized trials. Given the widespread acceptance of debridement and potential theoretical benefits, the utility of debridement should be proven in a more rigorous fashion.

## Conclusion and Summary

Debridement remains a standard of care among professionals. Accomplished by either surgical or nonsurgical means, it is thought to be fundamental to proper healing. Debridement may work by a variety of mechanisms. It removes devitalized tissue in addition to ridding the wound of detrimental bacteria, senescent fibroblasts, and hyperproliferative cells while also stimulating important growth factor activity. It reduces harmful inflammation and exudate and allows more adequate granulation and epithelialization to occur. The optimal method depends on the unique characteristics of the patient and his or her wound. Although many steps are required for optimal wound care management, debridement is an integral part of transforming the hostile environment of a chronic wound into a more receptive milieu to allow healing or to optimize the use of advanced wound care products.

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## Debridement: Rationale and Therapeutic Options

### Questions (Select one answer per question)

- Which of the following is NOT a debridement method?
  - Electrical
  - Mechanical
  - Surgical
  - Enzymatic
- Each of the following is a theoretic reason debridement may work EXCEPT?
  - Removal of senescent cells
  - Activation of complement
  - Improvement of matrix metalloproteinases
  - Removal of potential biofilm
- Which of the following is a poor prognostic factor for healing?
  - Wound color
  - Wound smell
  - Wound duration
  - Wound taste
- Bacteria may be detrimental for which of the following reasons?
  - Increased number
  - Species type
  - Increased adherence to wound
  - All of the above
- Maggots:
  - Stimulate growth of human fibroblasts *in vitro*
  - Digest living tissue
  - Secrete alpha 1 antitrypsin
  - Cause solidification of necrotic material
- Papain is derived from:
  - Avocado
  - Papaya
  - Apple
  - Mango
- Papain/urea will not debride:
  - Denatured collagen
  - Fibrin
  - Granulation tissue
  - Devitalized porcine tissue
- Diabetic foot ulcers will be improved by all of the following EXCEPT?
  - Offloading
  - Debridement
  - Platelet-derived growth factor
  - Dry gauze dressings
- Proof of efficacy of debridement for chronic wounds would best be supported by which of the following?
  - Randomized clinical trial
  - Case series
  - Case report
  - Expert opinion
- Biofilms differ from planktonic bacteria by which of the following?
  - Embedded in an extrapolsaccharide matrix
  - Demonstrate increased adherence to the wound bed
  - Have increased resistance to antimicrobial agents and to the immune system of the host
  - All of the above

### Answer and Evaluation Form

Please print clearly:

Name	Degree	Position/Title
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Organization/Institute	Department
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**Answers:** Circle one letter for each answer

- A B C D
- A B C D
- A B C D
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- A B C D
- A B C D
- A B C D
- A B C D
- A B C D

### Evaluation (circle one)

Excellent (4) Good (3) Satisfactory (2) Poor (1)

Accuracy and timeliness of content:	4	3	2	1
Relevance to your daily practice:	4	3	2	1
Impact on your professional effectiveness:	4	3	2	1
Relevance of the content to the learning objectives:	4	3	2	1
Effectiveness of the teaching/learning methods:	4	3	2	1
This activity avoided commercial bias or influence	YES	NO		

### Now that you have read this article, can you:

- Describe the rationale for debridement of chronic wounds? YES NO
- Appreciate the different types of debridement techniques? YES NO
- Discuss the advantages and limitations of each debridement technique? YES NO

What questions do you still have?

How will you use what you have learned from this activity?

All tests must be received by 9/15/03.